ESOP

Environmental Surveillance and Oversight Program

2017 DATA REPORT

Healthy People. Healthy Communities.

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DHEC's Creative Services

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DOE-SR Environmental Quality Management Division

PURPOSE OF THIS REPORT

WHAT: South Carolina's Department of Health and Environmental Control (SC DHEC) monitors the Savannah River Site (SRS) for potential contaminants and produces a report of all its annual findings.

WHY: Due to nuclear material testing and lack of environmental regulation during the Cold War era, the SRS property has been contaminated with radioactive and non-radioactive material. SRS scientists have been sampling the air, water, soil, and wildlife for many years. However, to verify the data being collected by site scientists, DHEC was brought on in 1995 to conduct their own monitoring of the site and serve as a second set of eyes.

HOW: In order to have a verification system for SRS's annual data, the Department of Energy-Savannah River (DOE-SR) partnered with SC DHEC to create the Environmental Surveillance and Oversight Program (ESOP), which is a division of SC DHEC specific to its Midlands Aiken Environmental Affairs Office. There are 10 scientists working in ESOP that collect and analyze samples of air, water, soil, sediment, vegetation, milk, fish, and game.

WHERE: Samples are collected on site property, around its perimeter, and in background (>50 miles outside boundary lines) locations. Depending upon the media, some DHEC sample locations coincide with those of DOE-SR. These locations are compared in our report.

WHEN: Weekly, quarterly, biannually, and annually---These are dependent upon the type of media and can be affected by availability of resource, accessibility, and weather.

Team Photo (left to right): Richard Burnett, Tim Mettlen, Katherine Kane, Gregg O'Quinn, Grace Anne Martin, Krista McCuen, Beth Cameron, Greg Mason, Thomas Rolka, Jeffrey Joyner

RADIATION – Occurs when an unstable atom tries to become stable by releasing some of its energy in the form of an alpha or beta particle or gamma wave.

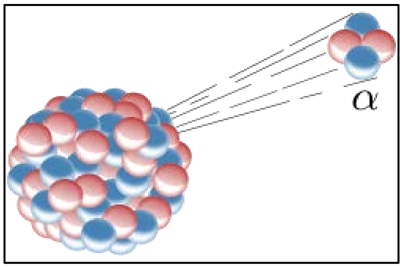
TYPES OF RADIATION

ALPHA – results when the nucleus of an atom releases two protons and two neutrons. Due to this particle being heavier in mass, it can be stopped by the air, skin, or paper. External exposure is not dangerous, but if swallowed, breathed in, or enters a person through a cut, it can harm the human body.

BETA – occurs when an atom releases an electron (negative charge). Since it is lighter in mass and faster moving, it can travel greater distances and can be stopped by a layer of wood or metal, but can penetrate outer layer of skin. It can cause skin burns.

GAMMA – is the release of pure energy that is fast moving and able to travel longer distances until it hits either concrete or lead. It will pass through the human body resulting in internal and external bodily damage.

ALPHA RADIATION:



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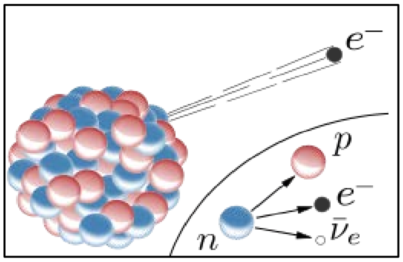
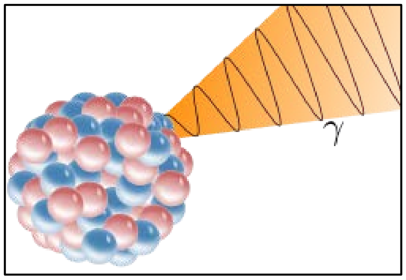


GAMMA RADIATION:



RADIATION:

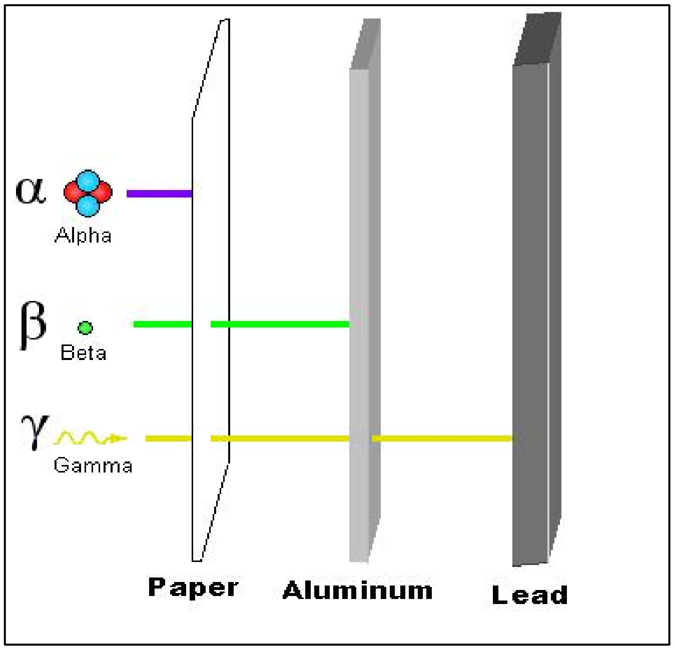


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Table 1. Gamma Analytes

Radioisotope	Abbreviation
Actinium-228	Ac-228
Americium-241	Am-241
Beryllium-7	Be-7
Cerium-144	Ce-144
Cobalt-58	Co-58
Cobalt-60	Co-60
Cesium-134	Cs-134
Cesium-137	Cs-137
Europium-152	Eu-152
Europium-154	Eu-154
Europium-155	Eu-155
Iodine-131	I-131
Potassium-40	K-40
Plutonium-238	Pu-238
Plutonium-239/240	Pu-239/240
Manganese-54	Mn-54
Sodium-22	Na-22
Lead-212	Pb-212
Lead-214	Pb-214
Radium-226	Ra-226
Ruthenium-103	Ru-103
Antimony-125	Sb-125
Thorium-234	Th-234
Yttrium-88	Y-88
Zinc-65	Zn-65
Zirconium-95	Zr-95

Table 2. Metal Analytes

Analyte	Abbreviation
Barium	Ba
Beryllium	Be
Cadmium	Cd
Chromium	Cr
Copper	Cu
Lead	Pb
Manganese	Mn
Mercury	Hg
Nickel	Ni
Zinc	Zn

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Acronyms and Units of Measure

LIST OF ACRONYMS

ABR	Allendale Barricade
AEI	Average Exposed Individual
AIK	Aiken
AKN	Sample locations in Aiken County
ALD	Sample locations in Allendale County
ALN	Allendale
B/J	Beaufort-Jasper
BGN	Burial Grounds North
BOD	Biochemical Oxygen Demand
BWL	Sample locations in Barnwell County
CDC	Centers for Disease Control and Prevention
DIL	Derived Intervention Level
DKH	Dark Horse at the Williston Barricade
DHEC	South Carolina Department of Health and Environmental Control
DNR	South Carolina Department of Natural Resources
DO	Dissolved Oxygen
DOE	Department of Energy
DOE-SR	Department of Energy-Savannah River
ESOP	Environmental Surveillance and Oversight Program
EPA	United States Environmental Protection Agency
ESV	Ecological Screening Value
FDA	United States Food and Drug Administration
HLW	High Level Waste
Hwy. 17	United States Highway 17
Hwy. 301	United States Highway 301
IAEA	International Atomic Energy Agency
JAK	Jackson
LLD	Lower Limit of Detection
LLW	Low Level Waste
MCL	Maximum Contaminant Level
MDA	Minimum Detectable Activity
MDC	Minimum Detectable Concentration
MDL	Minimum Detection Level
MEI	Maximum Exposed Individual
NA	Not Applicable
ND	Not Detected
NEL	New Ellenton
NORM	Naturally Occurring Radioactive Material
NS	No Sample
NSBLD	New Savannah Bluff Lock & Dam
PCB	Polychlorinated Biphenyls
PRG	Preliminary Remediation Goals
RM	River Mile
RSL	Regional Screening Level
RSW	Radiological Surface Water
SCAT	South Carolina Advanced Technology
SRNS	Savannah River Nuclear Solutions

Acronyms and Units of Measure

SRS	Savannah River Site
SSL	Soil Screening Level
TKN	Total Kjeldahl Nitrogen
TLD	Thermoluminescent Dosimeter
TSP	Total Suspended Particulates
TSS	Total Suspended Solid
USFS	United States Forestry Service
USGS	United States Geological Survey
VOC	Volatile Organic Compound

LIST OF ISOTOPES AND ABBREVIATIONS

I-129	Iodine-129
Sr-89/90	Strontium-89/90
Sr-90	Strontium-90

UNITS OF MEASURE

<	Less than
±	Plus or minus. Refers to one standard deviation unless otherwise stated
±2	Plus or minus 2 standard deviations.
°C	temperature in Celsius
Ci	Curie
cnt	counts
g/ml	grams per milliliter
hrs/yr	hours per year
kg/yr	kilograms per year
L/yr	liters per year
m^3/yr	cubic meters per year
mg/day	milligrams per day
mg/kg	milligrams per kilogram
mg/L	Milligrams Per Liter
mL	milliliter
ml/L	milliliter per liter
MPN	Most Probable Number
mrem	millirem or milliroentgen equivalent man
NTU	Nephelometric Turbidity Unit
pCi/g	picocuries per gram
pCi/L	Picocuries per liter
pCi/m^3	picoCuries per cubic meter
pCi/mL	picocuries per milliliter
SU	standard

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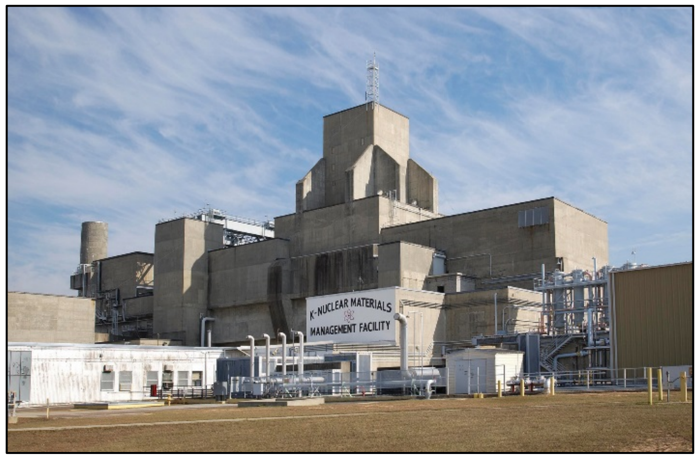
Introduction

In 1950, the U.S. Atomic Energy Commission established the Savannah River Site (SRS) (1954-1992) with the mission of producing nuclear materials, primarily tritium and plutonium. SRS is a Department of Energy (DOE) facility located approximately 20 miles from Aiken, South Carolina. SRS boundaries lie within Aiken, Allendale, and Barnwell counties and span approximately 310 square miles. During legacy operations, radionuclides were released into the surface water, groundwater, soils, and atmosphere. Although the reactors are no longer operating, work continues at SRS with the primary focus being on cleaning up legacy wastes and remediating areas associated with former operations.

Due to the large number of contaminants that could potentially be released from SRS, the Centers for Disease Control and Prevention (CDC) performed a site assessment to determine the potential health effects of any discharged radionuclides to the off-site public. Most of the radiological releases originated from processes associated with the reactor areas (R, K, P, L, and C) and the separations areas, but there are other areas of releases as a result of the varied processes at SRS.



K Reactor at SRS – No longer in operation

Tritium was one of the principle nuclear materials produced at SRS to multiply the firepower of plutonium in nuclear weapons (Till et al. 2001). Tritium releases originated from processes associated with the reactors, separations areas, D-Area, and tritium facilities. The two main types of tritium releases came from direct site facility releases and migration from seepage basins in the separations areas, the burial ground, and the K-Area containment basin. In the early operational years, nearly 100 percent of the discharges to streams were related to direct releases. Tritiated water's ability to react chemically like nonradioactive water in living cells lends itself to be more hazardous biologically than tritium gas (CDC SRSHES 1997).

Alpha-emitting and beta-emitting radionuclides were also released to liquid effluent. Alpha-emitting radionuclide releases from M-Area primarily affected Tims Branch, which ultimately flows into Upper Three Runs Creek. Fourmile Branch is the stream most affected by alpha- and beta-emitting releases coming from the separations areas, and releases from the reactor areas affected all streams except for Upper Three Runs Creek (Till et al. 2001). Steel Creek, Pen Branch, and Lower Three Runs Creek were mainly affected by beta-emitting releases from the reactors. Strontium-90 (Sr-90) is a main contributor of beta activity and came primarily from the reactors (Till et al. 2001).

Plutonium was manufactured at SRS in H-Area from fuel rods and in F-Area from targets (Till et al. 2001). Releases at SRS occurred primarily through the discharge of liquid effluent. Iodine-129 (I-129) is a fission product of reactor fuel that has a very long half-life. Most occurred during fuel processing (Till et al. 2001). Technetium-99 (Tc-99) was produced in SRS production reactors as a fission byproduct of uranium and plutonium. This radionuclide was released to the environment from the separations areas ventilation systems, the aqueous

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environment from liquid waste in waste tanks, and the Solid Waste Disposal Facility (WSRC 1993).

Strontium was a fission product in SRS reactors, subsequently released from F-area and H-area (WSRC 1998). SRS operations have also released strontium into the environment through normal site operations and equipment failure.

H Canyon at SRS – Still in operation at the site

Routine operations at SRS have released cesium-137 (Cs-137) to the regional environment surrounding SRS. The most significant releases occurred during the early years of site operation when Cs-137 was released to seepage basins and site streams. The SRS facilities that have documented Cs-137 releases are the production reactors, separations areas, liquid waste facilities, the solid waste disposal facility, central shops, heavy water rework facility, Saltstone Facility, and the Savannah River National Laboratory (SRNL).

The Department of Energy is self-regulating. Until 1995, the public had to rely solely on DOE to ensure their health and the environment was protected. The DOE formed an Agreement in Principal (AIP) with the South Carolina Department of Health and Environmental Control (SC DHEC) to perform independent environmental monitoring and oversight of SRS. This partnership provides an extra source of information to the public regarding the effectiveness of the DOE monitoring activities. From this agreement, the Environmental Surveillance and Oversight Program (ESOP) of DHEC was initiated to supplement and compliment monitoring functions of this unique facility. DHEC monitoring provides an added protection due to the potential for catastrophic environmental releases that pose a threat to the state.

Program development at SRS is stable and evolves based on changing missions. The primary focus is on legacy waste and materials that are stored or have been disposed of on-site and pose a current release to the environment. This report provides results of samples collected by DHEC related to SRS, trending data to document how contaminants are changing, and information on how these changes may impact the surrounding communities. DHEC's ESOP will continue its mission of monitoring and oversight around SRS to ensure the site's on-going activities continue to be safe for the public and the environment.

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Chapter 1 Radiological Atmospheric Monitoring on and Adjacent to SRS

1.1.0 PROJECT SUMMARY

Atmospheric transport has the potential to impact the citizens of South Carolina from releases associated with activities at SRS. The Atmospheric Monitoring project independently conducts routine, quantitative monitoring of atmospheric radionuclide releases associated with SRS, which it uses to identify concentration trends that could require further investigation. Air monitoring capabilities in 2017 included 19 thermoluminescent dosimeters (TLDs) and nine air monitoring stations that collected samples using glass fiber filters, rain collection pans, and silica gel columns. Glass fiber filters are used to collect total suspended particulates (TSP). Particulates are screened weekly for gross alpha and beta-emitting activity. Precipitation, when present, is sampled and analyzed monthly for tritium. Silica gel distillates of atmospheric moisture are analyzed monthly for tritium. TLDs are collected and analyzed every quarter for ambient beta/gamma levels. Radiological atmospheric monitoring sites were established to provide spatial coverage of the project area (Sections 1.4.0 Map and 1.5.0, Table 1). Six of the air monitoring stations are on or within two miles of the SRS perimeter, one is located at the center of the site, and two are 25 miles or more beyond the site perimeter. Thirteen of the TLDs are on or near the site perimeter, one is in the center of the site, and five are within 25 miles of the site in surrounding population centers. DHEC emphasizes monitoring for radionuclides in atmospheric media around SRS at potential public exposure locations.

Example of an Air Monitoring Station with Rain Collection Pans and Glass Fiber Filters (on top) and Silica Gel Columns (inside)

1.2.0 RESULTS AND DISCUSSION

Air Monitoring Summary Statistics can be found in Section 1.6.0 and all Air Monitoring Data can be found in 2017 DHEC Data File.

1.2.1 Total Suspended Particulates

DHEC and the Department of Energy-Savannah River (DOE-SR) had gross alpha detections in 2017. Section 1.5.0, Figure 1 shows average gross alpha activity for SRS perimeter locations and illustrates trends for the last five years of gross alpha values for DHEC and DOE-SR.

DHEC and DOE-SR had gross beta detections in 2017. Small seasonal variations at each monitoring location have been consistent with historically reported DHEC values (DHEC, 2017). The EPA Office of Radiation and Indoor Air uses gross beta counts as an indicator to determine if additional analyses will be performed. A gamma scan is conducted if the gross beta activity exceeds 1 pCi/m^3 (EPA, 2013). This tier of definitive analyses is used for all total suspended particulate sampling associated with RadNet, which is a nationwide network of sampling stations that identify trends in the accumulation of long-lived radionuclides in the environment (EPA, 2005). Section 1.5.0, Figure 2 shows average gross beta activity for the SRS perimeter locations and illustrates trending of gross beta values for DHEC and DOE-SR from the last five years.

Due to SRS finding higher levels of Pu in its filters at the Burial Ground - North in 2017, DHEC tested for Pu-238, Pu-239/240, and Am-241 in its glass fiber filters. In the future, additional isotopes will be considered for analysis on a rotating basis.

1.2.2 Ambient Beta/Gamma

DHEC conducts ambient beta/gamma monitoring through the deployment of TLDs around the perimeter of SRS. It should be noted that 4 millirem (mrem) are subtracted from the reported result for each TLD to account for the transcontinental flight from South Carolina to California and back (Walter 1995). In 2017, ambient beta/gamma average quarterly totals ranged from 22.23 (TLD-01) to 33.70 (TLD-02) mrem at the site perimeter. Section 1.5.0, Figure 3 shows data trends at the SRS Perimeter for average ambient beta/gamma values in TLDs for DHEC and DOE-SR.

Example of TLDs present at 19 locations

1.2.3 Tritium

Tritium continues to be the predominant radionuclide detected in the perimeter samples. In 2017, DOE-SR released approximately 15,200 Ci of tritium from SRS, which has been the lowest amount in 10 years and 30% less than in 2016 (SRNS, 2018). Most of the tritium detected in DHEC perimeter samples may be attributed to the release of tritium from tritium facilities, separation areas, and from diffuse and fugitive sources (SRNS, 2017).

<u>Tritium in Air</u>

Tritium in air values reported by DHEC are the result of using the historical method of calculating an air concentration of tritium based on the upper limit value of absolute humidity (11.5 grams of atmospheric moisture per cubic meter) in the geographic region (NCRP, 1984).
In 2017, the DHEC and DOE-SR average tritium activity was well below the EPA equivalent yearly average standard of 20,000 pCi/m^3 for airborne tritium activity (ANL, 2007).

Average DHEC tritium in air activity was lower than the DOE-SR activity. These variations could be caused by different sampling locations, number of locations, or sample frequency.

Average tritium in air activity at the SRS perimeter reported by DHEC for 2017 was higher than reported in 2016 and has fluctuated over the last six years. DOE-SR also reported a slight increase from 2016 to 2017 with fluctuations over the past six years. Section 1.5.0, Figure 4. illustrates data trends of atmospheric tritium activity for DHEC and DOE-SR as measured and calculated at the SRS perimeter.

Inside View of Air Monitoring Station

Silica Gel Column

Tritium in Precipitation

In 2017, DHEC and DOE-SR averages for tritium activity in precipitation were well below the EPA standard of 20,000 pCi/L for drinking water (EPA, 2002d). Section 1.5.0, Figure 5 shows average tritium in precipitation activity for SRS perimeter locations and illustrates trending tritium in precipitation values for DHEC and DOE-SR from the last five years.

During the 2017 sampling period, tritium in precipitation ranged from less than LLD to 16609.66 pCi/L (found on-site at Burial Ground North (BGN)). The maximum reported value for DHEC perimeter locations was collected at the JAK air station with 655.57 pCi/L in March. The DHEC average measured activity for all perimeter locations for tritium in precipitation was 436.95 (± 48.42) pCi/L. The DOE-SR average measured value for tritium activity in precipitation at the SRS perimeter was 452 (± 115.6 pCi/L) (SRNS, 2018).

1.3.0 CONCLUSIONS AND RECOMMENDATIONS

All DHEC data collected in 2017 confirmed historically reported DOE-SR values for gross alpha/beta, ambient beta/gamma, and tritium in the environment at the SRS boundary, with no anomalous data noted for any monitored parameters.

Due to continued releases from site facilities (tritium facilities, separations areas, etc.), DHEC will continue to collect weekly TSP for gross alpha/beta, monthly atmospheric and precipitation tritium samples, and quarterly ambient beta/gamma samples.

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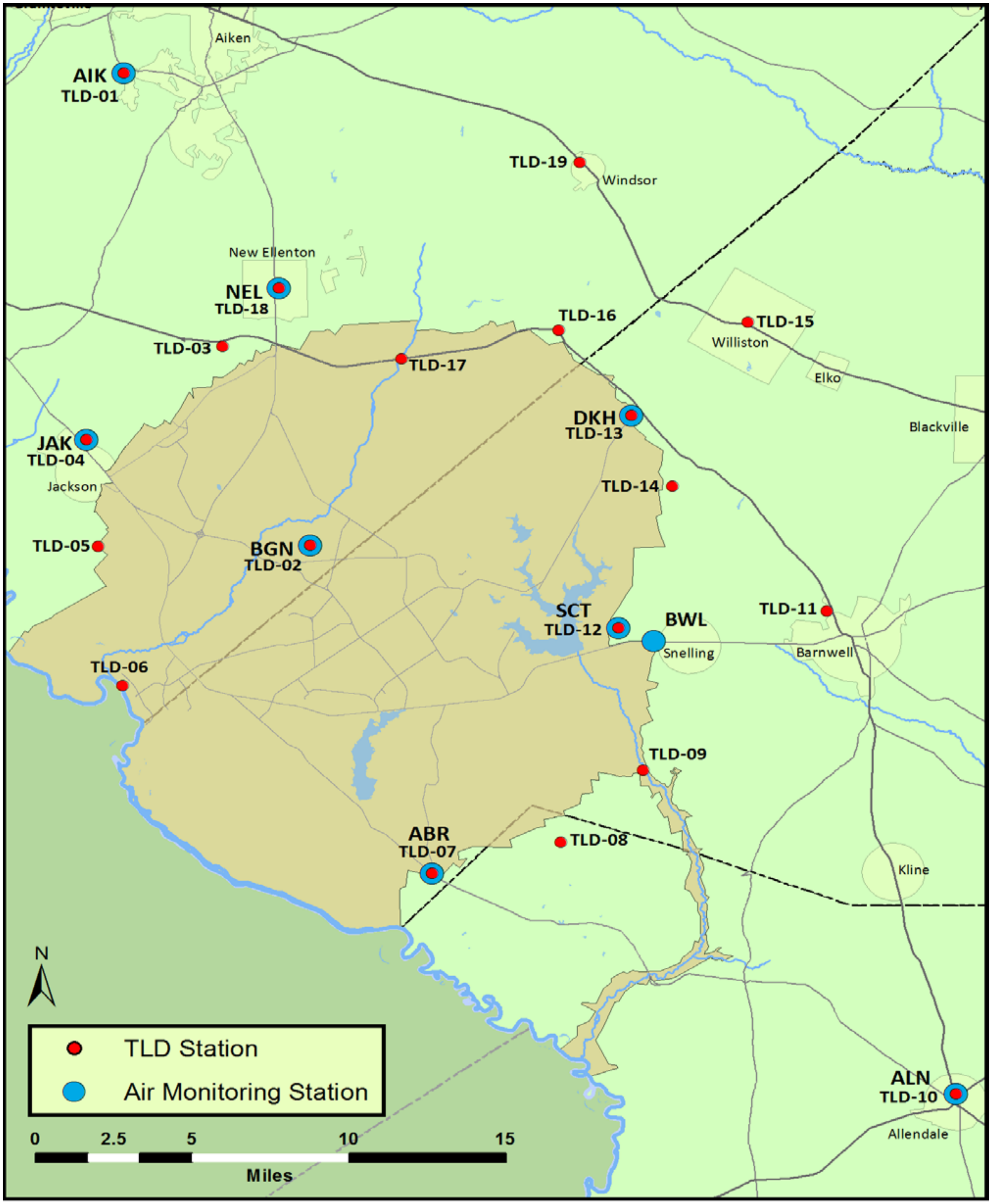
1.4.0 MAP

Radiological Atmospheric Monitoring Sample Locations



2017 ESOP Radiological Air Monitoring

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1.5.0 TABLES AND FIGURES

Table 1. Radiological Atmospheric Monitoring Locations

TLD Sample Locations

Sample ID	Location	Proximity to SRS
TLD-01	Collocated with AIK Air Station	Within 25 miles of SRS
TLD-02	Collocated with BGN Air Station	Center of SRS
TLD-03	Green Pond Road	SRS Perimeter
TLD-04	Collocated with JAK Air Station	SRS Perimeter
TLD-05	Crackerneck Gate	SRS Perimeter
TLD-06	TNX Boat Ramp	SRS Perimeter
TLD-07	Collocated with ABR Air Station	SRS Perimeter
TLD-08	Junction of Millet Road and Round Tree Road	SRS Perimeter
TLD-09	Patterson Mill Road at Lower Three Runs Creek	SRS Perimeter
TLD-10	Collocated with ALN Air Station	Within 25 miles of SRS
TLD-11	Barnwell Airport	Within 25 miles of SRS
TLD-12	Collocated with SCT Air Station	SRS Perimeter
TLD-13	Collocated with DKH Air Station	SRS Perimeter
TLD-14	Seven Pines Road Collocated with SRS Air Station	SRS Perimeter
TLD-15	Williston Police Department	Within 25 miles of SRS
TLD-16	Junction of US-278 and SC-781	SRS Perimeter
TLD-17	US-278 near Upper Three Runs Creek	SRS Perimeter
TLD-18	Collocated with NEL Air Station	SRS Perimeter
TLD-19	Windsor Post Office	Within 25 miles of SRS

Air Monitoring Stations

Sample ID	Location	Proximity to SRS
AIK	Aiken Elementary Water Tower	Within 25 miles of SRS/ Population Monitoring
BGN	Burial Grounds North, SRS	Center of SRS
BWL	Barnwell Barricade	SRS Perimeter
JAK	Jackson, S.C.	SRS Perimeter/ Population Monitoring
ABR	Allendale Barricade	SRS Perimeter
ALN	Allendale, S.C.	Background
SCT	Snelling, S.C.	SRS Perimeter
DKH	Dark Horse	SRS Perimeter
NEL	New Ellenton, S.C.	SRS Perimeter/ Population Monitoring

TABLES AND FIGURES

Figure 1. DOE-SR and DHEC Comparison of Average Gross Alpha for Total Suspended Particulates at the SRS Perimeter (SRNS, 2014-2018; DHEC, 2015-2018)

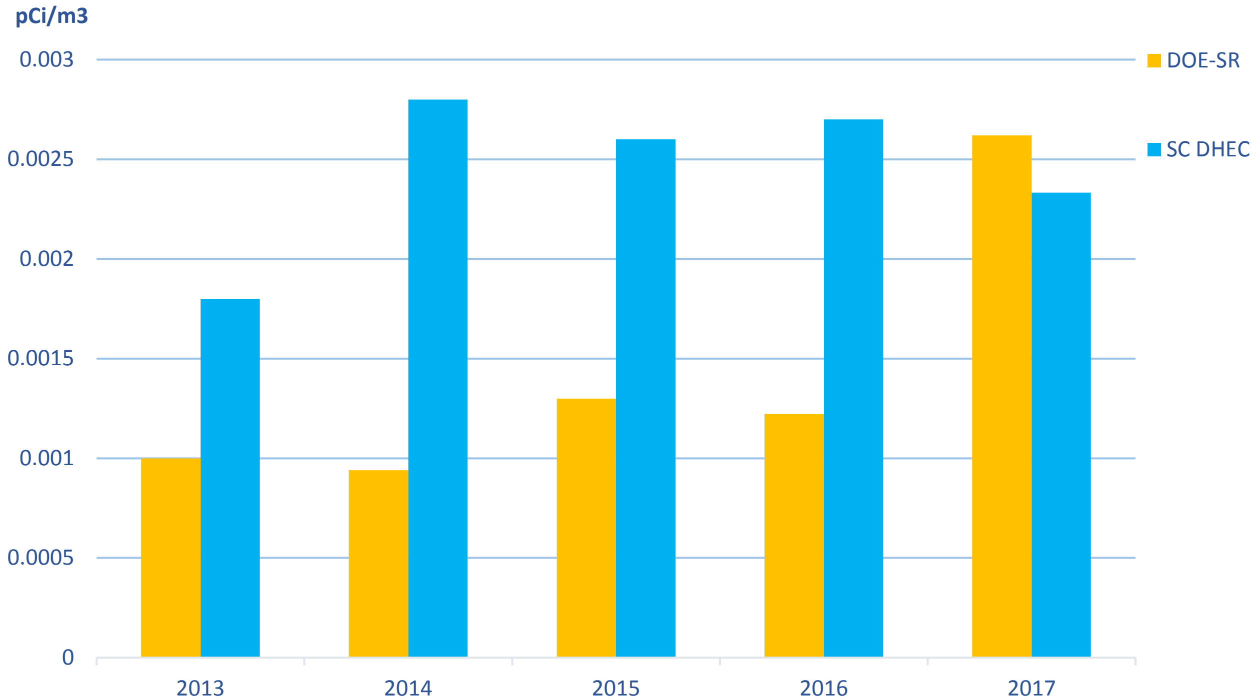

Figure 2. DOE-SR and DHEC Comparison of Average Gross Beta for Total Suspended Particulates at the SRS Perimeter (SRNS, 2014-2018; DHEC, 2015-2018)

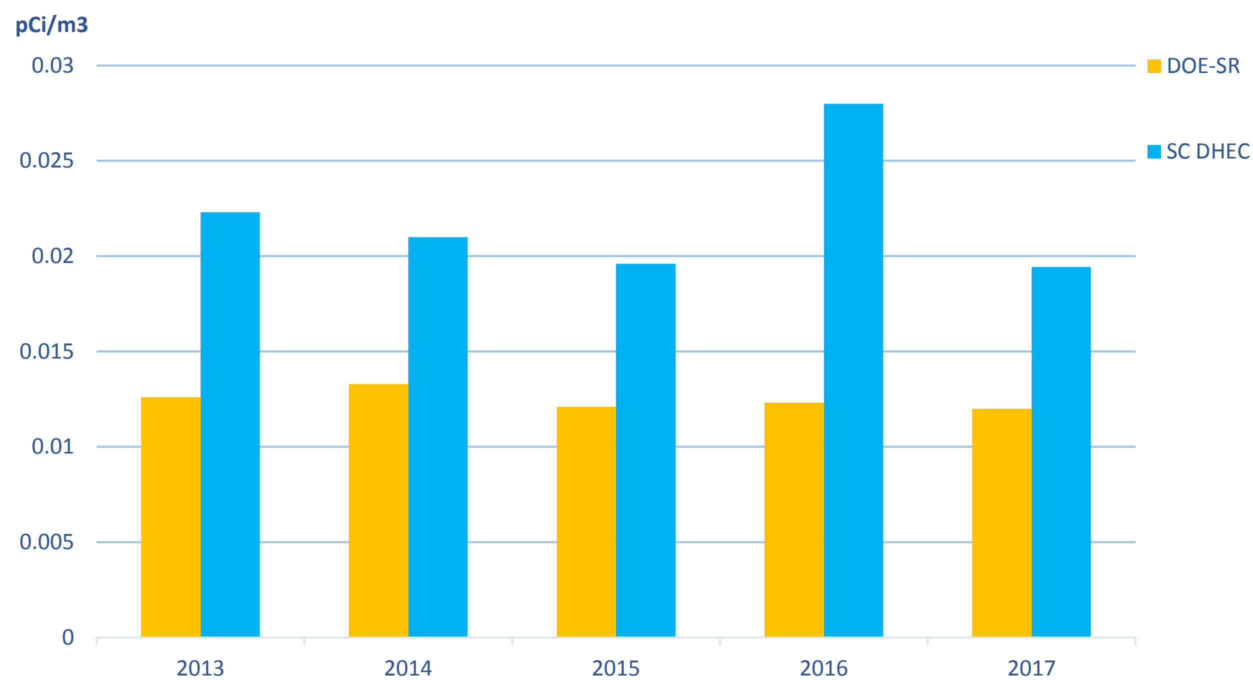

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Figure 3. DOE-SR and DHEC Comparison of Yearly Average Ambient Beta/Gamma in TLDs at the SRS Perimeter (SRNS, 2014-2018; DHEC, 2015-2018)

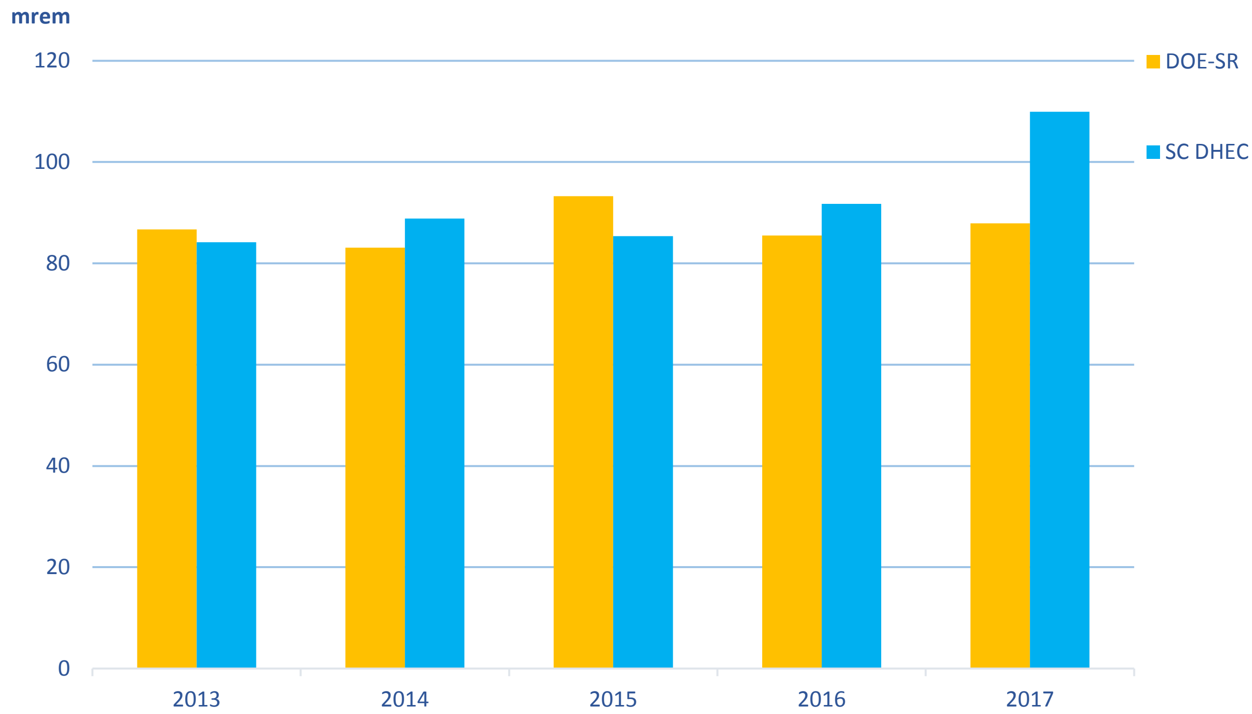

Figure 4. DOE-SR and DHEC Comparison of Average Tritium in Air at the SRS Perimeter (SRNS, 2014-2018; DHEC, 2015-2018)

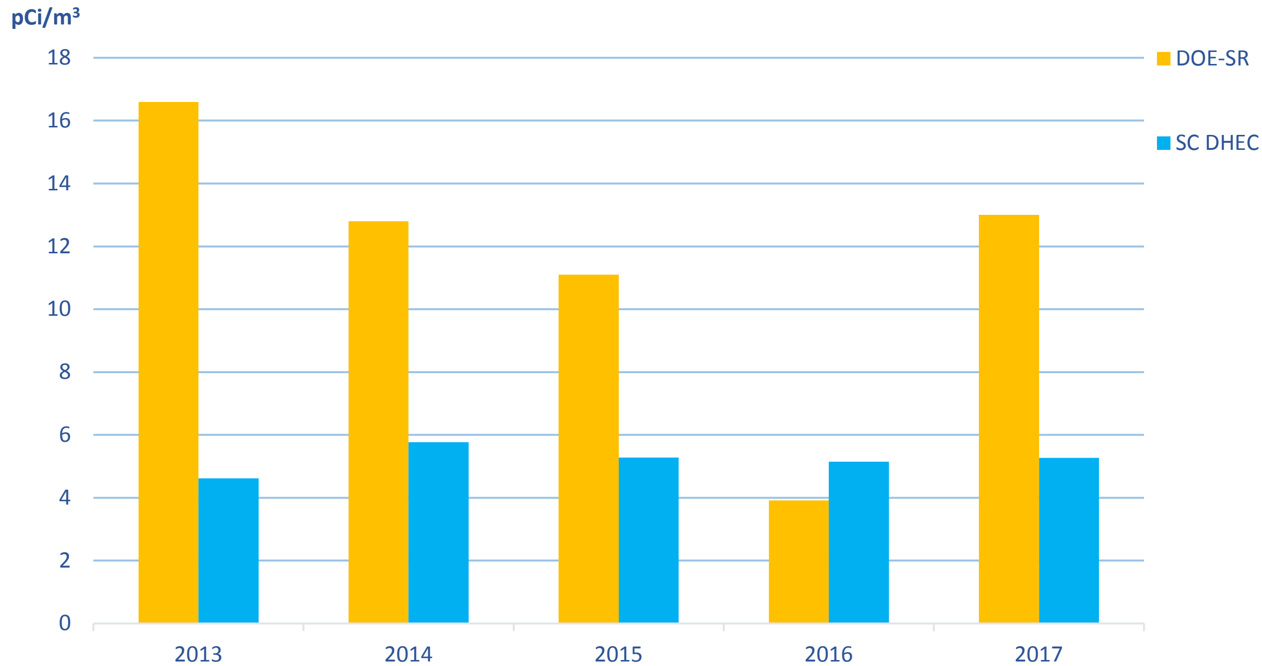

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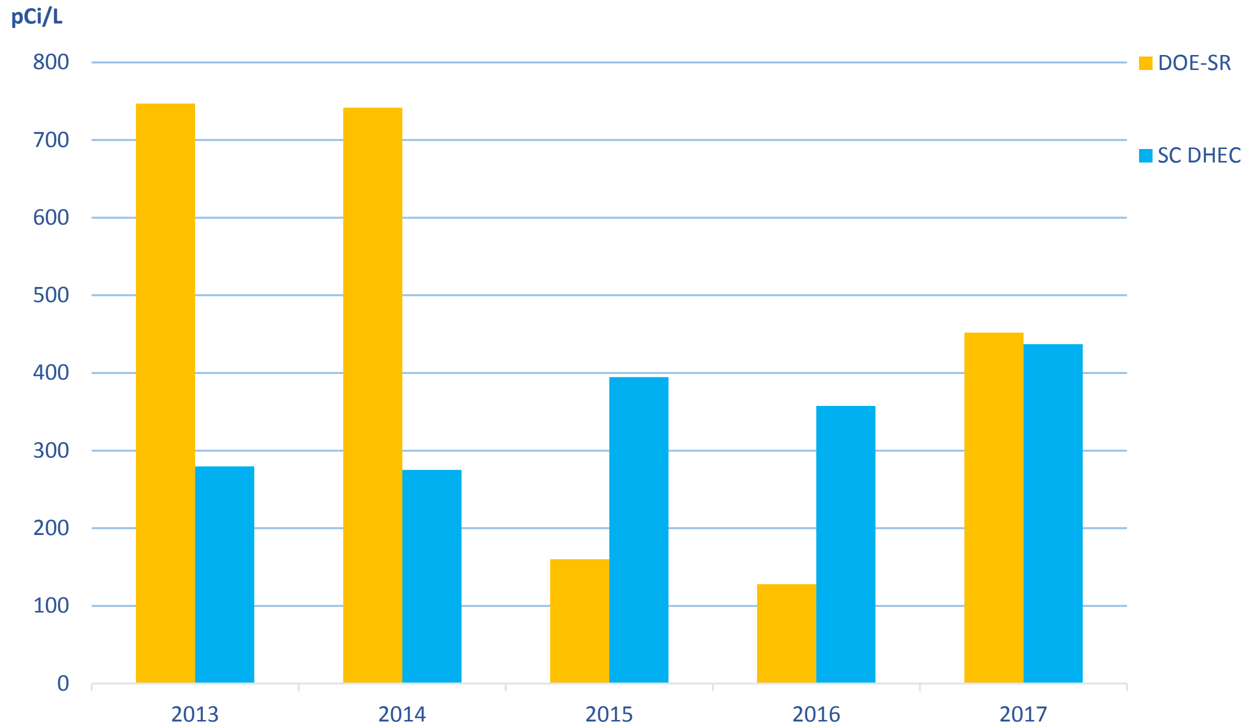
Figure 5. DOE-SR and DHEC Comparison of Average Tritium in Precipitation at the SRS Perimeter (SRNS, 2014-2018; DHEC, 2015-2018)



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1.6.0 SUMMARY STATISTICS

2017 Quarterly Averages of Ambient TLD Beta/Gamma Data

Sample ID	Average (mrem)	Standard Deviation (mrem)	Median (mrem)	Minimum (mrem)	Maximum (mrem)
TLD-01	22.23	0.39	22.10	21.90	22.80
TLD-02	33.70	1.34	33.90	31.90	35.10
TLD-03	26.63	1.18	26.85	25.10	27.70
TLD-04	23.08	2.40	22.90	20.40	26.10
TLD-05	29.98	0.75	30.10	29.10	30.60
TLD-06	28.10	3.66	26.75	25.40	33.50
TLD-07	22.68	2.04	22.50	20.80	24.90
TLD-08	28.63	1.14	28.60	27.50	29.80
TLD-09	30.48	1.28	30.95	28.60	31.40
TLD-10	26.28	1.71	26.85	23.80	27.60
TLD-11	26.60	1.23	26.70	25.00	28.00
TLD-12	27.25	0.97	27.10	26.40	28.40
TLD-13	28.48	1.10	28.25	27.40	30.00
TLD-14	31.33	1.91	31.15	29.20	33.80
TLD-15	30.25	1.13	30.50	28.80	31.20
TLD-16	28.90	4.80	30.55	22.00	32.50
TLD-17	33.30	3.60	33.30	29.70	36.90
TLD-18	26.93	0.91	26.95	25.80	28.00
TLD-19	28.43	0.98	28.65	27.10	29.30

SUMMARY STATISTICS

2017 DHEC Air Station Gross Alpha Data in pCi/m^3

Location	Average	Standard Deviation	Median	Minimum	Maximum	Number of Detects	Number of Samples
Allendale Barricade (ABR)	0.0024	0.0010	0.0023	0.0007	0.0050	51	51
Allendale, S.C. (ALN)	0.0026	0.0013	0.0023	0.0009	0.0067	32	32
Snelling, S.C. (SCT)	0.0025	0.0012	0.0022	0.0007	0.0071	51	52
Dark Horse (DKH)	0.0025	0.0011	0.0024	0.0009	0.0054	51	52
Aiken Elementary Water Tower (AIK)	0.0006	0.0057	0.0023	0.0007	0.0425	51	51
New Ellenton, S.C. (NEL)	0.0025	0.0012	0.0024	0.0006	0.0069	50	51
Jackson, S.C. (JAK)	0.0027	0.0010	0.0028	0.0008	0.0069	52	52
Burial Ground North (BGN)	0.0028	0.0015	0.0024	0.0007	0.0109	52	52
Barnwell Barricade (BWL)	0.0024	0.0010	0.0023	0.0008	0.0055	37	38

2017 DHEC Air Station Gross Beta Data in pCi/m^3

Location	Average	Standard Deviation	Median	Minimum	Maximum	Number of Detects	Number of Samples
Allendale Barricade (ABR)	0.0209	0.0071	0.0191	0.0107	0.0437	49	51
Allendale, S.C. (ALN)	0.0193	0.0045	0.0186	0.0105	0.0287	32	32
Snelling, S.C. (SCT)	0.0209	0.0074	0.0198	0.0021	0.0440	51	51
Dark Horse (DKH)	0.0223	0.0085	0.0206	0.0101	0.0498	50	50
Aiken Elementary Water Tower (AIK)	0.0206	0.0077	0.0189	0.0101	0.0504	50	51
New Ellenton, S.C. (NEL)	0.0222	0.0079	0.0206	0.0109	0.0437	50	50
Jackson, S.C. (JAK)	0.0229	0.0079	0.0210	0.0111	0.0473	51	51
Burial Ground North (BGN)	0.0234	0.0082	0.0215	0.0101	0.0499	51	51
Barnwell Barricade (BWL)	0.0024	0.0078	0.0205	0.0100	0.0440	38	38

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SUMMARY STATISTICS

2017 DHEC Air Station Tritium Data in pCi/m^3

Location	Average	Standard Deviation	Median	Minimum	Maximum	Number of Detects	Number of Samples
Allendale Barricade (ABR)	4.37	1.33	4.13	<LLD	5.81	3	12
Allendale, S.C. (ALN)	4.86	0.66	4.79	<LLD	<LLD	4	12
Snelling, S.C. (SCT)	5.26	2.02	4.97	<LLD	9.36	7	12
Dark Horse (DKH)	6.92	2.06	6.76	<LLD	9.36	6	12
Aiken Elementary Water Tower (AIK)	3.95	0.60	4.06	<LLD	<LLD	4	12
New Ellenton, S.C. (NEL)	6.74	2.44	7.05	<LLD	9.70	8	12
Jackson, S.C. (JAK)	5.46	3.24	4.07	<LLD	11.84	6	12
Burial Ground North (BGN)	161.01	93.99	144.93	27.43	354.34	12	12
Barnwell Barricade (BWL)	4.57	0.84	4.56	3.73	5.42	3	7

2017 DHEC Tritium in Precipitation Data in pCi/L

Location	Average	Standard Deviation	Median	Minimum	Maximum	Number of Detects	Number of Samples
Allendale Barricade (ABR)	364.09	137.45	364.09	<LLD	461.28	2	12
Allendale, S.C. (ALN)	426.00	136.82	389.25	<LLD	611.47	7	9
Snelling, S.C. (SCT)	424.19	214.74	424.19	<LLD	576.04	2	12
Dark Horse (DKH)	440.95	199.88	440.95	<LLD	528.29	2	11
Aiken Elementary Water Tower (AIK)	526.40	NA	526.40	526.40	526.40	1	12
New Ellenton, S.C. (NEL)	453.59	225.39	453.59	<LLD	612.96	2	12
Jackson, S.C. (JAK)	423.46	160.14	372.54	<LLD	655.57	4	10
Burial Ground North (BGN)	2882.42	4628.69	1681.88	442.18	16609.66	11	11
Barnwell Barricade (BWL)	ND	NA	NA	<LLD	<LLD	0	8

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Chapter 2 Ambient Groundwater Monitoring Adjacent to SRS

2.1.0 PROJECT SUMMARY

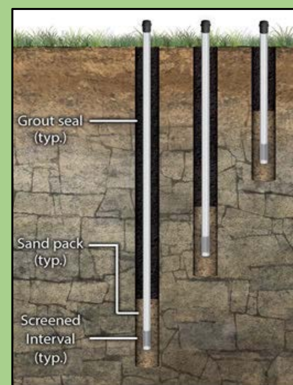
DHEC currently utilizes a regional groundwater monitoring well system consisting of cluster wells (C-wells) and network wells (private wells and public water systems). This groundwater well network consists of approximately 75 wells that are cyclically sampled every five years by DHEC. The C-wells are owned and maintained by the South Carolina Department of Natural Resources (DNR). These cluster wells are screened from shallow surficial aquifers up to depths exceeding 1,400 feet below ground surface. The C-well clusters are situated around the perimeter of SRS.

