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Periodic Report 6
for the
Steel Creek Integrator Operable Unit (U)

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EXECUTIVE SUMMARY

This periodic report (PR) has been developed in support of the Integrator Operable Unit (IOU) program at the Savannah River Site (SRS). The Steel Creek (SC) IOU is one of six IOUs under investigation at SRS. The IOUs are under investigation because they represent possible pathways for the release of contaminants from SRS activities, within their respective watershed, to on/off-unit receptors and the environment. IOUs are defined as surface water (SW) bodies (e.g., streams and lakes) and associated wetlands, including the SW, sediment, floodplain sediment (sediment/soil), and related biota.

The SC IOU is in Phase II of the IOU Program (Figure 1-1). Phase II is the ongoing sampling and assessment of the IOU and refinement of the conceptual site model (CSM) until the onset of Phase III. Phase III includes a Remedial Investigation to address final data needs and completion of the Baseline Risk Assessment and Feasibility Study process through the Record of Decision (ROD) and remedial action, if applicable.

The purpose of SC PR6 is to:

- Provide the status of potential contaminant sources;
- Present the refined CSM based on the potential contaminant sources;
- Evaluate SC PR6 data which includes new analytical data from sampling activities that have occurred within the IOU including new biological data;
- Assess the potential threat to human health (HH) and ecological receptors based on review of the new data;
- Evaluate the need for early actions; and
- Develop data needs for the ongoing monitoring and assessment of the IOU based on review of the new data and information presented in this PR.

Schedule

The next Federal Facility Agreement (FFA) milestone is the sixth Phase II Field Start scheduled for July 2019 (FFA 1993). Long-term projections are listed in Appendix E of the FFA. The projected date for issuance of the ROD is September 2064.

SC IOU Subunits and Contaminant Sources

The SC watershed includes L Area and P Area. L Area (which includes L Reactor) is located entirely within the SC watershed. Portions of P Area are located within the SC watershed and the Lower Three Runs watershed, respectively. The P Reactor building is located in the SC watershed, and the headwaters of SC originate near P Area.

The SC IOU includes the L-Area Reactor Discharge Canal, P-Area Reactor Discharge Canal, L Lake, and the Wetland Area at Dunbarton Bay (WADB). Remedial action is being pursued for the WADB to address ash deposits which emanated from the P-Area Basin which has already been closed. The ROD (Rev. 1) for the WADB was issued in June 2018 for excavation and land use controls. The FFA field start for the WADB is scheduled for February 19, 2019.

The following subunits comprise the SC IOU: Upper SC (the portion of SC above L Lake) L Lake, Lower SC (the portion of SC below Lake to the Savannah River swamp), and Meyers Branch, the main tributary of SC.

HH and Ecological Benchmark Screening

The HH and ecological screening is conducted by comparing constituent concentrations to pre-established benchmark values for each medium resulting in a screening level risk evaluation. The sediment, SW, and fish benchmark comparisons are used to support early action evaluations and data needs determinations.

For both the HH and ecological evaluations, a maximum hazard quotient (HQ) (maximum detected value/benchmark) and a mean HQ (mean of detected value/benchmark) are calculated for each constituent per subunit and are used to determine if maximum and/or mean values are greater than (>) the benchmark. In general, constituents with a low mean HQ (mean HQ less than [<] 1.0) do not warrant further evaluation. Similarly, constituents with a low frequency of exceedance (5% or

less), based on data grouped by subunit, do not require additional evaluation by the IOU program. Also, if levels observed within the IOU are within background levels, this indicates contaminants within the IOU are not necessarily (or "considered") unit related; and that further investigation by the IOU is not warranted at this time.

HH Benchmark Screening and Results

The HH benchmarks for SC PR6 reflect an update to the thresholds initially compiled for the IOU program. The updated benchmarks follow the approach established in the *Remedial Investigation Workplan/Baseline Risk Assessment for the Lower Three Runs IOU*. The HH screening is conducted based on the on-site worker (OSW) for the sediment medium and the subsistence fisherman for fish. The HH benchmark values for these receptors are used to identify constituent concentrations that result in a cancer risk >$1x10^{-4}$ or an HQ >3. The hypothetical resident is used to assess SW. The SW benchmarks are based on maximum contaminant levels.

Sediment

For PR6, there were cesium-137 OSW (benchmark = 14.4 pCi/g) benchmark exceedances for the for the Upper and Lower subunits. However, since the detected means were less than the benchmark for both the Upper and Lower subunits, further evaluation by the IOU program is not warranted. The locations of the exceedances are in areas of known cesium-137 contamination, and administrative controls remain in place for workers in these areas.

SW

The HH evaluation for resulted in SW exceedances for the hypothetical resident. Constituents with a mean ~~ratio~~HQ >1.0, a frequency of exceedance >5% (with at least 20 analyses), and with a detected mean above maximum background (or background data are non-detects and indeterminate) include benzo(a)pyrene in the Meyers Branch subunit and trichloroethylene (TCE) and tritium in the Upper subunit. Upper SC is an area with known tritium and TCE contamination. SW is being monitored in Upper SC as part of the P-Area Groundwater Operable Unit (PAGW OU). A non-time critical removal action will be implemented at PAGW OU to reduce the mass of TCE in groundwater that discharges to SC. Additional monitoring has been proposed for SW under the *Sampling and Analysis Plan Addendum for P-Area Groundwater Operable Unit* (SRNS-

RP-2018-00261) for TCE and tritium to determine the presence and extent of contamination (e.g., further evaluation by the IOU program is not warranted at this time).

Exceedances of benzo(a)pyrene were from sample locations associated with the Dunbarton Rail Road Yard (DRRY) 2015 sampling. Although the SW is not used as a drinking water source, further evaluation of the DRRY-associated exceedances is warranted as the SC IOU approaches Phase III of the IOU program. The DRRY is an active rail yard with an FFA Appendix G.1 (Site Evaluation) Site Evaluation Report (SER) submittal date of December 2035.

Fish

For the PR6 subsistence fisherman evaluation, there was one benchmark exceedance for mercury; however, the mean result of the detected results is less than the benchmark (mean ~~ratio~~HQ = 0.54); therefore, further evaluation is not warranted at this time. Also, Meyers Branch serves as a background location, and this location (side channel of Meyers Branch, unnamed tributary) is not influenced by SRS operational sources that would have provided contaminated discharges or a source of mercury.

Ecological Benchmark Screening ~~and Results~~

The biological data is supplemented with benchmark comparisons that are used as a screening step to identify constituents that may pose a threat to ecological receptors and require refinement during Phase II assessment. The ecological benchmarks for SC PR6 reflect an update to the thresholds following the approach established in the *Remedial Investigation Workplan/Baseline Risk Assessment for the Lower Three Runs IOU*.

Sediment

There were ecological benchmark exceedances in the Meyers Branch and Lower subunits. For the Meyers Branch subunit, dichlorodiphenyltrichloroethane, dichlorodiphenyldichloroethylene, dichlorodiphenyldichloroethane, and mercury require further evaluation (with mean ~~ratios~~HQs >1.0, a frequency of exceedance >5%, and mean detected levels ~~less~~greater than background). These exceedances are all located in the Meyers Branch subunit near or within the DRRY and are associated with the walk-down of the DRRY and IOU sampling conducted in 2015~~,~~. ~~and t~~These

pesticides and mercury will require further evaluation when the DDRY moves into the investigation phase. The DRRY is an active rail yard with an FFA Appendix G.1 (Site Evaluation) SER submittal date of December 2035.

SW

Constituents requiring further evaluation for SW include various semivolatiles: anthracene, benzo(a) pyrene, ~~benzo[b]fluoranthene,~~ benzo[g,h,i]perylene, benzo[k]fluoranthene, fluoranthene, and indeno[1,2,3-cd]pyrene in the Meyers Branch subunit, and cadmium and lead in the Lower SC subunit.

For the cadmium and lead in the Lower subunit, a review of all the SC PR6 cadmium data for SW in the IOU database for Lower SC revealed a total of 58 analyses for cadmium, with only one result is above background. Similarly, a review of the 58 analyses for lead revealed one result above background. As such, cadmium and lead do not require further evaluation for the Lower subunit.

The semivolatiles are all associated with a DRRY 2015 sampling effort, and, as with the ecological sediment exceedances, further evaluation is warranted. Although there is a low sample size (four samples), the data indicate contamination may be present. Therefore, the DRRY associated exceedances will require further evaluation as the DRRY approaches the SER submittal date.

Data Needs and Early Actions

The PR6 evaluation revealed a lack of recent fish data for Steel Creek/L Lake with the most recent field collections acquired in 2007. Passive diffusive gradients in thin films (DGT) samplers will be deployed in the SC IOU to provide screening data to estimate bioavailable concentrations of metal constituents to support future HH and the ecological screening. DGT samplers target bioavailable fractions of contaminants to help identify contaminants of interest that may pose a risk to ecological receptors, and in turn potential HH exposures such as fishing (consumption of fish). As the DGT sampling data is supplemented with biological data/tissue samples, the comparability of the approach to biological data collections such as fish will be demonstrated. These data will be reported in a future PR.

No constituents were retained for early action consideration based on the HH evaluation or the ecological assessment. Therefore, there are no early actions warranted for any portion of the SC IOU based on evaluation of PR6 data.

Data will continue to be compiled for periodic assessments. These data, typically consisting of IOU sampling efforts, OU investigations, annual environmental monitoring conducted by SRS and SCDHEC, and special studies that may be conducted by various data stewards will be used to assess the SC IOU as Phase II of the IOU program continues.