Monitoring these wells allows DHEC to evaluate groundwater quality adjacent to SRS, compare results with historical data, determine any potential SRS contaminant migration offsite, expand current ambient water quality databases, and provide the public with independently generated, region specific, groundwater quality information.

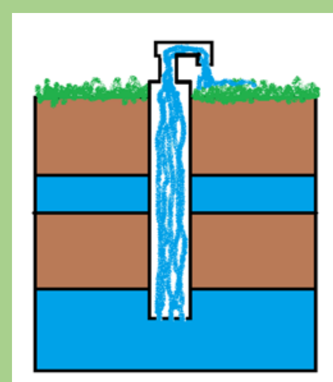
Groundwater samples are collected from wells within a 15-mile site boundary and background samples are collected from available municipal and private groundwater wells located between 30 and 100 miles from the SRS center point. A 15-mile sampling perimeter was selected based on regional well availability, and comparative review of known or suspected sources of groundwater contamination and local groundwater flow patterns. The project map in Section 2.4.0 depicts the network groundwater well locations, the extent of the study area, and the wells sampled in 2017. DHEC evaluates five aquifer zones (Upper Three Runs, Gordon, Crouch Branch, McQueen Branch, and the Piedmont Hydrogeologic Province) from the water table.

CLUSTER WELLS vs. NETWORK WELLS

CLUSTER WELLS are multiple wells that are in the same area but are positioned at varying depths to reach water at different levels of the aquifer to see if there is horizontal migration of contaminants in the water underground.



NETWORK WELLS tend to have one well that is at a set depth.



2.2.0 RESULTS AND DISCUSSION

Groundwater Monitoring Summary Statistics can be found in Section 2.6.0 and all Groundwater Monitoring Data can be found in 2017 DHEC Data File.

Above: Cluster well being pumped and tested for water perimeters

Right: Water parameter measurement system

DHEC collected groundwater from four private and municipal wells in 2017. Based on a review of the wet chemistry, metals, tritium, gross alpha, non-volatile beta, and gamma-emitting radioisotope analytical data provided by the DHEC analytical and radiological laboratories, various contaminants were detected in the groundwater wells sampled. See Section 2.5.0, Table 1 for a list of the network of sampling wells and their locations.

Groundwater investigations performed by state and federal agencies such as DHEC, DNR, and the United States Geological Survey (USGS) have confirmed the presence of naturally occurring radionuclides in groundwater across South Carolina (ATSDR, 2007). However, contaminants commonly found in SRS groundwater include:

volatile organic compounds (VOCs), metals, and tritium. If known contaminants are found in wells located within the DHEC sampling network, the affected wells would be investigated further to help determine the source.

The United States Environmental Protection Agency (EPA) has a drinking water Maximum Contaminant Level (MCL) of 15 pCi/L for gross alpha and 50 pCi/L for non-volatile beta (EPA, 2002d). In 2017, DHEC did not detect tritium, gross alpha, or non-volatile beta in its four groundwater wells. Lead-214 was documented in two wells, however, it is a naturally occurring gamma-emitting radionuclide.

Collecting water from pump to test for non-radiological material

The presence of metals and other non-radiological contaminants in the environment can be attributed to man-made processes (industrial manufacturing), agricultural activities, and the natural breakdown of mineral deposits. A review of detected metal and non-radiological contaminants indicates their limited presence and concentration is most likely due to the erosion of natural deposits and agricultural activities in the case of total nitrate/nitrite. Additionally, the position of these wells, as related to the SRS's centrally located process areas suggests the theory of other natural and manmade sources.

In 2017, four groundwater samples were collected for VOCs, nitrate/nitrite, metals, mercury, and turbidity. All detected non-radiological contaminants were below their respective MCLs and/or action levels except for two wells, D0310 and D06002, whose nitrate/nitrite levels were 4.8 mg/L and 1.2 mg/L which is above the nitrite MCL of 1 mg/L. These higher concentrations could be due to the introduction of nitrates/nitrites through fertilization processes.

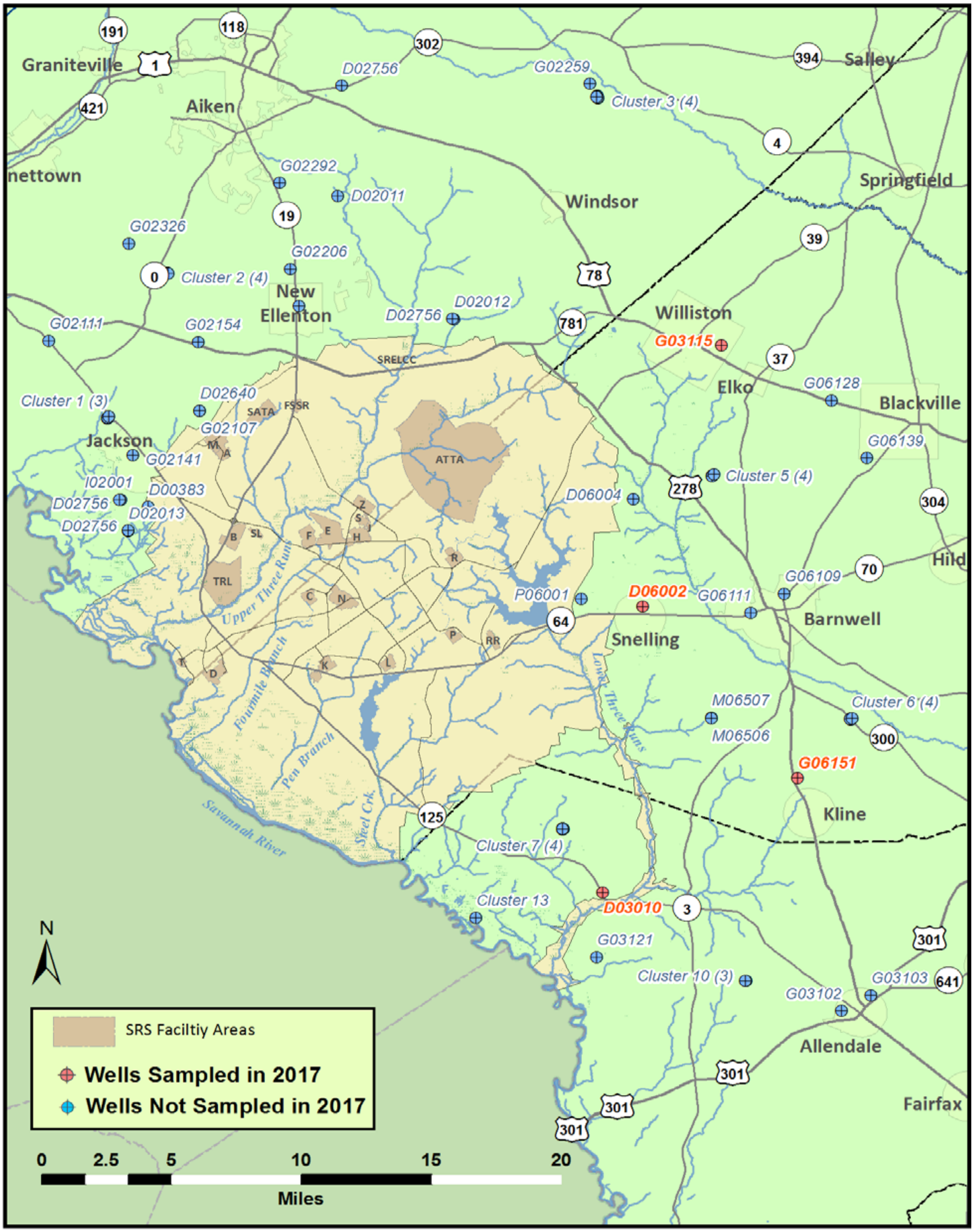
2.3.0 CONCLUSIONS AND RECOMMENDATIONS

DOE-SR collects groundwater samples from a separate onsite monitoring well network, therefore, direct DHEC offsite groundwater comparisons could not be made. However, the 2016 SRS report identifies numerous areas of groundwater contamination throughout the SRS property. Various contaminants such as VOCs, tritium, gross alpha/beta radionuclides, and strontium-90 have been found in these areas (SRNS, 2017). Contaminants detected in the 2017 DHEC groundwater sampling event include copper, nitrate/nitrite, lead, and iron.

Due to identified areas of groundwater contamination on SRS, DHEC will continue to monitor groundwater quality to identify any future SRS offsite contaminant migration.

2.4.0 MAP

2017 Groundwater Sampling Locations



2017 ESOP Ambient Groundwater Monitoring

2.5.0 TABLES AND FIGURES

Table 1. DHEC Groundwater Monitoring Well Network

Well Number	Well Name	Sample Year	Top of Casing Elevation (ft amsl)	Total Depth (ft bgs)	Aquifer
D00383	Brown Road	2014	*	*	*
D02640	Green Pond Road	2014	*	222	*
G02292	Hunter's Glen	2015	unknown	210	SP
G02206	Oak Hill Subdivision	2015	445	240	SP
G02107	New Ellenton	2015	421	425	CB
G02259	Aiken State Park	2015	262	*	SP
G02154	Talatha Water District	2015	250	185	CB
G02111	Beech Island Water District	2015	380	360	CB
G02326	ORA Site	2015	300	397	MB
D02014	Messer Well	2015	unknown	144	SP
D02013	Cowden Plantation, Well 2	2015	124	*	SP
I02001	Cowden Plantation, Well 1	2015	132	*	CB
D02011	Mettlen Well	2015	400	180	SP
D02012	Windsome Plantation, House Well	2015	260	*	SP
D02756	Montmorenci-Couchton WD, Well 2	2015	508	363	CB
D02640	Green Pond Road	2015	*	222	*
D00383	Brown Road	2015	*	*	*
G06109	Barnwell, Hwy. 3	2016	230	146	UTR
G06111	Barnwell, Rose St.	2016	220	166	UTR
G06128	Edisto Station	2016	322	360	GOR
P06001	Allied General Nuclear, Well 1	2016	250	*	MB
M06004	Chem Nuclear WO0061	2017	254.52	401	CB
M06014	Chem Nuclear WO0071	2017	255.33	250	GOR
M06010	Chem Nuclear WO0069	2017	254.28	145	UTR
D03010	Martin Post Office	**2017**	108	105	UTR
G03102	Allendale, Water St.	2017	201	343	UTR
G03103	Allendale, Googe St.	2017	180	347	UTR
G06151	Chappels Labor Camp	**2017**	250	260	UTR
G03121	Clariant	2017	180	812	CB
G03115	Martin District Fire Department	**2017**	*	*	*
D02241	Jackson	2017	225	105	SP
D06002	Moore Well	**2017**	240	*	UTR
D06004	J. Williams Well	2017	245	76.15	UTR

TABLES AND FIGURES

Table 1. (Continued) DHEC Groundwater Monitoring Well Network

Well Number	Well Name	Sample Year	Top of Casing Elevation (ft amsl)	Total Depth (ft bgs)	Aquifer
M02101	SCDNR Cluster C-01, AIK-2378	2013	220.3	185	CB
M02102	SCDNR Cluster C-01, AIK-2379	2013	224.2	266	CB
M02103	SCDNR Cluster C-01, AIK-2380	2013	228.9	385	MB
M02104	SCDNR Cluster C-01, AIK-902	2013	231.9	511	MB
M02202	SCDNR Cluster C-02, AIK-825	2013	418.8	231	CB
M02204	SCDNR Cluster C-02, AIK-818	2013	418.3	425	MB
M02205	SCDNR Cluster C-02, AIK-817	2013	418.9	535	MB
M02303	SCDNR Cluster C-03, AIK-847	2013	299	193	CB
M02305	SCDNR Cluster C-03, AIK-845	2013	296.9	356	MB
M02306	SCDNR Cluster C-03, AIK-826	2013	294.9	500	MB
M06501	SCDNR Cluster C-05, BRN-360	2013	264.3	140	UTR
M06502	SCDNR Cluster C-05, BRN-359	2013	265.5	214	GOR
M06503	SCDNR Cluster C-05, BRN-367	2013	263.8	285	GOR
M06504	SCDNR Cluster C-05, BRN-368	2013	265.1	443	CB
M06506	SCDNR Cluster C-05, BRN-366	2013	266.7	715	MB
M06507	SCDNR Cluster C-05, BRN-358	2013	265.6	847	MB
M03706	SCDNR Cluster C-07, ALL-368	2014	246.6	691	CB
M03707	SCDNR Cluster C-07, ALL-369	2014	242.1	800	CB
M03708	SCDNR Cluster C-07, ALL-370	2014	245.1	975	MB
M03709	SCDNR Cluster C-07, ALL-358	2014	243.1	1123	MB
M03131	SCDNR Cluster C-13, Artesian	2014	80	*	GOR
M03132	SCDNR Cluster C-13, ALL-378	2014	90	1060	MB
M03702	SCDNR Cluster C-07, ALL-364	2014	245.2	225	UTR
M03703	SCDNR Cluster C-07, ALL-365	2014	244.3	333	GOR
M03704	SCDNR Cluster C-07, ALL-366	2014	243.5	400	GOR
M03705	SCDNR Cluster C-07, ALL-367	2014	245.7	566	CB
M06601	SCDNR Cluster C-06, BRN-351	2014	207.3	95	UTR
M06602	SCDNR Cluster C-06, BRN-350	2014	207.4	170	UTR
M06603	SCDNR Cluster C-06, BRN-352	2014	207.1	293	GOR
M06604	SCDNR Cluster C-06, BRN-354	2014	207.6	411	GOR
M06605	SCDNR Cluster C-06, BRN-353	2014	207.7	588	CB
M06608	SCDNR Cluster C-06, BRN-349	2014	208.6	1045	MB
M03101	SCDNR Cluster C-10, ALL-347	2014	281.6	1423	MB
M03104	SCDNR Cluster C-10, ALL-374	2014	280.9	580	GOR

Notes:
1. * is total depth/top of casing information unknown, Aquifer assigned based on owner information.
2. ft amsl is feet above mean sea level
3. ft bgs is feet below ground surface
4. UTR is Upper Three Runs,
5. CB is Crouch Branch
6. SP is Steeds Pond
7. GOR is Gordon
8. MB is McQueen Branch

2.6.0 Regional Geology

STRATIGRAPHY – focuses on the different layers of soil that have built up over time

HYDROSTRATIGRAPHY – deals with water's movement through the layers of soil/sediment

The study area, including SRS, is in west-central South Carolina. The regional geology is characterized as the Aiken Plateau of the Coastal Plain physiographic province. SRS is located approximately 20 miles southeast of the fall line of the Piedmont physiographic province. A thickening wedge of Cenozoic and Cretaceous sediment, which overlies Paleozoic crystalline basement rock and Triassic sedimentary rocks, underlies the area south of the fall line (Aadland et al., 1995). The sediment, consisting of alternating sands and clays with Tertiary carbonates, thickens toward the southeast from zero at the fall line to more than 1,800 feet at the Allendale-Hampton County line. The sediment is about 1,100 feet thick beneath the central portion of SRS and dips toward the southeast at about 35 feet per mile. Table 1 in Section 2.5.0 summarizes the stratigraphy and hydrostratigraphy of the study area. For a more detailed review of regional geology and hydrogeology, refer to the 1997 Annual DHEC ESOP Report.

2.7.0. SUMMARY STATISTICS

2017 Non-radiological Groundwater Data in mg/L

mg/L	Average	St. Dev.	Median	Min	Max	Number of Detections	Number of Samples	MCL
Copper	0.023	0.013	0.023	0.014	0.032	2	4	1.3
Lead	0.0059	0.0009	0.0059	0.0053	0.0065	2	4	0.015
Nitrate/Nitrite	2.33	2.139	1.2	1	4.8	3	4	1
Iron	0.2116	0.1726	0.13	0.095	0.41	3	4	0.3

Notes:
1. Values are based upon detections only.
2. St. Dev. Is Standard Deviation.
3. Min is Minimum
4. Max is Maximum

Chapter 3 Radiological Monitoring of Drinking Water Adjacent to SRS

3.1.0 PROJECT SUMMARY

DHEC evaluates drinking water quality to provide information on the radiological impact of SRS to community drinking water systems adjacent to and downstream of the site. DHEC samples 23 drinking water systems. Monthly composite samples are taken from four Savannah River-fed systems: one upstream location (North Augusta) and three downstream of SRS (Purrysburg Beaufort/Jasper (B/J), Chelsea B/J, and Savannah, Georgia). Additionally, semi-annual grab samples are collected from 19 selected public drinking water systems that are not primarily served by the Savannah River. These systems are located outside of the SRS perimeter and are up to 30 miles from the center point of the site (Map, Section 3.4.0).

SURFACE WATER – water that does not sink into the ground but collects on the surface in the form of streams, ponds, lakes, rivers, or the ocean.

GROUNDWATER – water that has percolated (sunk) into the ground and is able to move through and be filtered by the soil layers. It will eventually be used by plants, taken up through wells by humans, or seep into another body of water.

DRINKING WATER – water that has been taken either from the surface of the earth or from the ground and is put through a cleaning process to be available for healthy consumption by humans.

In 2017, DOE-SR collected drinking water from two surface water fed systems (North Augusta and Purrysburg B/J) that are collocated with the DHEC Savannah River fed systems. Currently, DOE-SR does not conduct drinking water sampling from other public systems off SRS property. DHEC and DOE-SR analyze for and compare all samples for gross alpha, non-volatile beta, gamma-emitting radionuclides, and tritium.

3.2.0 RESULTS AND DISCUSSION

Drinking Water Monitoring Summary Statistics can be found in Section 6.0 and all Drinking Water Monitoring Data can be found in the 2017 DHEC Data File.

In 2017, DHEC and DOE-SR detected tritium above the lower limit of detection (LLD) in all the Savannah River-fed systems both upstream and downstream of SRS. Average tritium levels at the upstream system in North Augusta were 307 pCi/L for DHEC and 172.1 pCi/L for DOE-SR. The DHEC tritium detectable average for all systems downstream of SRS (Purrysburg B/J, Chelsea B/J and Savannah, Georgia), was 527 pCi/L and the DOE-SR average was 523.2 pCi/L. These activities are well below the EPA established 20,000 pCi/L drinking water limit (EPA, 2002d). Section 3.5.0, Figure 1 illustrates the DHEC trending data and Figure 2. illustrates a DHEC and DOE-SR comparison for Savannah River-fed systems over the past five years.

Gamma-emitting radionuclides of concern List of Tables, Table 1, page x, were not detected above the LLD and have not been detected for any of the drinking water samples collected by DHEC or DOE-SR since 2002.

DHEC detected gross alpha in four of the 19 samples from the drinking water systems not supplied by the Savannah River (Montmorenci Water District, Williston, College Acres Public Water District, and Talatha Water District) at an average of 2.84 pCi/L. DHEC found gross alpha in the upstream Savannah River-fed system at 1.34 pCi/L, however all downstream locations had no detections. DOE-SR had no gross alpha detections in the upstream location (North Augusta) or downstream area (Purrysburg).

DHEC detected non-volatile beta at one sample location (Montmorenci Water District) from the drinking water systems not supplied by the Savannah River at 4.49 pCi/L. DHEC and DOE-SR both had detections of gross beta in the upstream and downstream Savannah River-fed systems (Section 3.5.0, Table 2). Speciation is not conducted for gross alpha or non-volatile beta unless there is a detection above their respective EPA MCLs of 15 pCi/L and 50 pCi/L (EPA, 2002d).

Section 3.5.0, Figures 3 and 4 illustrate the trends in gross alpha and non-volatile beta activities over the past five years. Although there were several detections above the LLD during the 2017 reporting period, none of the analytes exceeded their respective EPA established MCLs. Gross alpha and non-volatile beta, at their observed concentrations, are not considered to be known human health risks.

3.3.0 CONCLUSIONS AND RECOMMENDATIONS

Tritium continues to be the most abundant radionuclide detected in public drinking water supplies potentially impacted by SRS. Tritium was detected in both groundwater and surface water systems during 2016, while tritium was detected only in surface water in 2017. Observed tritium activities were low when compared to the EPA MCL for tritium in drinking water, which is 20,000 pCi/L. Detections of gross alpha and non-volatile beta were all below their respective MCLs. DOE-SR does not sample systems not served by the Savannah River; therefore, DHEC will continue to monitor these off-site public water systems in the event these wells are impacted by contaminated groundwater from SRS.

The DHEC Drinking Water Monitoring Project continues to be an important source of essential data for assessing human health exposure pathways. DHEC will continue to monitor surface water quality due to the extent of the surface water contamination on SRS, and its potential to migrate, and potentially impact, drinking water systems downstream from SRS. Continued sampling will also provide the public with an independent source of radiological data for drinking water systems within the SRS study area.

DHEC continues to reevaluate the drinking water systems monitored by the drinking water project. Primary and background drinking water systems will be added and removed from the list of sampled drinking water systems as deemed necessary to maintain monitoring coverage. Sampling of background water systems will be done in the future, as they provide a more complete understanding of the distribution and nature of naturally occurring radionuclides in South Carolina drinking water systems.

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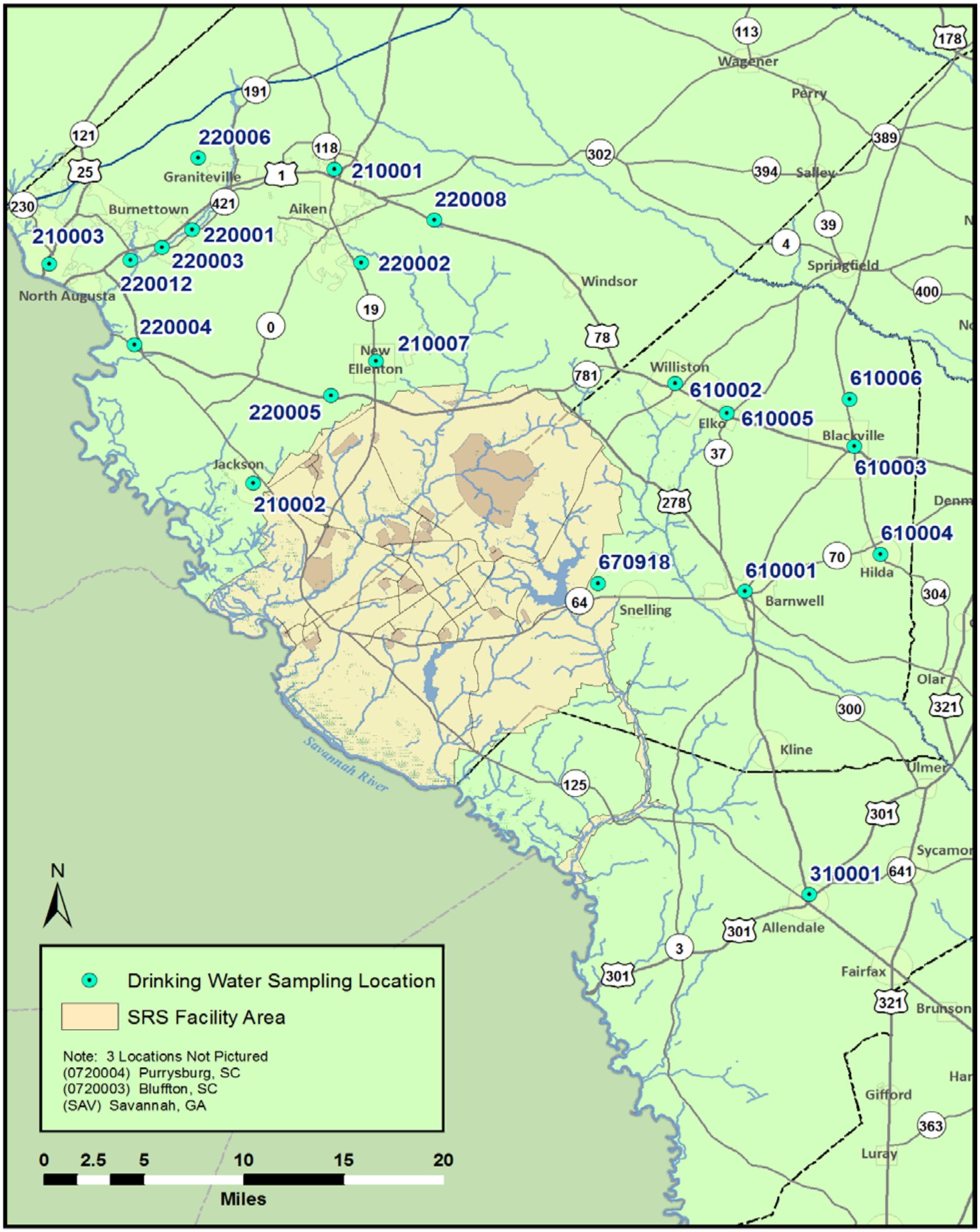
3.4.0 MAP

Drinking Water Sampling Locations



2017 ESOP Drinking Water Monitoring

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3.5.0 TABLES AND FIGURES

Table 1. Drinking Water Systems Sampled by DHEC

System Number	System Name	Number of Taps	Population
0210001	Aiken	19,444	42,286
0210002	Jackson	1,312	3,602
0210007	New Ellenton	2,417	5,763
0220001	Langley Water District	324	754
0220002	College Acres Public Water District	539	1,330
0220003	Bath Water District	315	755
0220004	Beech Island	3,320	7,916
0220005	Talatha Water District	727	1,698
0220006	Breezy Hill Water District	5,808	13,692
0220008	Montmorenci Water District	1,457	3,442
0220012	Valley Public Service Authority	2,959	6,828
0310001	Allendale	1,530	3,882
0610001	Barnwell	2,097	4,557
0610002	Williston	1,629	2,953
0610003	Blackville	1,208	2,973
0610004	Hilda	124	311
0610005	Elko	150	371
0670075	Healing Springs	1	6*
0670918	SCAT Park	11	125
0210003	North Augusta	11,854	21,072
0720003	Chelsea B/J	53,860	114,515
0720004	Purrysburg B/J		
SAV	Savannah	Unknown	168,958
	Total		
	Savannah River-fed systems downstream from SRS	53,860+Savannah	283,473
	Systems not fed from the Savannah River downstream of SRS	57,226	124,316

Notes:
1. Data was obtained from DHEC Environmental Facility Information System database
2. ***** This number is much higher due to public access to the natural spring

TABLES AND FIGURES

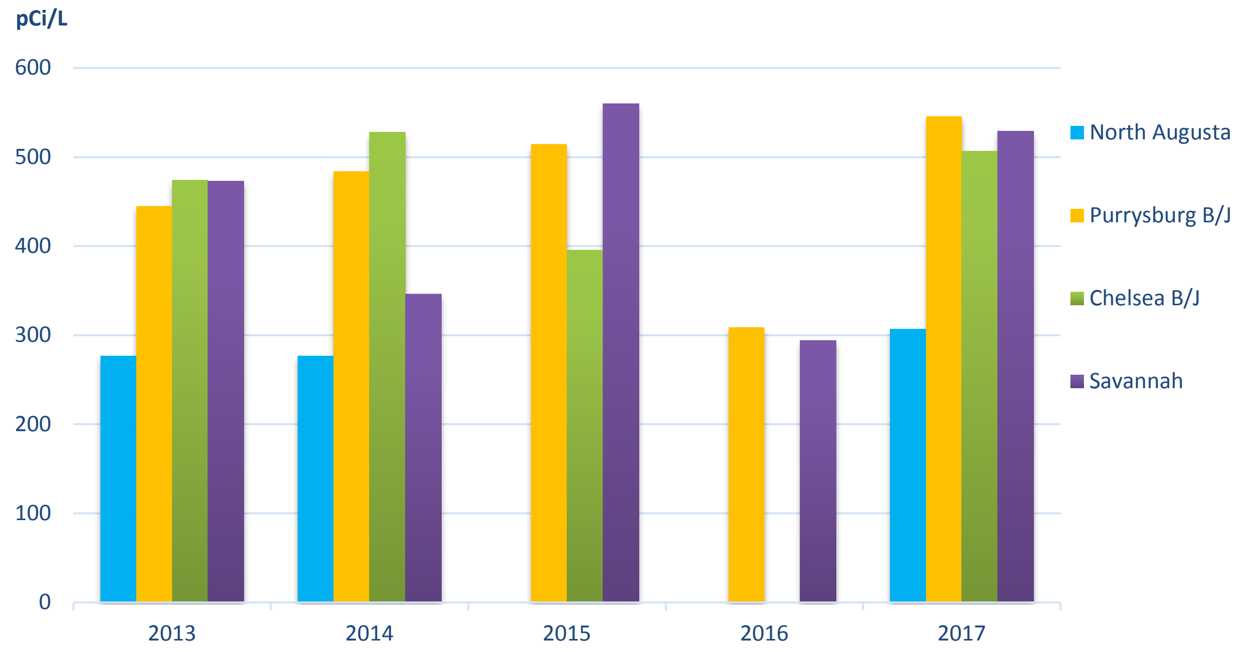
Table 2. DOE-SR and DHEC Data Comparisons for 2017 in pCi/L

Location	DHEC Tritium	DOE-SR Tritium	DHEC Gross Alpha	DOE-SR Gross Alpha	DHEC Gross Non-volatile Beta	DOE-SR Gross Non-volatile Beta
North Augusta	307	172.1	1.34	<LLD	4.66	1.72
Chelsea B/J	506	NS	<LLD	NS	<LLD	NS
Purrysburg B/J	546	523.2	<LLD	<LLD	4.70	1.53
Savannah	529	NS	<LLD	NS	3.82	NS
Upstream Average	307	172.1	1.34	<LLD	4.66	1.72
Downstream Average	527	523.2	<LLD	<LLD	4.26	1.53

Note: NS is Not Sampled

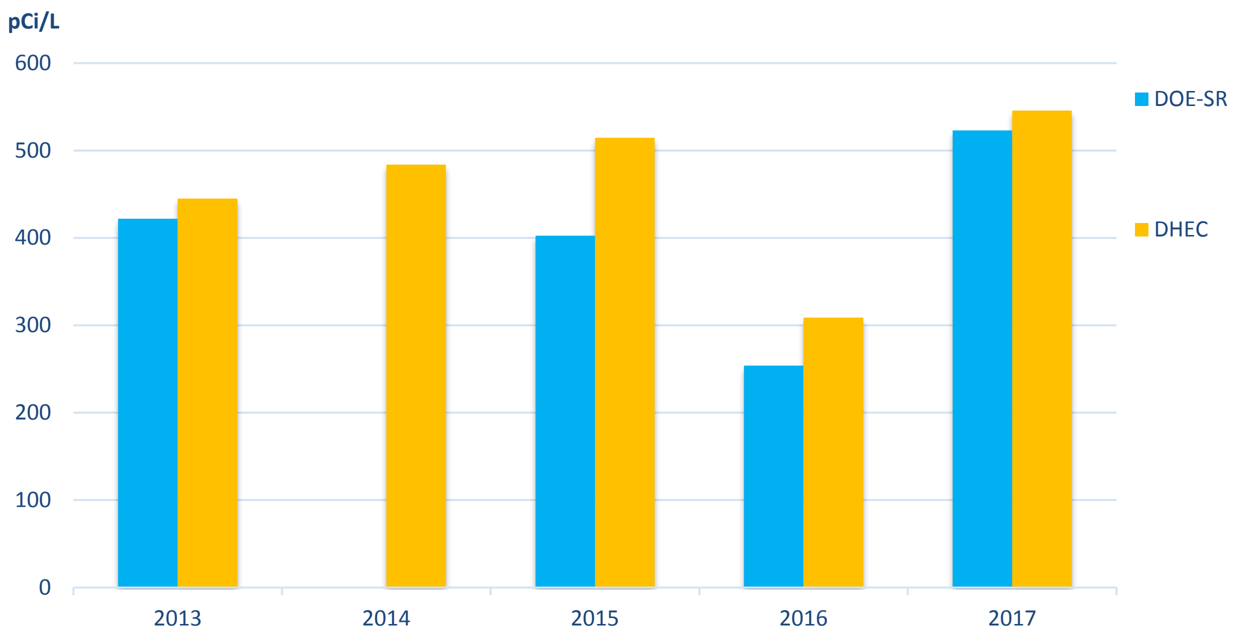
TABLES AND FIGURES

Figure 1. DHEC Yearly Tritium Averages in Savannah River-Fed Systems (DHEC, 2015--2018)



Note: Tritium was not detected at North Augusta in 2015 and 2016, or Chelsea B/J in 2016.

Figure 2. DHEC and DOE-SR Tritium Detection Averages Purrysburg B/J (SRNS, 2014-2018; DHEC, 2015-2018)



Note: DOE-SR did not sample Purrysburg B/J in 2014.

TABLES AND FIGURES

Figure 3. DHEC Yearly Gross Alpha Averages in Drinking Water Systems (DHEC, 2015-2018)

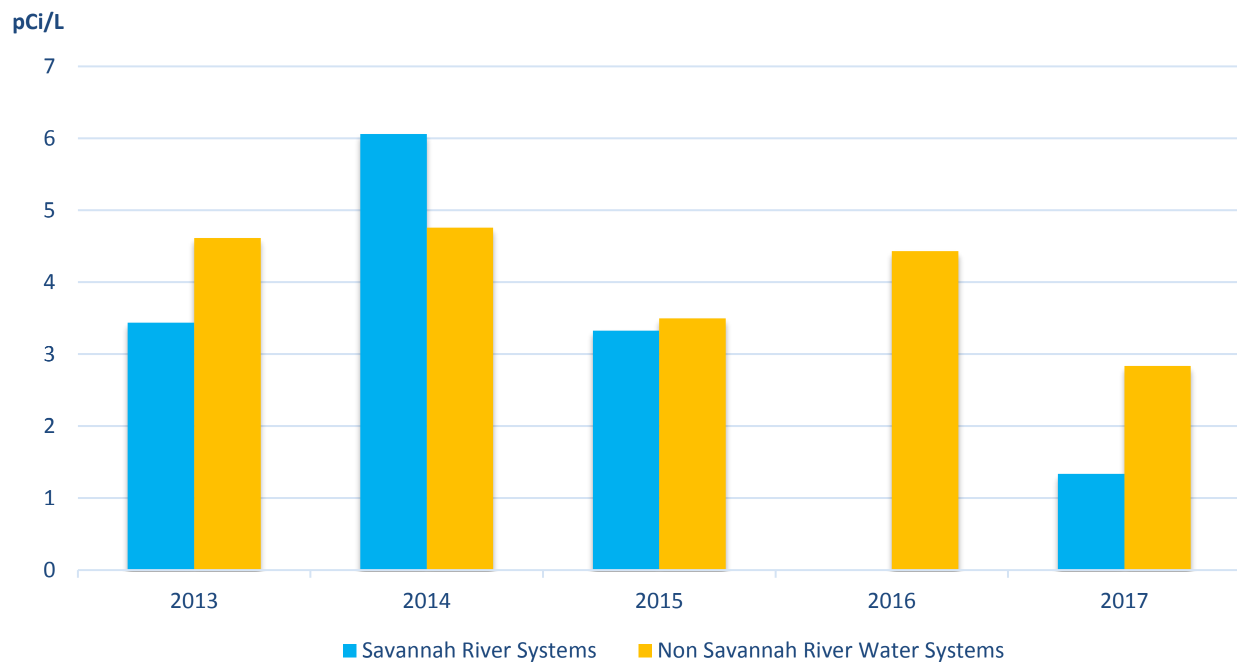
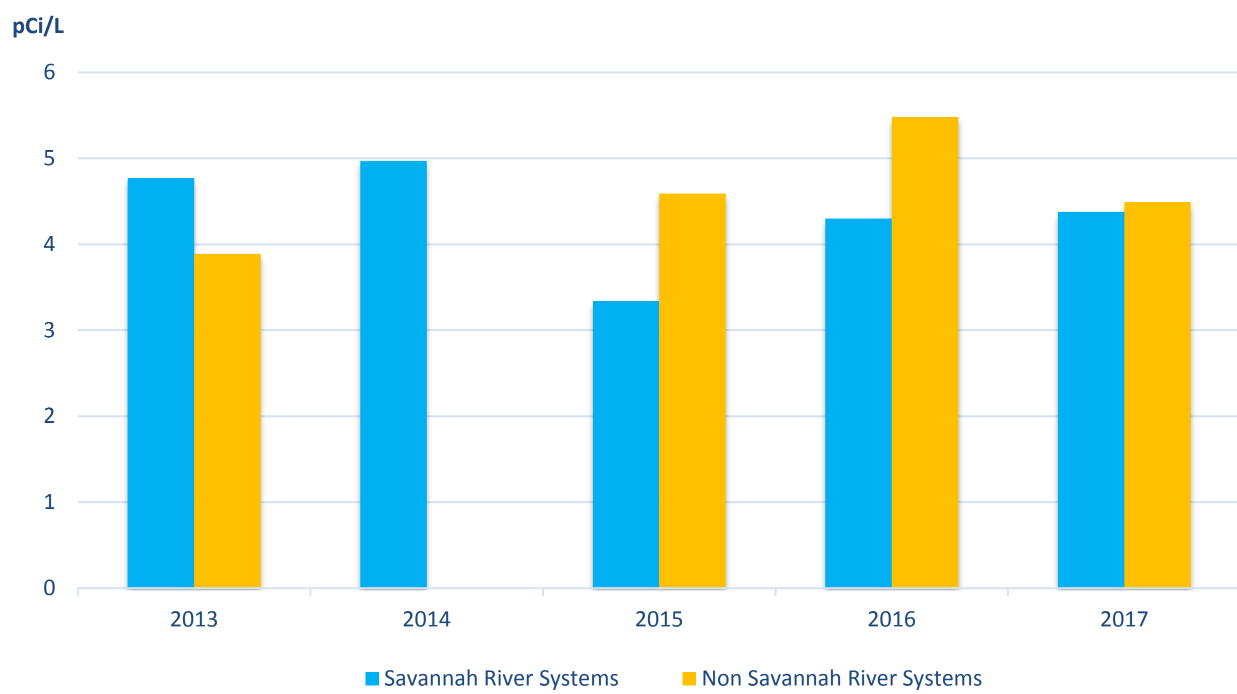


Figure 4. DHEC Yearly Non-Volatile Beta Averages in Drinking Water Systems (DHEC, 2015-2018)



3.6.0 SUMMARY STATISTICS

2017 DHEC Savannah River-Fed Water System Data

Gross Non-volatile Beta (pCi/L)							
System Name	Average	Standard Deviation	Median	Minimum	Maximum	Number of Detects	Number of Samples
North Augusta	4.66	NA	4.66	4.66	4.66	2	12
Chelsea B/J	ND	NA	NA	<LLD	NA	0	12
City of Savannah	3.82	0.35	3.82	3.57	4.07	2	12
Purrysburg B/J	4.70	NA	4.70	4.7	4.70	2	10
Yearly Average of Detectable Gross Beta			4.39				
Standard Deviation			0.50				

Tritium (pCi/L)							
System Name	Average	Standard Deviation	Median	Minimum	Maximum	Number of Detects	Number of Samples
North Augusta	307	27.66	307	279	335	3	12
Chelsea B/J	506	185.57	494	304	768	8	11
City of Savannah	529	129.24	535	373	615	8	12
Purrysburg B/J	546	195.74	490	316	790	6	7
Yearly Average of Detectable Tritium			472				
Standard Deviation			111.32				

Notes:
1. ND is Not Detected
2. NA is Not Applicable
3. Yearly Average and Standard Deviation were calculated from the averages listed in the tables above, not from the raw data.

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Chapter 4 Radiological Monitoring of Surface Water on and Adjacent to SRS

4.1.0 PROJECT SUMMARY

The focus of the Radiological Monitoring of Surface Water (RSW) project is to test and survey the streams and creeks on SRS as well as the Savannah River. Since the Savannah River is the primary drinking water source for some downstream communities, it is important to monitor radionuclide concentrations in the river. Surface water samples are collected and analyzed for radionuclides, and the results are compared to DOE-SR data. DOE-SR's activities are concerned with identifying concentrations and migration of radionuclides in the aquatic environment, detecting and verifying accidental releases, characterizing concentration trends, and determining associated impacts on human health and the environment. DHEC supports DOE-SR's objectives to ensure the primary goal of drinking water safety is established and met.

Collecting samples to be tested for tritium using the early detection system at SV-118

DHEC collects surface water samples from 13 specific locations within and outside of the SRS boundary as part of an ambient sampling network (Section 4.4.0, Map). Section 4.5.0, Table 1, identifies sample ID, location, rationale, and frequency. Some locations were chosen because they are considered public access locations. All but one of the public access locations are downstream of SRS, which provides a potential means for exposure to radionuclides. Jackson Boat Landing (SV-2010), is upstream from SRS activities and is a public access location.

Quarterly samples are collected for tritium analysis from the four creek mouths that flow from SRS directly into the Savannah River (Upper Three Runs Creek, Fourmile Branch, Steel Creek, and Lower Three Runs Creek). Pen Branch is not sampled because the Savannah River Swamp interrupts the flow of this creek and there is no creek mouth access.

An enhanced surface water monitoring program was implemented to provide downstream drinking water customers with advance notice of the potential for increased tritium levels in the Savannah River. This early detection facet is possible because of the continuous monitoring of the five SRS streams that flow to the Savannah River. Samples for tritium analysis are collected from seven locations with automatic water samplers. Additionally, a grab sample is collected from Johnson's Boat Landing (SV-2080) and U.S. Highway 301 at the Savannah River (SV-118).