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LIST OF ABBREVIATIONS AND ACRONYMS

~	approximately
>	greater than
<	less than
%	percent
ac	acre
AMD	acid mine drainage
AR	antibiotic resistance
As	arsenic
ATSDR	Agency for Toxic Substances and Disease Registry
β	beta
BRA	baseline risk assessment
C	carbon
CCR	coal combustion residue
Cd	cadmium
COPC	contaminants of potential concern
Cr	chromium
Cu	copper
CSM	conceptual site model
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyl/dichlorethylene
DDT	dichlorodiphenyltrichloroethane
DGT	diffusive gradients in thin films
DRRY	Dunbarton Rail Road Yard
DW	deionized water
ECODS	Early Construction and Operations Disposal System
ERA	ecological risk assessment
Fe	iron
FFA	Federal Facility Agreement
FS	Feasibility Study
gal	gallon
GPS	Global Positioning System
GW	groundwater
ha	hectare
Hg	mercury
HH	human health
HQ	hazard quotient
IBI	Index of Biotic Integrity
IOU	integrator operable unit
km	kilometer
km^2	square kilometer
L	liter
LAOU	L-Area Operable Unit

LIST OF ABBREVIATIONS AND ACRONYMS *(Continued)*

LiDAR	Light Detection and Ranging
LTR	Lower Three Runs
LUC	land use control
m	meter
MCL	maximum contaminant level
MeHg	methylmercury
mg/kg	milligram per kilogram
MHSP	Multiple Habitat Sampling Protocol
mi	mile
mi^2	square mile
mg/L	milligram per liter
mg/kg	milligram per kilogram
MMI	Multimetric Macroinvertebrate Index
mo.	month
N	nitrogen
NBN	no building number
NFA	no further action
Ni	nickel
NOM	natural organic matter
NPDES	National Pollution Discharge Elimination System
OSW	on-site worker
OU	operable unit
PAGW	P-Area Groundwater
PAOU	P-Area Operable Unit
Pb	lead
pCi/g	picocuries per gram
PCR	post construction report
ppm	parts per million
PR	Periodic Report
RB	Rainbow Bay
RESRAD	RESidual RADioactivity
RI	remedial investigation
ROD	Record of Decision
RSL	Refinement Screening Level
RSV	Refinement Screening Value
SAP	Sampling and Analysis Plan
SC	Steel Creek
SCDHEC	South Carolina Department of Health and Environmental Control
Se	selenium
SEA	Site Evaluation Area
SeMet	selenomethionine
SE	standard error

LIST OF ABBREVIATIONS AND ACRONYMS *(Continued/End)*

SEMS	Superfund Enterprise Management Systems
SER	Site Evaluation Report
SR	Savannah River
SRNS	Savannah River Nuclear Solutions
SRS	Savannah River Site
SW	surface water
TCE	trichloroethylene
TF	transfer factor
U	uranium
USDOE	U.S. Department of Energy
USEPA	U.S. Environmental Protection Agency
UTR	Upper Three Runs
U.S.	United States
V	vanadium
WADB	Wetland Area Dunbarton Bay
WSRC	Westinghouse Savannah River Company, LLC
yr	year
Zn	Zinc

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1.0 INTRODUCTION

This periodic report (PR) has been developed to support the Integrator Operable Unit (IOU) program at the Savannah River Site (SRS). It is the sixth PR for the Steel Creek (SC) IOU. It is referred to as Periodic Report 6 (PR6). IOUs are defined as surface water (SW) bodies (e.g., streams and reservoirs) and associated wetlands, including the SW, sediment, floodplain sediment (sediment/soil), and related biota. The SC IOU is one of six IOUs under investigation at SRS. The IOUs are under investigation because they represent possible pathways for the release of contaminants from SRS activities, within their respective watershed, to on/off-unit receptors and the environment. IOUs represent the integration of potential contaminants discharged to SW or migrating through groundwater (GW) from source operable units (OUs), site evaluation areas, operational facilities/National Pollutant Discharge Elimination System (NPDES) outfalls to points of potential receptor exposure. These sources are not formal components of the IOU but evaluating their potential impact to the IOU SW bodies is part of the IOU assessment.

The IOU program is being implemented in three phases that will ultimately culminate in a Record of Decision (ROD) (Figure 1-1). Phase I of the IOU program consisted of an initial assessment of existing data to determine if any early actions were necessary and to determine data needs.

Phase I has been completed for the SC IOU and all SRS IOUs. Phase II of the IOU program is the ongoing sampling and assessment of the IOU and refinement of the conceptual site model (CSM) for the IOU until the start of Phase III. Phase II includes a screening level evaluation of risk to evaluate the need for early action and to identify data needs, both of which are reported in a PR. The Phase II screening is based on benchmarks appropriate for early action determination. The SC IOU is currently in Phase II. Phase III includes a Remedial Investigation (RI) to address final data needs and completion of the Baseline Risk Assessment (BRA), and Feasibility Study process through the ROD and remedial action, if applicable. If a portion of the IOU has the potential to accelerate into Phase III, the subsequent PR would propose the acceleration strategy. A design team meeting would then be scheduled to obtain agreement between the United States (U.S.) Department of Energy (USDOE), U.S. Environmental Protection Agency (USEPA), and South Carolina Department of Health and Environmental Control (SCDHEC) on the path forward.

PR6 documents the Phase II status of the SC IOU investigation based on new data and information obtained since the completion of *Periodic Report 5 for the Steel Creek Integrator Operable Unit* (SRNS 2014).

The purpose of SC PR6 is to:

- Provide the status of potential contaminant sources;
- Present the refined CSM based on the potential contaminant sources;
- Evaluate SC PR6 data which includes new analytical data from sampling activities that have occurred within the IOU including since compilation of the last PR;
- Assess the potential threat to human health (HH) and ecological receptors based on review of the PR6 data;
- Evaluate the need for early actions; and
- Develop data needs for the ongoing monitoring and assessment of the IOU based on review of the new data and information presented in this PR.

A Sampling and Analysis Plan (SAP) to address IOU generated data collection efforts will be developed as a separate document when warranted by the IOU program for the SC IOU.

1.1 Schedule

Regulatory approval of this and future PRs are followed by a Field Start initiating the next round of monitoring, sampling, or data compilation associated with the SC IOU. The next Federal Facility Agreement (FFA) (1993) milestone for the SC IOU is the Sixth Phase II Field Start for the SC IOU (Including Wetland Area at Dunbarton Bay [WADB] no building number [NBN], L Lake [NBN], and L-Reactor Discharge Canal [NBN]) scheduled for July 30, 2019.

Long-term projections listed in the FFA for the SC IOU include the following:

FFA Milestone	Date
Sixth Phase II Field Start	July 2019
Seventh Phase II Field Start	May 2023
Eighth Phase II Field Start	May 2027
Ninth Phase II Field Start	August 2030
Phase III Field Start	February 2059

The WADB (NBN) is part of the SC IOU. The remedial action Field Start for the WADB is February 19, 2019.

1.2 SC Subunits and Contaminant Sources

SC is located in the southeastern portion of the SRS between the Pen Branch and Lower Three Runs (LTR) stream systems and flows southwesterly for approximately (~) 17.5 kilometers (km [10.6 miles {mi}]) before entering the Savannah River (SR) via the SR swamp. The SC stream system includes L Lake, a cooling water reservoir, that is ~6.5-km (4-mi) long and relatively narrow, encompassing an area of about 418 hectares (ha [1,034 acres {ac}]) (WSRC 1997). Flow from the L Lake dam travels about 5 km (3 mi) before entering the SR swamp and then another 3 km (1.8 mi) before entering the SR. Meyers Branch is the main tributary of SC and flows ~10 km (6.2 mi) before entering SC below L Lake. Meyers Branch is a small blackwater stream that has remained relatively undisturbed by SRS operations. The total area drained by the SC-Meyers Branch system is about 91 square kilometers (km^2 [35 square miles {mi^2}]) (WSRC 1997).

The SC watershed includes two SRS facility areas, L Area and P Area. L Area (which includes L Reactor) is located entirely within the SC watershed. Portions of P Area are located within the SC watershed and the LTR watershed, respectively. The P Reactor building is located in the SC watershed, and the headwaters of SC originate near P Area. The industrial areas associated with P and L Areas cover ~5% of the SC watershed.

The SC IOU includes the L-Area Reactor Discharge Canal, P-Area Reactor Discharge Canal, L Lake, and the WADB. Remedial action is being pursued for the WADB to address ash deposits which emanated from the P-Area Basin which has already been closed. The ROD (Rev. 1) for the WADB was issued in April 2018 for excavation and land use control (LUCs). The FFA field start for the WADB is scheduled for 2/19/2019.

For data evaluation purposes, the SC IOU is divided into subunits that are based on sub-watershed boundaries. The following subunits comprise the SC IOU: Upper SC (the portion of SC above L Lake), L Lake, Lower SC (the portion of SC below Lake to the Savannah River swamp), and

Meyers Branch, the main tributary of SC. Figure 1-2 shows the SC watershed and includes the 1998 gamma survey for cesium-137.

The potential for contaminant impacts to the IOU are assessed based on knowledge of the OUs or inferred from contaminant migration analysis. Figure 1-3 provides an overview of the OUs within SC watershed (and adjacent watersheds) and identifies whether the unit is in the Assessment Phase, Remediation Phase, or Complete. For Assessment and Remediation Phase units, the potential SW flow paths for land surfaces are based on Light Detection and Ranging (LiDAR) elevation data from the U.S. Forest Service (USFS 2009). The LiDAR data were acquired for the SRS in 2009 to produce detailed, high resolution bare ground surface models. Data were acquired with an average of 10 pulses/square meter, and the entire point data set includes over 18 billion points. The total area covered by the acquisition is ~119,000 ha (294,054 ac) which is used to approximate SW flow directions from the OUs (listed by unit identification number, "ID", as described in Table 1-1) to receiving water bodies. The LiDAR data-generated surface contours are shown in Figures 1-4a and 1-4b.

Figures 1-4a and 1-4b also show the OUs in relation to GW plumes and GW potentiometric contours for the water table surface based on a 2003 regional scale interpretation utilizing 1,324 wells (Westinghouse Savannah River Company [WSRC] 2003). The potentiometric lines assist in the visualization and interpretation of GW flow directions of OUs that potentially impact the Upper Three Runs (UTR) IOU. The SRS watershed boundaries have also been revised based on interpretation of the 2009 LiDAR data. OUs that are included in the SC PR6 evaluation are presented in Table 1-1. These units are included because potential GW and/or SW transport pathways lead to the SC IOU providing a possible route of exposure to HH and/or ecological receptors. The Unit Status column on Table 1-1 includes ROD and no further action (NFA) determinations, and projected FFA scheduled Field Starts for OUs with future FFA commitments. Table 1-1 also describes OUs with GW components that are currently being addressed by an OU monitoring/assessment program. The "Particle Track Flows to" column in Table 1-1 describes where GW or SW pathways from a particular OU would ultimately discharge, based on potentiometric or LiDAR surface contours. OUs that have not been closed, or units that have a GW component with ongoing monitoring requirements~~,~~ may have the potential to impact the IOU~~.~~

~~and are considered a potential contaminant source to the SC IOU. Whether impact to the IOU may need to be considered during Phase II of the IOU program is summarized in the Potential Impact to GW or SW columns. Units that no longer represent a potential threat to the IOU due to implementation of remedial actions or issuance of regulatory decisions~~. However, the Potential Impact to GW or SW columns in the table summarizes whether impact to the IOU needs to be considered during Phase II of the IOU program. Closed units or units with ongoing remedial actions in place are noted as a "No" and are not ~~longer~~ considered an uninvestigated source to the IOU requiring action during Phase II evaluations. The CSMs have been developed to illustrate the relationship between potential contaminant sources (listed in Table 1-1) and their potential to impact various exposure media (SW, sediment, and/or sediment/soil) within the IOU and, consequently, human and/or ecological receptors.