An additional component of the RSW Project is the Supplemental Surface Water Monitoring Program implemented in 2005. The purpose of this sampling program is to monitor any potential releases of radionuclides. Sample locations are located along Upper Three Runs, Fourmile Branch, and Steel Creek. This monitoring was established for early detection of unplanned releases from SRS source term areas. An additional sample location was added in 2015 at

Example of a Composite Sample

McQueen Branch. This location was added to monitor the Saltstone low level waste operations. The McQueen Branch sample is a monthly composite that is collected by DOE and split with DHEC. These samples are collected as unofficial results for notification purposes only.

In August of 2007, DHEC began collecting ambient grab samples from a location on Lower Three Runs. This sampling was conducted in response to elevated tritium levels detected in groundwater samples near the Energy Solutions (formerly Chem-Nuclear) facility in Snelling, South Carolina. The purpose of adding this location was to differentiate any potential tritium contributions to Lower Three Runs from Energy Solutions and SRS activities.

Quarterly sampling for I-129 and Tc-99 is conducted at the supplemental location on Fourmile Branch due to concerns that these are possible constituents related to effluent from the burial grounds, which could enter the surface water.

4.2.0 RESULTS AND DISCUSSION

Radiological Monitoring of Surface Water Summary Statistics can be found in Section 4.6.0 and all Radiological Monitoring of Surface Water Data can be found in the 2017 DHEC Data File.

The data presented in this report concerns DHEC's monitoring of SRS' ambient and on-site streams. Enhanced and supplemental water collections are not displayed or analyzed in the annual report and data file due to their sole purpose of serving as an early detection system for downstream drinking water users.

Example of a Grab Sample

DHEC data from 2017 was compared to DOE-SR reported results (Section 4.5.0, Tables 2, 3, and 4). The DHEC and DOE-SR collocated sampling sites were Tims Branch at Road C, Upper Three Runs Creek at Road A, Fourmile Branch at Road A-12.2, Pen Branch at Road A-13.2, Steel Creek at Road A, the Savannah River at U.S. Highway 301 Bridge, and Lower Three Runs Creek at Road B. DOE-SR sampled at several other locations along these streams. However, the data comparisons are only for the collocated sample sites.

<u>Tritium</u>

In 2017, DHEC and DOE-SR had detections for tritium at all collocated sample locations (Section 4.5.0, Table 2). DHEC Average tritium activities at Jackson Boat Landing (SV-2010) and Upper Three Runs Creek at United States Forestry Service (USFS) Road 2-1 (SV-2027) were not directly impacted by SRS operations; therefore, they were lower than the average tritium activities of all the other ambient sample locations. These locations are upstream from SRS impacts and are considered background locations. DHEC and DOE-SR samples indicate that Fourmile Branch and Pen Branch have the highest average tritium activity of all SRS streams**.** The 2017 DHEC and DOE-SR tritium results appear to be consistent with historically reported data values (Section 4.5.0, Figures 2-7, DHEC, 2015-2018; SRNS, 2014-2018). Section 4.5.0, Figure 1 shows trending data for DHEC 2013-2017 tritium averages.

Tritium activity in the Savannah River at the creek mouths of the four SRS streams was monitored quarterly by DHEC in 2017. Samples collected at the creek mouth of Fourmile Branch (SV-2015) had the highest average tritium activity of 3,706 pCi/L of all creek mouth locations**.**

Gamma

As part of a gamma spectroscopy analysis, samples were analyzed monthly for gamma-emitting radionuclides (List of Tables, Table 1, page x). DHEC had no gamma detections above the Minimum Detectable Activity (MDA) for analytes that are not Naturally Occurring Radioactive Material (NORM).

DOE-SR reported a single detection of Sr-89/90 at 1.27 pCi/L at the collocated sample site at Fourmile Branch. DOE-SR reported four single detections of Am-241 at DHEC collocated sites: Tims Branch near Road C, Upper Three Runs at Road A, Fourmile Branch at Road A, Steel Creek at Road A, and Lower Three Runs at Road B. All detections yielded an average value of 0.0138 pCi/L (SRNS, 2018).

Pouring a composite sample to be tested for tritium

Iodine-129 and Technetium-99

I-129 and Tc-99 samplings of the supplemental location on Fourmile Branch were monitored on a quarterly basis by DHEC. There were I-129 detections in three of the four quarterly samples above the MDA at an average of 0.69 pCi/L. There was a Tc-99 detection in one of the four quarterly samples at 1.31 pCi/L. DHEC and DOE-SR do not have a collocated sampling site for I-129 and Tc-99. Therefore, these analytes were not compared.

Tc-99 and I-129 would be included under the EPA established MCL of 4 millirem per year. The average concentration of Tc-99, which is assumed to yield 4 millirem per year, is 900 pCi/L. The average concentration of I-129, which is assumed to yield 4 millirem per year, is 1 pCi/L. If other radionuclides, emitting beta particles and photon radioactivity are present in addition to Tc-99 and I-129, the sum of the annual dose from all the radionuclides shall not exceed 4 millirem/year (EPA, 2002c).

Alpha

In 2017, alpha-emitting radionuclides were detected at eight of the nine DHEC locations where monthly composite samples were collected. DHEC detected gross alpha activity at six of the seven collocated sampling locations while DOE-SR detected activity at all the collocated locations. DHEC and DOE-SR samples indicate that Tims Branch and Upper Three Runs Creek exhibit the highest alpha activity of the collocated locations with 3.39 pCi/L and 5.56 pCi/L (Section 4.5.0, Table 3, SRNS, 2018).

Pouring a monthly composite sample to be tested for gamma and gross alpha/beta radionuclides

Historically, Upper Three Runs Creek at SC 125 (SV-325) yields detections for alpha activity (DHEC, 2015-2018). Isotopic analysis performed by DOE-SR revealed the source to be natural uranium (SRNS, 2011). This may contribute to the common occurrence of alpha detections at this location. The 2017 average alpha activity at SV-325 was below the EPA MCL for drinking water of 15 pCi/L (EPA, 2002c). Beginning in 2009, samples collected at this location exhibited particles of sediment and detritus. This increase in turbidity seems to be related to storm events. Samples with high turbidity can have potential interferences during alpha/beta analysis. Alpha particles, and to a lesser extent, beta particles, are attenuated by salts and solids dried onto a planchette (EPA, 2010). This sampling location is monitored for turbidity to ensure it is not a concern in collected samples.

Beta

Beta-emitting radionuclide activity was detected in five of nine locations where monthly composite samples were collected. DHEC detected gross beta activity at four of the seven collocated sampling locations while DOE-SR detected activity at all seven of the collocated locations (Section 4.5.0, Table 4). DHEC samples exhibiting the highest average gross beta activity were Steel Creek (SV-327) at 6.80 pCi/L and Lower Three Runs Creek at Rd. B (SV-2053) at 6.21 pCi/L. DOE-SR samples collected from Fourmile Branch exhibited the highest gross beta average activity at 6.51 pCi/L (SRNS, 2018).

EPA has established a Maximum Contaminant Level (MCL) of 4 millirem per year for beta particle and photon radioactivity from man-made radionuclides in drinking water. The EPA screening MCL for gross beta-emitting particles for drinking water systems is 50 pCi/L minus natural potassium-40 (K-40) (EPA, 2002c). All averages were below this limit.

4.3.0 CONCLUSIONS AND RECOMMENDATIONS

Differences in average values between DHEC and DOE-SR could be attributed, in part, to the nature of the medium and the specific point and time of when the sample was collected.

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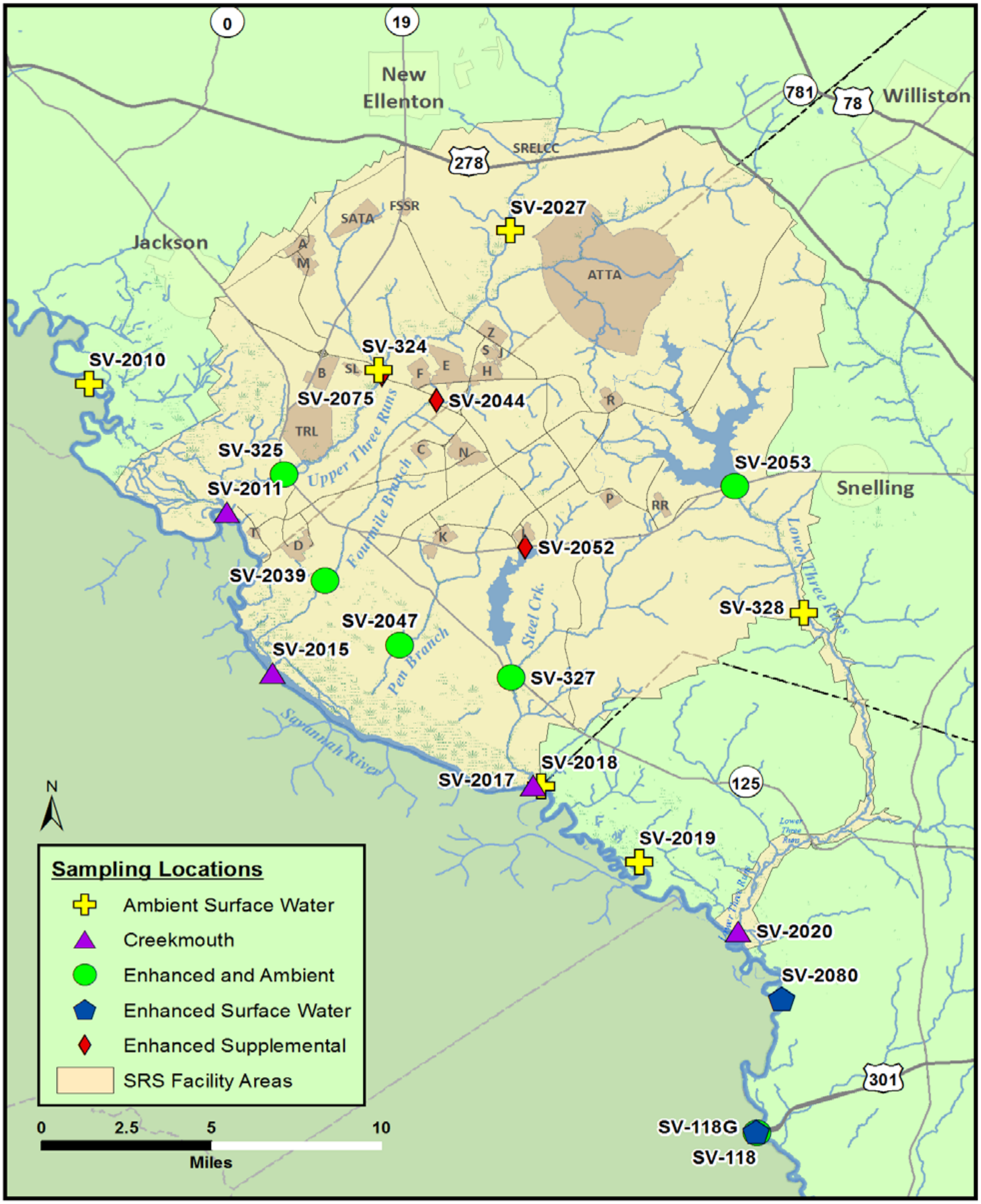
DHEC will continue to independently collect and analyze surface water on and adjacent to SRS. This monitoring effort will provide an improved understanding of radionuclide levels in SRS surface waters. DHEC will periodically evaluate modifying the monitoring activities to better accomplish the project's goals and objectives. Further refinement of the RSW project may result in additional sampling locations being incorporated into the ambient or enhanced monitoring regimes. Monitoring will continue as long as there are activities at SRS that create the potential for contamination to enter the environment, as well as past radioactive contamination that still exists due to unexpired half-lives.

4.4.0 MAP

Radiological Surface Water Monitoring Locations



2017 ESOP Radiological Surface Water Monitoring

4.5.0 TABLES AND FIGURES

Table 1. 2017 Surface Water Sampling Locations and Frequency

Ambient Monitoring Locations

ID	Location	Rationale	Frequency
SV-2010	Savannah River at RM 170.5 (Jackson Boat Landing)	Accessible to public; upstream all SRS operations; Near Jackson population center; Up river control; River monitoring	Weekly tritium; Monthly Alpha, Beta, and Gamma composite
SV-324	Tims Branch at SRS Road C	Within SRS perimeter; Downstream of SRS operations areas; Tributary monitoring	Weekly tritium; Monthly Alpha, Beta, and Gamma composite
SV-325	Upper Three Runs Creek at S.C. 125 (SRS Road A)	Within SRS perimeter; Downstream of SRS operations areas; Tributary monitoring	Weekly tritium; Monthly Alpha, Beta, and Gamma composite
SV-2039	Fourmile Branch at Road A-12.2	Within SRS perimeter; Downstream of SRS operations areas; Tributary monitoring	Weekly tritium; Monthly Alpha, Beta, and Gamma composite
SV-2047	Pen Branch at Road A-13.2	Within SRS perimeter; Downstream of SRS operations areas; Tributary monitoring	Weekly tritium; Monthly Alpha, Beta, and Gamma composite
SV-327	Steel Creek at S.C. 125 (SRS Road A)	Within SRS perimeter; Downstream of SRS operations areas; Tributary monitoring	Weekly tritium; Monthly Alpha, Beta, and Gamma composite
SV-2018	Savannah River at RM 141 (Steel Creek Boat Landing)	Accessible to the public; Adjacent to SRS perimeter Downstream of SRS operations; River monitoring	Weekly tritium; Monthly Alpha, Beta, and Gamma composite
SV-2019	Savannah River at RM 134.5 (Little Hell Boat Landing)	Accessible to the public; Downstream of SRS operations and tributaries; River monitoring	Weekly tritium grab
SV-2080	Savannah River at RM 125 (Johnson's Boat Landing)	Accessible to the public; Downstream of SRS operations and tributaries; River monitoring	Tri-weekly tritium grab
SV-118	Savannah River at RM 118.8 (Hwy 301 Bridge)	Accessible to the public; Downstream of SRS operations and tributaries; River monitoring	Weekly tritium; Monthly Alpha, Beta, and Gamma composite
SV-328	Lower Three Runs Creek at Patterson Mill Road	Within SRS perimeter; Downstream of SRS operations and Par Pond; Tributary monitoring	Weekly tritium grab
SV-2053	Lower Three Runs Creek at Road B	Within SRS perimeter; Downstream of SRS operations and Par Pond; Tributary monitoring	Weekly tritium; Monthly Alpha, Beta, and Gamma composite
SV-2027	Upper Three Runs Creek at SRS Road 2-1	Within SRS perimeter; Upstream from SRS operations; Upstream control; Tributary monitoring	Weekly tritium grab

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Table 1. (Cont.)

Creek Mouth Locations

ID	Location	Rationale	Frequency
SV-2011	Upper Three Runs Creek Mouth at RM 157.4	Accessible to public; Adjacent to SRS; Downstream of SRS operation areas; Tributary monitoring	Quarterly tritium
SV-2015	Fourmile Branch at RM 150.6	Accessible to public; Adjacent to SRS; Downstream of SRS operation areas; Tributary monitoring	Quarterly tritium
SV-2017	Steel Creek Mouth at RM 141.5	Accessible to public; Adjacent to SRS; Downstream of SRS operation areas; Tributary monitoring	Quarterly tritium
SV-2020	Lower Three Runs Creek at RM 129.1	Accessible to public; Adjacent to SRS; Downstream of SRS operation areas; Tributary monitoring	Quarterly tritium

Supplemental Locations

ID	Location	Rationale	Frequency
SV-2070	McQueen Branch	Downstream from Saltstone LLW Operations	Monthly gamma composite
SV-2075	Upper Three Runs Creek at Road C	Downstream from F-and H-Areas HLW Tanks	Weekly gamma composite
SV-2044	Fourmile Branch at Road C	Downstream from F-and H-Areas HLW Tanks	Weekly gamma composite
SV-2052	Steel Creek at the top of L-Lake	Downstream from P- and L- Areas	Weekly gamma composite

Notes:
1. ID is Sampling Location Identification Code Number
2. RM is River Mile
3. HLW is High Level Waste
4. LLW is Low Level Waste
5. Tri-Weekly Enhanced sample data is used for detection purposes only

TABLES AND FIGURES

Table 2. 2017 Tritium Data Comparison for DHEC and DOE-SR Collocated Sampling Locations

Sample Location	Sample ID	Average Concentration (pCi/L)	Standard Deviation (pCi/L)	Median (pCi/L)	Minimum Concentration (pCi/L)	Maximum Concentration (pCi/L)	Number of Detects	Number of Samples
Tims Branch at Road C	SV-324	415	68	404	282	566	46	51
	TB-5	565	NA	NA	<LLD	565	1	12
Upper Three Runs Creek at Road A	SV-325	754	331	654	303	1862	52	52
	U3R-4	608	180.5	558	478	1010	8	12
Fourmile Branch at Road 12.2	SV-2039	29775	5024	29598	10069	38490	52	52
	FM-6	27300	135	26000	21500	34600	15	15
Pen Branch at Road 13.2	SV-2047	14997	4323	15399	6391	24119	52	52
	PB-3	13000	3270.24	13200	6700	17900	12	12
Steel Creek at Road A	SV-327	1891	404	1939	489	2656	51	51
	SC-4	1620	349.7	1680	859	1980	12	12
Highway 301 Bridge at RM 118.8	SV-118	804	527	673	277	2544	49	52
	RM 118	566	7.74	462	148	1930	52	52
Lower Three Runs Creek at Road B	SV-2053	351	51	354	266	454	23	52
	L3R-1A	427	65.05	427	381	473	2	12

Notes:
1. Shaded areas represent DHEC data and unshaded areas represent DOE-SR data
2. DOE-SR data is from the SRS Environmental Data Report for 2017 (SRNS, 2018)
3. ND is No Detects
4. NA is Not Applicable
5. <LLD is less than the Lower Limit of Detection
6. The minimum detected did not include the <LLD, the minimum of the numbers that were significant was chosen to calculate the average, standard deviation, median, and minimum.

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Table 3. 2017 Alpha Data Comparison for DHEC and DOE-SR Collocated Sampling Locations

Sample Location	Sample ID	Average Concentration (pCi/L)	Standard Deviation (pCi/L)	Median (pCi/L)	Minimum Concentration (pCi/L)	Maximum Concentration (pCi/L)	Number of Detects	Number of Samples
Tims Branch at Road C	SV-324	3.39	1.53	2.61	2.08	5.88	5	11
	TB-5	4.53	0.104	3.91	1.87	9.49	12	12
Upper Three Runs Creek at Road A	SV-325	5.56	5.56	2.81	1.40	19.20	9	11
	U3R-4	6.11	0.124	3.92	1.19	22	12	12
Fourmile Branch at Road 12.2	SV-2039	1.79	NA	1.79	1.79	1.79	1	11
	FM-6	3.64	2.4	3.16	0.441	8.27	13	14
Pen Branch at Road 13.2	SV-2047	2.86	NA	2.86	2.86	2.86	1	11
	PB-3	0.535	0.365	0.432	0.242	1.47	9	12
Steel Creek at Road A	SV-327	1.61	NA	1.61	1.61	1.61	1	11
	SC-4	1.37	1.36	0.920	0.319	4.65	10	12
Highway 301 Bridge at RM 118.8	SV-118	2.84	NA	2.84	2.84	2.84	1	11
	RM 118	0.362	0.095	0.362	0.105	0.543	12	52
Lower Three Runs Creek at Road B	SV-2053	ND	NA	NA	<LLD	<LLD	0	11
	L3R-1A	0.366	0.123	0.338	0.259	0.5	3	12

Notes:
1. Shaded areas represent DHEC data and unshaded areas represent DOE-SR data
2. DOE-SR data is from the SRS Environmental Data Report for 2017 (SRNS, 2018)
3. ND is No Detects
4. NA is Not Applicable
5. <LLD is less than the Lower Limit of Detection

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TABLES AND FIGURES

Table 4. 2017 Beta Data Comparison for DHEC and DOE-SR Collocated Sampling Locations

Sample Location	Sample ID	Average Concentration (pCi/L)	Standard Deviation (pCi/L)	Median (pCi/L)	Minimum Concentration (pCi/L)	Maximum Concentration (pCi/L)	Number of Detects	Number of Samples
Tims Branch at Road C	SV-324	ND	NA	NA	<LLD	<LLD	0	11
	TB-5	2.39	0.0771	1.93	1.08	5.14	12	12
Upper Three Runs Creek at Road A	SV-325	4.87	NA	4.87	<LLD	4.87	1	11
	U3R-4	3.52	0.0896	2.36	0.722	13.4	12	12
Fourmile Branch at Road 12.2	SV-2039	5.26	0.99	5.16	4.33	6.40	4	11
	FM-6	6.51	0.11	6.36	3.3	13.1	14	14
Pen Branch at Road 13.2	SV-2047	ND	NA	NA	<LLD	<LLD	0	11
	PB-3	0.922	0.224	0.895	0.532	1.43	12	12
Steel Creek at Road A	SV-327	ND	NA	NA	<LLD	<LLD	0	11
	SC-4	1.59	0.907	1.28	0.735	4	12	12
Highway 301 Bridge at RM 118.8	SV-118	4.89	0.18	4.89	4.76	5.01	2	11
	RM 118	1.91	0.033	1.97	1.34	2.64	52	52
Lower Three Runs Creek at Road B	SV-2053	6.21	NA	6.21	6.21	6.21	1	11
	L3R-1A	1.11	0.152	1.10	0.908	1.42	12	12

Notes:
1. Shaded areas represent DHEC data and unshaded areas represent DOE-SR data
2. DOE-SR data is from the SRS Environmental Data Report for 2017 (SRNS, 2018)
3. ND is No Detects
4. NA is Not Applicable
5. <LLD is less than the Lower Limit of Detection

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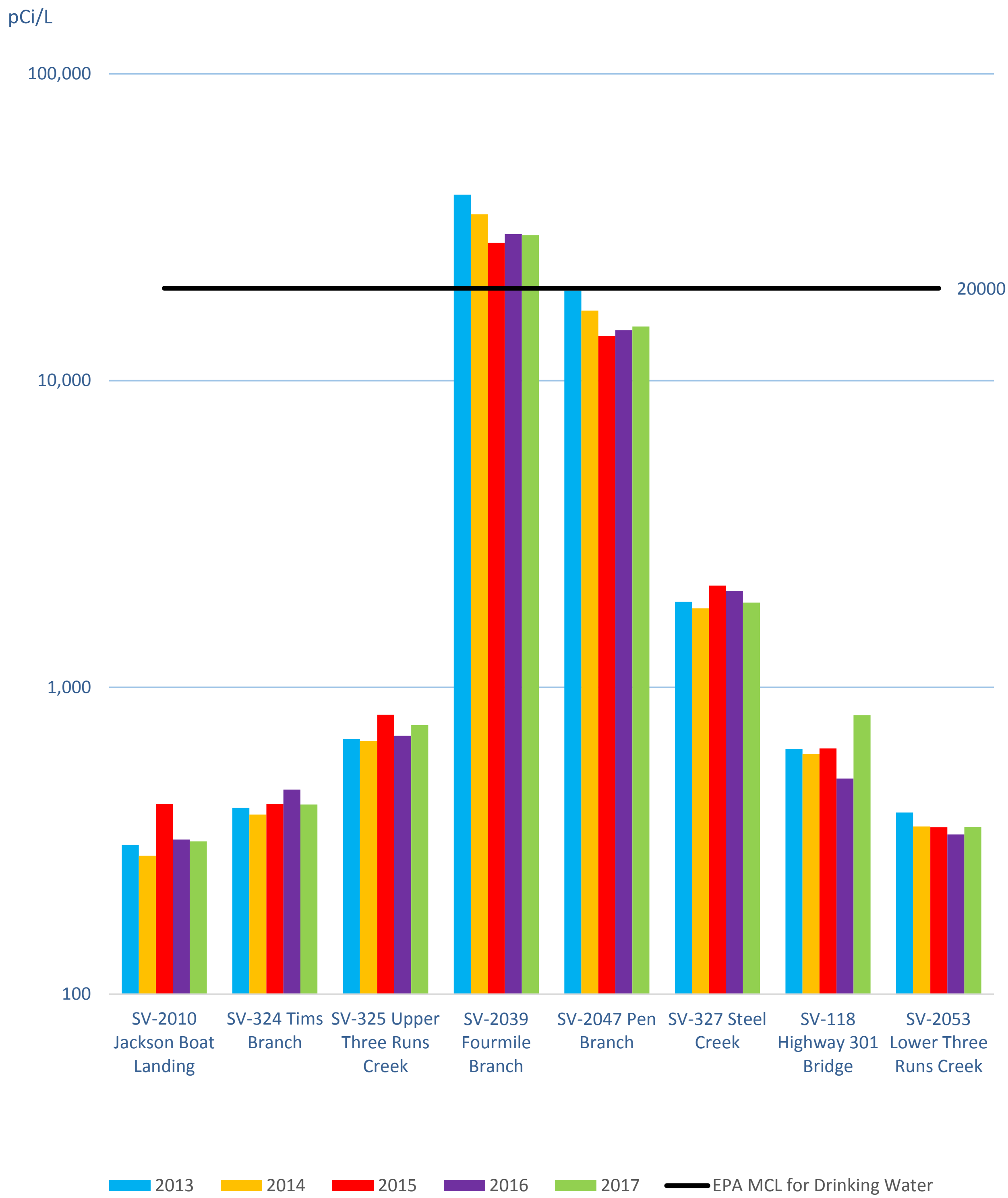
TABLES AND FIGURES

Figure 1. DHEC Average Tritium Data Trends for 2013-2017 (DHEC, 2015-2018)



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TABLES AND FIGURES

Figure 2. 2013-2017 Average Tritium Data Trends for DHEC and DOE-SR for Upper Three Runs Creek at S.C. Highway 125 (SRNS, 2014-2018; DHEC, 2015-2018)

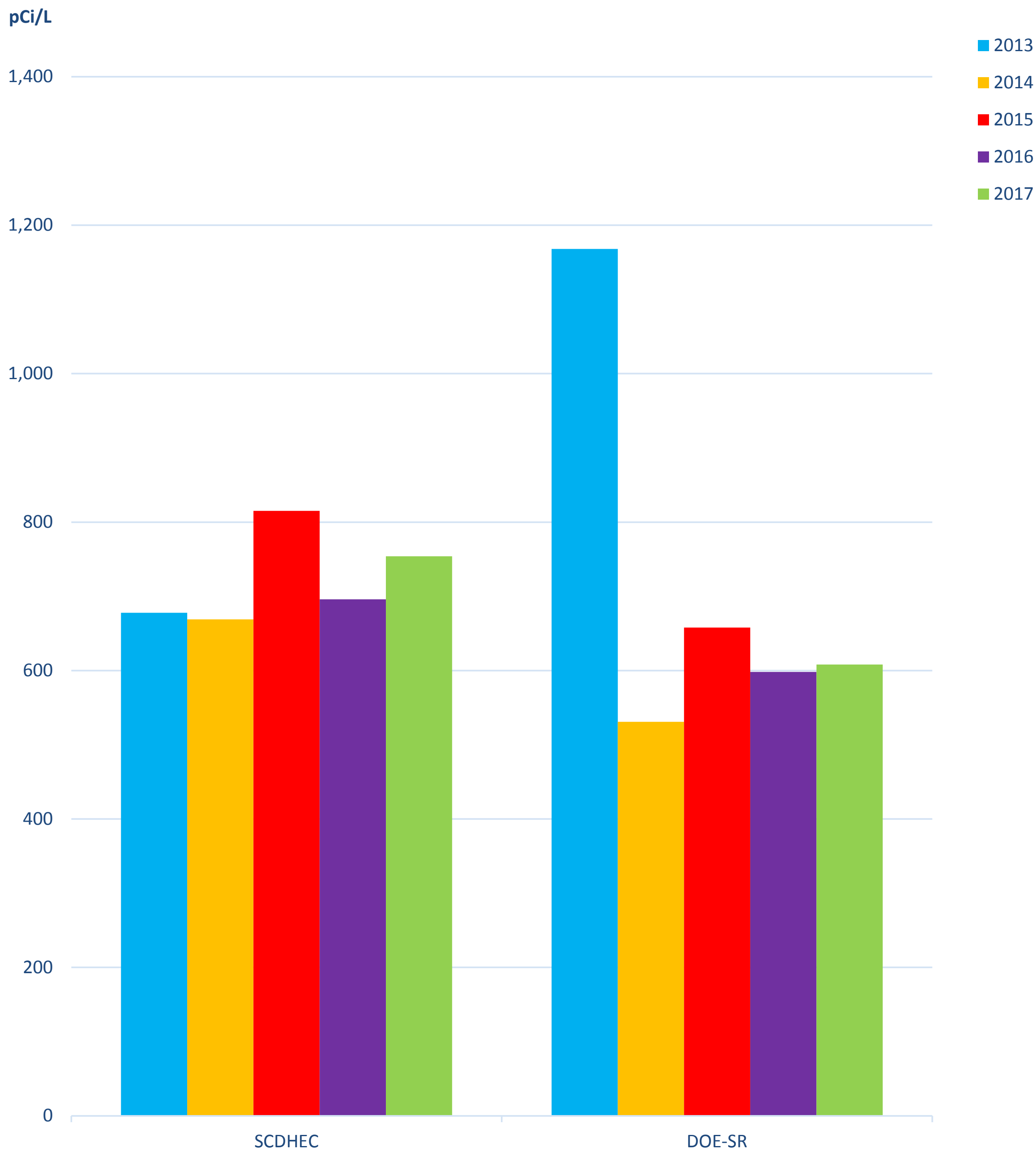

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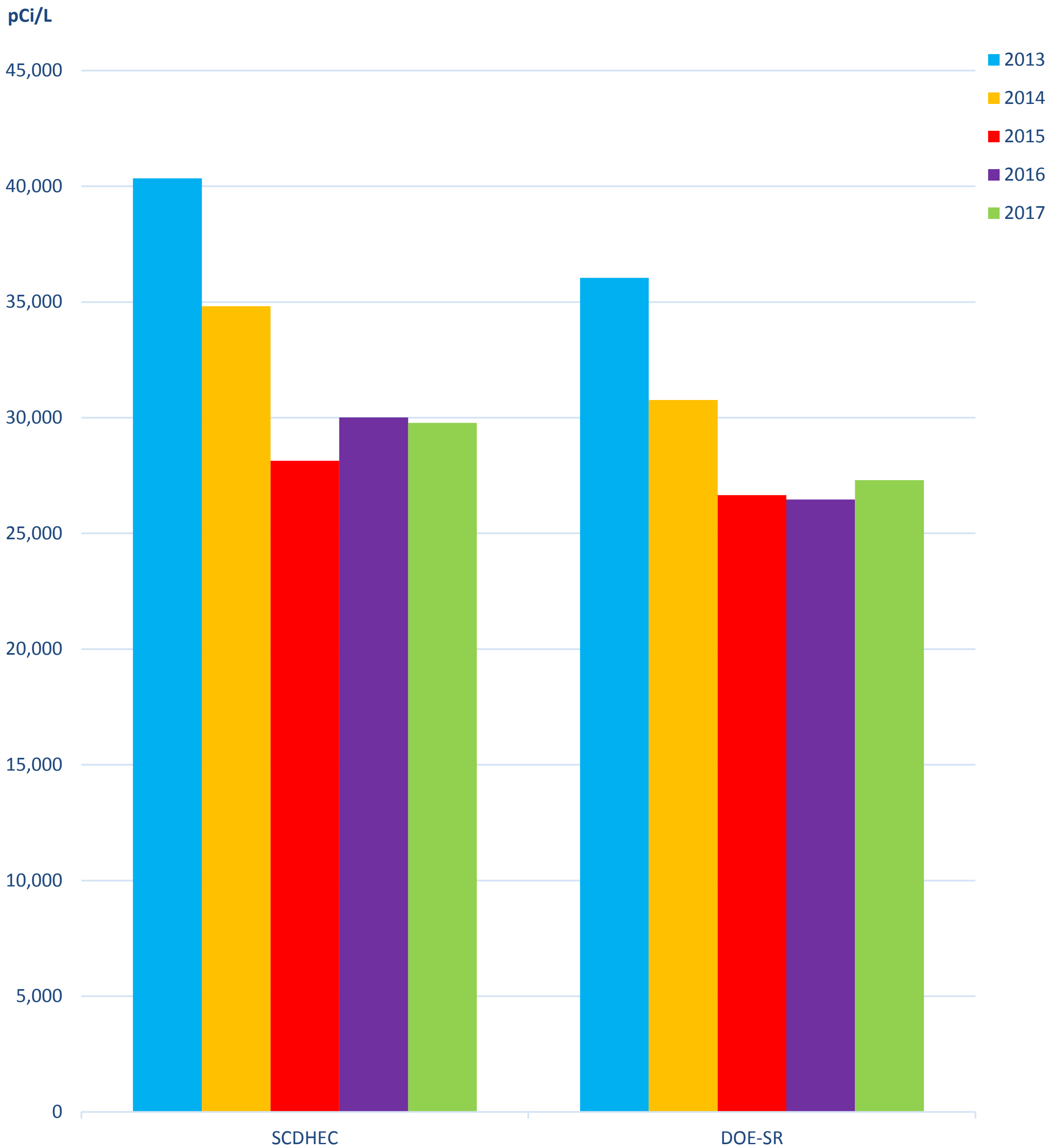
Figure 3. 2013-2017 Average Tritium Data Trends for DHEC and DOE-SR for Fourmile Branch at USFS Road 12. (SRNS, 2014-2018; DHEC, 2015-2018)



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TABLES AND FIGURES

Figure 4. 2013-2017 Average Tritium Data Trends for DHEC and DOE-SR for Pen Branch at USFS Road 13.2 (SRNS, 2014-2018; DHEC, 2015-2018)

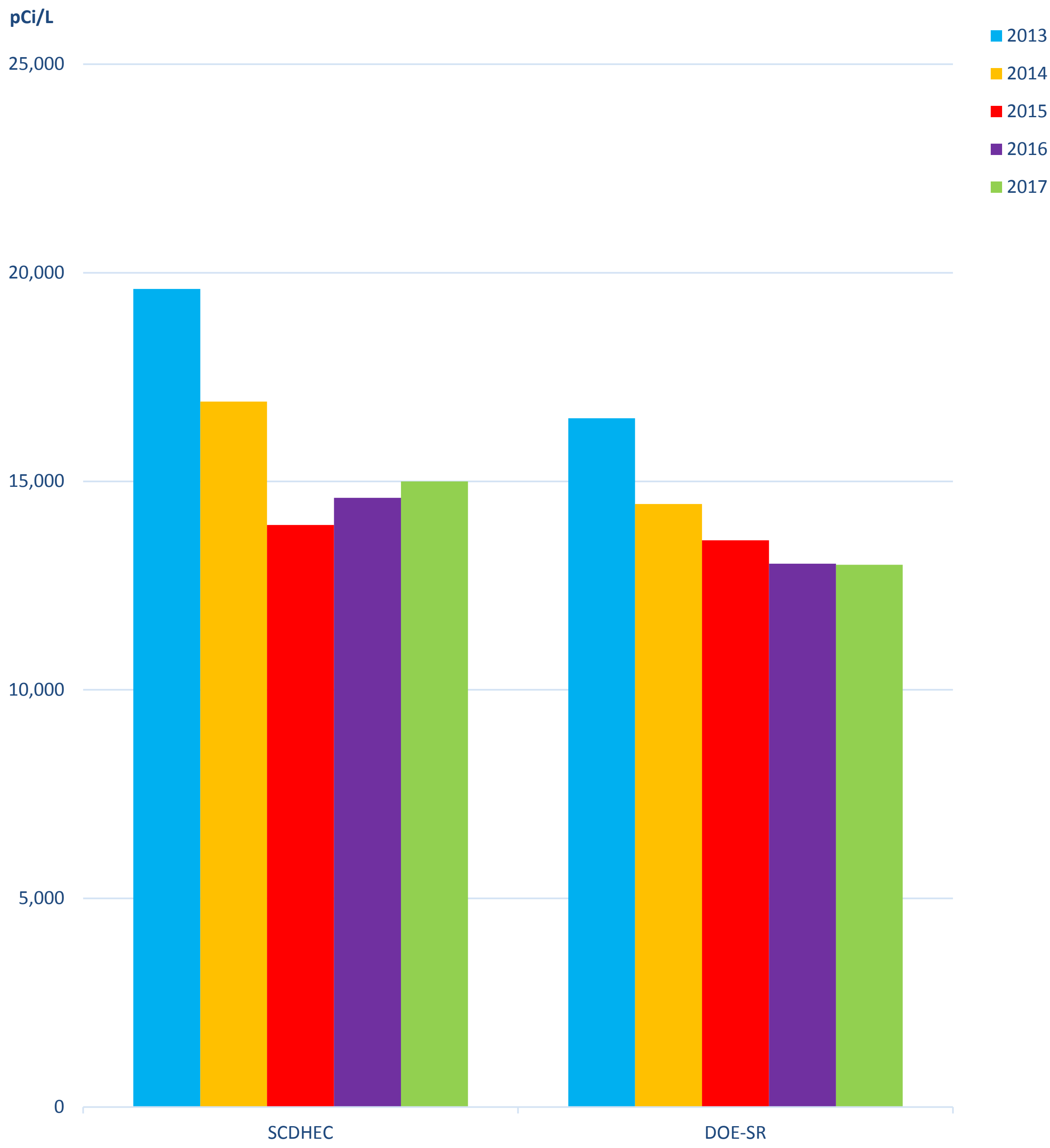

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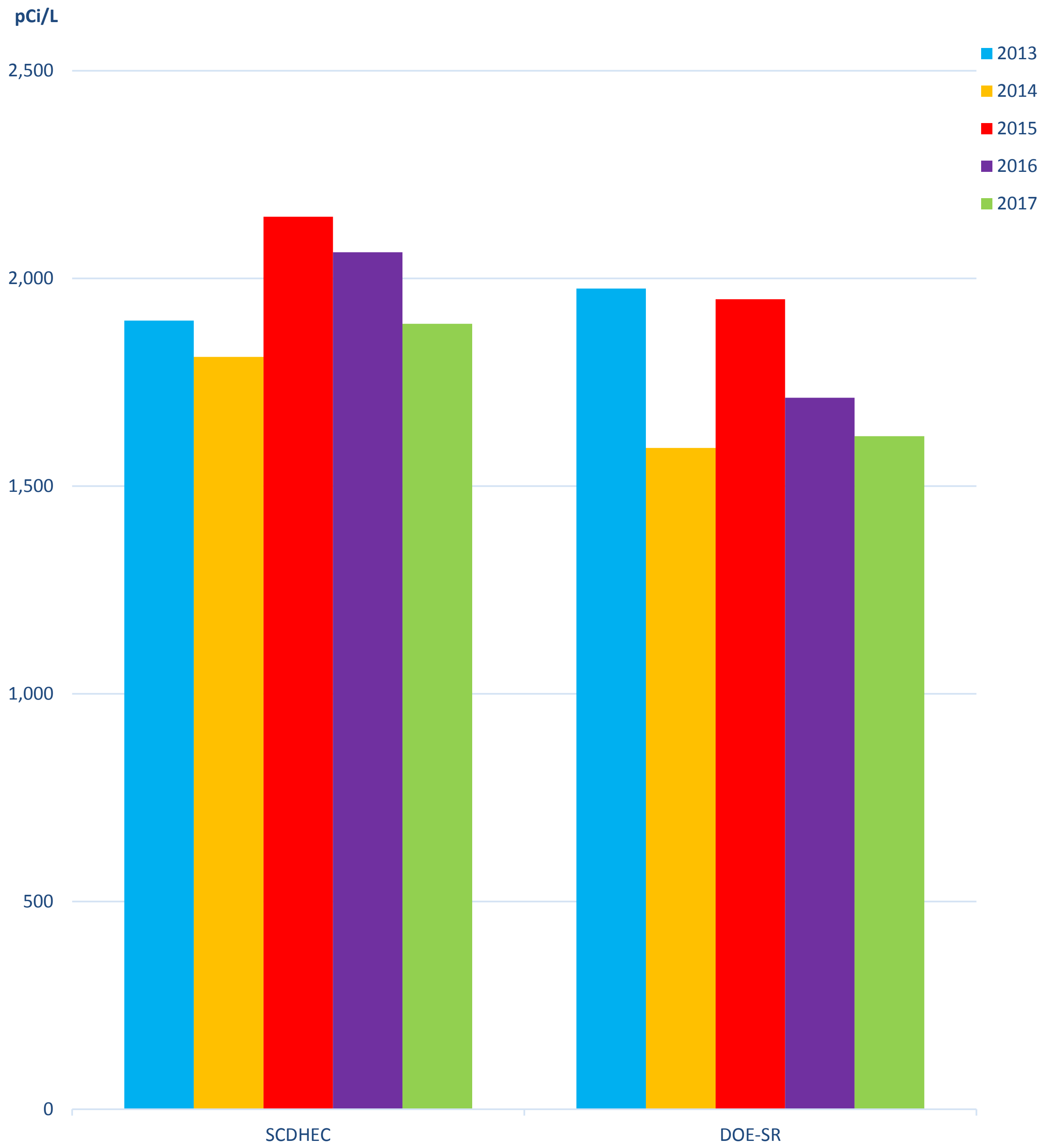
Figure 5. 2013-2017 Average Tritium Data Trends for DHEC and DOE-SR for Steel Creek at S.C. Highway 125 (SRNS, 2014-2018; DHEC, 2015-2018)



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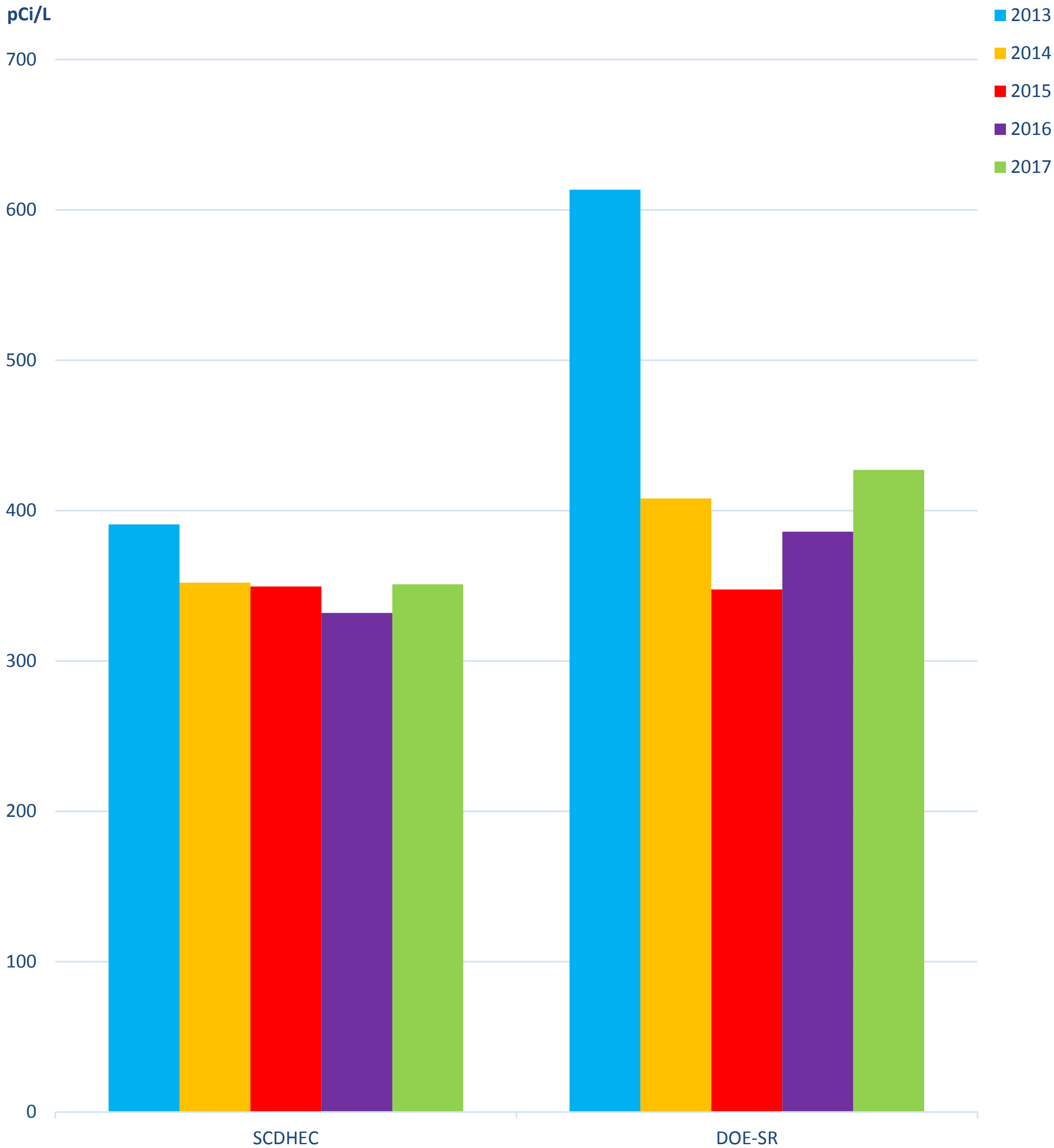
TABLES AND FIGURES