The SC CSM is presented in Figure 1-5 and reflects the current understanding of potential contaminant sources and migration pathways for the SC IOU. Sources listed in Table 1-1 with a potential to impact the IOU are included in the SC CSM. Primary sources of contamination include the waste materials and the effluents generated from process facilities. Environmental media impacted by the release of primary source contamination become a secondary source. Secondary sources of contamination include sediment, sediment/soils, SW, and GW. Figure 1-6 is a general overview Site-wide CSM model representing all the IOUs that includes historical pathways.

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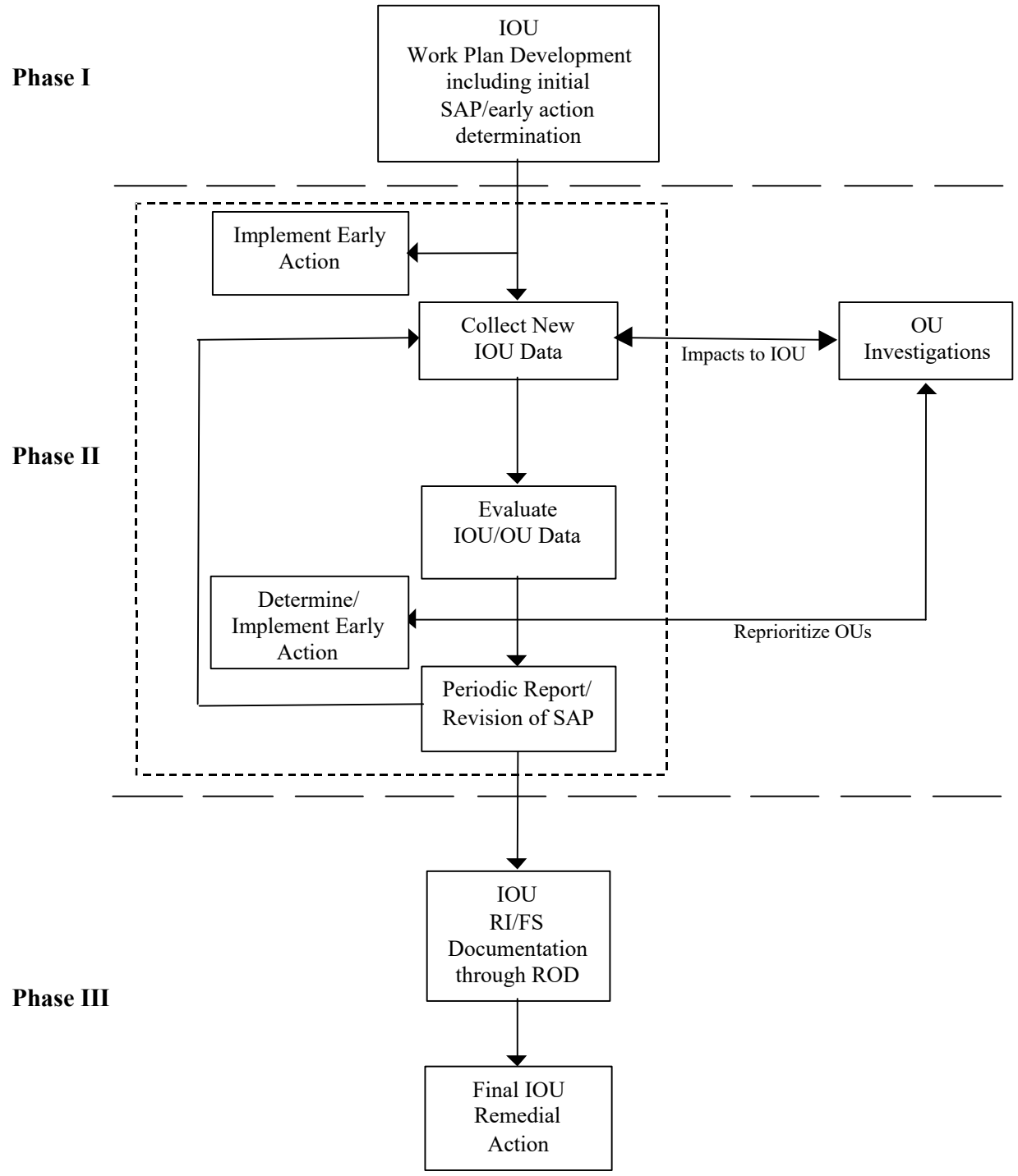

Figure 1-1. Flow Chart of the IOU Program

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Figure 1-2. SC IOU

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Figure 1-3. Operable Units Associated with the Steel Creek IOU

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Figure 1-4a. Operable Units, Potentiometric Contours, and Groundwater Plumes Associated with the UTR IOU – L Area

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Figure 1-4b. Operable Units, Potentiometric Contours, and Groundwater Plumes Associated with the UTR IOU – P Area and G Area

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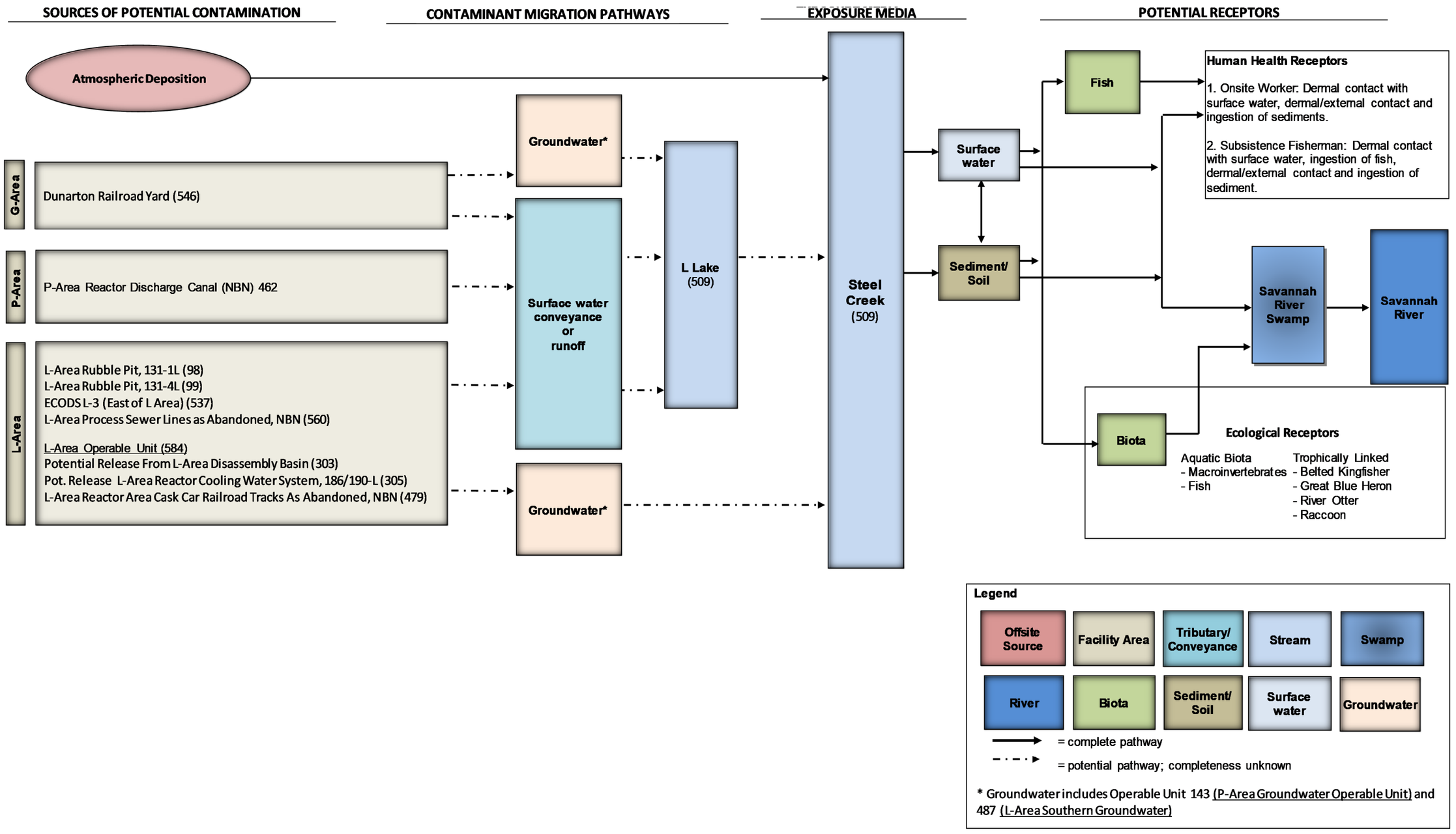