Figure 6. 2013-2017 Average Tritium Data Trends for DHEC and DOE-SR for Lower Three Runs Creek at SRS Road B (SRNS, 2014-2018; DHEC, 2015-2018)



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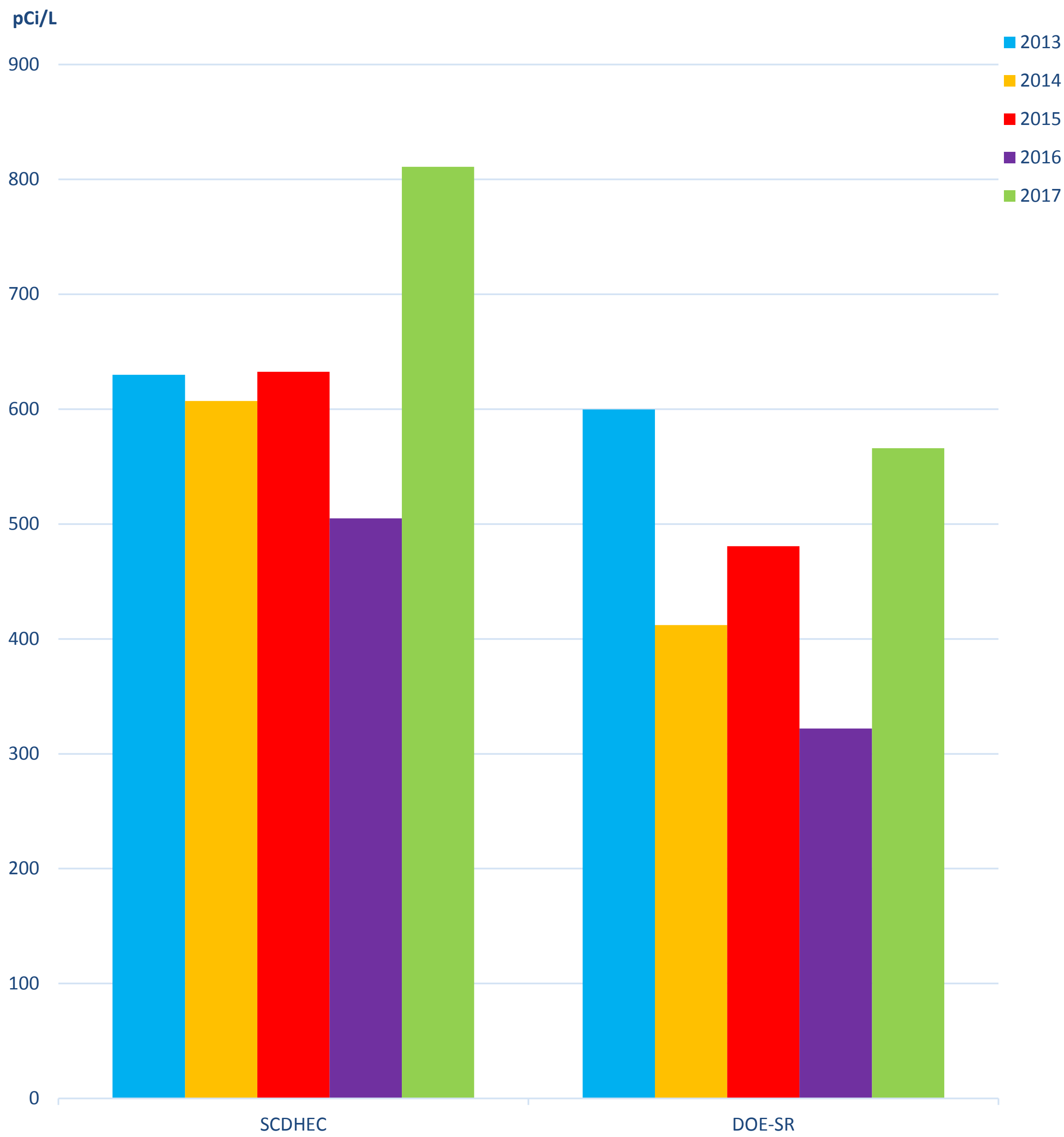
TABLES AND FIGURES

Figure 7. 2013-2017 Average Tritium Data Trends for DHEC and DOE-SR for the Savannah River at US Highway 301 Bridge (SRNS, 2014-2018; DHEC, 2015-2018)



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4.6.0 SUMMARY STATISTICS

2017 DHEC Ambient Monitoring Data-Tritium

Sample Location	Average Concentration (pCi/L)	Standard Deviation	Median (pCi/L)	Minimum (pCi/L)	Maximum (pCi/L)	Number of Detections	Number of Samples
Jackson Boat Landing (SV-2010)	315	46	329	262	363	5	52
Tims Branch (SV-324)	415	68	404	282	566	46	51
Upper Three Runs Creek at S.C. 125 (SV-325)	754	331	654	303	1862	52	52
Fourmile Branch (SV-2039)	29775	5024	29598	10069	38490	52	52
Pen Branch (SV-2047)	14997	4323	15399	6391	24119	52	52
Steel Creek (SV-327)	1891	404	1939	489	2656	51	51
Steel Creek Boat Landing (SV-2018)	938	1225	483	269	5108	48	52
Little Hell Boat Landing (SV-2019)	566	346	476	282	1985	37	52
Highway 301 Bridge (SV-118)	811	527	673	277	2544	49	52
Lower Three Runs Creek at Patterson Mill Rd. (SV-328)	1443	496	1378	422	2339	52	52
Lower Three Runs Creek at Road B (SV-2053)	351	51	354	266	454	23	52
Upper Three Runs Creek at SRS Road 2-1 (SV-2027)	328	55	312	266	401	6	52

2017 DHEC Creek Mouth Data-Tritium

Sample Location	Average Concentration (pCi/L)	Standard Deviation	Median (pCi/L)	Minimum (pCi/L)	Maximum (pCi/L)	Number of Detections	Number of Samples
Upper Three Runs Mouth @ RM 157.4 (SV-2011)	565	83	534	505	685	4	4
Fourmile Branch Mouth @ RM 150.6 (SV-2015)	3706	NA	NA	3706	3706	1	4
Steel Creek Mouth @ RM 141.5 (SV-2017)	2465	1211	2518	1020	3807	4	4
Lower Three Runs Mouth @ RM 129.1 (SV-2020)	578	278	478	376	982	4	4

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SUMMARY STATISTICS

2017 DHEC Ambient Monitoring Data-Alpha

Sample Location	Average Concentration (pCi/L)	Standard Deviation	Median (pCi/L)	Minimum (pCi/L)	Maximum (pCi/L)	Number of Detections	Number of Samples
Jackson Boat Landing (SV-2010)	1.86	NA	1.86	1.86	1.86	2	11
Tims Branch (SV-324)	3.39	1.53	2.61	2.08	5.88	5	11
Upper Three Runs Creek at S.C. 125 (SV-325)	5.56	5.56	2.81	1.40	19.20	9	11
Fourmile Branch (SV-2039)	1.79	NA	1.79	1.79	1.79	1	11
Pen Branch (SV-2047)	2.86	NA	2.86	2.86	2.86	1	11
Steel Creek (SV-327)	1.61	NA	1.61	1.61	1.61	1	11
Steel Creek Boat Landing (SV-2018)	4.43	0.87	4.43	3.81	5.04	2	11
Highway 301 Bridge (SV-118)	2.84	NA	2.84	2.84	2.84	1	11
Lower Three Runs Creek at Road B (SV-2053)	ND	NA	NA	<LLD	<LLD	0	11

2017 DHEC Ambient Monitoring Data-Beta

Sample Location	Average Concentration (pCi/L)	Standard Deviation	Median (pCi/L)	Minimum (pCi/L)	Maximum (pCi/L)	Number of Detections	Number of Samples
Jackson Boat Landing (SV-2010)	ND	NA	NA	<LLD	<LLD	0	11
Tims Branch (SV-324)	ND	NA	NA	<LLD	<LLD	0	11
Upper Three Runs Creek at S.C. 125 (SV-325)	4.87	NA	4.87	4.87	4.87	1	11
Fourmile Branch (SV-2039)	5.26	0.99	5.16	4.33	6.40	4	11
Pen Branch (SV-2047)	ND	NA	NA	<LLD	<LLD	0	11
Steel Creek (SV-327)	ND	NA	NA	<LLD	<LLD	0	11
Steel Creek Boat Landing (SV-2018)	6.80	NA	6.80	6.80	6.80	1	11
Highway 301 Bridge (SV-118)	4.89	0.18	4.89	4.76	5.01	2	11
Lower Three Runs Creek at Road B (SV-2053)	6.21	NA	6.21	6.21	6.21	1	11

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Chapter 5 Non-radiological Monitoring of Surface Water on SRS

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5.1.0 PROJECT SUMMARY

POINT SOURCE POLLUTION:
"Pollution that comes from a specific, identifiable source, such as a pipe or channel"

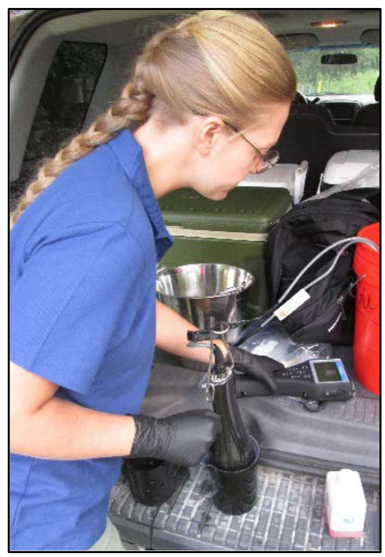
NONPOINT SOURCE POLLUTION:
"Sources that are diffuse, without a single identifiable point of origin, including runoff from agriculture, forestry, and construction sites"

Source: EPA

The streams located on SRS receive a wide variety of permitted point source discharges and non-point source run-off from on-site facilities and operations. These discharges specifically include, but are not limited to, industrial storm water, utility water, treated industrial and sanitary wastewater, and run-off from land-disturbing activities. Data from SRS Environmental Reports and DHEC ESOP are used to monitor the ambient water quality of streams on SRS.

DHEC assessed the surface water quality for non-radiological parameters in 2017 at SRS by sampling the on-site streams for inorganic and organic contaminants. The streams on SRS are tributaries that feed into the Savannah River and are classified as freshwater by DHEC's Bureau of Water (DHEC, 2012b). As an indication of possible water quality issues, DHEC data is compared to the freshwater standard guidelines in DHEC's Water Classifications and Standards, Regulation 61-68 (DHEC, 2014b). These guidelines give numeric criteria for specific parameters and narrative criteria that indicate conditions of biological integrity and water quality for aquatic life and human health. The fact that a stream does not meet the specified numeric standards for a particular parameter does not mean the stream is polluted or of poor quality. Natural conditions can cause streams to exceed the standards.

Nine DHEC sample locations were strategically chosen to monitor ambient surface water conditions and detect the non-radiological impact from DOE-SR operations. A map of DHEC sample locations can be found in Section 5.4.0. Six of the DHEC sample locations are collocated with DOE-SR sample locations to provide data comparisons (Section 5.5.0, Table 1). The stream sample locations were selected based on accessibility and their proximity upstream and downstream of DOE-SR operations before flowing into the publicly accessible Savannah River. A list of water quality parameter analyses and sample frequency can be found in Section 5.5.0, Table 2.


Standardizing the Horiba Water Testing System

5.2.0 RESULTS AND DISCUSSION

Non-radiological Monitoring of Surface Water Summary Statistics can be found in Section 5.6.0 and all Non-radiological Monitoring of Surface Water Data can be found in the 2017 DHEC Data File.

Many chemical and biological processes in surface waters can be affected by pH, a measurement that indicates the alkalinity or acidity of a substance (EPA, 1997). The streams encountered at

SRS are typical of southeastern streams characterized as black-water. A black-water stream is one that has a deep, slow-moving channel that flows through forested swamps and wetlands. Decaying vegetation in the water results in the leaching of tannins from the vegetation which results in transparent, acidic water that is darkly stained, resembling tea or coffee. Low pH is typical for black-water streams such as those sampled at SRS (USGS, 2000).

The pH standard for all South Carolina freshwater streams is between 6.0 and 8.5 standard units (SU) (DHEC, 2014b). All DHEC locations had yearly averages within the standard except for Upper Three Runs at Road 2-1 (NWSV-2027) whose average pH was 5.95. NWSV-2027 is a black-water stream, which could contribute to it having a pH lower than 6. See Section 5.5.0, Figure 1 for a comparison of DHEC and DOE-SR data for collocated samples (SRNS, 2018).

Oxygen is cycled through the environment and is both produced and consumed in streams. The amount of oxygen in its dissolved form in water is the Dissolved Oxygen (DO). The Biochemical Oxygen Demand (BOD) is the amount of oxygen consumed by microorganisms in stream water. Water quality is diminished when the BOD is high, which depletes the oxygen in the water. Low DO means less oxygen to support higher forms of aquatic life (EPA, 1997).

The South Carolina freshwater standard for DO is a daily average of no less than 5.0 milligrams per liter (mg/L) with no individual sample to be below 4.0 mg/L (DHEC, 2014b). All individual samples and yearly averages met the DO standard in 2017. A DO comparison of DHEC and DOE-SR data for collocated samples can be found in Section 5.5.0, Figure 2 (SRNS, 2018).

There are no numeric criteria in the South Carolina freshwater standards for a maximum BOD level; however, all 2017 DHEC samples were near or below the LLD of 2.0 mg/L. DOE-SR did not collect BOD samples in 2017, therefore, no comparison can be made for BOD.

Temperature can affect biological and chemical processes in a stream. All aquatic organisms can be negatively impacted by temperatures that vary from the naturally occurring range (EPA, 1997). The South Carolina freshwater standards state that the temperature of free-flowing freshwater shall not be increased more than 2.8°C above natural temperature conditions and shall not exceed a maximum of 32.2°C (DHEC, 2014b).
DHEC data showed that the stream temperatures during each sampling event were comparable to each other, including samples representative of natural conditions that were upstream of most SRS operations.

Alkalinity is important for aquatic life in freshwater systems because it buffers pH changes that occur naturally or as a result of anthropogenic sources. Components of alkalinity, such as carbonate and bicarbonate, will incorporate some toxic heavy metals and reduce their toxicity (EPA, 1997). There are no numeric criteria in the South Carolina freshwater standards for alkalinity. However, the National Technical Advisory Committee recommends a minimum alkalinity of 20 mg/L and that natural alkalinity not be reduced by more than 25 mg/L. Waters having insufficient alkalinity due to natural conditions do not have to be supplemented with artificially added materials to increase the alkalinity. Alkalinity resulting from naturally occurring materials, such as carbonate and bicarbonate, is not considered a health hazard in drinking water supplies (NAS, 1974).

Drawing up creek water for testing

In 2017, most of the locations sampled were below the recommended minimum level for alkalinity. The low alkalinity, as related to pH, in SRS streams may be due to the presence of naturally low buffering compounds in the streams. DOE-SR did not sample for alkalinity in 2017, therefore, no comparison can be made.

Turbidity is a measure of water clarity or the amount of light that passes through the water. The freshwater quality standard for turbidity in South Carolina streams is not to exceed 50 nephelometric turbidity units (NTU) provided existing uses are maintained (DHEC, 2014b). All DHEC monitored streams were below the standard for turbidity in 2017. DOE-SR did not sample for turbidity in 2017, therefore, no comparison can be made. Turbidity is directly affected by the water's Total Suspended Solids (TSS), which refers to the amount of material suspended in the water (EPA, 1997). There is no freshwater quality standard for TSS. A TSS comparison of DHEC and DOE-SR data for collocated samples can be found in Section 5.0, Figure 3 (SRNS, 2018).

The South Carolina freshwater *E. coli* standard is a daily maximum of 349 Most Probable Number per 100mL (MPN/100mL). All nine streams sampled had individual samples that exceeded 349 MPN/100mL. Three locations (SV-328, SV-2055, SV-2061) had a yearly average above the standard. DOE-SR did not collect samples for *E. coli* in 2017, therefore, no comparison can be made.

Phosphorous and nitrogen are essential nutrients for the plants and animals that make up the aquatic food web. However, in excess they can cause significant water quality problems. Phosphorous and nitrogen cycle through the environment in a variety of forms and can indirectly impact DO and other water quality indicators (EPA, 1997). In 2017, DHEC sampled for total phosphorous and various forms of nitrogen, including nitrite/nitrate, total Kjeldahl nitrogen (TKN), and ammonia. There are no numeric criteria in the South Carolina freshwater standard for any of these parameters.

DHEC uses the most conservative of the federally established drinking water standards for nitrate/nitrite levels to indicate ambient water quality in freshwater streams for nutrients. The EPA drinking water standards for nitrate/nitrite levels are 10 mg/L and 1 mg/L respectively and are designed to protect the public from consumption of high levels of these nutrients (EPA, 2009). As a conservative measure, DHEC uses a maximum of 1 mg/L as an indication of possible water quality issues.

Overall the nutrient levels on SRS are similar to the levels found throughout the Savannah River Basin. DOE-SR did not sample for TKN or ammonia in 2017, therefore, no comparison can be made. A comparison of DHEC and DOE-SR data from collocated samples for total phosphorous and nitrate/nitrite, respectively can be found in Section 5.5.0, Figures 4 and 5 (SRNS, 2018).

Most metals are considered to be pollutants, including some that are toxic or known carcinogens. In 2017, DHEC personnel collected samples for the following metals: cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, and zinc. Due to the potential health effects of some metals, a yearly average, even if based on a single detection that exceeds the freshwater standards, may indicate a water quality issue. These metals, except iron and manganese, have numeric criteria for the protection of human health and aquatic life in the South Carolina freshwater quality standards.

Iron has a recommended EPA limit in freshwater streams of 1 mg/L (EPA, 2008). One of the DHEC and DOE-SR sample locations indicated levels above the EPA recommended level. The yearly average at Tims Branch was 2.0 mg/L (DHEC) and 2.48 mg/L (DOE-SR) respectively (SRNS 2018). Tims Branch has several ground water seeps that contribute to its relatively low flow. It is likely that the elevated iron measured at this location is influenced by naturally occurring processes. A couple of locations had individual samples with low detections of iron in their monthly tests, with the highest being 1.6 mg/L. A comparison of DHEC and DOE-SR iron data for collocated samples can be found in Section 5.5.0, Figure 6.

All DHEC manganese sample results were within the levels seen in the Savannah River Basin (DHEC, 2013b). However, there is no standard for this parameter. DHEC and DOE-SR detected manganese in all the collocated sample locations. See Section 5.5.0, Figure 7 for a manganese comparison of DHEC and DOE-SR data for collocated samples (SRNS, 2018).

The freshwater quality standard for cadmium in South Carolina streams is not to exceed 0.0001 mg/L (DHEC, 2014b). DHEC samples had no cadmium levels above the standard. DOE-SR detected cadmium above the standard at three of the collocated sample locations in 2017 (SRNS, 2018). The detection limit for DOE-SR is higher than the standard at 0.0005 mg/L; therefore, any detection of cadmium would exceed the standard.

The freshwater quality standards for chromium, copper, and nickel in South Carolina streams are not to exceed 0.011 mg/L, 0.0029 mg/L and 0.016 mg/L, respectively (DHEC, 2014b). There were no DHEC or DOE-SR detections above the standard of chromium in 2017. DHEC detected copper above the standard in two samples: SV-2027 at 0.02 mg/L and SV-2061 at 0.012 mg/L. DOE-SR detected copper above the standard at Lower Three Runs with a reading of 0.0031 mg/L (SRNS, 2018). DHEC did not detect nickel in 2017. DOE-SR detected nickel in three of the collocated sample locations, but none of the averages exceeded the standard (SRNS, 2018).

The freshwater quality standard for lead in South Carolina streams is not to exceed 0.00054 mg/L (DHEC, 2014b). Due to laboratory limitations, DHEC and DOE-SR have LLDs higher than the standard. Therefore, any detection of lead would be over the standard. There was one DHEC detection at SV-2061 at 0.0021 mg/L. DOE-SR had no lead detections in 2017 in the collocated samples (SRNS, 2018).

The freshwater quality standard for mercury in South Carolina streams is not to exceed 0.00091 mg/L (DHEC, 2014b). Mercury was not detected in any of the DHEC samples in 2017. DOE-SR detected mercury at one of the collocated sampling locations, but not in exceedance of the standard (SRNS, 2018).

The freshwater quality standard for zinc in South Carolina streams is not to exceed 0.037 mg/L (DHEC, 2014b). DHEC and DOE-SR had no samples over the standard in 2017. A zinc comparison of DHEC and DOE-SR yearly averages for collocated samples can be found in Section 5.5.0, Figure 8.

Most VOCs, PCBs, and pesticides are pollutants including some that are toxic. Most have numeric criteria for the protection of human health and aquatic life in the South Carolina freshwater quality standards. There were no detections of VOC, PCB, or pesticide contaminants in 2017 in the DHEC or DOE-SR samples (SRNS, 2018).

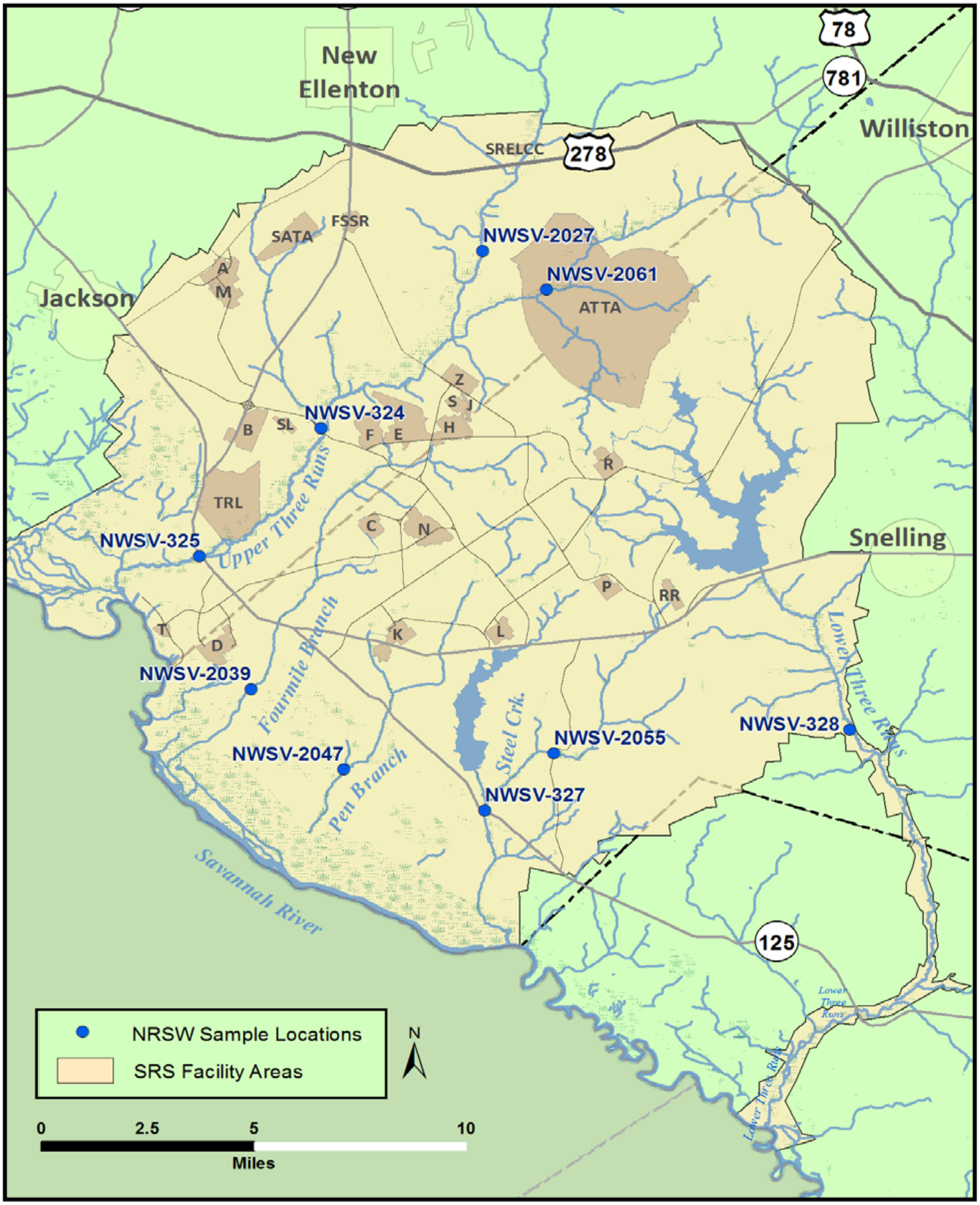
Small discrepancies in data between DOE-SR and DHEC may be attributed to differences in sample collection date and time, sample preservation, and lab analysis. Variances in statistical calculations, such as the yearly averages, may also attribute to dissimilarities. All data less than the LLD were left out of DHEC summary statistics due to lack of numeric information.

5.3.0 CONCLUSIONS AND RECOMMENDATIONS

The current parameters will continue to be monitored to establish trends that may warrant further investigation based on EPA or DHEC standards or recommended levels. Overall, the non-radiological water quality on SRS in 2017 compared favorably with the South Carolina Freshwaters Standard or other recommendations for the parameters and monitored locations. The 2017 DHEC results for most parameters were similar to the DHEC's Bureau of Water data for the Savannah River watershed (DHEC, 2013b). DHEC will continue to evaluate water quality based on the independent, non-radiological testing and surveillance of SRS surface water. Monitoring is required due to continued land disturbance from clean-up activities, new facility construction, logging, and new missions. The locations, number and frequencies of samples, and monitoring parameters are reviewed annually and modified as needed to maximize available resources and address SRS mission changes.

5.4.0 MAP

Non-radiological Surface Water Sampling Locations



2017 ESOP Non-radiological Surface Water Monitoring

5.5.0 TABLES AND FIGURES

Table 1. 2017 DHEC Surface Water Sample Locations

Sample Location	Location Description	Location Rationale
NWSV-2027	Upper Three Runs at Road 2-1	Upstream of most SRS Operations
NWSV-2061	Tinker Creek at Road 2-1	Upstream of most SRS Operations
NWSV-324*	Tims Branch at Road C	Downstream from M- & A-Areas
NWSV-325*	Upper Three Runs at Road A	Downstream from F-Area
NWSV-2055	Meyers Branch at Road 9	Downstream from P-Area
NWSV-2039*	Fourmile Branch at Road A-13.2	Downstream from F- and H-Areas
NWSV-2047*	Pen Branch at Road A-13.2	Downstream from K-Area
NWSV-327*	Steel Creek at Road A	Downstream from L-Lake
NWSV-328*	Lower Three Runs at Patterson Mill Road	Downstream from Par Pond

*Collocated with DOE-SR sample locations.

Table 2. 2017 DHEC Water Quality Parameter Analyses

Laboratory	Frequency	Parameter
DHEC Lab Aiken, S.C.	Monthly	Turbidity, BOD, E. Coli, and TSS.
DHEC Lab Columbia, S.C.	Monthly	Alkalinity, Ammonia, Nutrients, Mercury, and Metals
Field	Semi-annually	VOCs, Pesticides, and PCBs.

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TABLES AND FIGURES

Figure 1. pH 2017 Yearly Average DHEC and DOE-SR Comparison (SRNS, 2018)

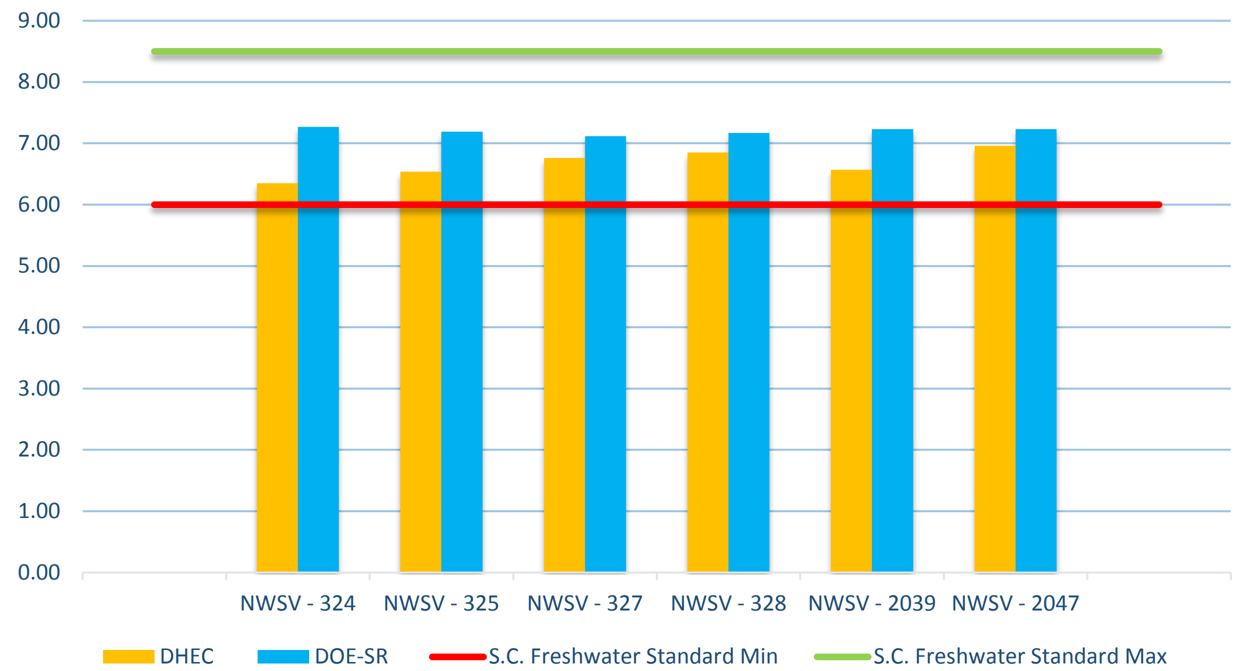
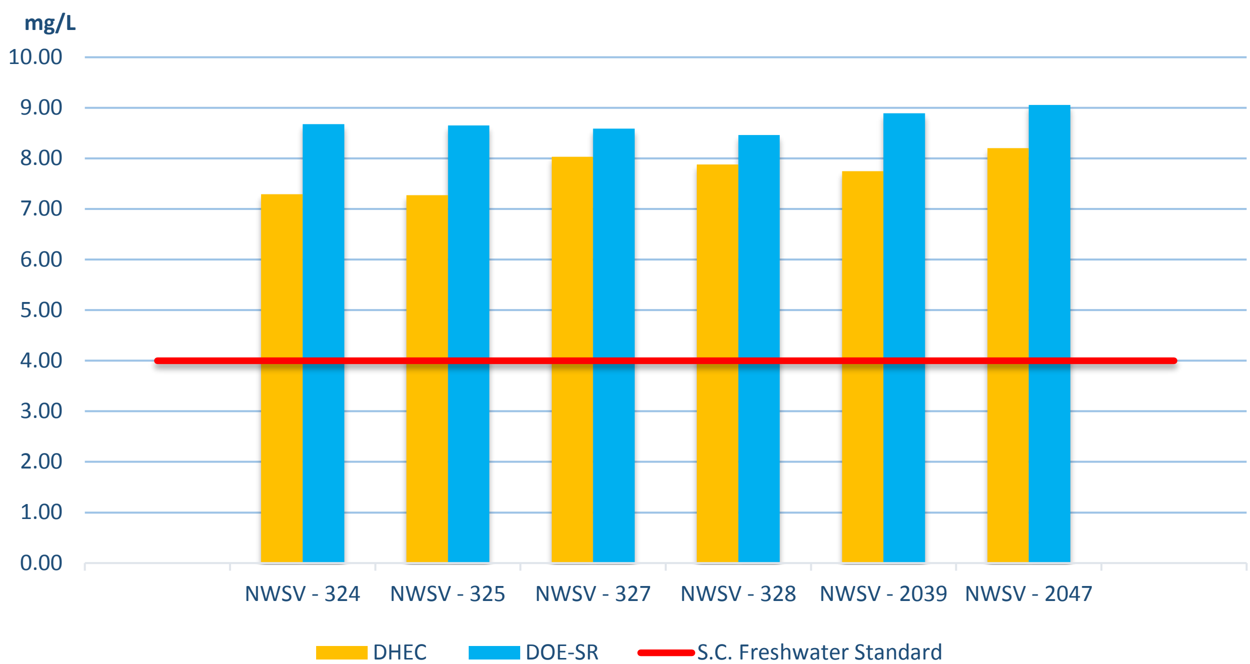


Figure 2. DO 2017 Yearly Average DHEC and DOE-SR Comparison (SRNS, 2018)



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TABLES AND FIGURES

Figure 3. TSS 2017 Yearly Average DHEC and DOE-SR Comparison (SRNS, 2018)

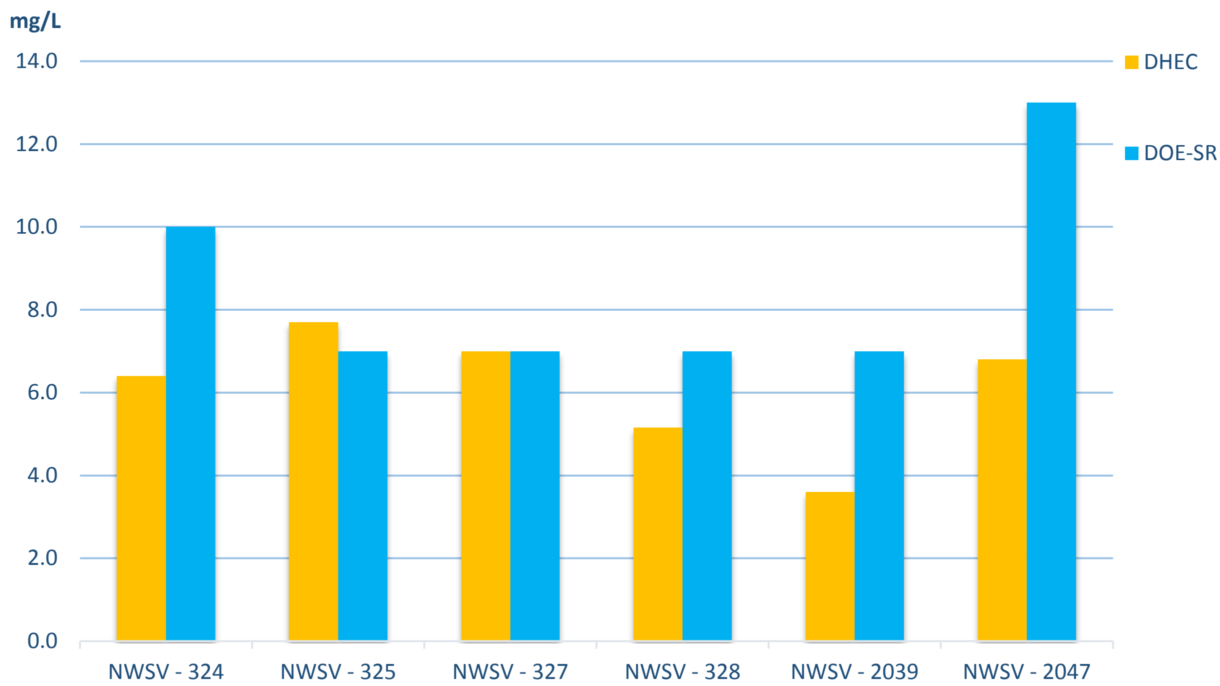
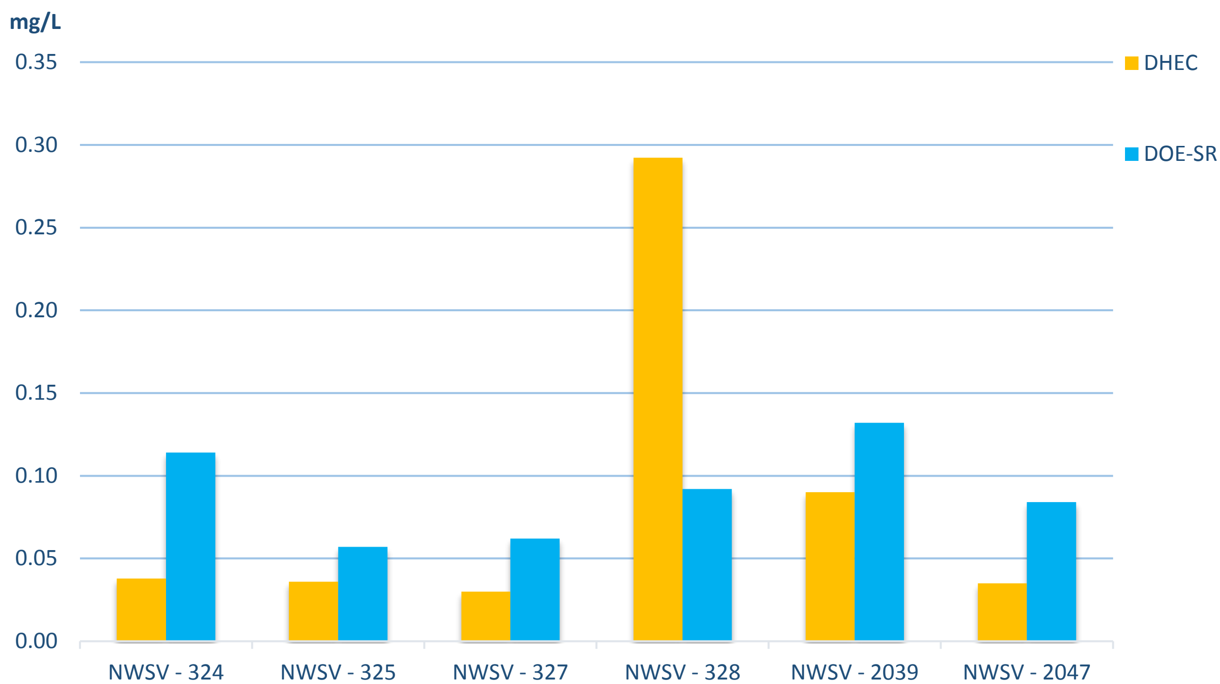


Figure 4. Total Phosphorous 2017 Yearly Average DHEC and DOE-SR Comparison (SRNS, 2018)



TABLES AND FIGURES

Figure 5. Nitrate/Nitrite 2017 Yearly Average DHEC and DOE-SR Comparison (SRNS, 2018)

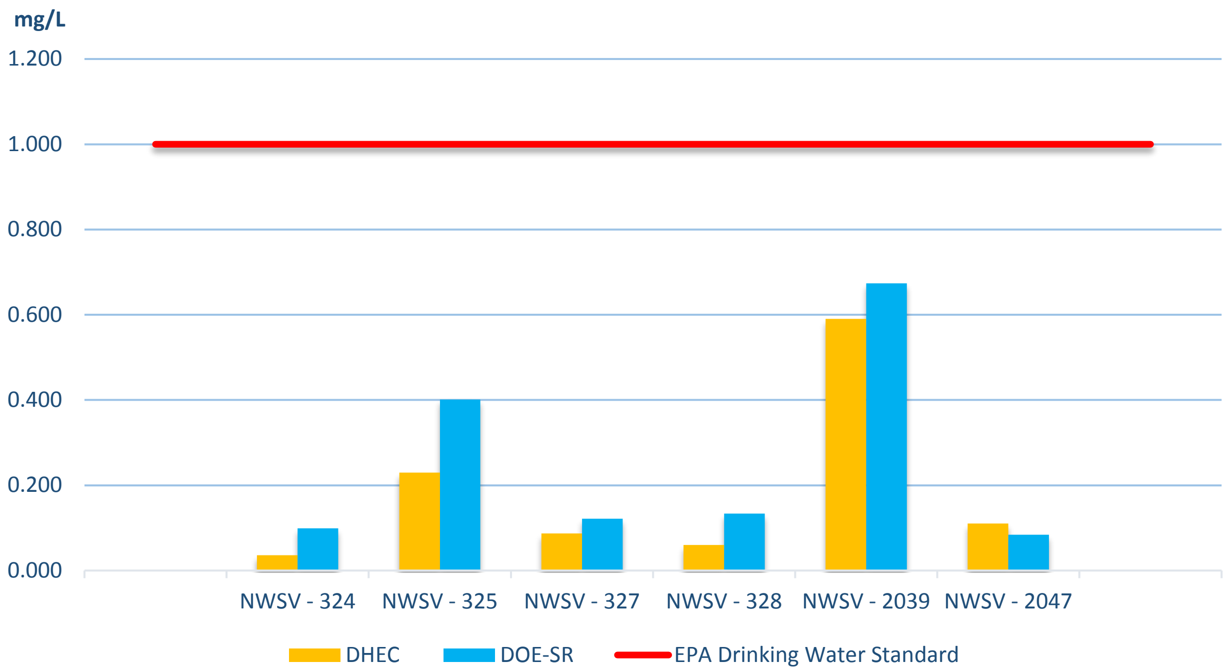
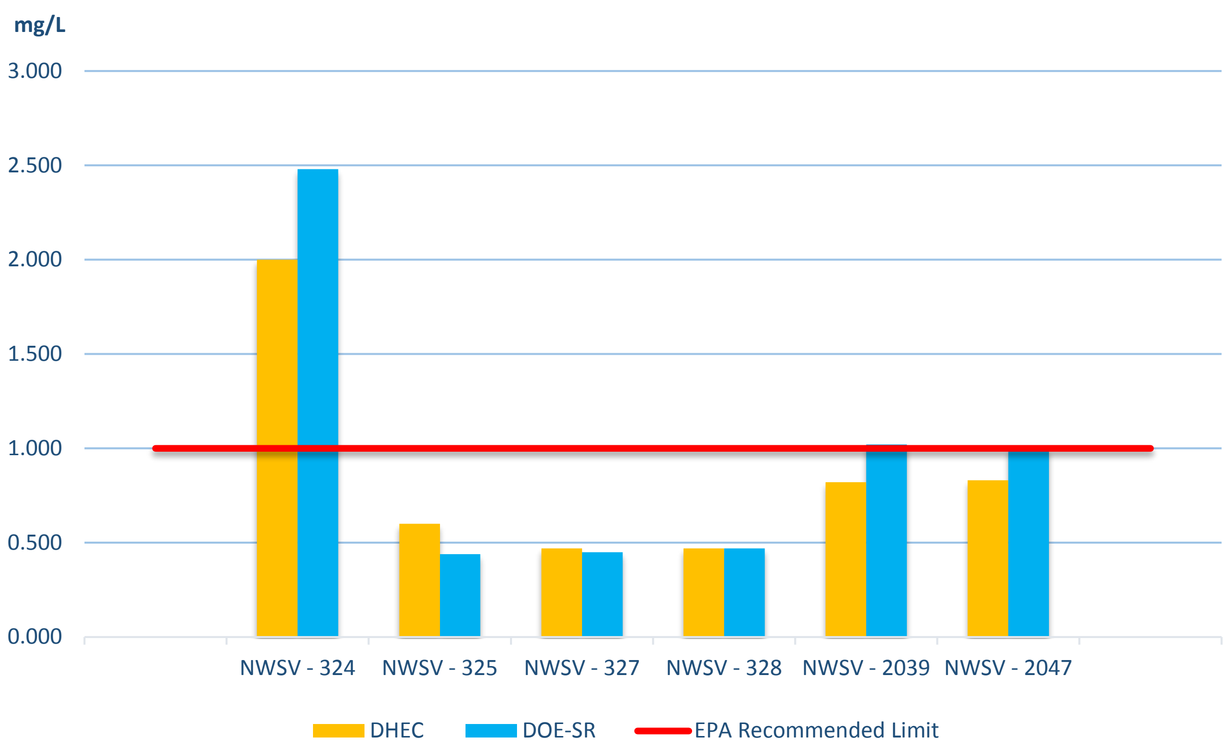


Figure 6. Iron 2017 Yearly Average DHEC and DOE-SR Comparison (SRNS, 2018)



TABLES AND FIGURES

Figure 7. Manganese 2017 Yearly Average DHEC and DOE-SR Comparison (SRNS, 2018)