Figure 1-5. SC IOU Conceptual Site Model

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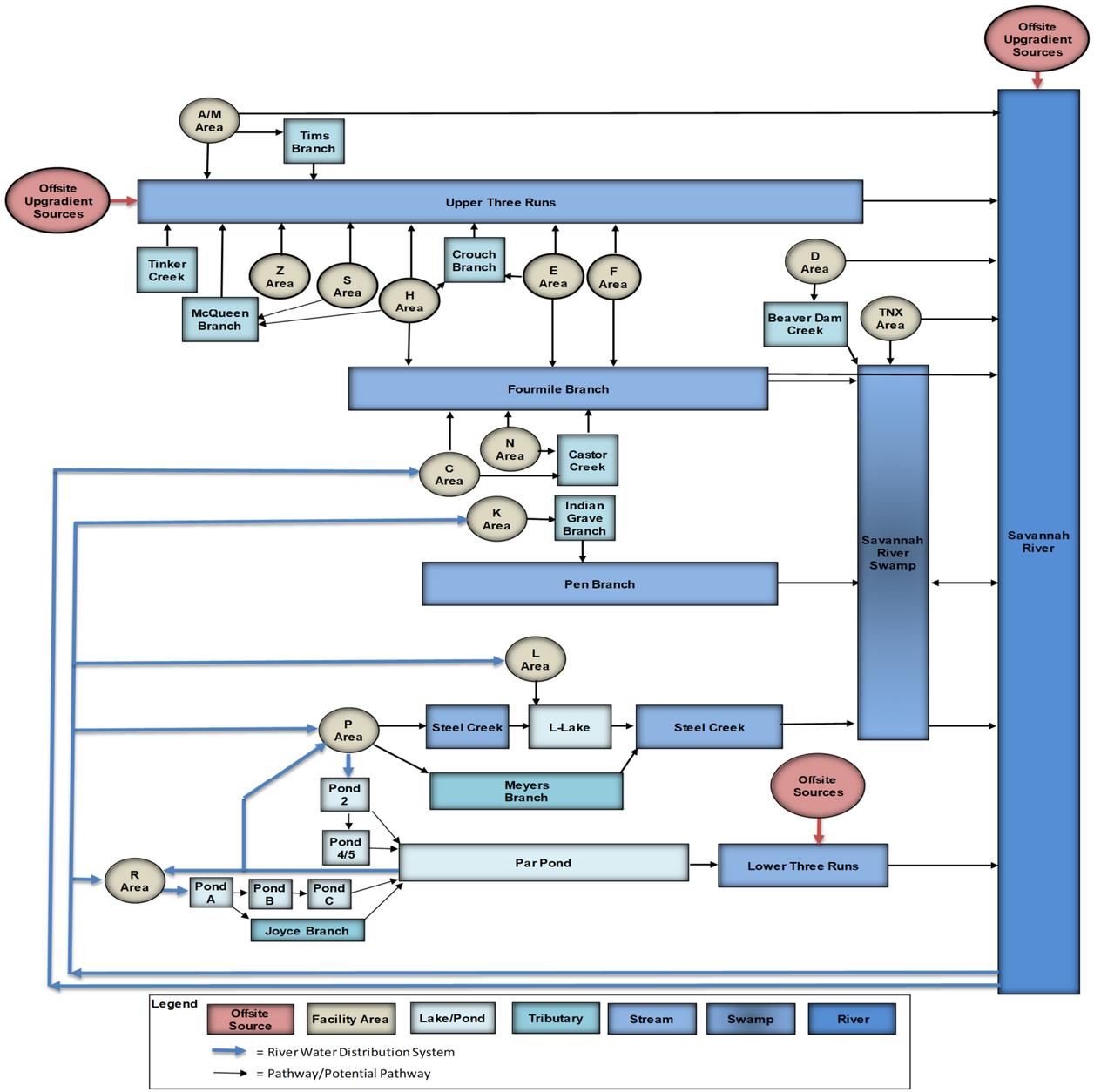

Figure 1-6. SRS–Wide Conceptual Site Model

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Table 1-1. Status of Potential IOU Contaminant Sources

Area	Unit ID	Particle Track Flows To	Unit Name	Potential Impact to GW*	Potential Impact to SW*	Contaminated Media	Unit Status
G	171	GW SC SW SC	Meyers Mill Siding Rubble Pile, NBN	No	No	Soil	NFA approved 6/19/1995
G	172	GW LTR SW SC	Miscellaneous Rubble at Dunbarton, NBN	No	No	Soil	NFA approved 11/4/1996
G	173	GW LTR SW SC	Miscellaneous Trash at Snapp, NBN	No	No	Soil	NFA approved 6/19/1995
G	192	GW SC SW SC	Scrap Metal Pile, 631-18G	No	No	Soil	NFA approved 7/13/1994
G	334	GW SC SW SC	Road 9 at Gate 23 Rubble Pile, NBN	No	No	Soil	NFA approved 12/20/1999
G	335	GW SC SW SC	Road 9 Rubble Pile, NBN	No	No	Soil	NFA approved 12/20/1999
G	509, 462	509 SC 462 GW SC SW SC	SC IOU (Including L Lake, NBN, L-Area Reactor Discharge Canal, NBN, P-Area Discharge Canal, NBN, and Wetland Area at Dunbarton Bay, NBN)	Yes	Yes	Sediment	IOU Phase II periodic reporting, SC IOU now includes the Wetland Area at Dunbarton Bay, NBN. SC IOU Sixth Phase II Field Start 7/20/2019. WADB ROD, Rev 1, issued 6/20/2018, selected remedial action is excavation and LUCs. FFA remedial actions start 2/30/2019.
G	518	GW SR SW SC	Gun Emplacement 407A & 407B Rubble Pile, NBN	No	No	Soil	NFA approved 5/30//30/2006.
G	546	GW LTR SW LTR/SC	Dunbarton Railroad Yard, NBN	Yes	Yes	Soil	Active Unit. Site Evaluation Report December 2035.
L	94	GW SC SW SC	L-Area Hot Shop (including Sandblast Area CML-003, NBN), 717-G	No	No	Soil	Unit Complete. ROD, Rev. 1.1, issued 11/3/2003. Post-Construction Report approved 1/30/2006. GW addressed under LASG (Unit 487). Request to remove the LUC requirement for the L-Area Hot Shop OU and designate as No Action OU approved by SCDHEC and USEPA 3/31/2014.
L	95	GW SC SW SC	L-Area Acid/Caustic Basin, 904-79G	No	No	Soil	Unit Complete. No Action, ROD, Rev. 1, issued 11/10/1998.

Table 1-1. Status of Potential IOU Contaminant Sources *(Continued)*

Area	Unit ID	Particle Track Flows To	Unit Name	Potential Impact to GW*	Potential Impact to SW*	Contaminated Media	Unit Status
L	96	GW SC SW SC	L-Area Oil/Chemical Basin, 904-83G	No	No	Soil	Unit Complete. ROD, Rev. 1, issued 11/10/1998, solidification/stabilization, capping. post construction report (PCR) approved 11/7/2001. GW addressed under LASG (Unit 487).
L	98	GW SC SW SC	L-Area Rubble Pit, 131-1L	Yes	Yes	Soil	Part of ECODS L-3 (East of L Area) (NBN), L-Area Rubble Pit (131-1L), L-Area Rubble Pit (131-4L), and L-Area Ash Basin (188-0L) OU. FFA Field Start 9/2022.
L	99	GW SC SW SC	L-Area Rubble Pit, 131-4L	Yes	Yes	Soil	Part of ECODS L-3 (East of L Area) (NBN), L-Area Rubble Pit (131-1L), L-Area Rubble Pit (131-4L), and L-Area Ash Basin (188-0L) OU. FFA Field Start 9/2022.
L	170	GW SC SW SC	L-Area Scrap Metal and Wood, NBN	No	No	Soil	NFA approved 11/4/1996.
L	176	GW SC SW SC	Pile of Telephone/Light Poles, NBN	No	No	Soil	NFA approved 6/19/1995.
L	303	GW SC SW SC	Potential Release from L-Area Disassembly Basin	Yes	Yes	Soil	Part of L-Area Operable Unit (LAOU) (Unit 584). FFA Field Start 9/2034.
L	305	GW SC SW SC	Potential Release from the L-Area Reactor Cooling Water System, 186/190-L	Yes	Yes	Soil	Part of LAOU (Unit 584). FFA Field Start 9/2034.
L	306	GW SC SW SC	L-Area Reactor Seepage Basin, 904-064G	No	No	Soil	Unit Complete. Plug-in ROD Amendment, Rev. 1, issued 12/5/2002, Post-construction report approved 3/23/2004. GW addressed under LASG (Unit 487).
L	323	GW SC SW SC	Potential Release of NaOH/ H_2SO_4 from 183-2L, NBN	No	No	Soil	NFA approved 7/2/1997.
L	452	GW SC SW SC	Spill on 09/21/84 of 200 gal of water -Rad, NBN	No	No	Soil	NFA approved 10/17/2005.
L	479	GW SC SW SC	L-Area Reactor Area Cask Car Railroad Tracks As Abandoned, NBN	Yes	Yes	Soil	Part of LAOU (Unit 584). FFA Field Start 9/2034

Table 1-1. Status of Potential IOU Contaminant Sources *(Continued)*

Area	Unit ID	Particle Track Flows To	Unit Name	Potential Impact to GW*	Potential Impact to SW*	Contaminated Media	Unit Status
L	487	GW SC SW SC	L-Area Southern Groundwater, NBN	Yes	Yes	Groundwater	ROD, Rev. 1.1, issued 5/9/2007; selected remedy monitored natural attenuation with LUCs. GW monitoring/reporting requirements continue. Next effectiveness monitoring report submittal 6/30/2020.
L	495	GW SC SW SC	Sandblast Area CML-001, NBN	No	No	Soil	NFA approved 9/29/2000.
L	496	GW SC SW SC	Sandblast Area CML-002, NBN	No	No	Soil	NFA approved 9/29/2000.
L	535	GW SC SW SC	ECODS L-1 (East of L Area)	No	No	Soil	Unit complete. ROD, Rev. 1, issued 3/30/2010, LUCs, DMIR/RACR approved 4/13/2011. Field inspections continue.
L	536	GW SC SW SC	ECODS L-2 (East of L Area)	No	No	Soil	NFA approved 1/4/2006.
L	537	GW SC SW SC	ECODS L-3 (East of L Area)	Yes	Yes	Soil	Part of ECODS L-3 (East of L Area) (NBN), L-Area Rubble Pit (131-1L), L-Area Rubble Pit (131-4L), and L-Area Ash Basin (188-0L) OU. FFA Field Start 9/2022.
L	560	GW SC SW SC	L-Area Process Sewer Lines as Abandoned, NBN	Yes	Yes	Soil	Part of LAOU (Unit 584). FFA Field Start 9/2034.
L	584	N/A	L Area Operable Unit	Yes	Yes	Soil	FFA Field Start 9/2034
P	107	GW SC SW LTR	P-Area Bingham Pump Outage Pit, 643-4G	No	No	Soil	Unit complete. Final Remediation Report approved 6/13/2000; LUCs. Field inspections continue.
P	108	GW SC SW SC	P-Area Burning/Rubble Pit, 131-P	No	No	Groundwater/Soil	Unit complete ROD, Rev. 1 issued 8/8/2003. PCR approved 10/29/2004. GW monitoring/reporting continues.
P	109	GW SC SW SC	P-Area Coal Pile Runoff Basin, 189-P	No	No	Soil	Basin soils removed in 1997. No Action ROD, Rev. 1, issued 11/10/1998.
P	126	GW SC SW SC	Spill on 3/15/79 of ,5500 gallons of contaminated water, NBN	No	No	Soil	Part of P-Area Operable Unit (PAOU) (Unit 587). Unit complete. Non-time critical removal action addressed with Unit 557. PCR approved 8/27/2012, LUCs for PAOU.
P	143	GW SC SW SC/LTR	P-Area Groundwater Operable Unit	Yes	Yes	Groundwater	Trichloroethylene Plumes Discharging to SC Removal Action start 04/30/2019. ROD issuance May 2031, Remedial Action Start July 2032.