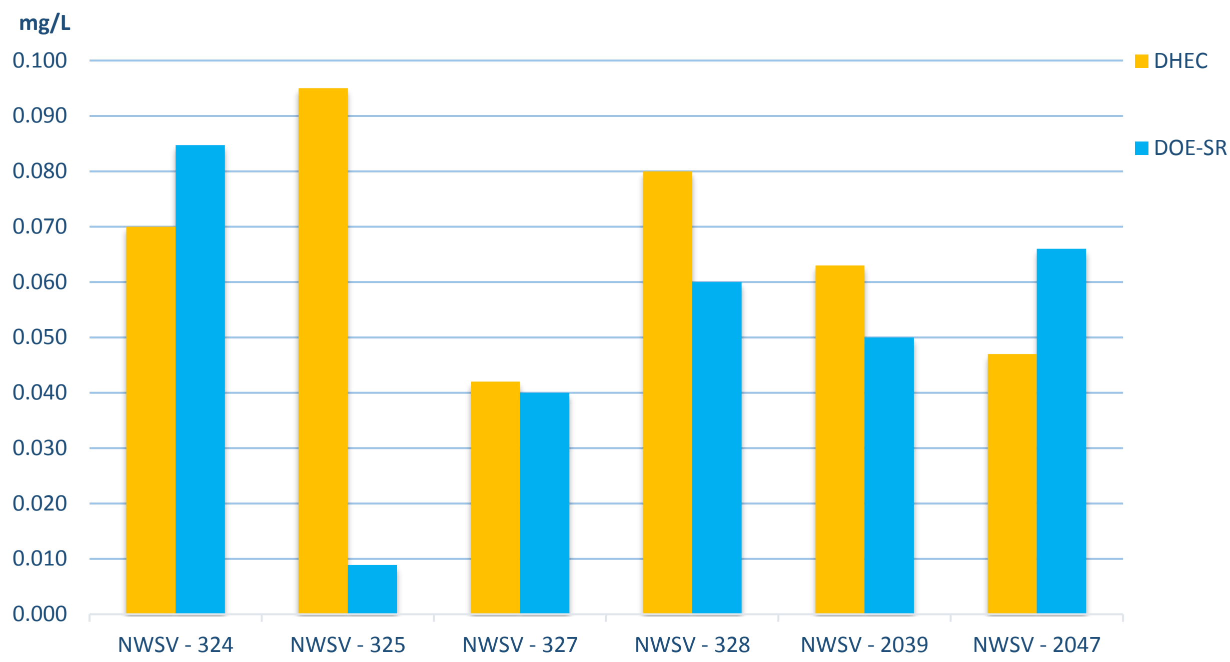
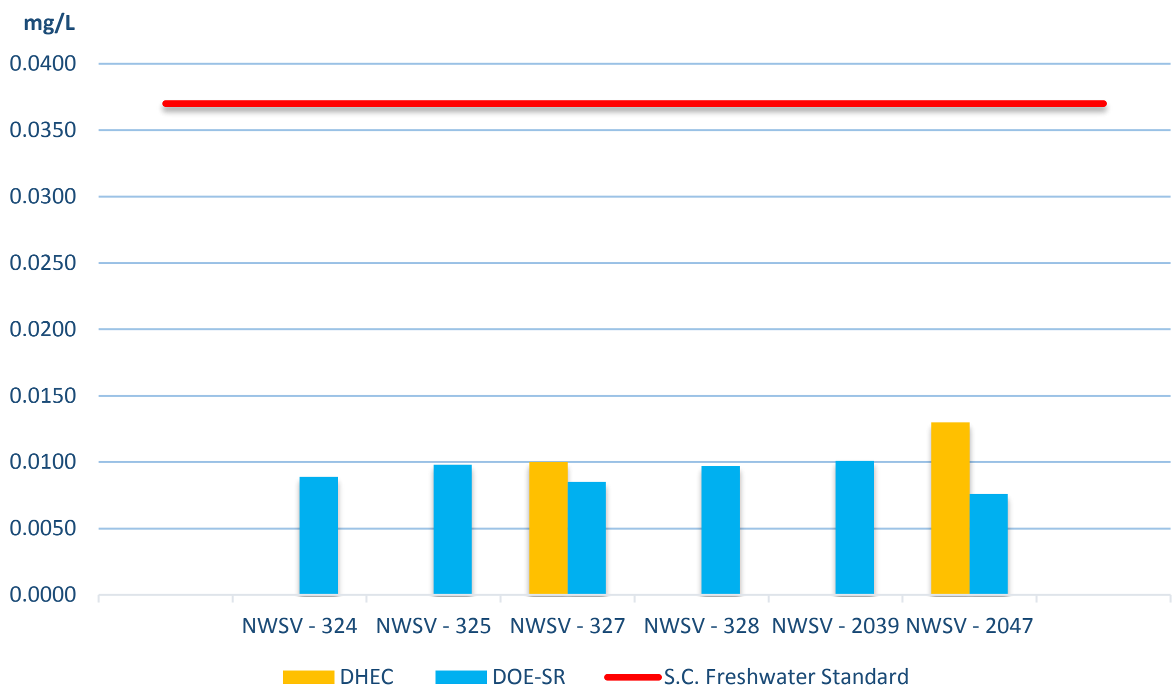


Figure 8. Zinc 2017 Yearly Average DHEC and DOE-SR Comparison (SRNS, 2018)



Note: No bar indicates the sample average is <LLD

5.6.0 2017 SUMMARY STATISTICS

NWSV–324 Tims Branch at Road C

Parameters		Average	Standard Deviation	Median	Minimum	Maximum	Number of Detects
Field	pH (SU)	6.35	0.44	6.24	5.87	7.42	12
	DO (mg/L)	7.29	1.90	7.44	3.75	9.95	12
	Water Temp (°C)	16.8	5.27	15.0	9.09	23.9	12
Laboratory	Alkalinity (mg/L)	5.33	2.53	5.00	1.7	10.0	12
	Turbidity (NTU)	5.10	2.68	4.40	2.6	12.	12
	BOD (mg/L)	2.45	0.07	2.45	2.4	2.5	2
	TSS (mg/L)	6.43	2.85	5.15	3.41	12.	12
	E. Coli (cnt/100mL)	212.	168.	160.	59.	649.	12
	TKN (mg/L)	0.38	0.20	0.36	0.14	0.8	11
	Ammonia (mg/L)	0.07	0.02	0.07	0.05	0.08	4
	Nitrate/Nitrite (mg/L)	0.04	0.01	0.04	0.02	0.05	9
	Total Phosphorus (mg/L)	0.04	0.01	0.04	0.03	0.06	12
	Cadmium (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Chromium (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Copper (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Iron (mg/L)	2.0	0.9	2.0	0.4	3.6	12
	Lead (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Manganese (mg/L)	0.07	0.033	0.06	0.013	0.14	12
	Nickel (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Zinc (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Mercury (mg/L)	<LLD	NA	NA	<LLD	<LLD	0

NWSV-325 Upper Three Runs at Road A

Parameters		Average	Standard Deviation	Median	Minimum	Maximum	Number of Detects
Field	pH (SU)	6.54	0.58	6.49	5.91	7.63	12
	DO (mg/L)	7.27	1.75	7.12	3.75	9.86	12
	Water Temp (°C)	17.4	4.79	16.3	9.97	23.6	12
Laboratory	Alkalinity (mg/L)	5.13	3.50	3.80	1.50	12.0	11
	Turbidity (NTU)	3.74	1.41	3.35	1.90	6.30	12
	BOD (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	TSS (mg/L)	7.70	7.19	4.50	1.90	26.0	12
	E. Coli (cnt/100mL)	301.	204.	228.	115.	727.	12
	TKN (mg/L)	0.29	0.13	0.26	0.16	0.60	10
	Ammonia (mg/L)	0.08	0.02	0.08	0.05	0.10	3
	Nitrate/Nitrite (mg/L)	0.23	0.32	0.14	0.11	1.20	11
	Total Phosphorus (mg/L)	0.04	0.01	0.04	0.03	0.05	12
	Cadmium (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Chromium (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Copper (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Iron (mg/L)	0.60	0.24	0.51	0.34	1.1	12
	Lead (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Manganese (mg/L)	0.095	0.178	0.018	0.010	0.510	12
	Nickel (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Zinc (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Mercury (mg/L)	<LLD	NA	NA	<LLD	<LLD	0

SUMMARY STATISTICS

NWSV-327 Steel Creek at Road A

Parameters		Average	Standard Deviation	Median	Minimum	Maximum	Number of Detects
Field	pH (SU)	6.76	0.50	7.03	5.71	7.25	10
	DO (mg/L)	8.03	0.87	7.90	6.75	9.37	10
	Water Temp (°C)	18.4	5.83	16.1	10.5	28.4	11
Laboratory	Alkalinity (mg/L)	21	4.0	22	14	25	12
	Turbidity (NTU)	3.8	1.9	3.2	1.8	8.0	12
	BOD (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	TSS (mg/L)	7.0	6.5	4.7	1.1	23	12
	E. Coli (cnt/100mL)	300	211	256	84	921	12
	TKN (mg/L)	0.3	0.2	0.3	0.1	0.7	11
	Ammonia (mg/L)	0.066	0.004	0.066	0.063	0.069	2
	Nitrate/Nitrite (mg/L)	0.087	0.138	0.046	0.028	0.500	11
	Total Phosphorus (mg/L)	0.030	0.0039	0.031	0.024	0.033	4
	Cadmium (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Chromium (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Copper (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Iron (mg/L)	0.47	0.23	0.38	0.25	0.88	12
	Lead (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Manganese (mg/L)	0.042	0.030	0.027	0.019	0.098	12
	Nickel (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Zinc (mg/L)	0.01	0.00	0.01	0.01	0.01	3
	Mercury (mg/L)	<LLD	NA	NA	<LLD	<LLD	0

NWSV-328 Lower Three Runs at Patterson Mill Road

Parameters		Average	Standard Deviation	Median	Minimum	Maximum	Number of Detects
Field	pH (SU)	6.85	0.52	6.97	5.84	7.36	10
	DO (mg/L)	7.88	1.04	7.44	6.72	9.40	10
	Water Temp (°C)	18.4	5.76	15.7	11.1	25.8	10
Laboratory	Alkalinity (mg/L)	34.9	9.80	34.5	17.0	50.0	12
	Turbidity (NTU)	2.80	1.14	2.30	1.50	4.70	12
	BOD (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	TSS (mg/L)	5.16	3.68	4.70	1.10	14.0	12
	E. Coli (cnt/100mL)	385.	293.	282.	124.	1120.	12
	TKN (mg/L)	0.27	0.15	0.25	0.10	0.61	10
	Ammonia (mg/L)	0.061	0.010	0.061	0.054	0.068	2
	Nitrate/Nitrite (mg/L)	0.058	0.033	0.044	0.022	0.120	12
	Total Phosphorus (mg/L)	0.29	0.77	0.028	0.022	2.70	12
	Cadmium (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Chromium (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Copper (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Iron (mg/L)	0.47	0.15	0.46	0.28	0.82	12
	Lead (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Manganese (mg/L)	0.076	0.089	0.046	0.030	0.35	12
	Nickel (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Zinc (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Mercury (mg/L)	<LLD	NA	NA	<LLD	<LLD	0

Return to TOC

SUMMARY STATISTICS

NWSV-2027 Upper Three Runs at Road 2-1

Parameters		Average	Standard Deviation	Median	Minimum	Maximum	Number of Detects
Field	pH (SU)	5.95	0.79	5.75	5.26	7.23	8
	DO (mg/L)	7.68	1.11	7.45	5.87	9.34	8
	Water Temp (°C)	17.6	4.28	15.9	12.3	23.1	8
Laboratory	Alkalinity (mg/L)	2.70	2.47	1.50	1.40	6.40	4
	Turbidity (NTU)	2.39	1.05	2.15	1.20	4.30	10
	BOD (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	TSS (mg/L)	4.7	2.3	4.5	1.0	8.2	10
	E. Coli (cnt/100mL)	279	242	182	72	770	10
	TKN (mg/L)	0.30	0.13	0.33	0.11	0.44	8
	Ammonia (mg/L)	0.050	NA	0.050	0.050	0.050	1
	Nitrate/Nitrite (mg/L)	0.26	0.04	0.26	0.21	0.36	10
	Total Phosphorus (mg/L)	0.022	0.0007	0.022	0.021	0.022	2
	Cadmium (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Chromium (mg/L)	0.0068	NA	0.0068	0.0068	0.0068	1
	Copper (mg/L)	0.02	0.004	0.02	0.01	0.018	2
	Iron (mg/L)	0.34	0.069	0.33	0.23	0.44	10
	Lead (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Manganese (mg/L)	0.014	0.004	0.013	0.010	0.018	3
	Nickel (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Zinc (mg/L)	0.01	0.0	0.01	0.01	0.01	2
	Mercury (mg/L)	<LLD	NA	NA	<LLD	<LLD	0

NWSV-2039 Fourmile Branch at Road A-13.2

Parameters		Average	Standard Deviation	Median	Minimum	Maximum	Number of Detects
Field	pH (SU)	6.57	0.32	6.69	6.03	7.01	12
	DO (mg/L)	7.75	1.66	7.99	3.79	9.92	12
	Water Temp (°C)	17.4	5.16	15.4	9.82	24.2	12
Laboratory	Alkalinity (mg/L)	14.3	7.22	12.5	4.20	29.0	12
	Turbidity (NTU)	4.61	2.04	4.10	2.60	9.50	12
	BOD (mg/L)	2.0	NA	2.0	2.0	2.0	1
	TSS (mg/L)	3.60	1.58	3.50	1.90	6.40	12
	E. Coli (cnt/100mL)	199.	138.	131.	50.4	411	12
	TKN (mg/L)	0.29	0.17	0.21	0.14	0.62	11
	Ammonia (mg/L)	0.08	NA	0.08	0.08	0.08	1
	Nitrate/Nitrite (mg/L)	0.59	0.19	0.57	0.26	0.97	12
	Total Phosphorus (mg/L)	0.09	0.01	0.09	0.07	0.10	12
	Cadmium (mg/L)	0.0001	NA	0.0001	0.0001	0.0001	1
	Chromium (mg/L)	0.01	NA	0.01	0.01	0.01	1
	Copper (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Iron (mg/L)	0.82	0.20	0.81	0.56	1.10	12
	Lead (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Manganese (mg/L)	0.06	0.094	0.03	0.02	0.36	12
	Nickel (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Zinc (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Mercury (mg/L)	<LLD	NA	NA	<LLD	<LLD	0

SUMMARY STATISTICS

NWSV-2047 Pen Branch at Road A-13.2

Parameters		Average	Standard Deviation	Median	Minimum	Maximum	Number of Detects
Field	pH (SU)	6.96	0.40	7.12	6.29	7.40	12
	DO (mg/L)	8.20	1.81	8.01	4.04	10.7	12
	Water Temp (°C)	17.5	5.2	15.5	10.2	24.6	12
Laboratory	Alkalinity (mg/L)	19.9	6.19	23.0	5.70	26.0	12
	Turbidity (NTU)	5.90	3.31	4.90	2.90	14.0	12
	BOD (mg/L)	<LLD	N/A	N/A	<LLD	<LLD	0
	TSS (mg/L)	6.8	6.6	5.2	0.13	20.0	12
	E. Coli (cnt/100mL)	243.	130.	209.	135.	613.	12
	TKN (mg/L)	0.34	0.17	0.33	0.15	0.69	9
	Ammonia (mg/L)	0.06	0.01	0.06	0.05	0.08	6
	Nitrate/Nitrite (mg/L)	0.11	0.03	0.10	0.065	0.15	12
	Total Phosphorus (mg/L)	0.035	0.011	0.031	0.023	0.063	11
	Cadmium (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Chromium (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Copper (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Iron (mg/L)	0.83	0.25	0.76	0.52	1.2	12
	Lead (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Manganese (mg/L)	0.047	0.023	0.043	0.019	0.084	12
	Nickel (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Zinc (mg/L)	0.013	0.003	0.014	0.010	0.016	3
	Mercury (mg/L)	<LLD	NA	NA	<LLD	<LLD	0

NWSV-2055 Meyers Branch at Road 9

Parameters		Average	Standard Deviation	Median	Minimum	Maximum	Number of Detects
Field	pH (SU)	6.76	0.40	6.94	5.98	7.19	10
	DO (mg/L)	8.25	0.93	7.97	7.12	9.75	10
	Water Temp (°C)	18.2	5.6	16.1	11.3	28.3	10
Laboratory	Alkalinity (mg/L)	16.3	9.0	17	5	40.0	12
	Turbidity (NTU)	5.0	4.1	3.5	2.0	16.0	12
	BOD (mg/L)	<LLD	N/A	N/A	<LLD	<LLD	0
	TSS (mg/L)	12.0	11.6	6.8	2.1	36.0	12
	E. Coli (cnt/100mL)	728.	736.	368.	228.	2420.	12
	TKN (mg/L)	0.33	0.25	0.20	0.12	0.81	11
	Ammonia (mg/L)	0.093	NA	0.093	0.093	0.093	1
	Nitrate/Nitrite (mg/L)	0.096	0.021	0.097	0.052	0.12	12
	Total Phosphorus (mg/L)	0.028	0.010	0.025	0.02	0.042	4
	Cadmium (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Chromium (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Copper (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Iron (mg/L)	0.63	0.36	0.55	0.33	1.60	12
	Lead (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Manganese (mg/L)	0.048	0.032	0.036	0.021	0.13	12
	Nickel (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Zinc (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Mercury (mg/L)	<LLD	NA	NA	<LLD	<LLD	0

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SUMMARY STATISTICS

NWSV-2061 Upper Three Runs at Road 2-1

Parameters		Average	Standard Deviation	Median	Minimum	Maximum	Number of Detects
Field	pH (SU)	6.27	0.49	6.31	5.34	7.22	10
	DO (mg/L)	7.87	1.18	7.61	6.36	9.80	10
	Water Temp (°C)	18.2	5.36	15.6	11.2	25.6	10
Laboratory	Alkalinity (mg/L)	6.37	3.51	5.40	2.90	16.0	11
	Turbidity (NTU)	8.02	15.0	3.15	1.70	55.0	12
	BOD (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	TSS (mg/L)	7.2	5.0	7.2	1.4	18.0	11
	E. Coli (cnt/100mL)	417.	471.	230.	88.	1553.	12
	TKN (mg/L)	0.46	0.50	0.28	0.14	1.90	11
	Ammonia (mg/L)	0.063	0.005	0.062	0.059	0.071	4
	Nitrate/Nitrite (mg/L)	0.044	0.010	0.042	0.028	0.06	9
	Total Phosphorus (mg/L)	0.089	0.11	0.059	0.040	0.42	12
	Cadmium (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Chromium (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Copper (mg/L)	0.012	NA	0.012	0.012	0.012	1
	Iron (mg/L)	0.50	0.23	0.46	0.24	1.10	12
	Lead (mg/L)	0.0021	NA	0.0021	0.0021	0.0021	1
	Manganese (mg/L)	0.026	0.014	0.022	0.012	0.052	12
	Nickel (mg/L)	<LLD	NA	NA	<LLD	<LLD	0
	Zinc (mg/L)	0.013	0.0021	0.013	0.011	0.014	2
	Mercury (mg/L)	<LLD	NA	NA	<LLD	<LLD	0

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Chapter 6 Monitoring of Sediments on and Adjacent to SRS

6.1.0 PROJECT SUMMARY

The accumulation of radiological and non-radiological contaminants in sediment can directly affect aquatic organisms which can lead to human exposure. Impacts to water bodies come through direct discharge, atmospheric fallout, or runoff. These accumulated contaminants may re-suspend in streams and rivers or disperse downstream, potentially affecting drinking water supplies and fish consumed by the public. The transportation of sediments is a dynamic process. Stream flow changes can redistribute contaminants or bury them as part of the natural sedimentation process. Patterns of sediment contamination are strongly affected by hydrologic factors and the physical and chemical characterization of the sediment (EPA, 1987).

Collecting sediment samples from the river bank

SRS streams receive surface water runoff and water from permitted discharges (DOE, 1995). SRS is within the Savannah River watershed, with five major streams feeding into the Savannah River. Dispersal of any contaminants from these streams has the potential to impact the Savannah River.

DHEC personnel evaluate sediment samples for radionuclide and non-radionuclide contaminant concentrations in SRS streams, SRS storm-water basins, creek mouths along the boundary of SRS, the Savannah River, and publicly accessible boat landings in the SRS vicinity. Radionuclide detections in sediment are typically the result of accumulation over many years and do not represent yearly depositions. Sediment samples on SRS are routinely split with DOE-SR to compare results.

Collecting sediment samples from a dock

A complete list of all radiological and non-radiological analytes can be found in List of Tables, Table 1 and Table 2 on page x. DHEC sediment sampling locations are illustrated in Section 6.4.0, Map. Split samples were collected from nine stream locations on SRS, and from three SRS storm-water basins. A complete list of sample locations is listed in Section 6.5.0, Table 1.

No background locations were sampled during 2017.

6.2.0 RESULTS AND DISCUSSION

DHEC sediment monitoring summary statistics can be found in Section 6.6.0 and sediment monitoring data can be found in the 2017 DHEC Data File.

6.2.1 Radiological Results

Cesium-137 releases from Z-Area have the potential to contaminate tributaries of McQueen Branch, which flows into Upper Three Runs. The impact for possible contamination warrants long-term monitoring by DHEC along SRS streams and the publicly accessible Savannah River.

The creek mouths of SRS are a conduit for the dispersal of radionuclides into publicly accessible water. Cesium-137 activity was found by DHEC in the sediment within several creek mouths at the Savannah River. Actinium-228, europium-155, potassium-40, lead-212, lead-214, radium-226, and thorium-234 are NORM decay products that account for the remaining gamma detections. All other gamma-emitting radionuclides had no detections above their respective MDA.

DHEC had sporadic gross alpha and gross non-volatile beta activity detections in 2017. The summary statistics can be found in Section 6.6.0.

There were no sediment samples collected in 2017 that were above the EPA Preliminary Remediation Goals (PRGs) (EPA, 2018c).

Cesium-137 is the most abundant anthropogenic radionuclide found in the sediment samples. Cesium-137 levels in 2017 data from samples collected outside SRS boundaries are all within the expected range and consistent with previous DHEC background data and may be attributed, in part, to fallout from past nuclear events in the 1950s and 1960s. The highest level of Cs-137 from all 2017 DHEC and DOE-SR collocated sediment samples occurred at Steel Creek at Hwy 125. DHEC had the highest Cs-137 detections at 5.73 pCi/g in the Steel Creek (Rd.125), 1.58 pCi/g at Steel Creek Mouth (RM 141.5), and 1.14 pCi/g at Fourmile Branch creek mouth. DOE-SR had readings of 1.58 pCi/g at Steel Creek Mouth and 0.139 pCi/g at Steel Creek Boat Landing (RM-141.0). Cesium-137 contamination in this area is well documented and not unexpected. All sample results were well below the PRG of 28 pCi/g for Cs-137.

Sediment is dried before radiological tests can be run

Figure 1 in Section 6.5.0 illustrates the DHEC average Cs-137 activity in sediment samples from SRS storm-water basins, SRS streams, SRS creek mouths, publicly accessible boat landings, and background sampling locations. DHEC Cs-137 data from the SRS creek mouths were trended for 2013-2017 (Section 6.5.0, Figure 2).

6.2.2 Non-radiological Results

Metals in sediment can be naturally occurring or a result of man-made processes such as those used in SRS operations, which have released elevated amounts into streams on SRS. Re-distribution of sediment from flooding can carry contaminants to downstream locations. Geological factors in the Savannah River basin contribute to the levels of metals through erosion and sedimentation. All 2017 DHEC samples were below the Ecological Screening Values (ESVs) for barium, beryllium, copper, manganese, nickel, and zinc (EPA, 2018a). All DOE-SR samples were below the ESVs with the exception of cadmium, at an average of 0.4 mg/kg, and manganese, at an average of 779.9 mg/kg.

Comparisons were made to the ESVs for sediment which does not represent remediation goals or cleanup levels but is used to identify constituents of potential concern (WSRC, 2005). The DHEC cadmium MDL is higher than the ESV of 0.36 mg/kg, therefore any detections are above the ESV. Cadmium was detected by DHEC in four of the on-site streams, five of the creek mouths, three of the storm-water basins, and four of the public boat landings. DOE-SR detected cadmium above the ESV in four of the on-site streams, three of the creek mouths, none of the storm-water basins, and two of the public boat landings.

Sediment is measured out to be tested for non-radiological parameters

Chromium was detected by DHEC above the ESV of 28 mg/kg at two of the storm-water basins. DOE-SR detected chromium above the ESV in two of the storm-water basins.

DHEC detected lead above the ESV of 11 mg/kg in three on-site streams, three creek mouths, three storm-water basins, and at two boat landings. DOE-SR detected lead above the ESV in three storm-water basins and in one on-site stream.

DHEC detected manganese above the ESV of 220 mg/kg in three on-site locations, five creek mouths, and three boat landings. DOE-SR had three on-site streams, five creek mouths, and three boat landings with results at or above the ESV of Mn.

Mercury was detected above the ESV of 0.1 mg/kg in three on-site stream samples. DOE-SR had five creek mouths, seven on-site streams, two storm-water basins, and three boat landings that had levels at or above the ESV of mercury.

Zinc was detected by DHEC above the ESV of 46 mg/kg in two on-site streams and at Upper Three Runs (RM 157.2) creek mouth and Burton's Ferry boat landing. DOE-SR detected zinc above the ESV in two on-site streams and at Burton's Ferry boat landing.

DHEC non-radiological sediment data can be found in the 2017 DHEC Data File and non-radiological summary statistics can be found in Section 6.6.0. No background samples were collected in 2017.

6.3.0 CONCLUSIONS AND RECOMMENDATIONS

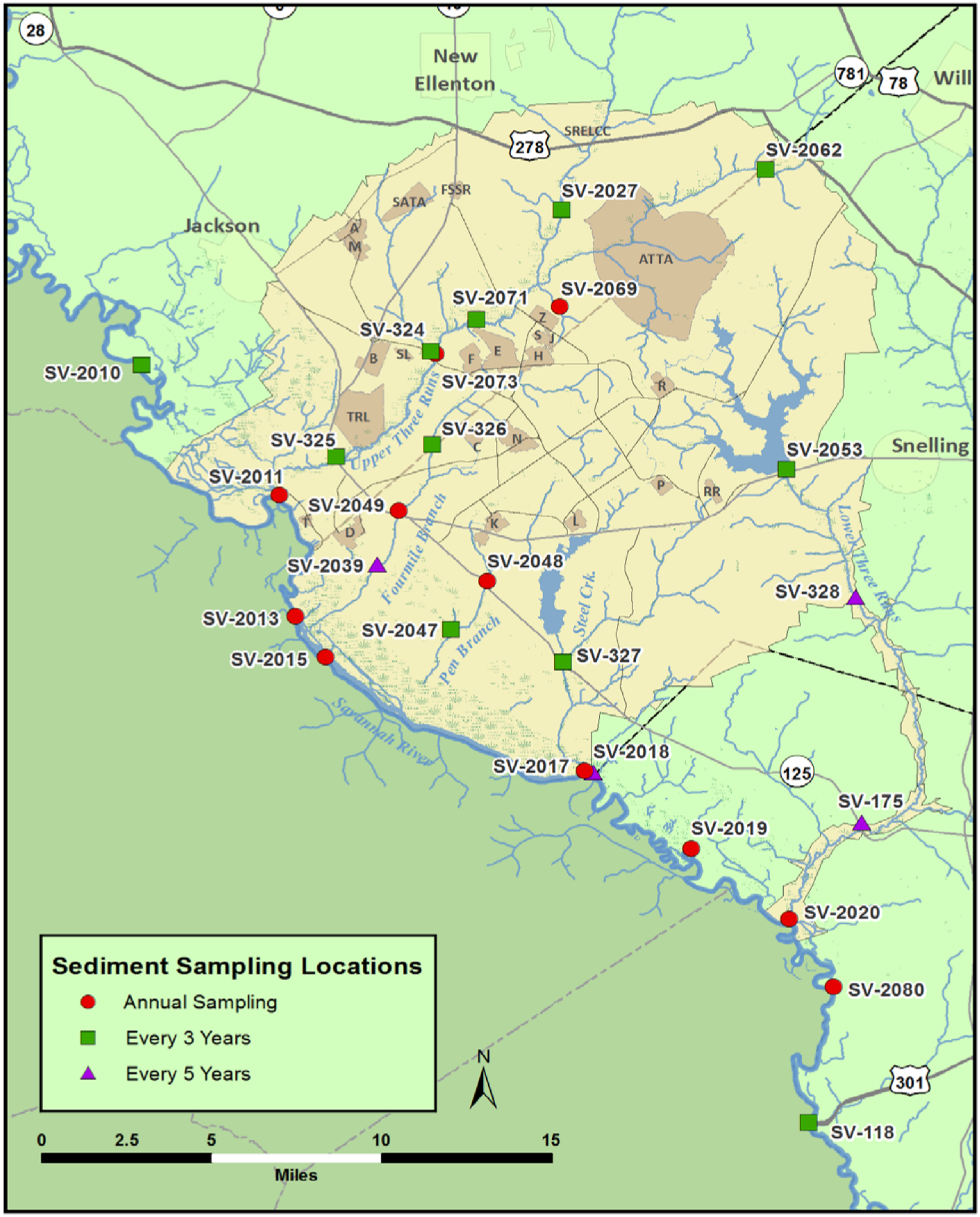
SRS sediments should continue to be monitored due to current releases of contaminants and the potential for future discharges from SRS operations, legacy wastes, and clean-up activities. Year-to-year data comparisons are difficult to interpret due to the nature of sediment accumulation. Differences among samples may be due to the fraction of clays that most effectively retain radionuclides. There is also difficulty in replicating the exact sampling point due to erosion and sedimentation. Monitoring of on-site sediments is of great importance since over-land precipitation and streams transport contaminated sediment with radionuclides outside the SRS boundary.

DHEC will continue to independently monitor sediment on SRS and in the Savannah River to improve our understanding of the presence of radionuclide and non-radionuclides. DHEC will also periodically evaluate and modify the sampling methodology to better accomplish project goals and objectives.

Trending of data over multiple years demonstrates whether radionuclide concentrations in the SRS area are declining through radioactive decay or possibly increasing due to disturbances on SRS. By comparing data throughout the years, DOE-SR can independently evaluate its results as well as show the differences between its data and the levels of chemicals/constituents collected through monitoring by DHEC. Cooperation between DOE-SR and DHEC provides credibility and confidence in the information being provided to the public.

6.4.0 MAP

SRS Sediment Sampling Locations



2017 ESOP Sediment Monitoring

6.5.0 TABLES AND FIGURES

2017 DHEC Sediment Sample Locations

Table 1a. Non-Publicly Accessible Sediment Sample Locations on SRS

Sample Location ID	Location Description
SRS Creek Mouth Samples	
SV-2011	Upper Three Runs Mouth @ RM 157.4
SV-2013	Beaver Dam Creek Mouth @ RM 152.3
SV-2015	Fourmile Branch Mouth @ RM 150.6
SV-2017	Steel Creek Mouth @ RM 141.5
SV-2020	Lower Three Runs Mouth @ RM 129.1
Non-Publicly Accessible Stream Samples	
SV-324	Tim's Brach @ Road C
SV-327	Steel Creek @ Road 125
SV-2027	Upper Three Runs @ USFS Road 2-1
SV-2039	Fourmile Creek @ Road A-13
SV-2040	Beaver Dam Creek
SV-2048	Pen Branch @ Road 125
SV-2053	Par Pond @ Road B
SV-2069	McQueen Branch @ Monroe Owens Road.
SV-2073	Upper Three Runs @ Road C
SRS Storm-water Basin Samples	
SME-004	E-004 E Area Storm-water Basin
SME-005	E-005 E Area Storm-water Basin
SME-006	E-006 E Area Storm-water Basin

Table 1b. Publicly Accessible Sediment Sample Locations on Savannah River Boat Landings

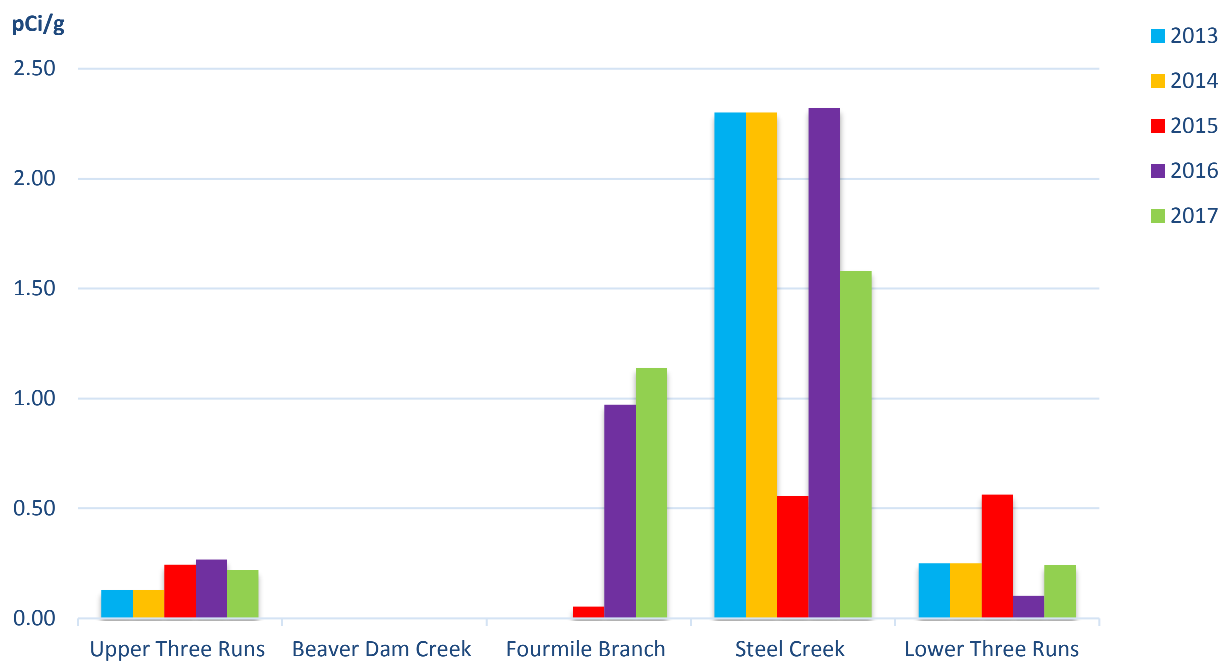
Sample Location ID	Location Description
Upstream of SRS	
SMRVP17	North Augusta Riverview Park Boat Landing
SMJBL17	Jackson Boat Landing
Downstream of SRS	
SMBFL17 (SV-118)	Burton’s Ferry Landing, Screven County, G.A.
SMCB17	Cohen's Bluff Landing
SMSCL17 (SV-2018)	Steel Creek Landing
SMLHL17 (SV-2019)	Little Hell Landing
SMJL17 (SV-2080)	Johnson's Landing

TABLES AND FIGURES

Figure 1. 2017 Comparisons of Cs-137 Average Activity Among Sample Location Type

Note: No bar denotes no detection.

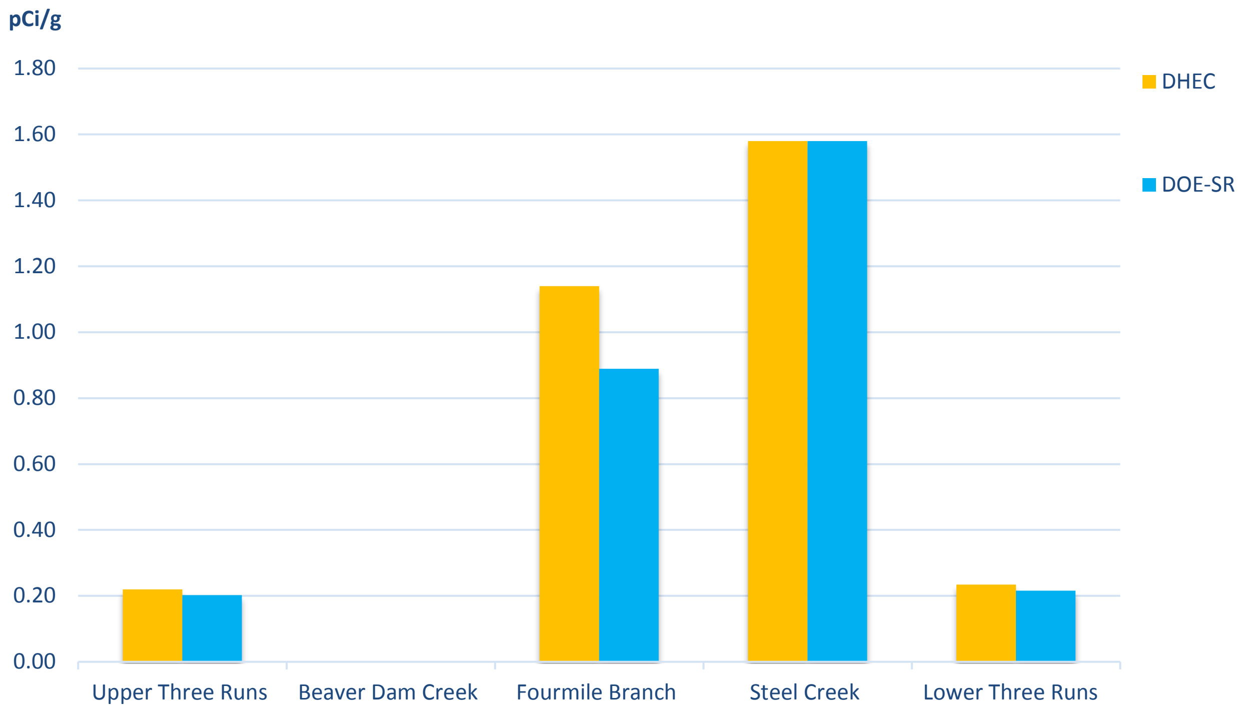
Figure 2. 2013-2017 Trending Data for Cs-137 in SRS Creek Mouth Samples (DHEC, 2015-2018)



Note: No bar denotes no detection for that year.

TABLES AND FIGURES

Figure 3. 2017 Cesium-137 in Savannah River Creek Mouths–DHEC Comparison to DOE-SR Data (SRNS, 2018)



Note: Beaver Dam Creek had no detection from DHEC or DOE-SR.

6.6.0 SUMMARY STATISTICS

2017 DHEC Radiological Data

On-Site Streams

Analyte	Average Concentration (pCi/g)	Standard Deviation	Median (pCi/g)	Minimum (pCi/g)	Maximum (pCi/g)	Number of Detections	Number of Samples
Cs-137	1.15	2.25	0.24	0.054	5.73	6	24
Gross Alpha	36.57	25.55	28.4	16.1	65.2	3	24
Gross Beta	21.92	11.16	22.4	9.39	33.7	5	24

Creek Mouths

Analyte	Average Concentration (pCi/g)	Standard Deviation	Median (pCi/g)	Minimum (pCi/g)	Maximum (pCi/g)	Number of Detections	Number of Samples
Cs-137	0.8	0.68	0.69	0.22	1.58	4	24
Gross Alpha	23.08	26.07	11.3	8.81	69.5	5	24
Gross Beta	28.2	11.97	21.7	19.9	48.6	5	24

Storm-water Basins

Analyte	Average Concentration (pCi/g)	Standard Deviation	Median (pCi/g)	Minimum (pCi/g)	Maximum (pCi/g)	Number of Detections	Number of Samples
Cs-137	<MDA	N/A	<MDA	<MDA	<MDA	0	24
Gross Alpha	21.7	3.68	21.7	19.1	24.3	2	24
Gross Beta	17.05	1.2	17.05	16.2	17.9	2	24

Boat Landings

Analyte	Average Concentration (pCi/g)	Standard Deviation	Median (pCi/g)	Minimum (pCi/g)	Maximum (pCi/g)	Number of Detections	Number of Samples
Cs-137	0.15	0.1	0.15	0.059	0.24	4	24
Gross Alpha	24.3	24.3	24.3	24.3	24.3	1	24
Gross Beta	21.77	5.73	20.7	15.8	31.8	6	24

SUMMARY STATISTICS

2017 DHEC Non-radiological (Metals) Data

On-Site Streams

Analyte	Average Concentration (mg/kg)	Standard Deviation	Median (mg/kg)	Minimum (mg/kg)	Maximum (mg/kg)	Number of Detections	Number of Samples	ESV
Barium	53.6	53.3	36.5	6.2	140	8	9	330
Beryllium	1.4	0.70	1.6	0.37	1.9	4	9	10
Cadmium	1.8	0.75	1.7	1	2.8	4	9	0.36
Chromium	9.2	9.2	3	1.6	24	9	9	28
Copper	9.725	4.6	11.5	2.9	13	4	9	28
Lead	13.8	6.6	12.5	7.3	23	4	9	11
Manganese	143.9	146.7	69	10	380	8	9	220
Nickel	8.2	6.6	7.7	0.71	18	6	9	38
Zinc	22.5	24.1	10	2.1	67	9	9	46
Mercury	0.23	0.17	0.14	0.13	0.43	3	9	0.1

Creek Mouth Locations

Analyte	Average Concentration (mg/kg)	Standard Deviation	Median (mg/kg)	Minimum (mg/kg)	Maximum (mg/kg)	Number of Detections	Number of Samples	ESV
Barium	98.4	19.7	100	68	120	5	5	330
Beryllium	0.56	0.26	0.47	0.36	0.94	4	5	10
Cadmium	1.4	0.32	1.4	1	1.8	5	5	0.36
Chromium	12.9	2.4	13	9.4	16.0	5	5	28
Copper	6.06	1.6	6.6	3.6	7.4	5	5	28
Lead	11.0	3.4	12.0	6.3	14.0	5	5	11
Manganese	766	372.3	880	270	1200	5	5	220
Nickel	7.08	1.9	6.9	4.6	10	5	5	38
Zinc	40.6	16.4	36	27	69	5	5	46

Storm-water Basins

Analyte	Average Concentration (mg/kg)	Standard Deviation	Median (mg/kg)	Minimum (mg/kg)	Maximum (mg/kg)	Number of Detections	Number of Samples	ESV
Barium	35.7	13.3	29.0	27.0	51.0	3	3	330
Beryllium	0.9	0.3	0.9	0.7	1.1	2	3	10
Cadmium	2.1	0.6	2.3	1.5	2.6	3	3	0.36
Chromium	28.3	4.0	29	24	32	3	3	28
Copper	6.8	1.8	5.8	5.7	8.9	3	3	28
Lead	29.7	8.0	29	22	38	3	3	11
Manganese	64.0	41.2	73.0	19.0	100.0	3	3	220
Nickel	8.1	4.5	7.2	4.2	13.0	3	3	38
Zinc	29.7	14.6	28	16	45	3	3	46

Boat Landings

Analyte	Average Concentration (mg/kg)	Standard Deviation	Median (mg/kg)	Minimum (mg/kg)	Maximum (mg/kg)	Number of Detections	Number of Samples	ESV
Barium	58.0	38.2	46.5	17	120	6	7	330
Beryllium	0.46	0.20	0.46	0.32	0.6	2	7	10
Cadmium	1.3	0.24	1.3	1	1.5	4	7	0.36
Chromium	11.6	4.8	11.4	6.6	19	6	7	28
Copper	6.1	3.6	5.1	2.6	11	6	7	28
Lead	11.5	4.8	12	6.4	16	3	7	11
Manganese	636.7	312.1	560	370	980	3	7	220
Nickel	5.7	2.6	5.9	3	9.4	5	7	38
Zinc	24.4	14.8	24	3	49	7	7	46

Chapter 7 Surface Soil Monitoring Adjacent to SRS

7.1.0 PROJECT SUMMARY

Collecting soil samples which will be tested for radiological material and metals

DHEC independently evaluates surface soil adjacent to SRS from ground surface to a 12-inch depth for gross alpha, gross non-volatile beta, and select gamma-emitting radionuclides, as well as specific metals of concern. Soil samples are collected to determine if SRS activities have had an impact on areas outside the site boundary. Radionuclide detections in soil are the result of accumulation over many years.

A 50-mile SRS center point area was chosen for the comparison of DHEC and DOE-SR SRS perimeter radiological data averages. Since DOE-SR environmental monitoring division does not report metals data for surface soil, no direct data comparisons can be made.

DHEC collected eighteen samples in 2017 from SRS perimeter locations (Section 7.5.0, Table 1). SRS perimeter sampling locations are depicted on the Map in Section 7.4.0.

No background locations were tested in 2017.

7.2.0 RESULTS AND DISCUSSION

7.2.1 Radiological Parameter Results

Soil Monitoring Summary Statistics for radionuclides and metals can be found in Section 7.6.0 and all Soil Monitoring Data can be found in the 2017 DHEC Data File.

Samples being prepped for the oven

Most samples had detectable amounts of Cs-137, an anthropogenic radionuclide that may be present due to a legacy of releases by SRS and atmospheric fallout from past nuclear weapons testing (EPA 2014). An assessment of Cs-137 activity in 2017 is comparable to levels detected by DHEC in the past. There were no surface soil samples collected in 2017 that were above the EPA PRGs (EPA, 2018c).