Table 1-1. Status of Potential IOU Contaminant Sources *(Continued)*

Area	Unit ID	Particle Track Flows To	Unit Name	Potential Impact to GW*	Potential Impact to SW*	Contaminated Media	Unit Status
P	221	GW SC SW SC	Sandblast Area CMP-003, NBN	No	No	Soil	NFA approved 12/6/1999
P	313	GW SC SW SC	P-Area Ash Basin, 188-0P	No	No	Soil	Part of PAOU (Unit 587). Unit complete. Non-time critical removal action for consolidation of ash with soil cover. PCR approved 8/27/2012. LUCs for PAOU.
P	314	GW SC SW SC	Potential Release from P-Area Disassembly Basin, 105-P	No	No	Soil	Part of PAOU (Unit 587). Unit complete. PCR approved 8/27/2012. No action required for this unit. LUCs for PAOU.
P	315	GW SC SW SC	P-Area Erosion Control Site, 131-1P	No	No	Soil	NFA approved 6/5/2003
P	317	GW SC SW SC	P-Area Reactor Seepage Basin, 904-061G	No	No	Soil	Unit Complete. ESD to Plug-in ROD issued 10/2/2003, PCR approved 5/30/2006.
P	318	GW SC SW SC	P-Area Reactor Seepage Basin, 904-062G	No	No	Soil	Unit Complete. ESD to Plug-in ROD issued 10/2/2003, PCR approved 5/30/2006
P	319	GW SC SW SC	P-Area Reactor Seepage Basin, 904-063G	No	No	Soil	Unit Complete. ESD to Plug-in ROD issued 10/2/2003, PCR approved 5/30/2006
P	356	GW SC SW SC	Sandblast Area CMP-004, NBN	No	No	Soil	NFA approved 9/10/1998.
P	358	GW SC SW SC	Sandblast Area CMP-001, NBN	No	No	Soil	NFA approved 9/10/1998
P	434	GW SC SW SC	Spill on 05/09/85 of 375 gal of Process Water from 106-P, NBN	No	No	Soil	NFA approved 9/10/1998
P	439	GW SC SW LTR	Spill on 06/26/86 of 1 gal of Tritiated Waste Oil from 110-P, NBN	No	No	Soil	NFA approved 3/15/1999.
P	453	GW SC SW SC	Spill on 09/28/87 of <30 gal of Bromocide Soln from 607-22p, NBN	No	No	Soil	NFA approved 1/26/1999

Table 1-1. Status of Potential IOU Contaminant Sources *(Continued/End)*

Area	Unit ID	Particle Track Flows To	Unit Name	Potential Impact to GW*	Potential Impact to SW*	Contaminated Media	Unit Status
P	477	GW SC SW SC	P Reactor Area: P-Area Reactor Area Cask Car Railroad Tracks as Abandoned, NBN	No	No	Soil	Part of PAOU (Unit 587). Unit complete. PCR approved 8/27/2012. No action was required for this unit. LUCs for PAOU
P	498	GW SC SW SC	Sandblast Area CMP-002, NBN	No	No	Soil	NFA approved 12/6/1999
P	515	GW SC SW SC	Combined Spills from 105-P, 106-P, and 109-P, NBN	No	No	Soil	NFA approved 3/15/1999
P	538	GW SC SW SC	ECODS P-1 (South of P Area)	No	No	Soil	NFA approved 7/18/2003
P	539	GW SC SW SC	ECODS P-2 (South of P Area)	No	No	Soil	Unit complete. ROD, Rev. 1 issued 3/30/2010, CMIR/RACR approved 4/13/2011, LUCs, Field inspections continue.
P	547	GW SC SW SC	P-Area Coal Pile, NBN	No	No	Soil	NFA approved 4/18/2005.
P	557	GW LTR SW LTR	P-Area Process Sewer Lines as Abandoned, NBN	No	No	Soil	Part of PAOU (Unit 587). Unit complete. Non-Time Critical Removal Action addressed with Unit 126. PCR approved 8/27/2012, LUCs for PAOU
P	587	N/A	P-Area Operable Unit	No	No	Soil	Unit complete. PCR approved 8/27/2012. LUCs for PAOU.

***** The term "potential impact" is used to denote whether further evaluation may be required by the IOU program during Phase II monitoring and assessment. The potential impact consideration does not apply to closed units or units with ongoing remedial actions in place.

CMI/RAIP = Corrective Measures Implementation/Remedial Action Implementation Plan;
CMI/RACR = Corrective Measures Implementation Report/Remedial Action Completion Report;
EPA = Environmental Protection Agency;
FFA = Federal Facility Agreement;
GW = Groundwater;
IOU = Integrator Operable Unit;
LAOU = L Area Operable Unit;
LASG = L Area Southern Groundwater;
LTR = Lower Three Runs IOU;
LUCs = Land Use Controls;
MISC = Miscellaneous;
N/A = Not Applicable (Particle tracks are associated with individual units, not Operable Units);
NFA = No Further Action;
OU = Operable Unit;
PAHs = Polycyclic Aromatic Hydrocarbons;
PAOU = P Area Operable Unit;
PCR = Post-Construction Report;
ROD = Record of Decision; SCDHEC = South Carolina Department of Health and Environmental Control;
SC IOU = Steel Creek Integrator Operable Unit;
SW = Surface Water;
SR = Savannah River and Floodplain Swamp IOU;
VOCs = Volatile Organic Compounds
WADB = Wetland Area at Dunbarton Bay

Orange shaded rows indicate units with a potential impact to the SC IOU.

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2.0 PRESENTATION OF SC IOU DATA AND BENCHMARK SCREENING

The SC PR6 data set includes analytical results for constituents in sediment and SW that are screened as potential contaminants against HH and ecological benchmarks established for each media. The data set also includes fish data that are screened against HH benchmarks. The benchmarks for SC PR6 represent a change to the IOU program and were developed following the approach established in the *Remedial Investigation Workplan/Baseline Risk Assessment for the Lower Three Runs IOU* (SRNS 2017). The LTR IOU is the first IOU to reach Phase III of the IOU program (final action determination). In general, the IOU benchmarks have been revised to reflect final action screening levels to assist in problem formulation and refinement of the risk assessment as Phase II continues over the next several decades. The benchmarks used for the LTR BRA are also in line with the BRA for the G-Area Oil Seepage Basin, the most recently developed BRA. Further discussion on the updated benchmarks is provide in Section 2.1. The benchmarks used for screening data for this PR are provided in Appendix A.

The analytical data collected and compiled for SC PR6 are used to screen the IOU from a HH and ecological risk perspective. The screening is conducted by comparing constituent concentrations to pre-established benchmark values for each medium resulting in a screening level risk evaluation. The SC PR6 data set includes SW, sediment, and fish data. The sediment medium represents stream/pond sediments that generally remain inundated (covered) with SW. The sediment, SW, and fish benchmark comparisons are used to support early action determinations and data need determinations.

Benchmark screening is conducted to:

- identify any discernable areas within the IOU warranting early action consideration,
- identify OUs for potential reprioritization, and
- identify areas in need of additional sampling or periodic monitoring.

The benchmark evaluations are based on the SC PR6 dataset compiled by subunit but are also supplemented by additional data from the IOU database if further scrutiny is required. For both the HH and ecological evaluations, the benchmark exceedance discussions are supplemented with

statistical parameters associated with the magnitude and frequency of benchmark exceedances. A maximum hazard quotient (HQ) (maximum detected value/benchmark) and a mean HQ (mean detected value/benchmark) are calculated for each constituent per subunit and are used to determine if maximum and/or mean values are greater than the benchmark (i.e., maximum and/or mean HQ greater than [>] 1.0). The mean HQ is used to represent receptors that average their exposure within the IOU subunit. For Phase II IOU evaluations, the mean is calculated using only detected values to provide a more conservative approach to screening. Constituents with a low mean HQ (mean HQ <1.0), as grouped by subunit, do not warrant further evaluation. Similarly, constituents with a low frequency of exceedance (5% or less) do not require additional evaluation by the IOU program. The background data are also used to determine the importance of benchmark exceedances. If levels observed within the IOU are within background levels, this indicates contaminants within the IOU are not unit related, and that further investigation by the IOU is not warranted at this time.

The tables presenting the statistical parameters associated with each media-receptor combination are provided in Sections 2.1.2 and 2.1.3 for the HH and ecological screening, respectively. HH benchmark exceedances are provided in Table 2-2. Figure 2-1 identifies historical sediment/soil sampling locations. There are no new sediment/soil data for SC PR6. The figures showing the sampling locations for constituents with benchmark exceedances are presented in Figures 2-2 through 2-4 for sediment, SW, and fish media, respectively. Several exceedances may be present at a single sampling location; therefore, the total number of exceedances may not be visible on the figures. The sample locations are color-coded to represent the SC subunit associated with each particular sample location.

2.1 HH Benchmark Screening and Results

For the SC IOU, benchmarks screening is conducted to evaluate potential contaminants in sediment, sediment/soil, SW, and fish media. The HH screening is conducted based on the following exposure scenarios:

> The on-site worker (OSW) receptor scenario is site specific and describes a worker who is performing maintenance, collecting samples, or conducting research within

the SC IOU. The exposure assumptions for the onsite worker are 20 years, 150 days/year, and 8 hours per day. These site-specific assumptions are based on input provided by the Savannah River Ecology Laboratory and describe a wetlands researcher. Exposure routes associated with sediment/soil include inhalation, external exposure to radiation, dermal absorption, and incidental ingestion. This receptor is routinely evaluated by the IOU program and is the most likely receptor exposure scenario for the SC IOU.

The hypothetical resident receptor scenario is evaluated for the SW media. This includes a comparison of constituents to SW threshold levels based on regulatory based maximum contaminant levels (MCLs). Use of this scenario is new to the IOU program and is being implemented to assess contaminants in SW from a promulgated regulatory-based contaminant level for protection of HH exposure to drinking water sources. Although the SC IOU does not serve as a drinking water source, MCLs are pertinent thresholds for future final action determinations as the SC IOU approaches Phase III of the IOU program.

The subsistence fisherman receptor scenario is site specific and describes a person who fishes frequently enough to provide a substantial portion of his diet from fish (26 years, 20 days/year, 6 hours/day). This exposure scenario is evaluated by comparing fish tissue concentrations to receptor-based threshold levels for fish based on ingestion. The exposure assumptions for fish ingestion are 26 years, 350 days/year, and 170 grams (6 ounces) of fish fillet ingested per day.

Analytical data for each media (i.e., sediment, SW, and fish) are combined by subunit and evaluated based on established criteria as discussed below.

For the SC IOU HH evaluation, benchmark screening is conducted to evaluate potential contaminants in sediment, SW, and fish media. The on-site worker benchmarks are used to screen sediment data. For SW, the benchmarks are MCLs. The subsistence fisherman benchmarks are used to evaluate the fish medium. The sediment data are screened against a $1x10^{-4}$ risk level benchmarks for the OSW, similarly, fish data are screened against a $1x10^{-4}$ risk level for a subsistence fisherman. The $1x10^{-4}$ risk (or HQ = 3) level is appropriate for Phase II early action determination. Alternatively, the HH screening for SW is based on MCLs. Although SW on the

SRS is not used as a drinking water source, the MCL screening assists in problem formulation as the IOU program continues with Phase II reporting.

If a HH benchmark value is exceeded, the following criteria are considered to determine the significance of the exceedance(s):

1. exceedance frequency (number of exceedances/the number of samples x 100),
2. a mean-value consideration (detected mean value/benchmark greater than 1.0),
3. background data (mean detected value greater than maximum background levels (or if background is indeterminate), and
4. receptor appropriateness.

If the frequency of exceedance is >5%, the mean HQ >1.0, and the mean detected value is greater than maximum background levels (or if background is indeterminate) for a constituent, further evaluation is required. The benchmarks used for the HH evaluation are provided in Appendix A.

Sediment

A summary of the HH exceedances for the sediment medium for the OSW are provided in Table 2-2 and shown in Figure 2-2. For PR6, there were cesium-137 benchmark (14.4 pCi/g) exceedances for the OSW for the Upper and Lower subunits. Although the detected mean value (10.7 pCi/g for the Upper subunit, 4.84 pCi/g for the Lower subunits) is greater than background (0.623 pCi/g), mean ~~ratios~~ HQs are <1.0. For the Upper subunit, there was one exceedance out of two analyses with a mean ~~ratio~~HQ of 0.74. For the Lower subunit, there was one exceedance out of five analyses with a mean ~~ratio~~HQ of 0.34. Since the detected means were less than the benchmark
(14.4 pCi/g) for both the Upper and Lower subunits, further evaluation by the IOU program is not warranted. The locations of the exceedances are in areas of known cesium-137 contamination. Administrative controls remain in place for workers in these areas.

SW

A summary of the HH hypothetical resident exceedances for the SW medium are provided in Table 2-2 and shown in Figure 2-3.

The HH evaluation for SW resulted in SW exceedances for the hypothetical resident for benzo(a)pyrene (benchmark = 0.0002 mg/L), cadmium (benchmark = 0.005 mg/L), lead (benchmark = 0.015 mg/L), thallium (benchmark = 0.002 mg/L), trichloroethylene (TCE) (benchmark = 0.005 mg/L), and tritium (benchmark = 20,000 pCi/L). Constituents with a mean ~~ratio~~HQ >1.0, a frequency of exceedance >5% (with at least 20 analyses), and with a detected mean above maximum background (or background data are non-detects and indeterminate) include benzo(a)pyrene in the Meyers Branch subunit and TCE and tritium in the Upper subunit. Therefore, these constituents warrant further evaluation.

TCE was present with a mean detected value of 0.0111 mg/L, mean ~~ratio~~HQ of 2.22 and a frequency of exceedance of 25%). Tritium has with a mean detected value of 256,222 pCi/L, mean ~~ratio~~HQ of 12.8, and a frequency of exceedance of 87.7%). Upper SC is an area with known tritium and TCE contamination. SW is being monitored in Upper SC as part of the PAGW OU. A non-time critical removal action will be implemented at PAGW OU to reduce the mass of TCE in GW that discharges to SC. The start date for the removal action is currently scheduled for April 30, 2019. Additional monitoring has been proposed for SW under the *Sampling and Analysis Plan Addendum for P-Area Groundwater Operable Unit* (SRNS 2018) for TCE and tritium to determine the presence and extent of contamination. As such, further evaluation by the IOU program is not warranted at this time.

Exceedances of benzo(a)pyrene were from sample locations associated with the Dunbarton Rail Road Yard (DRRY) 2015 sampling. This would indicate potential contamination that warrants further evaluation. There were only four samples taken during the 2015 sampling effort, and two of those locations resulted in SW exceedances. Although the SW is not used as a drinking water source, further evaluation of the DRRY associated samples is warranted as the SC IOU approaches Phase III of the IOU program.

Fish

A summary of the HH exceedances for the subsistence fisherman are provided in Table 2-2 and shown in Figure 2-4.

For the PR6 subsistence fisherman evaluation, there was one benchmark exceedance for mercury (benchmark = 0.1473 mg/kg) in the Meyers Branch subunit out of three analyses with a mean of 0.0801 mg/kg. The mean result of the three detected results, 0.0801 mg/kg, is less than the benchmark (mean ~~ratio~~HQ = 0.54), therefore, further evaluation is not warranted at this time. Also, Meyers Branch serves as a background location, and this location (side channel of Meyers Branch, unnamed tributary) is not influenced by SRS operational sources that would have provided contaminated discharges or a source of mercury. Mercury is elevated regionally due to atmospheric deposition; and although not a potential source to Meyers Branch, mercury is also elevated in the Savannah River because of upgradient SR historic discharges. There is a SCDHEC issued fish advisory for mercury in the SR.

2.2 Ecological Benchmark Screening and Results

The purpose of the ecological evaluation is to provide an overall indicator of ecological health for the SC IOU. The biological data is supplemented with benchmark comparisons that are used as a screening step to identify constituents that may pose a threat to ecological receptors and require refinement during Phase II assessment. The ecological benchmark screening process provides the basis for determining whether early action may need to be considered and provides the justification for subsequent investigations that support the ecological risk assessment process for the SC IOU.

The ecological benchmarks for SC PR6 reflect an update to the thresholds initially compiled for the IOU program. The updated benchmarks following the approach established in the *Remedial Investigation Workplan/Baseline Risk Assessment for the Lower Three Runs IOU*. The LTR IOU was the first IOU to reach Phase III of the IOU program (final action determination). In general, the IOU benchmarks have been revised to reflect final action screening levels to assist in problem formulation and refinement of the ecological risk assessment process as Phase II continues over the next several decades.

The ecological screening thresholds (benchmarks) are based on a single benchmark for each analyte/medium combination. The sediment benchmarks are based on Refinement Screening Value to focus the evaluation on constituents that may require further discussion and scrutiny. The SW threshold values are based on the SCDHEC, R.61-68, Water Classifications and Standards

(SCDHEC 2014) and USEPA Region 4 ERA Supplement Guidance (USEPA 2018) chronic values. The RESidual RADioactivity (RESRAD) screening values are used for detected radionuclides. The RESRAD Tier 3 values were generated by Savannah River National Laboratory for each detected nuclide available and is based on dose calculations for aquatic animals. The ecological benchmarks are provided in Appendix A.

Constituents that exceed benchmark values are processed further using a lines-of-evidence approach for three criteria: 1) the frequency of benchmark exceedances, 2) mean HQ (mean detected value/the benchmark, and 3) a background evaluation. For constituents with a frequency of exceedance >5%, a mean HQ >1.0, and a mean detected value greater than maximum background levels (or if background is indeterminate), further evaluation is required. Biological data are used to determine if possible early actions may need to be considered. For the ecological evaluation, early actions may include additional ecological data collection during Phase II of the IOU program (long-term monitoring and assessment) to further assess potential threats.

Sediment

A summary of the ecological exceedances for the sediment medium are provided in Table 2-3 and depicted in Figure 2-5.

There were ecological benchmark exceedances in the Meyers Branch and Lower subunits. For the Meyers Branch subunit, there were exceedances for barium (benchmark = 60 mg/kg, with one exceedance out of five analyses), dichlorodiphenyltrichloroethane (DDT) (benchmark = 0.007 mg/kg, with two exceedances out of four analyses), dichlorodiphenyldichloroethane (DDD) (benchmark = 0.0085 mg/kg, with two exceedances out of four analyses), dichlorodiphenyl/dichlorethylene (DDE) (benchmark = 0.0068 mg/kg, with three exceedances out of four analyses) mercury (benchmark = 0.0045 mg/kg, with four exceedances out of five analyses), and selenium (benchmark = 1.2 mg/kg, with two exceedances out of five analyses).

The barium exceedances for the Meyers Branch subunit had a mean ~~ratio~~HQ below 1.0 (0.54) and does not require further evaluation. The selenium exceedances~~, as well~~, (with a mean HQ of 1.23),

have a background value of 5.65 mg/kg, (greater than both detected results of 1.73 mg/kg and 1.21 mg/kg), and do not require further evaluation. For DDT (mean ~~ratio~~HQ 62.1), DDD (mean ~~ratio~~HQ 6.6), DDE (mean ~~ratio~~HQ 55.7) and mercury (mean ~~ratio~~HQ 16.4), mean ~~ratios~~ HQs were greater than 1.0, and the background levels were either non-determinant or less than unit values. Therefore, these constituents do require further evaluation.