DHEC had Cs-137 detections in 11 of 18 SRS perimeter samples in 2017 (Section 7.6.0). Cesium-137 was the only gamma-emitting radionuclide that DHEC and DOE-SR shared in analytical results. Both DHEC and DOE-SR resulted in similar findings. DHEC had an average Cs-137 concentration of 0.097 pCi/g, which was slightly lower than DOE-SR’s findings of 0.2 pCi/g. The PRG for C-137 is 28 pCi/g. and all sample results were well below that level. DOE-SR reports in 2017 that Cs-137 concentrations are consistent with historical results (SRNS, 2018). Trending data for Cs-137 in SRS perimeter samples is in Section 7.5.0, Figures 1.

All radiological samples are placed in an oven to burn off organic material and bacteria

The results found by both DHEC and DOE-SR are influenced by the number of samples used to determine the average and by collecting samples from different locations. The average level of Cs-137 in surface soil can vary due to the highly variable nature of soils. Radiocesium bioavailability in soil is influenced by soil properties such as clay content, pH, organic matter, and soil microflora (Absalom et al., 2001). In previous years, increases of Cs-137 activity in the perimeter samples could be due to the addition of samples in closer proximity to the boundary of SRS, specifically in the Steel Creek floodplain. Until recently, DHEC only collected samples within 50-miles of the SRS center point to determine the yearly average.

The only other gamma-emitting radionuclides detected in DHEC surface soil samples were potassium-40, lead-212, lead-214, radium-226, actinium-228, and thallium-234. These are NORM decay products (2017 DHEC Data File).

7.2.2 Non-radiological Parameter Results

DOE-SR did not analyze for metals; therefore, no comparisons could be made. DHEC saw no exceedances of the EPA Regional Screening Levels (RSLs) in any of the surface soil samples in 2017 (EPA, 2018b). A complete list of all DHEC non-radiological analytes and RSLs can be found in Section 7.5.0, Table 2.

Barium has been a constituent of the H-Area Hazardous Waste Management Facility (WSRC, 1993). Barium was detected in 18 of the 18 SRS perimeter samples.

Beryllium is a strong, lightweight metal used in nuclear weapons work as a shield for radiation and as a neutron source (Till et al., 2001). Beryllium was not detected in the SRS perimeter samples in 2017.

Cadmium enters the atmosphere through fuel and coal combustion (Till et al. 2001). None of the perimeter surface soil samples yielded detections.
Chromium solutions were used at SRS as corrosive inhibitors. Chromium was a part of wastewater solutions resulting from dissolving stainless steel. It was also used in cleaning solutions in the separations areas (Till et al., 2001). The legal disposal of fly ash on land as a result of burning coal is a contributor of both chromium and nickel to soils. Fly ash particles can travel considerable distance in the air and contain trace elements of chromium (Alloway, 1995). Chromium was detected in all SRS perimeter samples.

Copper, while naturally occurring, can also be released to the environment through the combustion of wood, coal, and oil (Alloway, 1995). D-Area and the other coal combustion powerhouses emitted copper and other heavy metals (Till et al., 2001). These mechanisms are possible sources of elevated copper levels in surface soils. Copper was detected in 14 of the SRS perimeter samples.

Atmospheric emissions of lead from SRS occurred through coal and fuel combustion (Till et al., 2001). Lead can deposit in soil and due to its immobility can have a long residence time when compared to other pollutants. Lead can accumulate in soils where its bioavailability can persist long-term (Alloway, 1995). Lead was detected in 11 of the SRS perimeter samples.

Manganese has been released in the separations areas processes and discharged to liquid waste tanks (Till et al., 2001). It is also a byproduct of coal burning. Manganese was detected in all 18 of the SRS perimeter samples.

The largest anthropogenic source of nickel globally is the burning of fuels and coal combustion (Alloway, 1995). At SRS, nickel was directly released through M-Area effluent from the plating rinse tanks and through site use of diesel generators (Till et al., 2001). Nickel was detected in 12 SRS perimeter samples.

Non-radiological samples are stored on ice before testing occurs

Zinc was released in relatively small amounts to the separations areas seepage basins as well as the M-Area seepage basin (Till et al., 2001). Zinc was detected in all SRS perimeter samples.

SRS facilities, such as F- and H- Area, tritium facilities, waste tanks, and the coal-fired power plants have emitted mercury to the atmosphere (Till et al., 2001). Atmospheric fallout contributes to mercury findings in surface soil. There were no mercury detections in surface soil samples collected in 2017.

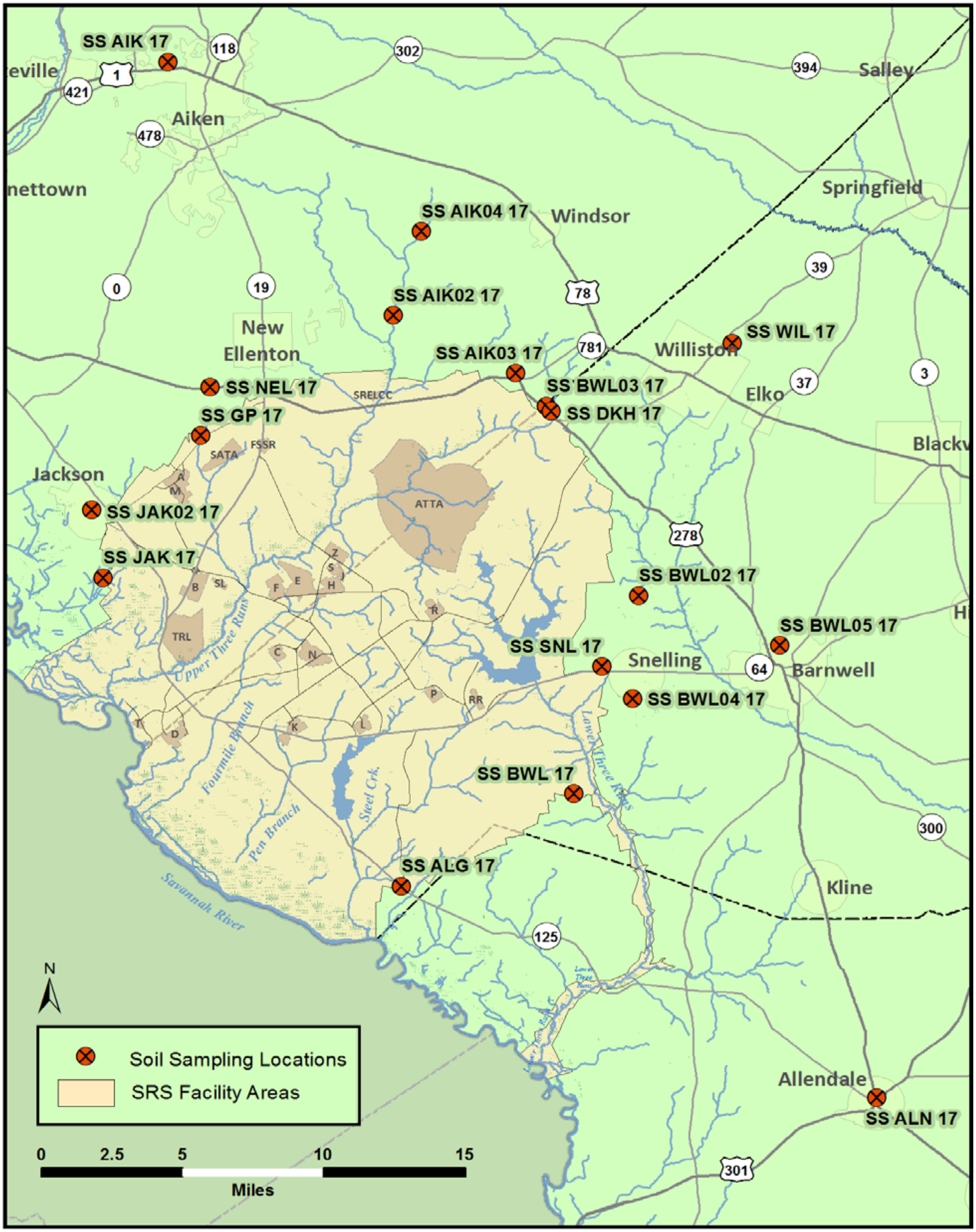
7.3.0 CONCLUSIONS AND RECOMMENDATIONS

Soil samples from DHEC and DOE-SR programs varied by location and in number. When interpreting data, it should be taken into consideration that samples were collected from a variety of soil types and locations.

DHEC will continue to independently monitor SRS perimeter surface soil and will periodically evaluate modification of the monitoring activities to better accomplish project goals and objectives. Monitoring will continue as long as there are activities at SRS that create the potential for contamination to enter the environment. Continued monitoring will provide an improved understanding of radionuclide and non-radionuclide activity in SRS perimeter surface soils and the surrounding areas. Additional monitoring will impart valuable information to human health exposure pathways. Trending of data over multiple years will give a more definitive answer as to whether radionuclide concentrations in the SRS area are declining due to radioactive decay or possibly increasing due to flooding, soil disturbances and prescribed burns on SRS. The comparison of data allows for independent data verification of DOE-SR monitoring activities. Cooperation between DOE-SR and DHEC provides credibility and confidence in the information being provided to the public.

7.4.0 MAP

SRS Perimeter Surface Soil Monitoring



2017 ESOP Soil Monitoring

7.5.0 TABLES AND FIGURES

Table 1. Perimeter Soil Samples Collected in 2017

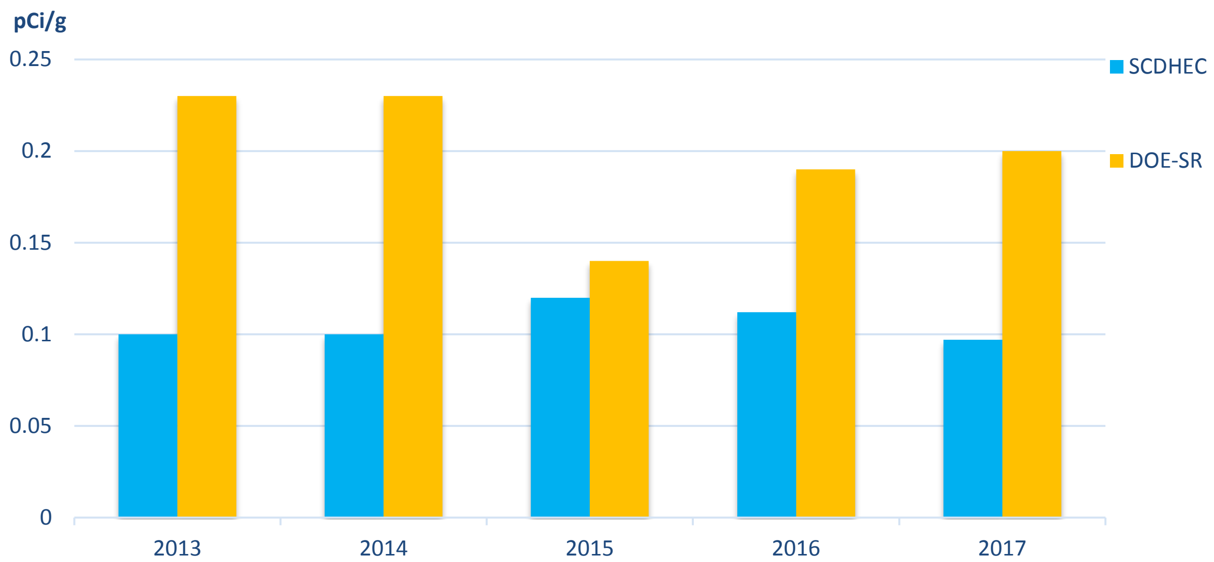
Sample ID	Location	County
SS ALG 17	Allendale Gate	Allendale
SS SNL 17	Snelling Gate	Barnwell
SS DKH 17	Darkhorse	Barnwell
SS ALN 17	Allendale	Allendale
SS GP 17	Green Pond	Aiken
SS JAK 17	Jackson	Aiken
SS AIK 17	Aiken	Aiken
SS JAK02 17	Jackson	Aiken
SS NEL 17	New Ellenton	Aiken
SS BWL 17	Collocated at VG site BWL-004	Barnwell
SS AIK02 17	Boggy Gut Road	Aiken
SS BWL02 17	Collocated at VG site BWL-002	Barnwell
SS BWL03 17	Collocated at VG site BWL-001	Barnwell
SS AIK03 17	Collocated at VG site AIK 0903	Barnwell
SS BWL04 17	Collocated at VG site BWL-003	Barnwell
SS AIK04 17	Upper Three Runs at Barnwell Rd	Aiken
SS BWL05 17	Barnwell Lake Edgar Brown	Barnwell
SS WIL 2017	Williston Plum Location EVBWL-02	Barnwell

Table 2. Regional Screening Levels of Metals

Analyte	RSL (mg/kg)
Barium	15,000
Beryllium	160
Cadmium	70
Chromium	230
Copper	3,100
Lead	400
Manganese	1,800
Mercury	400
Nickel	1,500
Zinc	23,000

TABLES AND FIGURES

Figure 1. 2013-2017 DHEC and DOE-SR Trending Averages for Cesium-137 (SRNS, 2014-2018; DHEC, 2015-2018)



7.6.0 SUMMARY STATISTICS

2017 DHEC Radiological Statistics

SRS Perimeter Samples

Analyte	Average Concentration (pCi/g)	Standard Deviation	Median (pCi/g)	Minimum (pCi/g)	Maximum (pCi/g)	Number of Detections	Number of Samples
Gross Beta	14.1	2.9	13.3	11.7	17.4	3	18
Cs-137	0.097	0.046	0.11	0.042	0.18	11	18

2017 DHEC Non-radiological (Metals) Statistics

SRS Perimeter Samples

Analyte	Average Concentration (mg/kg)	Standard Deviation	Median (mg/kg)	Minimum (mg/kg)	Maximum (mg/kg)	Number of Detections	Number of Samples
Barium	18.7	7.6	18.0	7.4	36.0	18	18
Cadmium	0.0	0.0	0.0	0.0	0.0	0	18
Chromium	5.2	2.5	5.0	2.1	11.0	18	18
Copper	2.1	0.8	2.0	1.1	3.2	14	18
Lead	8.8	4.1	7.3	5.3	18.0	11	18
Manganese	50.1	44.7	38.5	4.8	170.0	18	18
Nickel	2.9	1.1	2.7	1.5	5.2	12	18
Zinc	10.4	8.2	6.4	1.6	25.0	18	18

Chapter 8 Radiological Monitoring of Terrestrial Vegetation Adjacent to SRS

8.1.0 PROJECT SUMMARY

DOE-SR contracts for the collection and analysis of terrestrial vegetation, primarily Bermuda grass, to determine concentrations of radionuclides (SRNS, 2017). The samples are obtained from 10 locations at the SRS perimeter, one onsite location at the burial grounds, and three locations 25 miles from the center of SRS. DHEC monitors for the presence of radionuclides in vegetation collecting leaves from broad-leafed evergreen trees and shrubs, such as wax myrtle (*Myrica cerifera*), laurel oak (*Quercus laurifolia*), or Carolina laurel cherry (*Prunus caroliniana*). The type of plant sampled each year is dependent upon its availability at the separate locations.

Collecting leaves from a Carolina Laurel Cherry

In 2017, DHEC conducted independent vegetation monitoring at 17 perimeter, three background locations, and three 25-mile locations. These 25-mile samples allow comparisons to be made between tritium levels at the SRS perimeter and in the general SRS area. DHEC and DOE-SR perimeter stations sampled in 2017 are shown in Section 8.4.0, Map.

8.2.0 RESULTS AND DISCUSSION

Terrestrial Vegetation Data

Terrestrial Vegetation Monitoring Summary Statistics can be found in Section 8.6.0 and all Terrestrial Vegetation Monitoring Data can be found in the 2017 DHEC Data File.

Tritium was detected in vegetation from nine of the 11 perimeter sites sampled in 2017 (Section 8.5, Figure 1). Tritium was detected at one of the three 25-mile stations in 2017.

Additional samples collected as background samples in St. George, South Carolina, Pickney Island, South Carolina, and at the Old Sheldon Church ruins in Beaufort County yielded no detections.

Tritium analysis results from DHEC and DOE-SR sampling are presented in Section 8.5.0, Table 1. However, differences between the two programs in sampling dates, vegetation sampled, and analysis methods should be considered during comparison. Provided there are detections, data comparison of associated locations from the two programs was conducted by converting from pCi/g to pCi/L.

DHEC and DOE-SR had three collocated sampling locations (Patterson Mill Road, Allendale Gate, and Talatha Gate). DHEC had detections of tritium at Patterson Mill Road at 281 pCi/L and at Talatha Gate with an average of 1276 pCi/L.

DOE-SR and DHEC sampled vegetation at nine comparable locations, including colocations, in 2017. At these locations, DOE-SR reported one detection at 249.5 pCi/L, while DHEC had five with a total average of 665.6 pCi/L. Most of the tritium activity detected was from samples collected in the later part of the year: DOE-SR only sampled in the spring.

Gamma

In 2017, DHEC detected actinium-228 (Bkg St. George), beryllium-7, potassium-40, and lead-214. These isotopes are NORM; therefore, the results will not be discussed in this section, but are presented in the 2017 DHEC Data File. A list of radionuclides in the gamma spectroscopy analysis are in List of Tables, Table 1, page x.

Carolina Laurel Cherry leaf samples ready to be processed

There is no EPA standard for radionuclides in terrestrial vegetation. Therefore, the drinking water MCL is used for comparison. EPA has established an MCL of four mrem per year for total beta particle and photon radioactivity from man-made radionuclides in drinking water. The average concentration of cesium-137 which is assumed to yield four mrem per year is 200 pCi/L (EPA, 2002a).

DOE-SR detected Cs-137 at four of the nine sampling stations that had a comparable DHEC location or colocation. DHEC had detections at three of nine comparable locations in 2017. Gamma analysis results for Cs-137 from DHEC and DOE-SR sampling in 2017 are presented in Section 8.5.0, Table 2.

The man-made isotopes Co-60 and Am-241 were not detected in the DHEC 2017 samples.

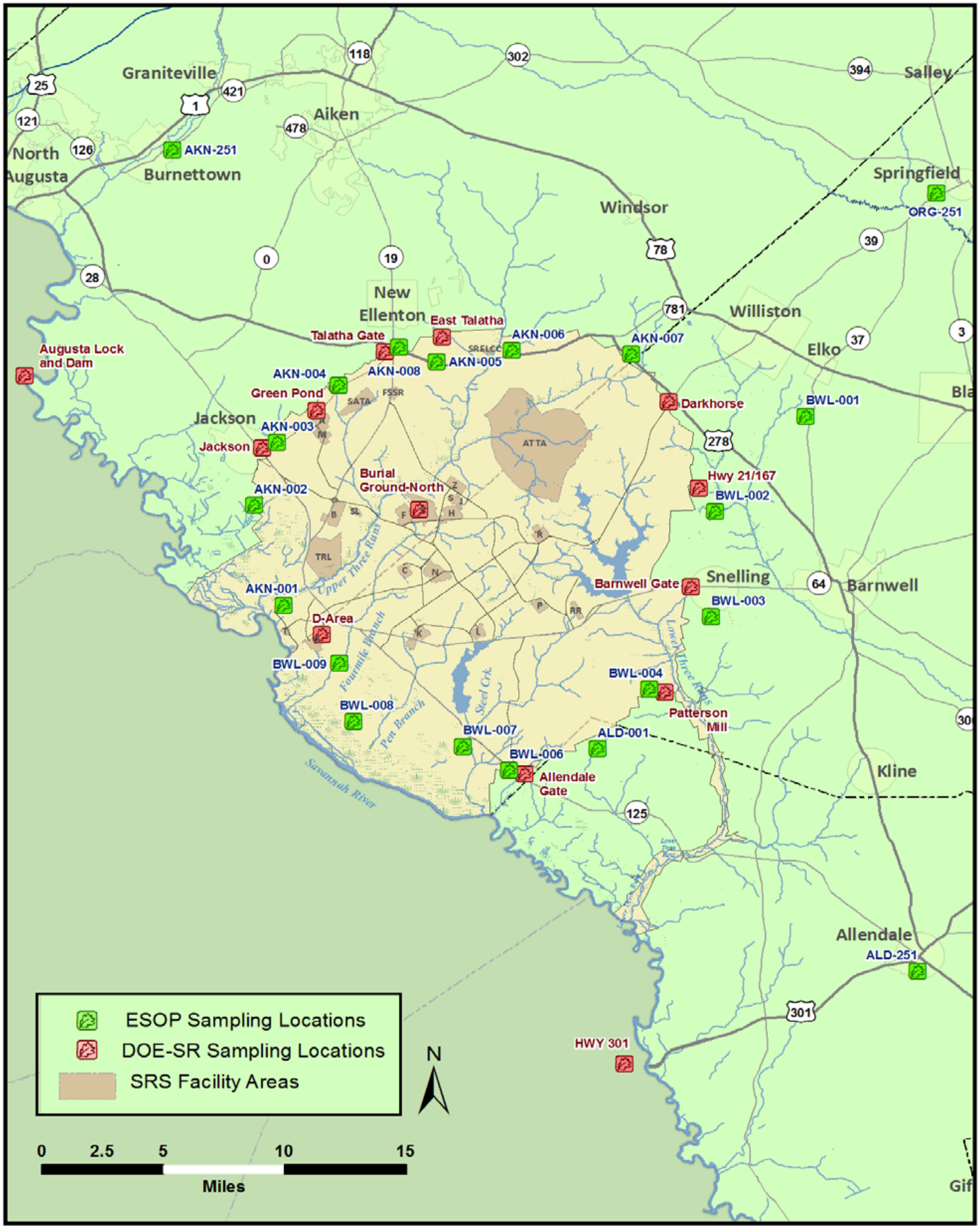
8.3.0 CONCLUSIONS AND RECOMMENDATIONS

DHEC and DOE-SR collect a different suite of terrestrial vegetation (e.g., DHEC collects leaves from trees, whereas DOE-SR conducts annual grass collections). Both sample sets are complimentary and allow indirect comparisons to be made.

Differences in analysis, sampling methods, and the date samples were obtained may account for observed differences in detection levels.

8.4.0 MAP

Terrestrial Vegetation Sampling Locations



2017 ESOP Terrestrial Vegetation Monitoring

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8.5.0 TABLES AND FIGURES

Table 1. 2017 Tritium Data Comparison for DHEC and DOE-SR Sampling Locations

DOE-SR Data		DHEC Data	
Station	**Average Results (pCi/L)**	**Station**	**Average Results (pCi/L)**
D-Area	<MDC	**BWL-009[a]**	NS
Jackson	<MDC	**AKN-003[a]**	471
Green Pond	<MDC	**AKN-004[a]**	NS
Talatha Gate	<MDC	**AKN-008[b]**	1275.5
East Talatha	<MDC	**AKN-005[a]**	635
Darkhorse	<MDC	**BWL-001[a]**	NS
Barnwell Gate	<MDC	**BWL-003[a]**	NS
Patterson Mill Road	249.5	**BWL-004[b]**	281
Allendale Gate	<MDC	**BWL-006[b]**	NS
Average	249.5	**Average**	665.6
Standard Deviation	NA	**Standard Deviation**	431.5
Median	249.5	**Median**	553

Notes:
1. For AKN-008, two samples had detections. Their average is high because one of the measurements was 201 pCi/L and the other was a lot greater with 2350 pCi/L.
2. Total averages were calculated using the averages in the table not raw data
3. <MDC denotes less than the DOE-SR Minimum Detectable Concentration
4. NS is No Sample
5. NA is Not Applicable
6. [a] Comparable DHEC Location
7. [b] Colocation
8. [c] DHEC Average based on one detection

8.5.0 TABLES AND FIGURES

Table 2. 2017 Cesium-137 Data Comparison for DHEC and DOE-SR Sampling Locations

DOE-SR Data		DHEC Data	
Station	**Average Result (pCi/g)**	**Station**	**Average Result (pCi/g)**
D-Area	<MDC	**BWL-009[a]**	NS
Jackson	<MDC	**AKN-003[a]**	<MDA
Green Pond	<MDC	**AKN-004[a]**	NS
Talatha Gate	<MDC	**AKN-008[b]**	0.0746
East Talatha	0.252	**AKN-005[a]**	0.313
Darkhorse	<MDC	**BWL-001[a]**	NS
Barnwell Gate	0.303	**BWL-003[a]**	NS
Patterson Mill Road	0.0576	**BWL-004[b]**	0.106[c]
Allendale Gate	0.253	**BWL-006[b]**	<MDA
Average	0.216	**Average**	0.165
Standard Deviation	0.109	**Standard Deviation**	0.130
Median	0.253	**Median**	0.106

Notes:
1. Total averages were calculated using averages from the table above and not from raw data
2. <MDC denotes less than the DOE-SR Minimum Detectable Concentration
3. <MDA denotes less than the DHEC Minimum Detectable Activity
4. NS is No Sample
5. NA is Not Applicable
6. [a] Comparable DHEC Location
7. [b] Colocation
8. [c] DHEC Average based on one detection

TABLES AND FIGURES

Figure 1. 2013-2017 Tritium in Vegetation at SRS Perimeter (DHEC, 2015-2018)

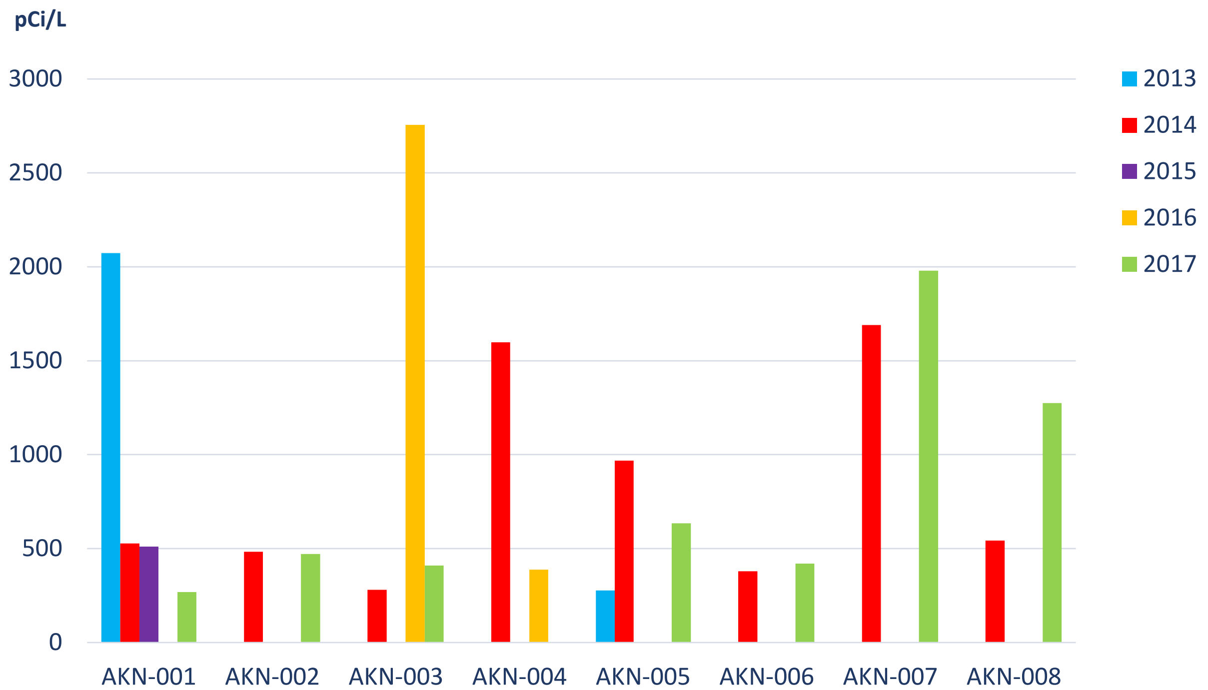

Figure 2. 2013-2017 Tritium in Vegetation at SRS Perimeter (DHEC, 2015-2018)

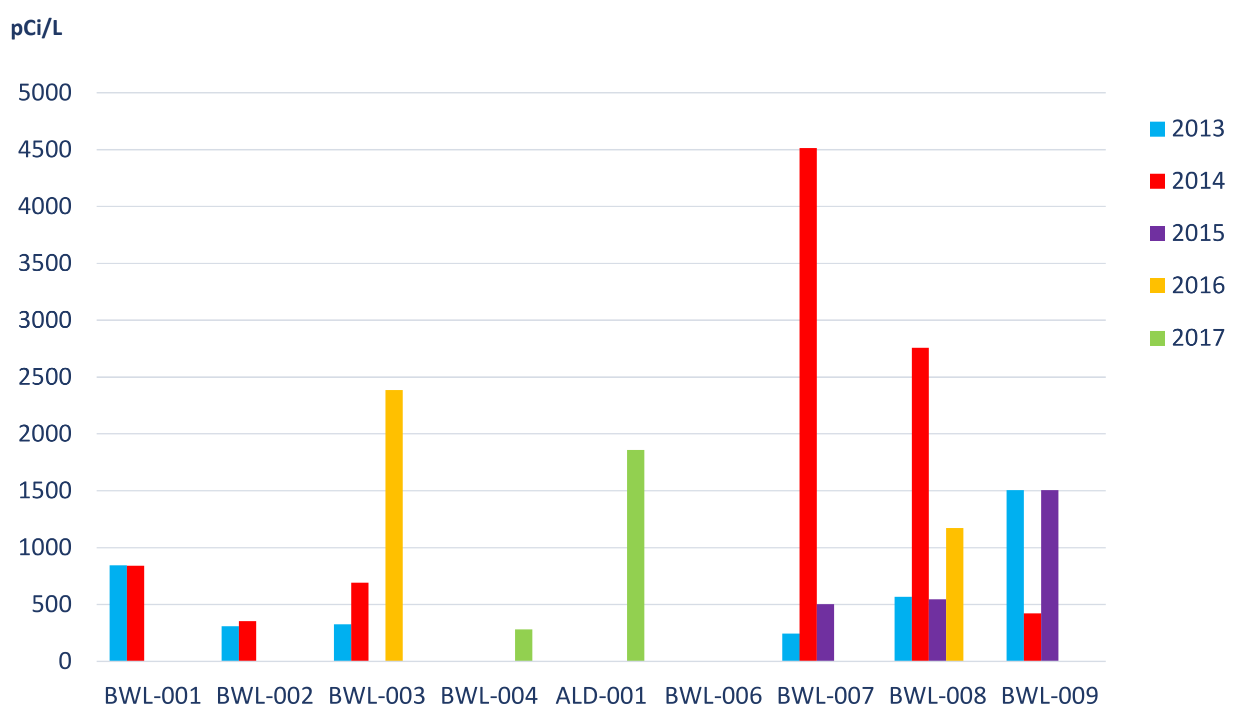

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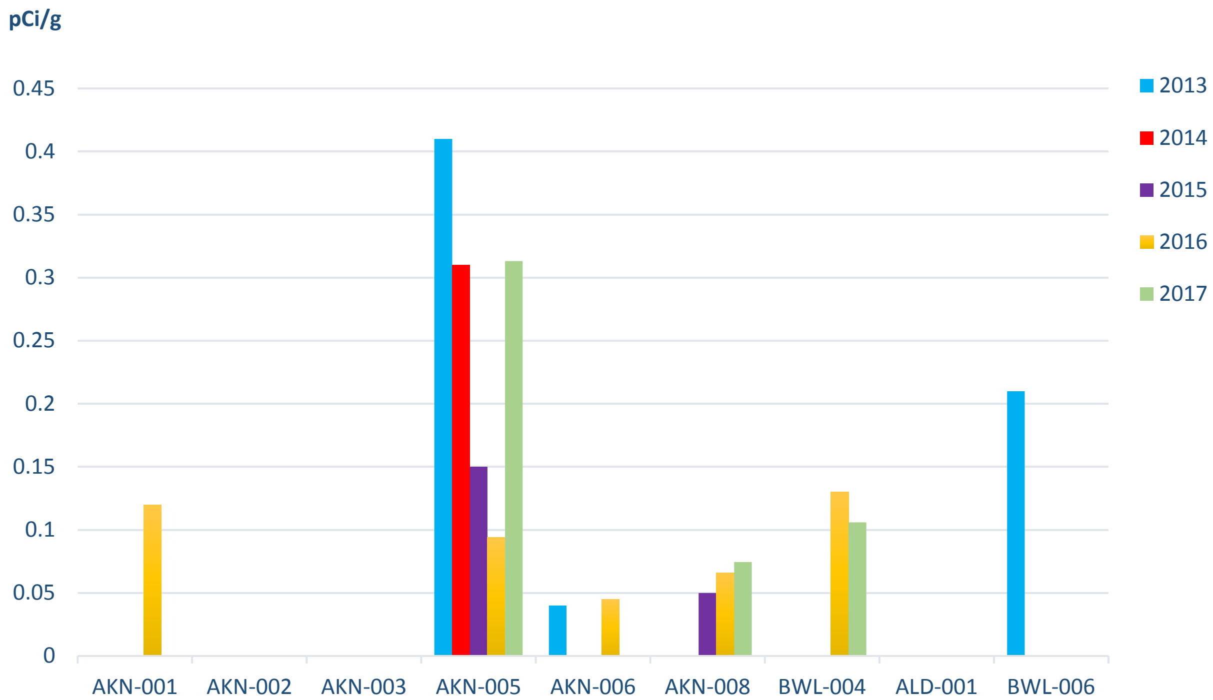
Figure 3. 2013-2017 Cs-137 in Vegetation at SRS Perimeter (DHEC, 2015-2018)



Notes:
1. Missing bars indicate an average that was less than the minimum detectable activity
2. Some bars may be based on a single detection

8.6.0 SUMMARY STATISTICS

2017 SRS Perimeter and 25-Mile Radius Locations-Tritium

Sample Location	Average (pCi/L)	Minimum (pCi/L)	Maximum (pCi/L)	Number of Samples	Number of Detections
Sample Perimeter Locations - Tritium					
AKN-001	269	<LLD	269	2	1
AKN-002	471	<LLD	471	2	1
AKN-003	410	<LLD	410	2	1
AKN-004	ND	<LLD	<LLD	2	0
AKN-005	635	<LLD	635	2	1
AKN-006	421	<LLD	421	2	1
AKN-007	1980	<LLD	1980	2	1
AKN-008	1275.5	201	2350	2	2
BWL-001	ND	<LLD	<LLD	2	0
BWL-002	ND	<LLD	<LLD	2	0
BWL-003	ND	<LLD	<LLD	2	0
BWL-004	281	<LLD	281	2	1
ALD-001	1860	<LLD	1860	2	1
BWL-006	ND	<LLD	<LLD	2	0
BWL-007	ND	<LLD	<LLD	2	0
BWL-008	ND	<LLD	<LLD	2	0
BWL-009	ND	<LLD	<LLD	2	0
25-Mile Radius Locations - Tritium					
AKN-251	261	<LLD	261	2	1
ALD-251	ND	<LLD	<LLD	2	0
ORG-251	ND	<LLD	<LLD	2	0
Total	786.4	201	2350	40	11

Notes:

1. Total averages were calculated using averages from the table above and are not calculated from raw data
2. “Number of Samples” and “Number of Detections” in the Total row are a summation rather than an average
3. ND is Not Detected
4. LLD is Lower Limit of Detection
5. NA is Not Applicable

SUMMARY STATISTICS

2017 SRS Perimeter-Cesium-137

Sample Location	Average (pCi/g)	Median (pCi/g)	Minimum (pCi/g)	Maximum (pCi/g)	Number of Detections	Number of Samples
AKN-001	ND	NA	<MDA	<MDA	0	2
AKN-002	ND	NA	<MDA	<MDA	0	2
AKN-003	ND	NA	<MDA	<MDA	0	2
AKN-005	0.313	0.313	0.244	0.383	2	2
AKN-006	ND	NA	<MDA	<MDA	0	2
AKN-008	0.0745	0.0745	0.033	0.116	2	2
BWL-004	0.106	0.106	<MDA	0.106	1	2
ALD-001	ND	NA	<MDA	<MDA	0	2
BWL-006	ND	NA	<MDA	<MDA	0	2
Total	0.165	0.106	0.0745	0.313	5	18

Notes:
1. Total average was calculated using the averages in the table and are not calculated raw data
2. “Number of Detections” and “Number of Samples” “Totals” were summations instead of averages
3. pCi/g is picocuries per gram
4. MDA is Minimum Detectable Activity
5. ND is Not Detected
6. NA is Not Applicable
7. Averages may be based on one detection and exclude non-detections

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Chapter 9 Radiological Monitoring of Edible Vegetation Adjacent to SRS

9.1.0 PROJECT SUMMARY

The Radiological Monitoring of Edible Vegetation Project is a component of the DHEC ESOP that monitors edible vegetation in SRS perimeter and background locations.

DHEC defined a study area comprised of grids radiating out to 25 miles from the SRS center point, 25 miles to 50 miles, and background locations greater than 50 miles from the SRS center point (Map in Section 9.4.0). DOE-SR, as compared to DHEC, has five defined quadrants where samples are collected annually: four quadrants are within 10 miles of SRS in each direction (NE, NW, SE, SW), along with one quadrant located within 25 miles SE. Comparisons are based on tables and data sections of this report with the DOE-SR Environmental Report 2017 (SRNS, 2018). Direct comparisons between DOE-SR and DHEC could not be made due to variation in sampling and analysis methodologies.

Edible vegetation is collected based solely on availability and is directly dependent upon the growing season. Certain farmers, gardeners, and/or businesses surrounding the perimeter of SRS contribute domestically grown crops. Wild, edible vegetation, such as muscadines and plums, are also collected. References to vegetation in this section pertain to the edible parts of plants.

DHEC background sampling helps to separate atomic test fallout contamination levels and other sources (e.g. ongoing permitted releases at other nuclear facilities) from SRS source potential contamination. However, fallout dispersion patterns and concentrations are weather related and not uniform, and no assignment of a specific source can be made.

9.2.0 RESULTS AND DISCUSSION

Edible Vegetation Monitoring Summary Statistics can be found in Section 9.6.0 and all Edible Vegetation Monitoring Data can be found in the 2017 DHEC Data File.

Section 9.5.0, Tables 1 and 2 show the radionuclides of concern, the guideline levels, the intervention levels and their conversion to pCi/g for data comparison. The International Atomic Energy Agency (IAEA, 2004) has established guideline levels for radionuclides in foods for general consumption, emphasizing the cumulative radioactivity guideline levels (Section 9.5.0, Table 1).

The U.S. Food and Drug Administration (FDA) also has guidance levels for specific radionuclides called Derived Intervention Levels (DILs). The FDA adopted DILs to help determine whether domestic food in interstate commerce or food offered for import into the United States presents a safety concern (Section 9.5.0, Table 2) (FDA, 2005).

DHEC had tritium detections in one of the five greens/vegetable samples, fruits/nuts had two detections out of eight samples, and fungi had one detection out of eight samples (Section 9.6.0, Table 2). DOE-SR no detection for tritium in greens collected in the southwest quadrant within ten miles of the SRS perimeter (SRNS, 2017).

DHEC had the highest tritium detection from a nut sample in Allendale County (SE-1 and EV-460) at 2,430 pCi/L. The observed levels of tritium in edible vegetation were below the IAEA Radionuclides Guidelines for Food of 270,000 pCi/L.

In 2017, DOE-SR edible vegetation exhibited radiological detections of strontium-89/90, uranium-234, uranium-235, uranium-238, americium-241, plutonium-239, and technetium-99 (SRNS, 2018). All DOE-SR vegetation sample radionuclide detections were less than the IAEA guideline levels and the FDA DILs. All the detected gamma radionuclides, except Cs-137, originated from naturally occurring radioactive material. NORM radionuclides were the source of most detections in edible vegetation and are not discussed further as radionuclides of concern unless greater than a South Carolina background.

DHEC only had Cs-137 detections in fungi samples in 2017. There were four Cs-137 detections out of eight samples, with the highest detection being a fungi sample from Aiken County (EV-445) at 0.82 pCi/g, which is well below the guideline levels. DOE-SR had detections in five of the twenty samples collected in 2017 at an average of 0.023 pCi/g (the highest detection being greens in NW Quadrant 0-10 Miles).

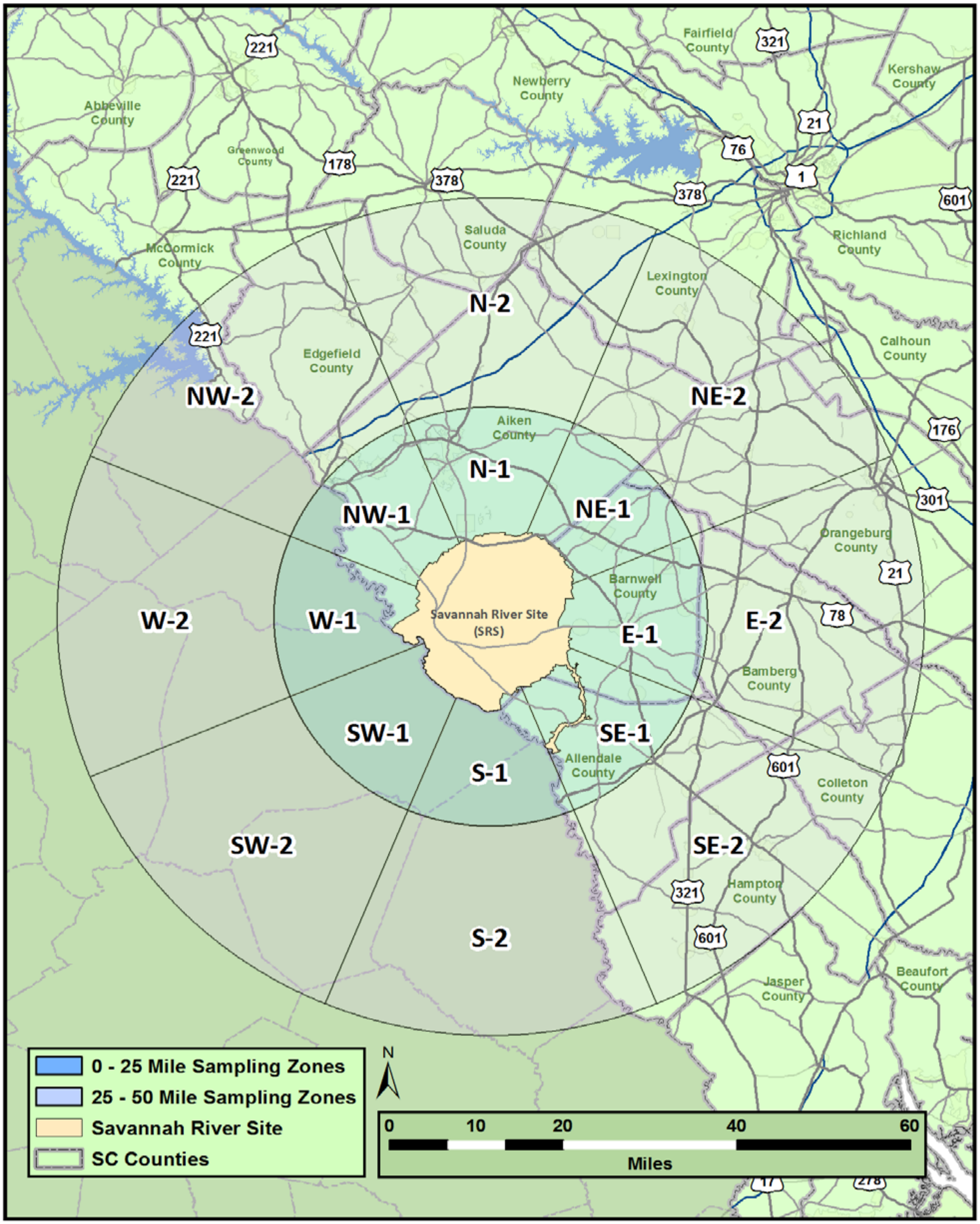
9.3.0 CONCLUSIONS AND RECOMMENDATIONS

DHEC and DOE-SR have different edible vegetation sampling schemes. DOE-SR samples primarily domestic plants collected from annual contributors in quadrants at zero to 10 miles from the perimeter of the SRS border and one quadrant at 25 miles; whereas, DHEC accepts domestic plants as donations from citizens and collects perennial, wild, edible vegetation and fungi found within 50 miles of the SRS center point and background locations (Section 9.4.0).

In the future, DHEC will explore opportunities to split samples with DOE-SR and attempt to establish collocated sampling locations for better comparisons between the two. DHEC will consider analyzing samples for Sr-89/90 to compare to the DOE-SR data. In addition, DHEC will continue to collect wild fungi due to its inherent ability to bioconcentrate Cs-137.