There were two DDD exceedances, three DDE exceedances, and two DDT exceedances based on 2015 data for SC PR6. These exceedances are all located in the Meyers Branch subunit near or within the DRRY and are associated the walk-down of the DRRY and IOU sampling conducted in 2015. It is likely that there was a past presence of DDT at/near the DRRY. DDT (and its metabolites, DDE and DDD) are infrequently detected within the IOUs and are likely associated with past farming practices prior to SRS becoming federal property. DDT (and its metabolites) are persistent contaminants, and these pesticides will require further evaluation when the DDRY moves into the investigation phase. The DRRY is an active rail yard with an FFA Appendix G.1 (Site Evaluation) Site Evaluation Report (SER) submittal date of December 2035.

~~The mean detected value for mercury associated with the DRRY (0.0575 mg/kg) is above the background value (0.021 mg/kg). For the Meyers Branch subunit, t~~There were four exceedances ~~(above the background level) out of five analyses~~ for mercury (benchmark = 0.0045 mg/kg) for the Meyers Branch subunit with a mean ~~ratio~~HQ of ~~16.4~~12.8 associated with the DRRY. The mean detected value for mercury (0.0575 mg/kg) is above the background value (0.021 mg/kg). Mercury ~~L~~levels in the Meyers Branch subunit ranged from 0.0724 mg/kg to 0.0249 mg/kg. The DRRY associated mercury exceedances will require further evaluation as the DRRY unit approaches the SER submittal date.

For mercury ~~(benchmark = 0.0045 mg/kg)~~ in the Lower subunit, there was one exceedance (0.0165 mg/kg) out of four analyses with a mean ~~ratio~~HQ of ~~4.7~~3.7. The current maximum IOU background level for mercury in sediment is 0.021 mg/kg. The mean detected value for mercury for Lower subunit (0.0165 mg/kg) was below background and, therefore, does not require further evaluation.

SW

The IOU database compiles data from various data stewards; therefore, the assessment of SW classifies results for metals as representative of total metals. For freshwater metals criteria-based benchmarks that are hardness-dependent (cadmium, chromium, copper, lead, nickel, silver, and zinc), the benchmark values are based on a water hardness of 25 mg/l (as expressed as CaCO3) which is appropriate for the SC IOU based on review of SC hardness data. A summary of SW benchmark exceedances is provided in Table 2-3 and depicted in Figure 2-6. There were ecological exceedances for aluminum (benchmark = 0.0870 mg/L), anthracene (benchmark = 0.00002 mg/L), benzo(a) pyrene (benchmark = 0.00006 mg/L), benzo[b]fluoranthene (benchmark = 0.0026 mg/L), benzo[g,h,i]perylene (benchmark = 0.000012 mg/L), benzo[k]fluoranthene (benchmark = 0.00006 mg/L), cadmium (benchmark = 0.0001 mg/L), copper (benchmark = 0.0029 mg/L), fluoranthene (benchmark = 0.0008 mg/L), indeno[1,2,3-cd]pyrene (benchmark = 0.000012 mg/L), iron (benchmark = 1.000 mg/L), lead (benchmark = 0.00054 mg/L), manganese (benchmark = 0.0930 mg/L), nickel (benchmark = 0.016 mg/L), thallium (benchmark = 0.006 mg/L) and zinc (benchmark = 0.037 mg/L).

Constituents requiring further evaluation (with mean ~~ratio~~HQs >1.0, a frequency of exceedance >5%, and mean detected levels greater than background) include various semivolatiles: anthracene (mean HQ of 114), benzo(a) pyrene (mean HQ of 30), ~~benzo[b]fluoranthene,~~ benzo[g,h,i]perylene (mean HQ of 255), benzo[k]fluoranthene (mean HQ of 34.8), fluoranthene (mean HQ of 2.8), and indeno[1,2,3-cd]pyrene (mean HQ of 253) in the Meyers Branch subunit, and cadmium (mean HQ of 121) and lead (mean HQ of 39) in the Lower SC subunit.

For the cadmium and lead in the Lower subunit, a review of all the SC PR6 cadmium data for SW in the IOU database for Lower SC revealed a total of 58 analyses for cadmium, with only one result is above background. Similarly, a review of the 58 analyses for lead revealed one result above background. As such, cadmium and lead do not require further evaluation for the Lower subunit.

The semivolatiles are all associated with a DRRY 2015 sampling effort, and, as with the ecological sediment exceedances, further evaluation is warranted. Although there is a low sample size (four

samples), the data indicate contamination may be present. Therefore, the DRRY associated exceedances will require further evaluation as the DRRY approaches the SER submittal date.

Biological Data and Benchmark Screening Results

There are ecological benchmark exceedance warranting further evaluation for SW (several semivolatiles) and sediment (a few pesticides and mercury) associated with DRRY. The DRRY will be investigated further. The unit is slated for investigation supporting a 2035 site evaluation. Other constituents also exceeded benchmarks but not the early action screening criteria.

Although benchmark screening is useful in assessing potential contaminant threats to ecological receptors based on toxicity thresholds, site-specific biological data are a better indicator of site conditions. Site-specific data include the bioassessment data collected for the IOU program and are used to assess overall stream system health. Bioassessment explicitly evaluates effects on receptor organisms and reflects the cumulative effects of ecological disturbances. The Index of Biotic Integrity (IBI) is a bioassessment method that uses fish assemblage data to assess biotic integrity. The IBI is a multi-metric index composed of a number of community, population, and organism level metrics that are ecologically important and sensitive to environmental disturbances of different types. These variables are measured at assessment sites, compared with the same variables in a range of similar, but relatively undisturbed benchmark streams, and the results summarized in a single number that reflects the extent to which the assessment site resembles the benchmarks. The IBI has been modified for use in SRS streams where it accurately discriminates undisturbed sites from sites affected by physical habitat alterations and chemical pollution
(Paller, et al. 1996). Bioassessment monitoring at the SRS involves taxonomic assemblages of macroinvertebrates, as well as, fish to increase the accuracy of an assessment because different taxonomic groups may respond differently to stressors. The SCDHEC developed a bioassessment protocol for macroinvertebrates collected from natural substrates in coastal plain streams referred to as the Multiple Habitat Sampling Protocol (MHSP) in 1998. This methodology has been employed in SRS streams where it has been modified to produce more accurate results in these habitats (Paller et al. 2007). Macroinvertebrates have also been collected from SRS streams with Hester-Dendy artificial substrates, which were deployed for a period sufficient to permit

colonization by benthic organism. Artificial substrates provide a uniform substrate for macroinvertebrates, which can reduce biases stemming from habitat variations among sites that produce differences among macroinvertebrate assemblages unrelated to the presence of contaminants.

The collection of IOU bioassessment data used to assess the cumulative effects of SRS waste sites and discharges on the ecological health of SRS streams was initiated in 1996-1998 and has been conducted periodically through 2017. The most recent compilation of these data present results from the entirety of this assessment period to evaluate changes in the biotic integrity of SRS streams over time, and to determine the current biotic integrity of SRS streams (Paller and Blas 2017). The last comprehensive report on SRS bioassessments was provided in 2007. Many SRS streams have improved over time and now support fish and macroinvertebrate communities comparable to those in reference streams. The largest improvements occurred prior to 2005 in streams that formerly received reactor cooling water discharges. This discharge was characterized by extreme temperatures and current velocities, and resulted in extensive bed scouring, removal of instream structure, and death or exclusion of aquatic life in all but marginal backwater areas with cooler temperature refugia. Such conditions predominated in SC prior to the construction of L Lake, a cooling reservoir built in 1986 to mitigate the effects of reactor operations. While L Lake substantially reduced water temperatures in SC, the system was adversely affected by high flow rates and moderately elevated temperatures in water discharged until the reactors were shut down. With the discontinuation of all reactor operations by 1988, the processes of secondary ecological succession began resulting in the gradual recovery of instream and riparian habit. Recovery has been sufficient to permit the establishment of communities of aquatic macroinvertebrates and fish that are largely indistinguishable from those in high quality reference streams. The existence of these communities indicates that contamination by metals or other materials in these streams is insufficient to adversely impact ecological processes that sustain diverse ecological communities.

However, Upper SC has consistently exhibited IBI scores below the reference site range indicating that the fish community is impaired. However, MHSP and Hester-Dendy metrics for this stream reach have remained within the reference site range, which indicate that environmental conditions

are adequate for the maintenance of lower food chain communities. This is also suggested by habitat assessment scores in Upper SC, which were slightly below the reference site average in 2007, but near reference site levels in 2017. The discrepancy between results as measured by different fish and macroinvertebrate bioassessment methods in Upper SC may be attributable to the presence of L Lake, which separates Upper SC from lower SC and acts as a barrier to the upstream migration of stream fish from lower SC. Upstream migrations are needed to replenish species losses in the headwater reaches of streams, which are typically characterized by relatively harsh and variable environmental conditions (e.g., larger changes in temperature and flow than in lower reaches). In such environments, the upstream migration of fish from more stable lower stream reaches is important in restoring species lost during environmental bottlenecks imposed by droughts and other extreme conditions. The presence of a reservoir (i.e., L Lake) constitutes a physical barrier that isolates upstream reaches and prevents such migrations. Isolation may not affect aquatic insects (which form the basis for the MHSP) as strongly as fish because many of the former have flying adult stages that can bypass physical obstacles.

Examination of fish tissue contaminant levels provides additional evidence concerning the possibility of contaminant related effects on fishes in Upper SC. Of 15 metals typically measured in fish tissues as part of the ACP IOU program, only arsenic was substantially higher in fish from Upper SC than in fish from Meyers Branch (a reference site) or fish from lower SC, where IBI values recovered by 2003. Arsenic levels in fish from Upper SC (slightly over 7 mg/kg), although higher than in fish from other locations in the SC IOU, were somewhat lower than in fish from reference sites in Upper Pen Branch (about 10 mg/kg). These data suggest that the relatively low IBI in Upper SC is more likely a result of the isolation of this stream reach by L Lake than the result of contamination from SRS waste sites or industrial operations.