9.4.0 MAP

DHEC Edible Vegetation Monitoring



2017 Edible Vegetation Monitoring

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9.5.0 TABLES AND FIGURES

Table 1. IAEA Guideline Levels for Radionuclides in Foods

Radionuclides	Bq/kg	pCi/g
Pu-238, Pu-239, Pu-240, Am-241	10	0.27
Sr-90, Ru-106, I-129, I-131, U-235	100	2.7
S-35, Co-60, Sr-89, Ru-103, Cs-134, Cs-137, Ce-144, Ir-192	1000	27
H-3, C-14, Tc-99	10000	270

Table 2. FDA Derived Intervention Levels for Radionuclides in Food

FDA Derived Intervention Levels for Each Radionuclide Group for Food in Domestic Commerce and Food Offered for Import		
	Guidance Levels	
Radionuclide Group	Bq/kg	pCi/g
Sr-90	160	4.32
I-131	170	4.59
Cs-134, Cs-137	1200	32.4
Pu-238, Pu-239, Am-241	2	0.054

9.6.0 SUMMARY STATISTICS

2017 Tritium Detections in Edible Vegetation by Grid

Grid	Average (pCi/L)	Standard Deviation (pCi/L)	Median	Minimum	Maximum	Number of Detections	Number of Samples
W-1	ND	NA	ND	<LLD	<LLD	0	1
NW-1	NS	NA	NA	<LLD	<LLD	0	0
NW-2	NS	NA	NA	<LLD	<LLD	0	0
N-1	238	NA	238	<LLD	238	1	3
N-2	ND	NA	ND	<LLD	<LLD	0	4
NE-1	245	NA	245	<LLD	245	1	2
NE-2	ND	NA	ND	<LLD	<LLD	0	1
E-1	596	NA	596	<LLD	596	1	5
E-2	NS	NA	NA	<LLD	<LLD	0	0
SE-1	2430	NA	2430	<LLD	2430	1	2
S-1	ND	NA	ND	<LLD	<LLD	0	2
Background	ND	NA	ND	<LLD	<LLD	0	1
Total	877.25	1048.6	420.5	238	2430	4	21

2017 Tritium Detections in Edible Vegetation by Type

Type	Average (pCi/L)	Standard Deviation (pCi/L)	Median	Minimum	Maximum	Number of Detections	Number of Samples
Greens/Vegetables	245	NA	245	<LLD	245	1	5
Fruits/Nuts	1513	1296.8	1513	596	2430	2	8
Fungi	238	NA	238	<LLD	238	1	8

Note: Used lowest minimum recorded sample for the minimum of Fruits/Nuts

Chapter 10 Radiological Monitoring of Dairy Milk

10.1.0 PROJECT SUMMARY

Operations at SRS have resulted in the potential for radiological constituents to be released to the surrounding environment.

Consumption of milk products containing radioactive materials can be a human exposure pathway. When an atmospheric release occurs, radionuclides can be deposited on pastures and ingested by grazing dairy animals. The animals may release a portion of the radionuclides into their milk that could be consumed by humans (CDC, 2001). Radionuclides could also enter milk through the irrigation of a pasture using groundwater containing radioactive materials and through uptake by plants from soil containing radioactive materials.

In 2017, DHEC collected milk from five dairies within South Carolina (Section 10.4.0, Map). Four of these locations are within a 50-mile radius of the SRS center point and one is a background location beyond the 50-mile radius. This project provides analytical data for trending and comparison to published DOE-SR data.

DHEC personnel collected unpasteurized milk samples on a quarterly basis in 2017. All milk samples from each quarter were analyzed for tritium, Sr-89/90, and gamma-emitting radionuclides. While a select group of gamma-emitting radionuclides (iodine-131 (I-131), Cs-137, and cobalt-60 (Co-60)) are analytes of concern in dairy milk for this project, all other detections such as Potassium-40 (K-40) are considered naturally-occurring radioactive material (NORM). Naturally occurring radionuclides are the source of most public exposure; however, they are not discussed in this report unless detections are significantly greater than those of the background location detections. DHEC analyzes samples for total strontium (Sr-89/90) instead of only Sr-90. This is done to provide a more conservative result, and it is assumed the total strontium detected is in the form of Sr-90.

10.2.0 RESULTS AND DISCUSSION

None of the 20 DHEC milk samples collected in 2017 exhibited tritium activity above the LLD (2017 DHEC Data File). DOE-SR detected tritium in one sample from one South Carolina dairy out of the 16 samples collected for 2017.

DHEC analyzed for gamma-emitting radionuclides (K-40, I-131, Cs-137, and Co-60) in 20 milk samples collected in 2017. All analytical results for these radionuclides were below the sample MDA except for natural occurring K-40. These results can be found in the 2017 DHEC Data File. These results are consistent with past gamma results and no summary statistics were calculated for these radionuclides due to a lack of numerical data. DOE-SR had no detections of Cs-137.

Five of the 20 DHEC milk samples collected in 2017 exhibited strontium activity above the MDA. The highest detection came from a perimeter location in Zone 2 near Denmark (Section 10.6.0). Section 10.5.0, Figure 1 shows the trend for DHEC strontium detections for the last five years. All strontium averages have been below the EPA established MCL of 8 pCi/L for Sr-90 since testing initiated in 1998 (EPA, 2002b). DOE-SR detected Sr-89/90 in one of 16 samples collected in 2017, which found the activity level to be 1.41 pCi/L (SRNS, 2018).

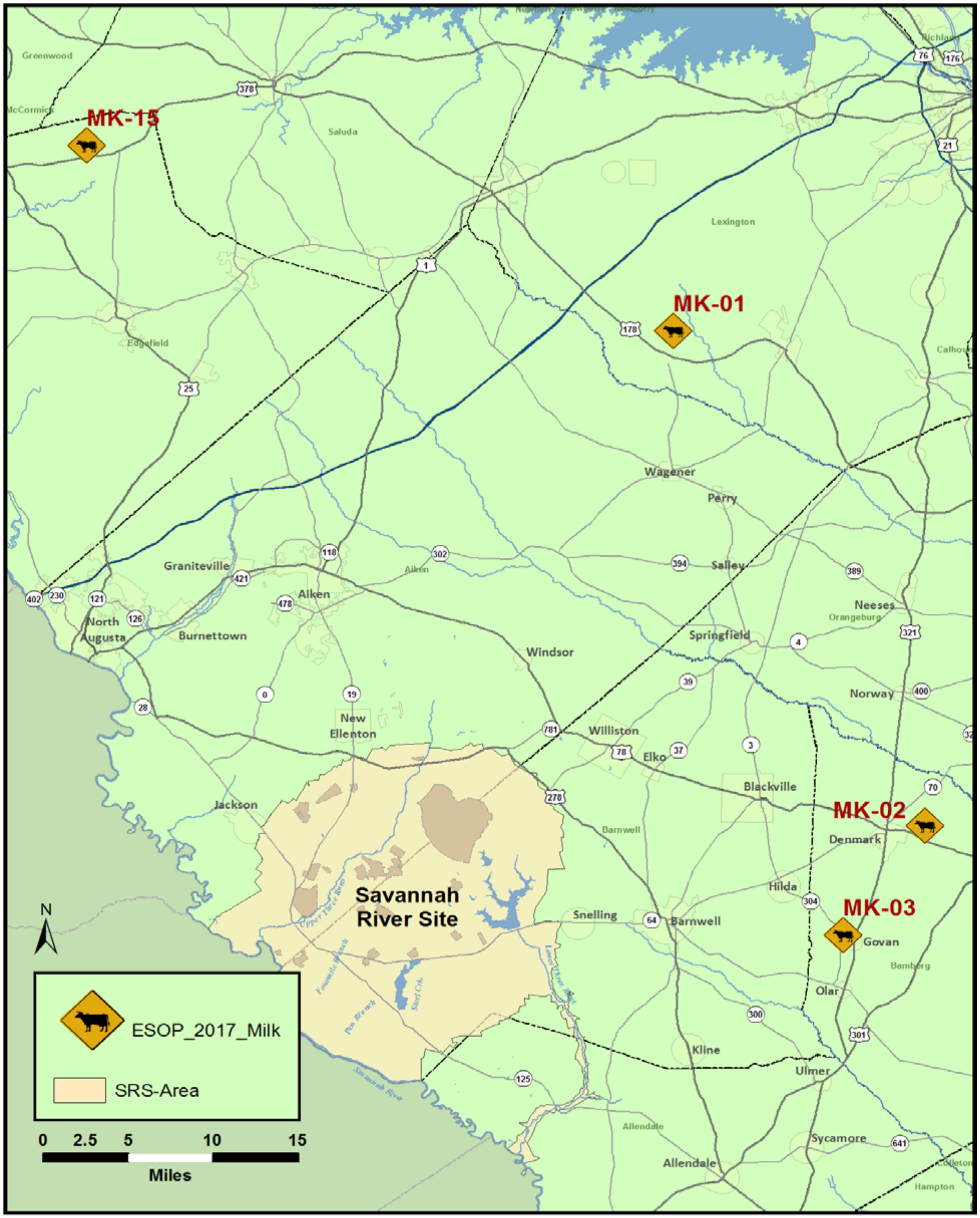
10.3.0 CONCLUSIONS AND RECOMMENDATIONS

A large portion of the radiological activity observed in milk samples can be attributed to fallout from past nuclear testing (Kathren, 1984). Also, radionuclides within soil and plants can potentially be redistributed because of farming practices and prescribed burns. Due to strontium's ability to be stored in bones and cesium being more likely to build up in muscles, DHEC will continue to monitor tritium, gamma-emitting radionuclides, and strontium in milk to ensure the safety of milk consumption by the public.

The dairies in DHEC's study area appear to be stable with no indication of closing in the foreseeable future. DHEC will continue to seek opportunities to add additional dairies to the sampling program for better coverage of the study area.

10.4.0 MAP

Radiological Dairy Milk Monitoring Sampling Locations



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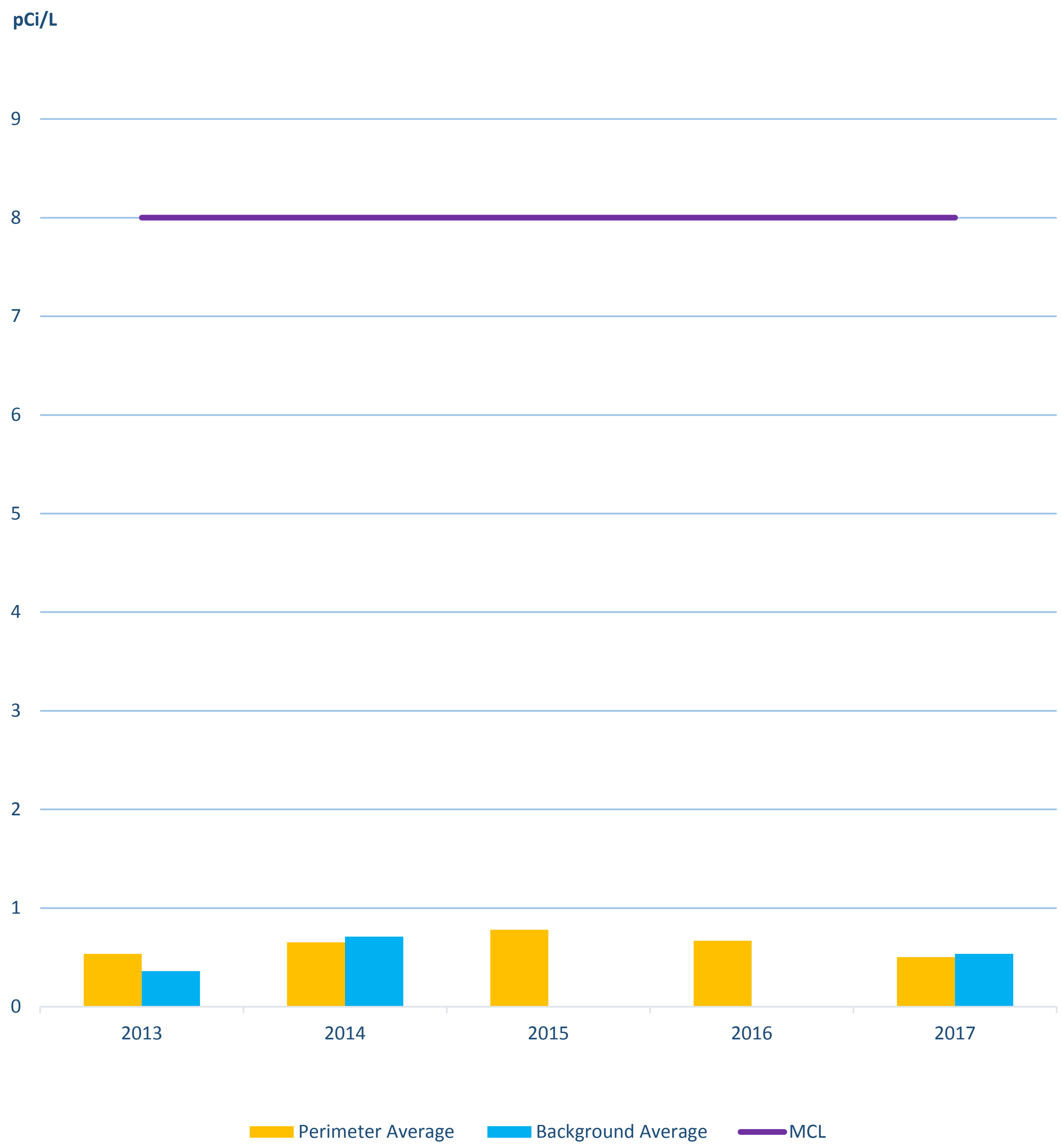
10.5.0 TABLES AND FIGURES

Figure 1. DHEC Average Strontium-89/90 Data Trends for 2013-2017 (DHEC, 2015-2018)



Note: No bar indicates <MDA

10.6.0 SUMMARY STATISTICS

2017 Strontium-89/90 All Sample Detections

Sample Location	Average (pCi/L)	Standard Deviation	Median (pCi/L)	Minimum (pCi/L)	Maximum (pCi/L)	Number of Samples	Number of Detections
MK-01	0.512	NA	0.512	0.512	0.512	4	1
MK-02	0.556	NA	0.556	0.556	0.556	4	1
MK-03	ND	NA	ND	<MDA	<MDA	4	0
MK-15	0.470	0.084	0.470	0.411	0.529	4	2
MK-99[a]	0.536	NA	0.285	0.536	0.536	4	1

2017 Strontium 89/90 Comparison of Perimeter and Background Locations

Strontium-89/90 (pCi/L)	Perimeter Locations (<50 Miles)			Background Locations (>50 Miles)		
	Average	Standard Deviation	Median	Average	Standard Deviation	Median
	0.513	0.043	0.512	0.536	NA	0.536

Notes:
1. ND is Not Detected
2. NA is Not Applicable
3. Averages were calculated using the data in the tables above not the raw data
4. [a] is the one background sample taken

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Chapter 11 Radiological Monitoring of Fish Associated with SRS

11.1.0 PROJECT SUMMARY

DHEC ESOP conducts non-regulatory, independent monitoring and surveillance of fish to determine the magnitude, extent, and trend levels for radionuclides and selected metals.

Preparing the electroshocking equipment

In 2017, DHEC collected largemouth bass (*Micropterus salmoides)* and channel catfish (*Ictalurus punctatus*) from four stations where creeks from SRS meet the Savannah River: Upper Three Runs Creek (SV-2011), Fourmile Branch (SV-2015), Steel Creek (SV-2017), and Lower Three Runs Creek (SV-2020). Samples were also collected from the background station on the Combahee river between Beaufort and Colleton counties (MD-119), one Savannah River station upstream of SRS **(**New Savannah Bluff Lock and Dam (NSBLD SV-2028)), and two stations downstream of SRS (Highway 301 (SV-118) and Highway 17 saltwater (SV-2091 – the only area where mullet and red drum are caught)). Stations sampled in 2017 are shown in Section 11.4.0, Map. These stations are accessible to the public.

Front view of the boat and probes

A total of five largemouth bass and five channel catfish were collected from all Savannah River stations and the Combahee River background site. Five red drum and five sea trout were collected from the saltwater station (SV-2091). Non-edible portions (bone) were tested for Sr-89/90. Edible portions (muscle tissue) of the fish were analyzed for mercury and other selected metals and gamma-emitting isotopes. Recently, tritium was found to contribute to "less than 1% of the estimated total fisherman dose" (SRNS, 2016b). This is due to tritium's ability to reach concentration equilibrium (the ability of a chemical to balance out) in both water and fish flesh resulting in no bioaccumulation (build up) in fish muscle (SRNS, 2016b). With this discovery, DOE-SR and DHEC have at this time discontinued its testing of tritium in fish flesh.

Attempting to bring in fish

11.2.0 RESULTS AND DISCUSSION

Fish Monitoring Summary Statistics can be found in Section 11.6.0 and all Fish Monitoring Data can be found in the 2017 DHEC Data File.

11.2.1 Radiological Data Comparison

DHEC bass and catfish data collected in 2017 were compared to DOE-SR reported data (SRNS, 2018). Data comparisons are in Section 11.6.0. One difference between the two programs is that DHEC analyzes one composite from each species for each station, whereas the DOE-SR program analyzes three composites per station. Therefore, a single composite for a DHEC station was compared to the average of the three DOE-SR composites reported.

Trending graphs for 2017 and 2013-2017 activity levels of Cs-137 and Sr-89/90 are reported in Section 11.5.0.

Channel Catfish (left) and Largemouth Bass (right) being weighed and length being measured

DHEC largemouth bass samples from three stations and DOE-SR bass samples from six stations exhibited Cs-137 activity. Three of the DHEC catfish composites from the Savannah River stations exhibited a detectable level of Cs-137 in 2017. DOE-SR detected Cs-137 in all catfish samples. Both DHEC's bass and catfish background samples displayed Cs-137, while saltwater stations did not exhibit Cs-137 activity in any samples (Section 11.5.0, Figure 1).

Strontium-89/90 was not detected in any catfish caught by DHEC, but it was found in bass at two DHEC stations and in all stations for DOE-SR in both bass and catfish (SRNS, 2018) (Section 11.5.0, Figure 2).

11.2.2 Non-radiological Data Comparison

DHEC and DOE-SR analyze fish for antimony, arsenic, cadmium, manganese and mercury, chromium, copper, lead, nickel, and zinc. DOE-SR collected shellfish, seatrout, flounder, and panfish, which DHEC did not collect. Therefore, no comparison is made for those fish.

Individual fish parts are combined to form composite samples which are tested for strontium (bones) and gamma and metals (muscles)

DOE- SR had no detections in 2017 for antimony or lead. DOE-SR had one detection of arsenic in mullet, three in red drum, five in catfish, and three in bass. DHEC did not detect arsenic in freshwater fish. Cadmium was detected in four DOE-SR bass and two catfish samples. DOE-SR detected chromium in six mullet, one red drum, 20 bass, and 13 catfish. DOE-SR detected copper in seven mullet samples, seven red drum, 35 bass, and 42 catfish. DOE-SR detected nickel in one bass and two catfish samples. DOE-SR had zinc detections in eight mullet, seven red drum, 48 bass and 46 catfish samples. DHEC detected copper and zinc in all 16 composites analyzed (2017 DHEC Data File). DHEC did not detect arsenic, antimony, cadmium, nickel and lead in any samples in 2017. However, DHEC detected chromium in one catfish sample. DHEC detected manganese in four bass and four catfish composites, and DOE-SR had detections in 23 bass, 43 catfish, eight mullet, and seven red drum samples.

Mercury was detected in all DHEC bass and catfish composite samples from all six Savannah River stations (Section 11.5.0, Figure 3). DOE-SR detected mercury in 41 bass and 40 catfish samples. DOE-SR detected mercury in one mullet and seven red drum. Mercury was also detected by DHEC in red drum from the Hwy 17 saltwater location (Section 11.5.0, Table 5 and 6). DHEC composites from the background station on the Combahee River exhibited detectable mercury in bass and catfish.

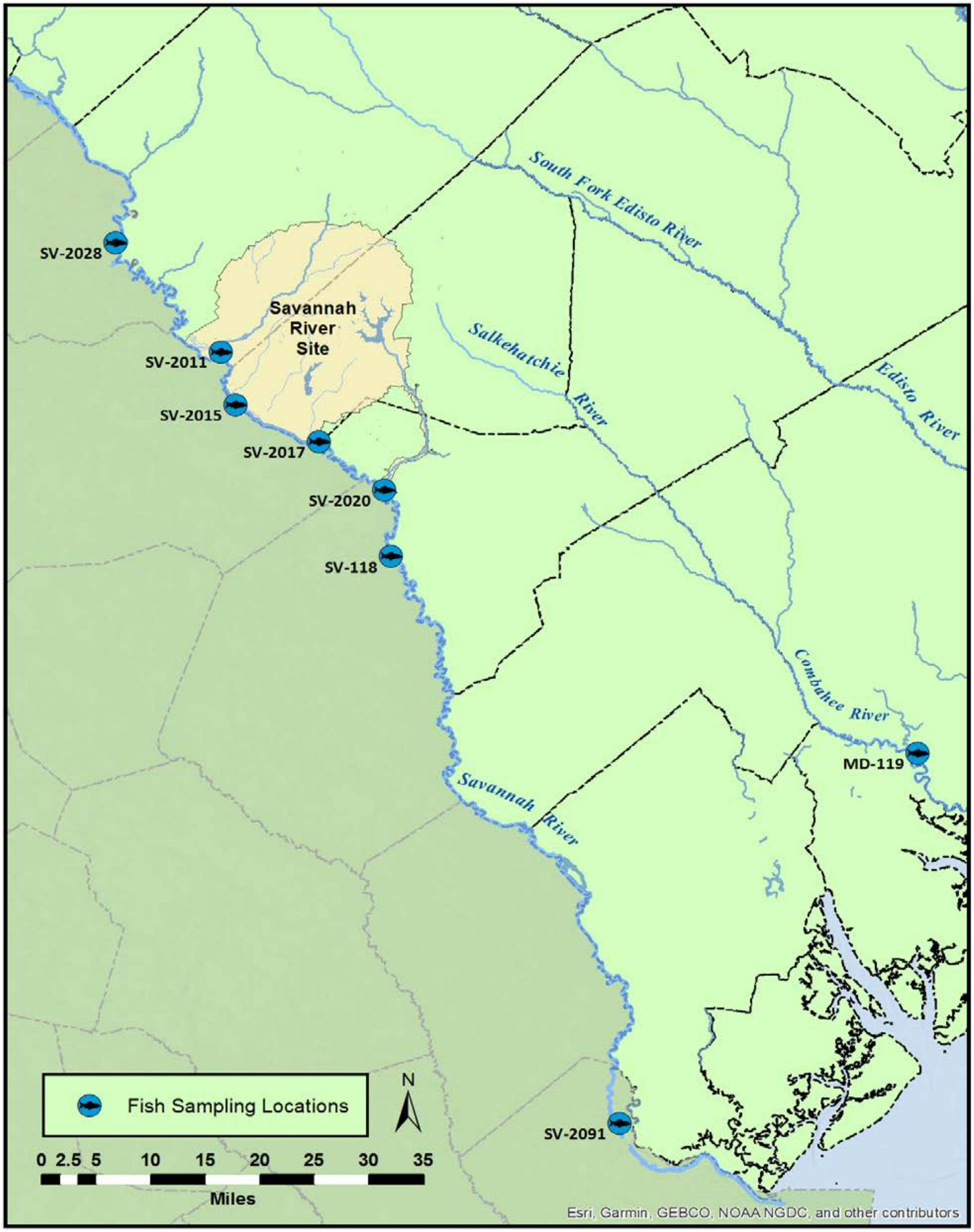
11.3.0 CONCLUSIONS AND RECOMMENDATIONS

A review of DHEC data indicates that DOE-SR operations have had an impact on fish. Higher levels of radionuclides are found in Savannah River fish collected adjacent to and downstream of SRS compared to upstream.

Independent monitoring of radionuclide levels in Savannah River fish will continue along with evaluating the DOE-SR Radiological Fish Monitoring Program. Continued monitoring will provide a better understanding of actual radionuclides, their extent, and trends. This data will allow DHEC to advise and inform the public. Data comparison will also be part of the further evaluation of the DOE-SR program. This independent evaluation will provide credibility and confidence in the DOE-SR data and its uses.
Future analyses of the target species will continue to include mercury and selected metals. This will augment the existing data on Savannah River fish, provide information for human health assessment, and provide another basis for comparison of results with DOE-SR data.

11.4.0 MAP

Fish Monitoring Sampling Locations



2017 ESOP Fish Monitoring

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11.5.0 TABLES AND FIGURES

2017 DHEC and DOE-SR Data Comparison

Table 1. Cesium-137 in Edible Bass

Location	Agency	Number of Samples	Result (pCi/g)
NSBLD	DHEC	1	<MDA
	DOE-SR	2	0.02
Upper Three Runs	DHEC	1	0.03
	DOE-SR	3	0.05
Fourmile Branch	DHEC	1	<MDA
	DOE-SR	3	0.07
Steel Creek	DHEC	1	0.08
	DOE-SR	3	0.11
Lower Three Runs	DHEC	1	0.05
	DOE-SR	3	0.07
Hwy. 301	DHEC	1	<MDA
	DOE-SR	3	0.04

Note: DOE-SR data are averages

Table 2. Cesium-137 in Edible Catfish

Location	Agency	Number of Samples	Result (pCi/g)
NSBLD	DHEC	1	0.05
	DOE-SR	1	0.02
Upper Three Runs	DHEC	1	0.10
	DOE-SR	3	0.08
Fourmile Branch	DHEC	1	0.11
	DOE-SR	2	0.03
Steel Creek	DHEC	1	<MDA
	DOE-SR	3	0.10
Lower Three Runs	DHEC	1	<MDA
	DOE-SR	3	0.30
Hwy. 301	DHEC	1	<MDA
	DOE-SR	3	0.02

Note: DOE-SR data are averages

Table 3. Strontium-89/90 in Non-Edible Bass

Location	Agency	Number of Samples	Result (pCi/g)
NSBLD	DHEC	1	<MDA
	DOE-SR	3	0.70
Upper Three Runs	DHEC	1	0.02
	DOE-SR	3	0.59
Fourmile Branch	DHEC	1	0.03
	DOE-SR	3	1.04
Steel Creek	DHEC	1	<MDA
	DOE-SR	3	0.72
Lower Three Runs	DHEC	1	<MDA
	DOE-SR	3	0.50
Hwy. 301	DHEC	1	<MDA
	DOE-SR	3	0.63

Table 4. Strontium-89/90 in Non-Edible Catfish

Location	Agency	Number of Samples	Result (pCi/g)
NSBLD	DHEC	1	<MDA
	DOE-SR	3	0.91
Upper Three Runs	DHEC	1	<MDA
	DOE-SR	3	0.61
Fourmile Branch	DHEC	1	0.01
	DOE-SR	3	0.76
Steel Creek	DHEC	1	0.02
	DOE-SR	3	0.83
Lower Three Runs	DHEC	1	<MDA
	DOE-SR	3	0.79
Hwy. 301	DHEC	1	<MDA
	DOE-SR	3	0.62

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TABLES AND FIGURES

2017 DHEC and DOE-SR Data Comparison

Table 5. Mercury in Edible Bass

Location	Agency	Number of Samples	Result (mg/kg)
NSBLD	DHEC	1	0.49
	DOE-SR	6	0.21
Upper Three Runs	DHEC	1	0.83
	DOE-SR	7	0.92
Fourmile Branch	DHEC	1	0.43
	DOE-SR	7	0.44
Steel Creek	DHEC	1	0.66
	DOE-SR	7	0.35
Lower Three Runs	DHEC	1	1.1
	DOE-SR	7	0.55
Hwy. 301	DHEC	1	0.18
	DOE-SR	7	0.78

Note: DOE-SR data are averages

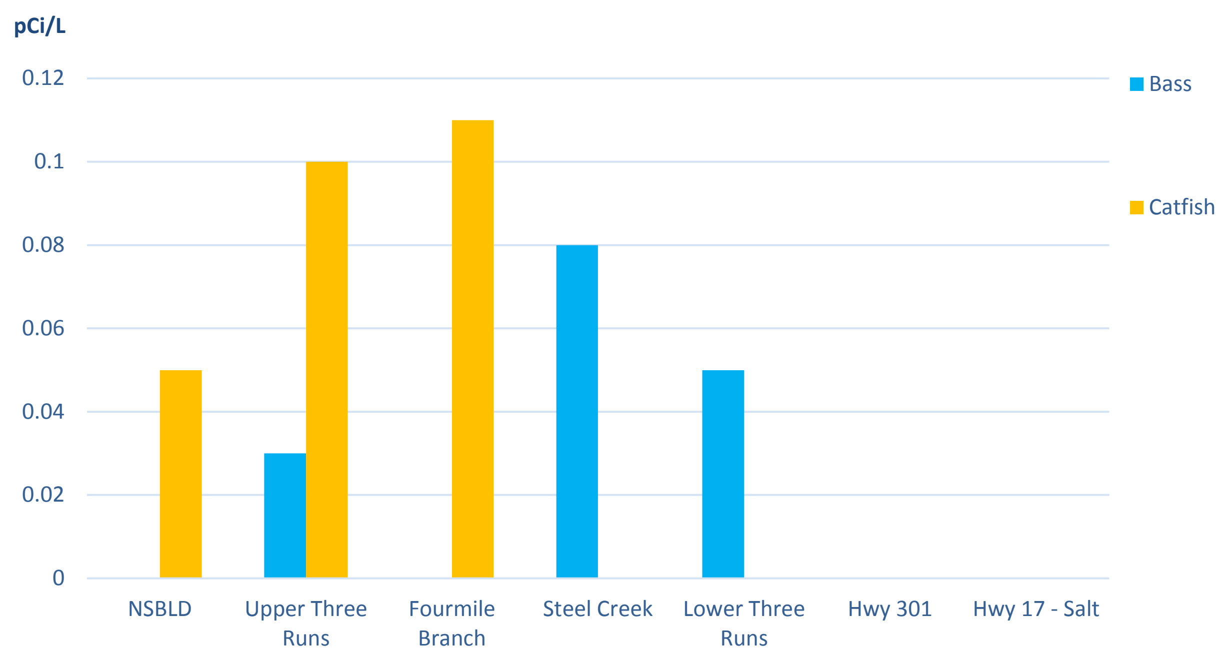
Table 6. Mercury in Edible Catfish

Location	Agency	Number of Samples	Result (mg/kg)
NSBLD	DHEC	1	0.2
	DOE-SR	7	0.13
Upper Three Runs	DHEC	1	0.14
	DOE-SR	7	0.32
Fourmile Branch	DHEC	1	0.19
	DOE-SR	7	0.13
Steel Creek	DHEC	1	0.17
	DOE-SR	7	0.20
Lower Three Runs	DHEC	1	0.17
	DOE-SR	5	0.24
Hwy. 301	DHEC	1	1.7
	DOE-SR	7	0.22

Note: DOE-SR data are averages

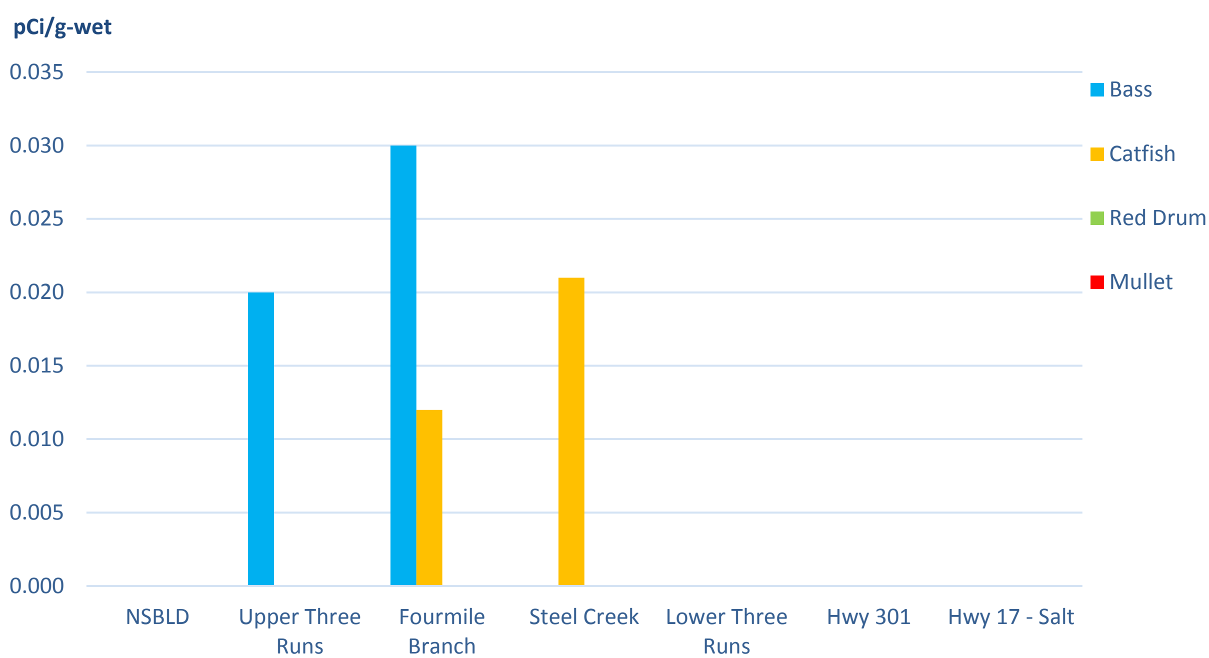
TABLES AND FIGURES

Figure 1. 2017 Cesium-137 in Fish Composites



Note: Missing bars indicate <MDA

Figure 2. 2017 Strontium-89/90 in Fish Bone Composites



Note: Missing bars indicate <MDA

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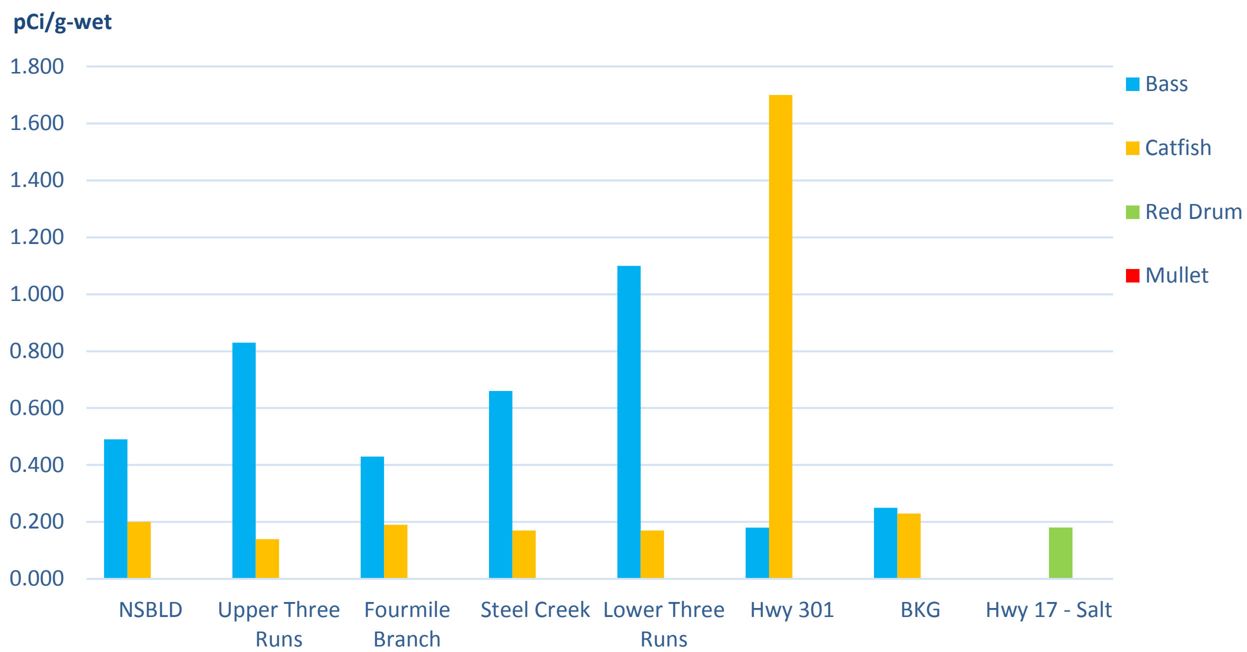
TABLES AND FIGURES

Figure 3. 2017 Mercury in Fish



Note: Missing bars indicate <LLD

11.6.0 SUMMARY STATISTICS

2017 DHEC Cesium-137 Levels in Savannah River Fish (pCi/g–wet)

Edible	Average	Standard Deviation	Median	Minimum	Maximum	Number of Detects	Number of Samples
Bass	0.05	0.03	0.05	0.03	0.08	3	6
Catfish	0.09	0.0314	0.10	0.05	0.11	3	6

2017 DHEC Strontium-89/90 Levels in Savannah River Fish (pCi/g–wet)

Non-Edible	Average	Standard Deviation	Median	Minimum	Maximum	Number of Detects	Number of Samples
Bass	0.02	0	0.02	0.02	0.03	2	6
Catfish	0.016	0.006	0.016	0.012	0.021	2	6

2017 DHEC Mercury Levels in Savannah River Fish (mg/kg)

Edible	Average	Standard Deviation	Median	Minimum	Maximum	Number of Detects	Number of Samples
Bass	0.615	0.323	0.575	0.18	1.1	6	6
Catfish	0.428	0.623	0.18	0.14	1.9	6	6

Notes:
1. ND is Not Detected
2. NA is Not Applicable
3. Cs-137 results represent the activity level in fish tissue
4. Sr-89/90 results represent the activity level in an aliquot of fish bone
5. Some samples were below the MDA and are not displayed in these charts

Chapter 12 Game Animal Monitoring Adjacent to SRS

12.1.0 PROJECT SUMMARY

Due to white-tailed deer and feral hogs having the highest potential of mammalian species for human exposure pathway from Cs-137 (Haselow, 1991), DHEC conducts game animal monitoring activities around SRS. The game animal project addresses concerns of potentially contaminated white-tailed deer and feral hogs migrating off SRS. It also provides valuable information concerning potential exposure to Cs-137 from consuming game animals harvested around SRS.

White-tailed deer and feral hogs have access to several contaminated areas on and off SRS which allows them to be a vector for the redistribution of contaminants (primarily Cs-137). A five-mile study area was established based on a typical white-tailed deer upper limit home range to ensure that potentially contaminated deer residing at or near the SRS boundary would be included in the sample set. Cesium-137 is of concern because of its 30-year half-life, its availability to game animals, and associated health risk to humans (Haselow, 1991).

Cesium-137 is the isotope of focus for game due to its ability to accumulate in an animal's skeletal muscles (Brisbin et al., 1975). When contaminated game is eaten by hunters, Cs-137 is readily incorporated into the human body because of its similarity to K-40 in physiological processes (Davis 1963). Once Cs-137 is consumed, the human body will experience both internal and external radiation. Cs-137's emission of both beta and gamma radiation can result in a person having gastrointestinal, genetic, hematopoietic, and central nervous system damage (Bond et al., 1965).

12.2.0 RESULTS AND DISCUSSION

Game Monitoring Summary Statistics can be found in Section 12.6.0 and all Game Monitoring Data can be found in the 2017 DHEC Data File.

DHEC analyzed muscle tissue collected in 2017 for Cs-137 from 26 deer and five hogs collected from area hunters via hunting clubs, plantations, and Crackerneck Wildlife Management Area within a five-mile study area adjacent to SRS (Section 12.4.0, Map). Additionally, four deer tissue samples were collected and analyzed from a background location 85 miles southeast of SRS in Beaufort County, South Carolina. Sample size, location, and collection dates were dependent on the participating hunters.

Cesium-137 and the naturally occurring isotope K-40 were the only isotopes detected in game samples collected in 2017. Naturally occurring isotopes will not be discussed in this report. Cesium-137 concentrations from deer and hogs collected in the SRS perimeter study area are shown in Section 12.5.0, Figure 1.

DOE-SR does not collect game animal samples within the DHEC study area, and off-site hunter doses are based on DOE-SR models. DHEC data presents a challenge for direct comparisons to DOE-SR data because the perimeter area is heavily baited. Therefore, the uptake of Cs-137 by these animals will be reduced based on the increased K-40 levels in the corn from fertilizers (Heckman, 1992).

12.3.0 CONCLUSIONS AND RECOMMENDATIONS

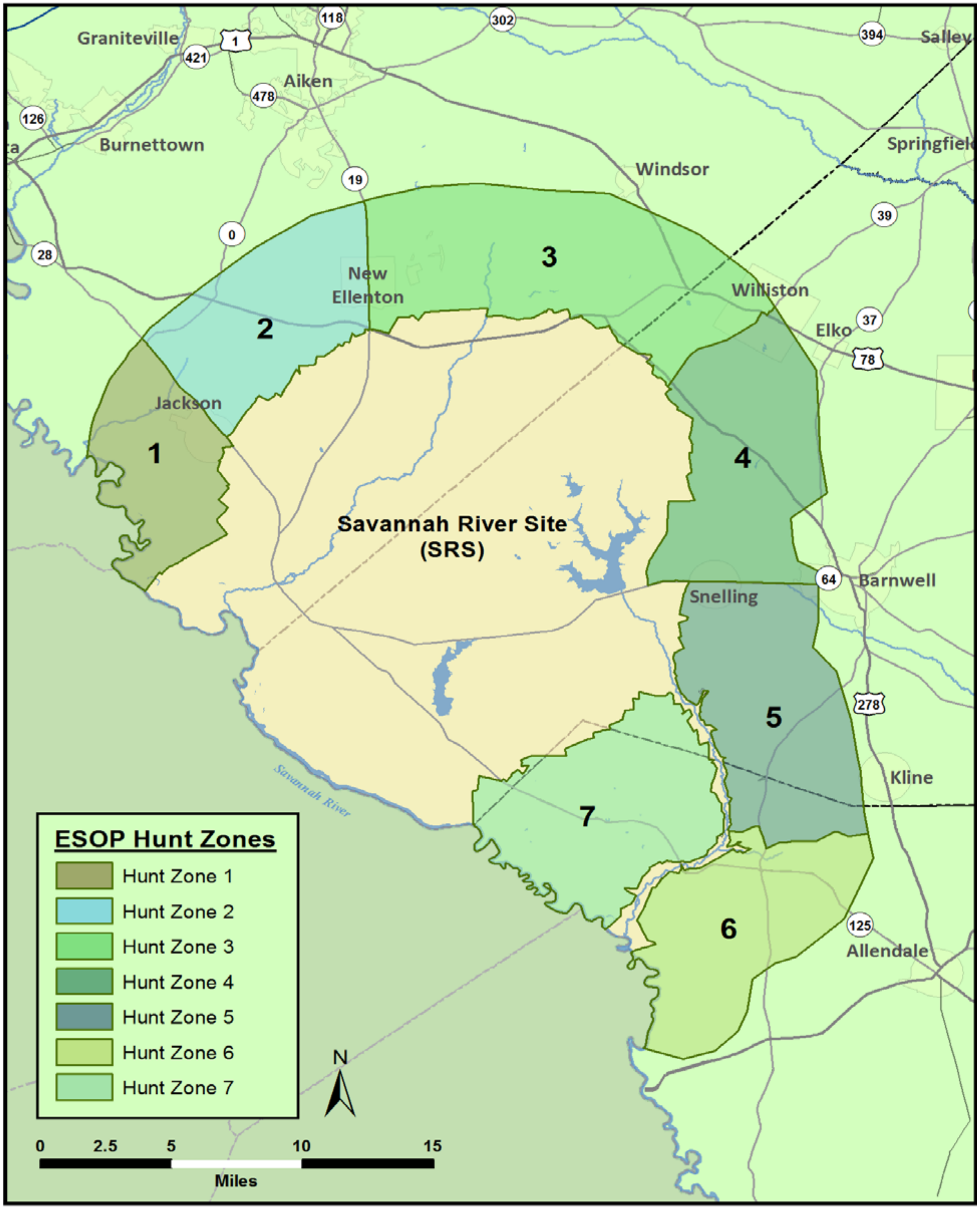
Historic SRS operations released known Cs-137 contamination to Steel Creek, Par Pond, Lower Three Runs, their floodplains, and the Savannah River swamp (Till et al., 2001), all of which impact hunt zones four, five, six, and seven (Section 12.4.0, Map). Although a portion of Cs-137 was deposited on SRS from site operations, levels found in the study area and background location are likely results of above ground nuclear weapons testing (Haselow, 1991).

Age, sex, body weight, soil type, diet, and collection location may affect the Cs-137 activities found in white-tailed deer and hogs (Haselow, 1991). A hunter consuming deer from SRS, the study area, or background locations would most likely ingest a portion of the activity associated with these animals. Refer to the 2017 DHEC Critical Pathway Dose report for a better understanding of the contamination found in game versus other food sources.

DHEC will continue to monitor Cs-137 levels in deer and hogs within the established study area and background locations to assess trends and human health impacts. DHEC will continue to pursue new hunters within the five-mile study area to ensure adequate sample numbers can be achieved each year. DHEC will also put additional efforts into trapping wild hogs within the study area.

12.4.0 MAP

Radiological Monitoring of Game Adjacent to SRS



2017 ESOP Game Monitoring

12.5.0 TABLES AND FIGURES

Figure 1. 2017 DHEC Hunt Zone Average Cs-137 Concentration in Game

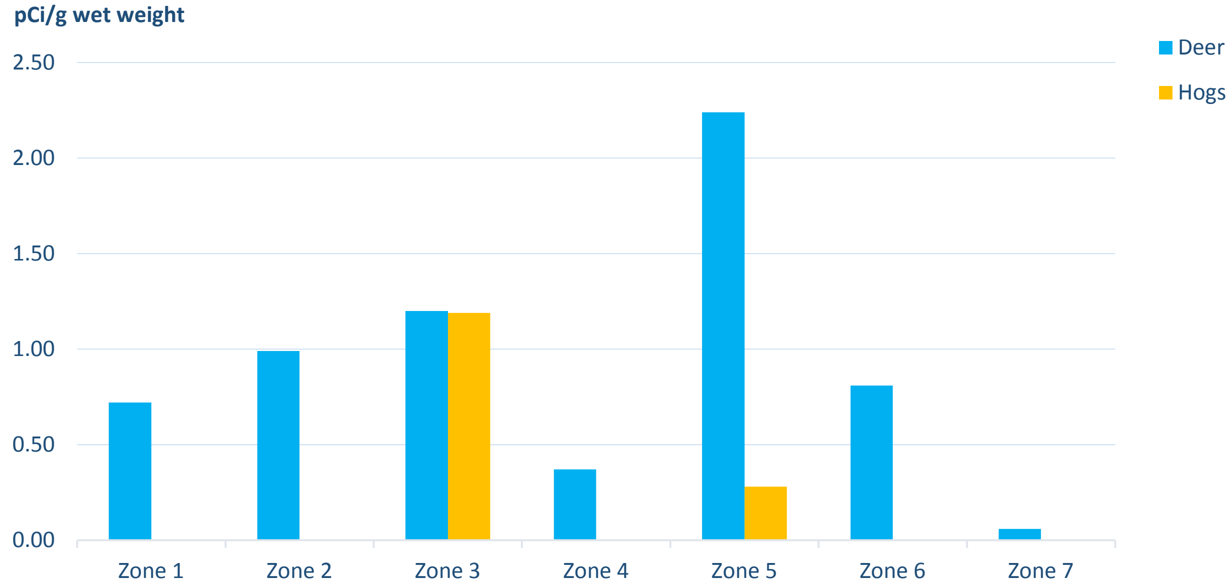
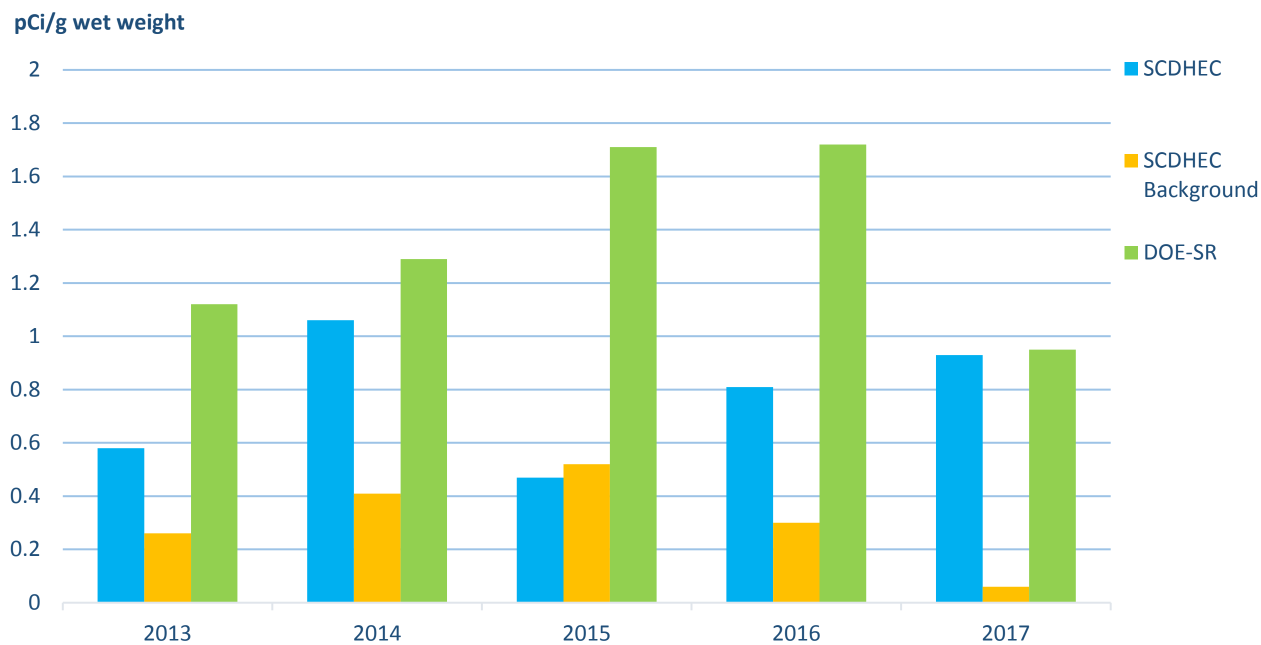


Figure 2. 2013-2017 Average Cs-137 Concentration in Deer (SRNS, 2014-2018; DHEC, 2015-2018)



Notes:
1. 2013-2016 background location was Pinkney Island National Wildlife Refuge
2. SRS data is from on-site deer only and DHEC data is from SRS 5-mile perimeter only
3. DOE-SR data is the gross average concentration of Cs-137 calculated from field averages, which is used in an algorithm to provide a comparable dose to DHEC. DOE-SR lab's average Cs-137 concentration was 0.698 pCi/g.

12.6.0 SUMMARY STATISTICS

2017 Cs-137 Concentration (pCi/g wet weight) in Deer

	Number of Samples	Average	Standard Deviation	Median	Minimum.	Maximum
Study Area Deer	26	0.93	0.62	0.03	5.1	26
Background Deer	4	0.06	0.02	0.07	0.03	0.08

2017 Cs-137 Concentration (pCi/g wet weight) in Deer DHEC Hunt Zones

Hunt Zone	Number of Samples	Average	Standard Deviation	Median	Minimum.	Maximum
Zone 1 Deer	6	0.72	0.56	0.50	0.26	1.6
Zone 2 Deer	3	0.99	0.94	0.61	0.3	2.06
Zone 3 Deer	2	1.20	0.74	1.20	0.68	1.72
Zone 4 Deer	4	0.37	0.05	0.37	0.32	0.43
Zone 5 Deer	4	2.24	1.94	1.53	0.8	5.1
Zone 6 Deer	5	0.81	0.72	0.65	0.12	0.79
Zone 7 Deer	2	0.06	0.03	0.06	0.04	0.08

2017 Cs-137 Concentration (pCi/g wet weight) in Hogs DHEC Hunt Zones

Hunt Zone	Number of Samples	Average	Standard Deviation	Median	Minimum.	Maximum
Zone 3 Hogs	3	1.19	0.02	1.18	1.18	1.21
Zone 5 Hogs	2	0.28	0.05	0.28	0.24	0.31

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Chapter 13 Critical Pathway Dose Report

13.1.0 PROJECT SUMMARY

DHEC implemented a Radionuclide Dose Calculation Project/Critical Pathway Project to calculate the potential exposure or dose to the public within 50-miles of the SRS center point. This study area was chosen for comparison to DOE-SR's 80-km (50-mile) radius dose results. Individual project managers chose differing sample locations/schemes within this study area to establish trends in media radionuclide concentrations.

DHEC and DOE-SR programs were evaluated based on media potential exposure in millirem (mrem) (Section 13.2.0). The figures in Section 4.0 illustrate the trends and central tendencies in the critical pathway potential dose exposures. The critical pathway dose is calculated on an average exposed individual (AEI) and maximum exposed individual (MEI) bases which are summarized in Section 13.4.0, Table 1.

EXPOSURE vs. DOSE

EXPOSURE -- when a body comes in contact with a substance whether through air, skin, and/or consumption

DOSE -- the amount, frequency, and duration that a person is exposed to a substance will determine how much of that substance is taken up by a human body. Once a body receives a certain dose, how they respond to it may be affected by their health, age, gender, and/or genetics.

The DHEC MEI is an imaginary, self-sufficient, and survivalist type of individual who resides in the downriver swamp area below all SRS contributions to the Savannah River, visits the entire 50-mile perimeter study area, and receives the MEI dose based on the single highest detection per radionuclide per media detected in the environment.

The AEI is an individual whose dose is a conservative estimate based on average dose per media and consumption rates, which are represented by the consumption rate column in the data tables (Section 13.5.0). The AEI dose skews high, as only detections are used in the dose calculations. For a typical person in the study area, the dose they receive should be lower than the AEI dose.

13.2.0 RESULTS AND DISCUSSION

All 2017 Dose Data can be found in Section 13.5.0

The 2017 data and dose results are discussed under the following headings in this section: 2017 AEI and MEI Dose, Critical Pathways 2017 Summary, and DOE-SR and DHEC 2017 Comparisons. Total AEI Dose covers the 2008-2017 period, whereas other headings discuss only 2017 data. Not all media were collected for all years during this summary period (2008-2017).

The critical pathways were analyzed in terms of both millirems (mrem) and percentage of dose (Section 13.4.0, Table 4). Percentages denote relative importance, whereas mrem indicates potential exposure levels. The dose critique attempts to point out the limits of this dose estimate and why any DOE-SR and DHEC estimates may or may not be similar.

13.2.1 2017 AEI and MEI Dose

The basis for dose calculations is not limited to any particular exposure pathway that is based on lifestyle or media encountered. The calculation is simply a tabulation of all detected doses found in all media sampled regardless of applicability to an individual. Table 1 in Section 13.4.0 summarizes all DHEC detections by media on an AEI and MEI detection basis. Background readings are not subtracted before dose calculations are performed.

In 2017, the calculated AEI dose was 2.384 mrem (Section 13.4.0, Table 1), with 2.372 mrem from food dose. If wild game is not consumed, the AEI dose falls to 0.101 mrem.
In 2017, the total calculated MEI dose was 9.997 mrem, of which 9.950 mrem was attributable to food consumption. If wild game is not consumed, the MEI dose falls to 0.697 mrem. The MEI basis column uses the single highest detection for a media radionuclide. From this detection, dose is calculated as if the high dose occurrence was somehow stored and the exposure continued throughout the year. If the individual did not store the media at the location, date, and time of DHEC sample collection and achieve a full year's exposure to that media, then the MEI estimate represents a sizable overestimate.

Only speciated doses for specific radionuclides were included in the estimated doses for 2017. A protective dose was estimated using detections-only in determining AEI dose per radionuclide per media, the calculation of dose based on the MEI detection for each radionuclide/media, and conservative consumption references. Each media radionuclide dose, excluding NORM, was considered as part of a critical pathway with contributions through the inhalation, ingestion, and direct exposure routes.

The MEI dose can be received by only one individual since that individual had to consume the specific dose basis animals. Two elevated dose bases (AEI and MEI) were used because they were measured and protective without the inclusion of screening value assumptions for alpha and beta. The assumption of all alpha as plutonium-239 (Pu-239) and all beta as strontium-90 (Sr-90) may double the calculated dose without evidence for that assumption in speciated data. Unspeciated dose assignments were discontinued in 2008 and replaced by calculating an MEI dose potential from the single highest detection per radionuclide per media.

13.2.2 Critical Pathways 2017 Summary

Atmospheric Pathway 2017 Summary

The DHEC 2017 atmospheric pathway contributed dose to the individual through the inhalation of tritium (H-3) in air, the consumption of food (predominantly from wild game), and direct exposure from farm soil. Section 13.4.0, Table 2 illustrates the dominance of the atmospheric pathway, which accounted for 2.348 mrem, at 98.49 percent, of dose to the AEI and 9.726 mrem, at 97.29 percent, of dose to the MEI.

Pathway

The route through which a human can come in contact with a radionuclide. Three paths for humans to be exposed to chemicals include the atmosphere/air, liquid, and food.

Liquid Pathway 2017 Summary

The DHEC 2017 liquid pathway estimated AEI dose to the individual was from the consumption of fish, drinking water from the Savannah River, swimming ingestion, and direct exposure from swimming and wading (Section 13.4.0, Table 1). The liquid pathway contributions to dose

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exposure were second to those contributed by the atmospheric pathway. In 2017, the liquid pathway contribution to the AEI was 0.036 mrem, accounting for 1.51 percent of dose. The contribution to the MEI dose was 0.271 mrem at 2.71 percent. The primary contributor to dose in the liquid pathway was Cs-137 in fish.

Food Subpathway 2017 Summary

The food subpathway was covered under the atmospheric and liquid pathways except for these few additional observations. The annual 2017 DHEC AEI food subpathway dose order, highest to lowest for averages, was wild game (deer), wild game (hog), fungi, fish, and edible vegetation. Milk and incidental soil ingestion did not contribute any quantifiable dose.

The 2017 MEI food pathway order was wild game (hog), wild game (deer), fungi, fish, edible vegetation, and milk. There was no quantifiable dose contributed through incidental soil ingestion. Cs-137, Sr-90/90, and H-3 each contributed to dose in food. Cs-137 was the predominant dose contributor in wild game (deer) for the AEI, at 1.182 mrem, and in wild game (hog) for the MEI, at 4.710 mrem.

Isotopic Contribution Summary

Most of the AEI dose exposure in 2017 was due to Cs-137 at 2.370 mrem (99.41 percent) of the 2.384 mrem total. The primary contributor to the Cs-137 AEI dose was wild game (deer). Tritium was the second highest dose contributor in 2017 at 0.014 mrem. Cesium-137 and H-3 were both found in the atmospheric and the liquid pathways.

Cs-137 was also the primary contributor to the MEI at 9.940 mrem (99.43 percent) of the 9.997 mrem total, and H-3 was second at 0.055 mrem. Wild game (hog) was the single largest dose contributor to the MEI, all of which was due to Cs-137.

13.2.3 2008-2017 Total AEI Dose

Section 13.4.0, Table 4 summarizes dose associated with all media on an AEI basis from 2008-2017. The critical pathway basis of comparison for the DHEC-detected dose comes from releases of radionuclides that were deposited outside of SRS during 2008-2017 and within 50-miles of the SRS center-point.

Table 4 illustrates the dominance of the atmospheric pathway accumulated dose which accounted for 87.29 percent, over the liquid pathway which was 12.71 percent. 99.23 percent of the ten-year dose was from the consumption of food. In total, the AEI received a 3.175 mrem average dose per year during that ten-year period.

Section 13.4.0, Figures 1-3 and Table 4 illustrate the various pathways of cumulative dose exposure. The 2017 AEI basis critical pathway dose was 2.384 mrem which is less than the 7.00 mrem dose an individual typically receives from living in a brick house for one year (Wahl, 2011). Section 13.4.0, Figures 1-3 illustrate the media exposure trends via line graphs.

The predominant source of AEI exposure from 2008-2017 was wild game (deer and hog). In total it accounted for 20.575 mrem, which amounts to 64.79 percent of the total accumulated AEI exposure (31.754 mrem) during that time period. Following wild game were fungi (5.631 mrem; 17.73 percent), fish (3.814 mrem; 12.01 percent), and edible vegetation (1.268 mrem; 3.99 percent). Furthermore, wild game accounted for 74.23 percent of the accumulated dose from the atmospheric pathway and 65.30 percent of the food sub-pathway.

The predominant routes of accumulated exposure from 2008-2017 for water sources were public water systems which pull from the Savannah River (0.100 mrem) and drinking water from private wells (0.036 mrem). The primary routes for minor sources of accumulated dose were accidental ingestion from swimming (0.042 mrem) and direct exposure from wading (0.019 mrem).

13.2.4 DOE-SR and DHEC 2017 Comparisons

DOE-SR calculates potential doses to members of the public from atmospheric and liquid releases, as well as from special-case exposure scenarios, on an annual basis (SRNS, 2018). These include liquid pathway and air pathway doses, an all-pathway dose, a sportsman dose, onsite and offsite hunter doses, and an offsite fisherman dose. Though there are differences between DOE-SR and DHEC sampling and dose estimation protocols, DOE-SR dose estimates are analogous to DHEC dose estimates as follows:

1. The DOE-SR all-pathway dose and the sum of the DHEC fish, wading, swimming, public system drinking water from the Savannah River, vegetation, and milk doses serve as a means of comparison of the dose a typical member of the public in the study area (an individual who doesn’t consume wild game or gather edible mushrooms) could receive from SRS activities during a given year.

2. The sum of the DOE-SR offsite hog consumption, offsite deer consumption, swamp hunter soil exposure, Steel Creek fish consumption, and Steel Creek soil exposure doses and the sum of the DHEC hog, deer, soil, and fish doses serve as a means of comparison of the dose a survivalist type of individual who consumes fish from the Savannah River and wild game could receive in a given year.

The DOE-SR total representative person dose and the DHEC Public Scenario basis were the most relevant dose estimates that represent the potential dose exposure for the public in 2017. The DOE-SR representative person dose for 2017 was 0.25 mrem, an increase from 0.19 mrem in 2016. The sum of the DHEC AEI fish, wading, swimming, public system drinking water from the Savannah River, vegetation, and milk doses was 0.038 mrem in 2017. The DHEC public scenario dose estimate for 2017 is 0.038 percent of the DOE all-pathway dose standard of 100 mrem/yr (SRNS, 2018).

The sum of the DOE-SR offsite hog consumption, offsite deer consumption, swamp hunter soil exposure, Steel Creek fish consumption, and Steel Creek soil exposure doses was 12.01 mrem in 2017, of which the single largest contributor was the DOE-SR offsite hog consumption dose, at 6.11 mrem. It should be noted that the DOE-SR dose summations are only done for comparison to DHEC results. The sum of the DHEC hog, deer, soil, and fish doses, derived from offsite

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measurements only, was 9.532 mrem.

13.2.5 Dose Critique

Sampling results in most DHEC media showed that the environmental data detections are asymmetric and skewed to the left (most detections are low and near the origin). Most sampling resulted in less than MDA determinations and was not included in the DHEC summary statistics, which used detections only. The use of detections only in calculations was protective (Gilbert, 1987) and biases the measures of average higher.

The NORM averages and maximums were not included in the dose estimates since this dose was part of the background dose for the study area. The yearly dose averages were based on DHEC detections only and are inflated since most sample results were less than MDA. The rationale for using detections only was to allow for undetected radionuclides and media. The justification for selecting higher source consumption levels was due to the conceptualization of the DHEC MEI as a survivalist type who consumed natural media at a greater than typical use rate. The basis for both considerations was to be protective of the public and environment.

The inclusion of alpha and beta assumed dose in the past provided an excessively high dose estimate and was not supported by media radionuclide species detections. The inclusion of calculations based on a single highest maximum detection for each radionuclide/media was a more definable basis for establishing an upper bound rather than the dose assumption of unknown alpha as Pu-239 and unknown beta as Sr-90. This upper bound is not practically achievable by the MEI due to the unlikely exposure to all maximums at a constant rate throughout the year (via storage of media). However, since most of the dose was due to wild-type food (animal or plant) consumption containing Cs-137, a single individual who ate all of the worst-case deer, hog, and edible plant and mushrooms could approach the MEI dose if these contaminated media were stored and consumed over the entire year.

The DHEC 2008 Critical Pathway Dose Report noted that 38.50 percent of the dose was assigned and represented a potential dose overestimate that may in fact be NORM detections (alpha and beta). Also, if all NORM potentials were excluded, only 44.25 percent of the detected dose above background was potentially from SRS. The DHEC dose calculations since then were still protective due to the use of detections only in determining dose, the calculation of a maximum dose for the MEI based on a single maximum detection for each radionuclide/media, and the use of conservative consumption rates.

The AEI was given prominence as protective for general dose considerations, and the reader should be aware that the AEI dose estimate was conservative or biased high due to the use of detections only for dose calculation. For example, the omission of less than MDA assignments from calculations would raise any calculated number to a higher value. Alternatively, less than MDA represents an undetermined low number that may be zero or any number up to the given MDA value for that analysis.

This project used dose instead of risk so that direct comparisons of dose magnitude can be made with similar media data published in the SRS Environmental Reports. DOE-SR-modeled radionuclide releases for a particular year were not directly comparable to DHEC yearly detected dose in some media due to bioaccumulation.

13.3.0 CONCLUSIONS AND RECOMMENDATIONS

The 2017 results indicated that monitoring of bioaccumulation of radionuclides and the associated dose should continue in addition to the primary inhalation, ingestion, and direct exposure routes from the atmospheric and liquid pathways. Ground water, surface water, sediments, plants, and animals should be carefully monitored for any signs of the contaminants that are present at basins, seepage areas, and the F and H-Area tank farms. Early detection is paramount to protecting the public and the environment if a release to offsite streams or groundwater occurs. DHEC will continue to monitor SRS and adjacent areas for the primary radionuclide contributors to dose potentially associated with DOE-SR operations.

13.4.0 TABLES AND FIGURES

TABLES AND FIGURES

Table 1. DHEC Dose Estimates (mrem) for all Media: AEI and MEI

Pathway	Route	Source of Exposure	AEI	MEI
Atmospheric	Inhalation	Surface Soil Resuspension	0.000	0.000
Atmospheric	Inhalation	Inhalation of H-3 in Air	0.002	0.005
Air Inhalation Total			**0.002**	**0.005**
Liquid	Ingestion	Fish	0.026	0.230
Atmospheric	Ingestion	Cow Milk	0.000	0.002
Atmospheric	Ingestion	Wild Game (Deer)	1.182	4.590
Atmospheric	Ingestion	Wild Game (Hog)	1.101	4.710
Atmospheric	Ingestion	Vegetation	0.002	0.009
Atmospheric	Ingestion	Fungi	0.061	0.409
Atmospheric	Ingestion	Soil Ingestion with Food	0.000	0.000
Food Ingestion Total			**2.372**	**9.950**
Liquid	Ingestion	Public System Drinking Water-Savannah River	0.010	0.040
Liquid	Ingestion	Public System Drinking Water-Groundwater	ND	ND
Liquid	Ingestion	Private Wells	ND	ND
Liquid	Ingestion	Ingestion from Swimming	0.000	0.001
Drinking Water Total			**0.010**	**0.041**
Liquid	Direct	Direct Exposure from Swimming	0.000	0.000
Liquid	Direct	Direct Exposure from Wading	0.000	0.000
Atmospheric	Direct	Direct Exposure from Farm Soil	0.000	0.001
Direct Exposure Total			**0.000**	**0.001**
Overall Total Dose			**2.384**	**9.997**

Note: ND is No Detections in 2017

Table 2. DHEC Dose Estimates (mrem) for the Atmospheric and Liquid Pathways: AEI and MEI

Critical Pathway Summary	AEI	MEI
The Atmospheric Pathway Totals	2.348	9.726
The Liquid Pathway Totals	0.036	0.271
Combined Dose	**2.384**	**9.997**

TABLES AND FIGURES

Table 3. DHEC/DOE-SR Dose Comparisons

Pathway	Comparison Basis	DOE-SR[1]	DHEC[2]
All-Pathway	DHEC All Pathway Approximation[3]	0.25	0.28
Sportsman	Onsite Hunter	12.2	NS
	Onsite Hunter - Turkey	ND	NS
	Fish[4]	0.13	0.231
	Fisherman - Soil Exposure	2.08	0.001
	Offsite Hunter - Deer	1.83	4.59
	Offsite Hunter - Hog	1.86	4.71
	Hunter - Soil Exposure[5]	1.86	0.001
	Edible Fungi	NS	0.409

Notes:
1. DOE-SR data from Table 6-5a and Table 6-6 (SRNS, 2018)
2. DHEC maximums or single highest detection basis for all media per route of exposure (Table 1.)
3. Sum of DHEC fish, wading exposure, swimming ingestion, Savannah River derived drinking water, vegetation, and milk (all MEI)
4. DHEC and DOE-SR fish dose includes fisherman soil exposure dose.
5. Soil sources were from Creek Plantation (DOE-SR) and direct exposure from farm soil (DHEC).

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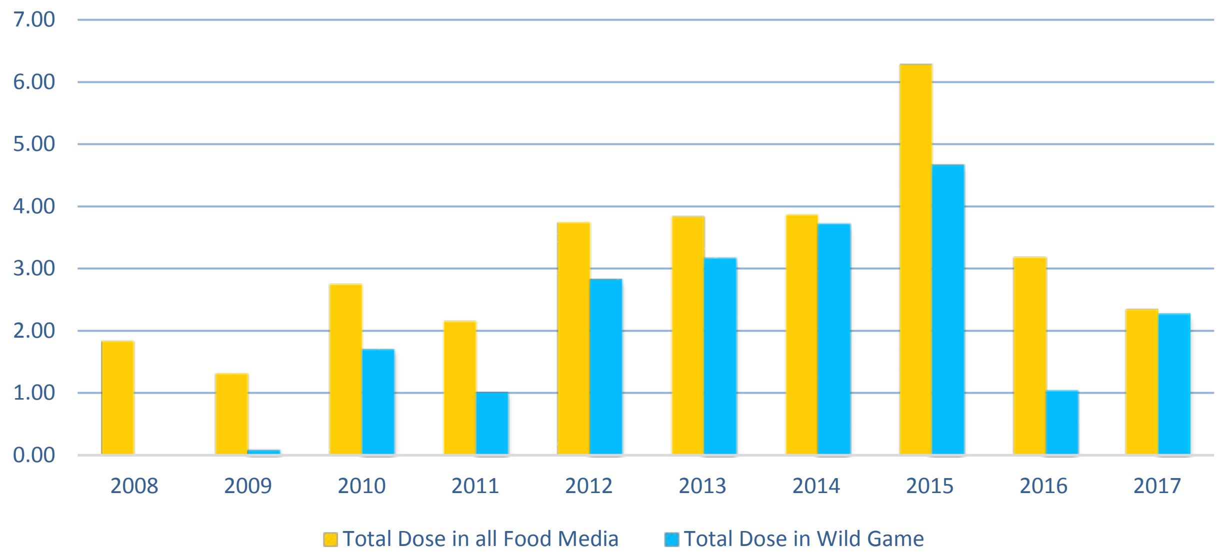
Table 4. 2008-2017 AEI Exposure: Total AEI Dose (mrem) and Percentage

Pathway	AEI Media Categories	2017[1]	2008-2017[2]	2008-2017 % AEI[3]
Atmospheric	Surface Soil Resuspension Inhalation	0.000	0.009	0.03
Atmospheric	H-3 Inhalation	0.002	0.014	0.04
Liquid	Fish	0.026	3.814	12.01
Atmospheric	Cow Milk	0.000	0.218	0.69
Atmospheric	Wild Game	2.283[4]	20.575	64.79
Atmospheric	Vegetation (Leafy, Fruit, and Nuts)	0.002	1.268	3.99
Atmospheric	Fungi	0.061	5.631	17.73
Atmospheric	Soil Ingestion with Food	0.000	0.000	0.00
Liquid	Public System Water from the Savannah River	0.010	0.100	0.32
Liquid	Public System Water from Groundwater	ND[5]	0.024	0.08
Liquid	Private Wells	ND[5]	0.036	0.11
Liquid	Ingestion from Swimming	0.000	0.042	0.13
Liquid	Direct Exposure from Swimming	0.000	0.000	0.00
Liquid	Direct Exposure from Wading	0.000	0.019	0.06
Atmospheric	Direct Exposure from Farm Soil	0.000	0.004	0.01
Totals		**2.384**	**31.754**	**100%[6]**

Notes:
1. The 2017 column is dose in mrem during 2017.
2. The 2008-2017 column is total dose in mrem over the 2008-2017 ten-year period.
3. The AEI % basis column is the percentage of the 2008-2017 total dose due to a given media.
4. Deer and hog in 2017.
5. There were no detections in 2017.
6. Sum of percentages is slightly lower than 100 percent due to rounding error.

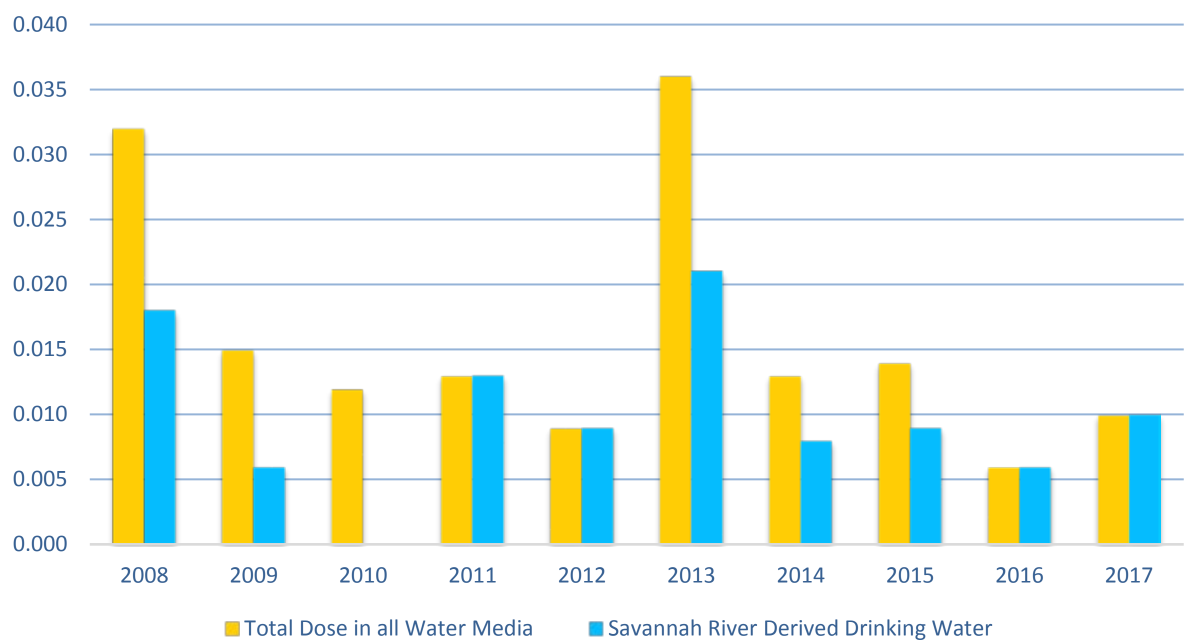
TABLES AND FIGURES

Figure 1. 2008-2017 DHEC AEI Food Dose



Note: This graph shows the total food AEI dose trend and the trend for the primary contributor to that dose for 2017 in mrem.

Figure 2. 2008-2017 DHEC AEI Water Dose



Note: This graph shows the total water AEI dose trend and the trend for the primary contributor to that dose from 2017 in mrem.

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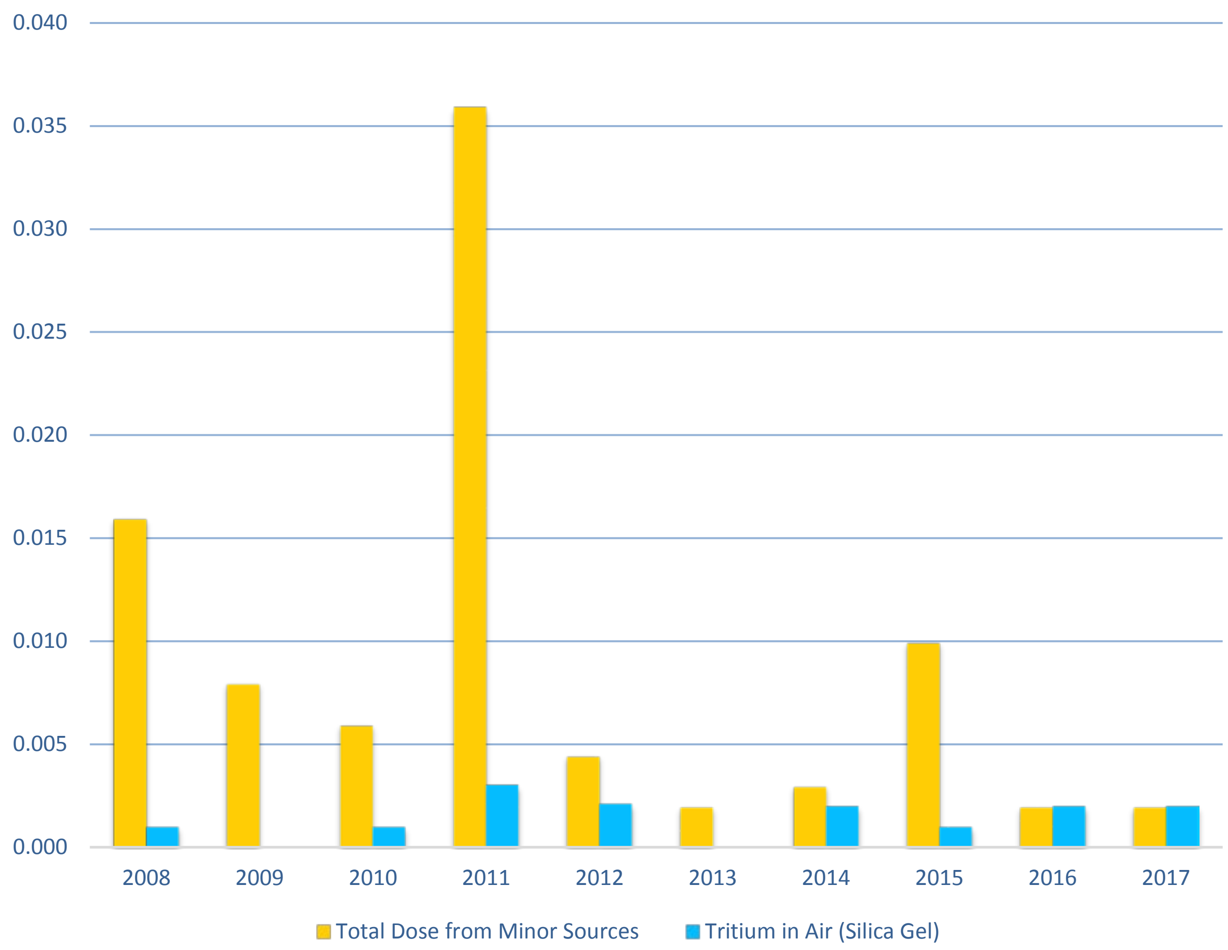
Figure 3. 2008-2017 DHEC AEI Dose from Minor Sources



Notes:

1. This graph shows the total minor sources AEI dose trend and the trend for the primary contributor to that dose from 2017 in mrem.
2. For tritium in air in 2009 and 2013, the levels detected were not enough to assign a dose, so the results are listed as 0.000 mrem.

13.5.0 2017 DOSE DATA

Notes:

1. ND is No Detects
2. NA is Not Applicable
3. NS is Not Sampled
4. All consumption rates are from USEPA, 2011 and SRNS, 2014 except for Soil Shine which is from Iowa State University, (Edwards,2012)

2017 DOSE DATA

AEI Fish Dose

Dose from Fish Ingestion (AEI)				
Media	**Radionuclide**	**Activity**	**Consumption Rate**	**Dose**
		pCi/g	kg/yr	mrem
Bass	Cs-137	0.054	3.7	0.010
Catfish	Cs-137	0.086	3.7	0.016
Flounder	Cs-137	ND	NA	NA
Redfish	Cs-137	ND	NA	NA
Fish Total				**0.026**

MEI Fish Dose

Dose from Fish Ingestion (MEI)				
Media	**Radionuclide**	**Activity**	**Consumption Rate**	**Dose**
		pCi/g	kg/yr	mrem
Bass	Cs-137	0.083	24.0	0.100
Catfish	Cs-137	0.108	24.0	0.130
Flounder	Cs-137	ND	NA	NA
Redfish	Cs-137	ND	NA	NA
Fish Total				**0.230**

AEI Milk Dose

Dose from Milk (AEI)				
Media	**Radionuclide**	**Activity**	**Consumption Rate**	**Dose**
		pCi/L	kg/yr	mrem
Milk	H-3	ND	NA	NA
	Sr-89/90	0.513	69.0	0.000
	I-131	ND	NA	NA
Milk Total				**0.000**

MEI Milk Dose

Dose from Milk (MEI)				
Media	Radionuclide	**Activity**	**Consumption Rate**	**Dose**
		pCi/L	kg/yr	mrem
Milk	H-3	ND	NA	NA
	Sr-89/90	0.556	260.0	0.002
	I-131	ND	NA	NA
Milk Total				**0.002**

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2017 DOSE DATA

AEI Wild Game Dose

Dose from Wild Game (AEI)		
Media	**Radionuclide**	**Dose**
Deer	Cs-137	1.182
Hog	Cs-137	1.101
Game Total		**2.283**

MEI Wild Game Dose

Dose from Wild Game (MEI)		
Media	**Radionuclide**	**Dose**
Deer	Cs-137	4.59
Hog	Cs-137	4.71
Game Total		**9.300**

AEI Edible Vegetation Dose

Dose in Edible Vegetation (AEI)				
Media	**Radionuclide**	**Activity**	**Consumption Rate**	**Dose**
		pCi/g	kg/yr	mrem
Fruit and Vegetables	H-3	0.421	92	0.002
	Cs-137	ND	NA	NA
Fruit and Vegetable Total				**0.002**
Nuts	H-3	2.43	1.9	0.000
	Cs-137	ND	NA	NA
Nuts Total				0.000
Fungi	H-3	0.238	3.65	0.000
	Cs-137	0.332	3.65	0.061
Fungi Total				**0.061**
Combined Vegetation Total				**0.063**

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2017 DOSE DATA

2017 MEI Edible Vegetation Dose

Dose in Edible Vegetation (MEI)				
Media	**Radionuclide**	**Activity**	**Consumption Rate**	**Dose**
		pCi/g	kg/yr	mrem
Fruit and Vegetables	H-3	0.596	248	0.009
	Cs-137	ND	NA	NA
Fruit and Vegetable Total				**0.009**
Nuts	H-3	2.43	1.9	0.000
	Cs-137	ND	NA	NA
Nuts Total				0.000
Fungi	H-3	0.24	10	0.000
	Cs-137	0.817	10	0.409
Fungi Total				**0.409**
Combined Vegetation Total				**0.418**

2017 AEI Ingestion from Surface Water and Wells Dose

Ingestion from Surface Water and Wells (AEI)				
Source	**Radionuclide**	**Activity**	**Consumption Rate**	**Dose**
Savannah River Sourced Drinking Water		pCi/L	L/yr	mrem
Surface Water	**H-3**	**527**	**300**	**0.010**
Groundwater Sourced Drinking Water		pCi/L	L/yr	mrem
Groundwater	**H-3**	**ND**	**300**	**NA**
Private Wells Groundwater		pCi/L	L/yr	mrem
Groundwater	**H-3**	**ND**	**300**	**NA**
Ingestion from Surface Water and Wells Total				**0.010**

Note: Non-potable drinking water is no longer evaluated for dose.

2017 DOSE DATA

2017 MEI Ingestion from Surface Water and Wells Dose

Ingestion from Surface Water and Wells (MEI)				
Source	**Radionuclide**	**Activity**	**Consumption Rate**	**Dose**
Savannah River Sourced Drinking Water		pCi/L	L/yr	mrem
Surface Water	**H-3**	**790**	**800**	**0.040**
Groundwater Sourced Drinking Water		pCi/L	L/yr	Mrem
Groundwater	**H-3**	**ND**	**800**	**NA**
Private Wells Groundwater		pCi/L	L/yr	mrem
Groundwater	**H-3**	**ND**	**800**	**NA**
Ingestion from Surface Water and Wells Total				**0.040**

Note: Non-potable drinking water is no longer evaluated for dose.

AEI Incidental Water Ingestion and Direct Exposure from Water Dose

Incidental Water Ingestion and Direct Exposure from Water (AEI)				
Source	**Radionuclide**	**Activity**	**Consumption Rate**	**Dose**
Swimming at Savannah River Creek Mouths				
Surface Water Swimming	H-3	pCi/L	hrs/yr	mrem
Ingestion		**1547**	**9**	**0.000**
Surface Water Swimming	H-3	pCi/L	hrs/yr	mrem
Surface Water Immersion		**1547**	**9**	**0.000**
Savannah River Creek Mouth Total				**0.000**

MEI Incidental Water Ingestion and Direct Exposure from Water Dose

Incidental Water Ingestion and Direct Exposure from Water (MEI)				
Source	**Radionuclide**	**Activity**	**Consumption Rate**	**Dose**
Swimming at Savannah River Creek Mouths				
Surface Water Swimming	H-3	pCi/L	hrs/yr	mrem
Ingestion		**3807**	**36**	**0.001**
Surface Water Swimming	H-3	pCi/L	hrs/yr	mrem
Surface Water Immersion		**3807**	**36**	**0.000**
Savannah River Creek Mouth Total				**0.001**

2017 DOSE DATA

AEI Sediment at Creek Mouths and Boat Landings Dose

Sediment at Creek Mouths and Boat Landings (AEI)				
Source	**Radionuclide**	**Activity**	**Consumption Rate**	**Dose**
Sediment Dose		pCi/g	hrs/yr	mrem
Creek Mouths	**Cs-137**	**0.795**	**9**	**0.000**
Boat Landings	**Cs-137**	**0.152**	**9**	**0.000**
Sediment Total				**0.000**

MEI Sediment at Creek Mouths and Boat Landings Dose

Sediment at Creek Mouths and Boat Landings (MEI)				
Source	**Radionuclide**	**Activity**	**Consumption Rate**	**Dose**
Sediment Dose		pCi/g	hrs/yr	mrem
Creek Mouths	**Cs-137**	**1.58**	**36**	**0.000**
Boat Landings	**Cs-137**	**0.243**	**36**	**0.000**
Sediment Total				**0.000**

AEI Surface Soil Ingestion Dose

Surface Soil Ingestion (AEI)				
Source	**Radionuclide**	**Activity**	**Consumption Rate**	**Dose**
Surface Soil		pCi/g	Mg/day	mrem
Ingestion	Cs-137	0.097	20	0.000
Ingestion	Eu-155	0.136	20	0.000
Soil Ingestion Total				**0.000**

Note: This represents soil inadvertently consumed with plants.

MEI Surface Soil Ingestion Dose

Surface Soil Ingestion (MEI)				
Source	**Radionuclide**	**Activity**	**Consumption Rate**	**Dose**
Surface Soil		pCi/g	Mg/day	mrem
Ingestion	Cs-137	0.178	20	0.000
Ingestion	Eu-155	0.136	20	0.000
Soil Ingestion Total				**0.000**

Note: This represents soil inadvertently consumed with plants.

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AEI Soil Shine Dose

Soil Shine (AEI)				
Source	**Radionuclide**	**Activity**	**Consumption Rate**	**Dose**
Surface Soil		pCi/g	hrs/yr	mrem
Ingestion	Cs-137	0.097	2602	0.000
Ingestion	Eu-155	0.136	2602	0.000
Soil Shine Total				**0.000**

2017 MEI Soil Shine Dose

Soil Shine (MEI)				
Source	**Radionuclide**	**Activity**	**Consumption Rate**	**Dose**
Surface Soil		pCi/g	hrs/yr	mrem
Ingestion	Cs-137	0.178	2602	0.001
Ingestion	Eu-155	0.136	2602	0.000
Soil Shine Total				**0.001**

AEI Atmospheric Inhalation Dose

Atmospheric Inhalation (AEI)				
Surface Soil Resuspension and Air Inhalation				
Source	**Radionuclide**	**Activity**	**Consumption Rate**	**Dose**
Surface Soil Resuspension		**pCi/g**	**m3/yr**	**mrem**
Inhalation	Cs-137	0.097	5000	0.000
Inhalation	Eu-155	0.136	5000	0.000
Surface Soil Resuspension Total				**0.000**
Air Inhalation (Silica Gel)		**pCi/m^3**	**m3/yr**	**mrem**
Inhalation	H-3	5.25	5000	0.002
Atmospheric Inhalation Total				**0.002**

MEI Atmospheric Inhalation Dose

Atmospheric Inhalation (MEI)				
Surface Soil Resuspension and Air Inhalation				
Source	**Radionuclide**	**Activity**	**Consumption Rate**	**Dose**
Surface Soil Resuspension		**pCi/g**	**m3/yr**	**mrem**
Inhalation	Cs-137	0.178	6400	0.000
Inhalation	Eu-155	0.136	6400	0.000
Surface Soil Resuspension Total				
Air Inhalation (Silica Gel)		**pCi/m^3**	**m3/yr**	**Mrem**
Inhalation	H-3	11.84	6400	0.005
Atmospheric Inhalation Total				**0.005**

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