Also, there are several studies being conducted by the Savannah River Ecology Laboratory pertaining to mercury that will assist in problem formulation for the SC IOU including use of stable mercury isotopes to track sources of mercury, mercury bioavailability in isolated ephemeral wetlands associated with a range of hydroperiods~~,~~ and examining the relationship between total mercury and methylmercury within sediment and selected biota. The results of these efforts, as well, will be reported in upcoming PRs as these research efforts are finalized.

Other site-specific lines of evidence for ecological stream health include the annual update of the literature-based wildlife survey. For SC PR6, the wildlife survey represents a review of publications from 2014 through 2017. While none of the studies pertained particularly to the SC IOU, several studies included contaminants that are pertinent to the SC IOU, particularly trace metals and mercury. For the SC IOU, the studies addressed in the wildlife survey, in general, indicate mercury is a potential threat on a regional scale. Abstracts from the wildlife survey are provided in Appendix B.

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Figure 2-1. Location of Sediment/Soil Samples for the Steel Creek IOU

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Figure 2-2. Location of Sediment Samples Exceeding Human Health On-Site Worker Benchmarks for the Steel Creek IOU

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Figure 2-3. Location of Surface Water Samples Exceeding Human Health Hypothetical Resident Benchmarks for the Steel Creek IOU

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Figure 2-4. Location of Fish Samples Exceeding Human Health Subsistence Fisherman Benchmarks for the Steel Creek IOU

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Figure 2-5. Location of Sediment Samples Exceeding Ecological Benchmarks for the Steel Creek IOU

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Figure 2-6. Location of Surface Water Samples Exceeding Ecological Benchmarks for the Steel Creek IOU

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Table 2-1. Data Summary for SC PR6

Medium	Data Steward	Dataset Name	Study Description	Start Date	End Date	Analyte Type	# Analytical Records
Fish	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event IOUSC2015	20150423	20150423	Inorganics	6
Fish	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event IOUSC2015	20150423	20150423	Metals	66
							72
Sediment	SRS Sampling and Data Management of SRNS	SRS Environmental NonRadiological Monitoring for 2011	SC EMS SEDIMENT NONRAD DATA	20110315	20110315	Inorganics	2
Sediment	SRS Sampling and Data Management of SRNS	SRS Environmental NonRadiological Monitoring for 2011	SC EMS SEDIMENT NONRAD DATA	20110315	20110315	Metals	15
Sediment	SRS Sampling and Data Management of SRNS	SRS Environmental NonRadiological Monitoring for 2013	SC EMS SEDIMENT NONRAD DATA	20130430	20130430	Inorganics	2
Sediment	SRS Sampling and Data Management of SRNS	SRS Environmental NonRadiological Monitoring for 2013	SC EMS SEDIMENT NONRAD DATA	20130430	20130430	Metals	15
Sediment	SRS Sampling and Data Management of SRNS	SRS Environmental NonRadiological Monitoring for 2013	SC EMS SEDIMENT NONRAD DATA	20130430	20130430	Other	1
Sediment	SRS Sampling and Data Management of SRNS	SRS Environmental NonRadiological Monitoring for 2013	SC EMS SEDIMENT RAD DATA	20130430	20130430	Radionuclides	14
Sediment	SRS Sampling and Data Management of SRNS	SRS Environmental NonRadiological Monitoring for 2014	SC EMS SEDIMENT NONRAD DATA	20140429	20140429	Inorganics	2
Sediment	SRS Sampling and Data Management of SRNS	SRS Environmental NonRadiological Monitoring for 2014	SC EMS SEDIMENT NONRAD DATA	20140429	20140429	Metals	15
Sediment	SRS Sampling and Data Management of SRNS	SRS Environmental Radiological Monitoring for 2011	SC EMS SEDIMENT RAD DATA	20110315	20111012	Radionuclides	22
Sediment	SRS Sampling and Data Management of SRNS	SRS Environmental Radiological Monitoring for 2014	SC EMS SEDIMENT RAD DATA	20140429	20140429	Radionuclides	14
Sediment	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event 2015 ANNUALS	20150311	20150601	Inorganics	4
Sediment	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event 2015 ANNUALS	20150311	20150601	Metals	30
Sediment	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event 2015 ANNUALS	20150311	20150601	Radionuclides	33
Sediment	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event IOUSC2015	20150324	20150330	Inorganics	4
Sediment	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event IOUSC2015	20150324	20150330	Metals	88
Sediment	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event IOUSC2015	20150324	20150330	Pesticides/PCBs	116
Sediment	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event IOUSC2015	20150324	20150330	Radionuclides	8
Sediment	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event IOUSC2015	20150324	20150330	Semivolatiles	260
Sediment	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event IOUSC2015	20150324	20150330	Semivolatiles/Volatiles	20
Sediment	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event IOUSC2015	20150324	20150330	Unknown	4
Sediment	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event IOUSC2015	20150324	20150330	Volatiles	188
Sediment	South Carolina Department of Health and Environmental Control	SCDHEC Sediment Radiological Monitoring for 2011	SCDHEC SEDIMENT RAD DATA	20110315	20110315	Radionuclides	26
							883
Surface Water	SRS Sampling and Data Management of SRNS	SRS Environmental NonRadiological Monitoring for 2011	SC EMS SURFACE WATER NONRAD DATA	20110101	20111201	Inorganics	60
Surface Water	SRS Sampling and Data Management of SRNS	SRS Environmental NonRadiological Monitoring for 2011	SC EMS SURFACE WATER NONRAD DATA	20110101	20111201	Metals	132
Surface Water	SRS Sampling and Data Management of SRNS	SRS Environmental NonRadiological Monitoring for 2011	SC EMS SURFACE WATER NONRAD DATA	20110101	20111201	Other	60
Surface Water	SRS Sampling and Data Management of SRNS	SRS Environmental NonRadiological Monitoring for 2011	SC EMS SURFACE WATER NONRAD DATA	20110101	20111201	Pesticides/PCBs	104
Surface Water	SRS Sampling and Data Management of SRNS	SRS Environmental NonRadiological Monitoring for 2011	SC EMS SURFACE WATER NONRAD DATA	20110101	20111201	Semivolatiles	4
Surface Water	SRS Sampling and Data Management of SRNS	SRS Environmental NonRadiological Monitoring for 2013	SC EMS SURFACE WATER NONRAD DATA	20130112	20131214	Inorganics	60
Surface Water	SRS Sampling and Data Management of SRNS	SRS Environmental NonRadiological Monitoring for 2013	SC EMS SURFACE WATER NONRAD DATA	20130112	20131214	Metals	132
Surface Water	SRS Sampling and Data Management of SRNS	SRS Environmental NonRadiological Monitoring for 2013	SC EMS SURFACE WATER NONRAD DATA	20130112	20131214	Other	48
Surface Water	SRS Sampling and Data Management of SRNS	SRS Environmental NonRadiological Monitoring for 2013	SC EMS SURFACE WATER NONRAD DATA	20130112	20131214	Pesticides/PCBs	104
Surface Water	SRS Sampling and Data Management of SRNS	SRS Environmental NonRadiological Monitoring for 2013	SC EMS SURFACE WATER NONRAD DATA	20130112	20131214	Semivolatiles	4
Surface Water	SRS Sampling and Data Management of SRNS	SRS Environmental NonRadiological Monitoring for 2013	SC EMS SURFACE WATER RAD DATA	20130128	20131203	Radionuclides	196
Surface Water	SRS Sampling and Data Management of SRNS	SRS Environmental NonRadiological Monitoring for 2014	SC EMS SURFACE WATER NONRAD DATA	20140101	20140522	Inorganics	60
Surface Water	SRS Sampling and Data Management of SRNS	SRS Environmental NonRadiological Monitoring for 2014	SC EMS SURFACE WATER NONRAD DATA	20140101	20140522	Metals	132
Surface Water	SRS Sampling and Data Management of SRNS	SRS Environmental NonRadiological Monitoring for 2014	SC EMS SURFACE WATER NONRAD DATA	20140101	20140522	Other	43
Surface Water	SRS Sampling and Data Management of SRNS	SRS Environmental NonRadiological Monitoring for 2014	SC EMS SURFACE WATER NONRAD DATA	20140101	20140522	Pesticides/PCBs	104
Surface Water	SRS Sampling and Data Management of SRNS	SRS Environmental NonRadiological Monitoring for 2014	SC EMS SURFACE WATER NONRAD DATA	20140101	20140522	Semivolatiles	4
Surface Water	SRS Sampling and Data Management of SRNS	SRS Environmental NonRadiological Monitoring for 2014	SC EMS SURFACE WATER NONRAD DATA	20140101	20140522	Unknown	12
Surface Water	SRS Sampling and Data Management of SRNS	SRS Environmental Radiological Monitoring for 2011	SC EMS SURFACE WATER RAD DATA	20110207	20111206	Radionuclides	196
Surface Water	SRS Sampling and Data Management of SRNS	SRS Environmental Radiological Monitoring for 2014	SC EMS SURFACE WATER RAD DATA	20140603	20141215	Radionuclides	217
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	PB ERDMS: Sampling Event 1Q15NPDES	20150210	20150210	Other	1
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	SC ERDMS: Sampling Event 4Q12LASG	20121031	20121031	Radionuclides	5
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	SC ERDMS: Sampling Event 4Q12LASG	20121031	20121031	Volatiles	30
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	SC ERDMS: Sampling Event RXSW1106	20110622	20110622	Radionuclides	6

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Table 2-1. Data Summary for SC PR6 *(Continued)*

Medium	Data Steward	Dataset Name	Study Description	Start Date	End Date	Analyte Type	# Analytical Records
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	SC ERDMS: Sampling Event RXSW1106	20110622	20110622	Volatiles	36
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	SC ERDMS: Sampling Event RXSW1206	20120626	20120626	Radionuclides	3
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	SC ERDMS: Sampling Event RXSW1206	20120626	20120626	Volatiles	18
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	SC ERDMS: Sampling Event RXSW1211	20121211	20121211	Radionuclides	3
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	SC ERDMS: Sampling Event RXSW1211	20121211	20121211	Volatiles	18
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	SC ERDMS:Sampling Event 4Q13LASG	20131113	20131113	Radionuclides	5
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	SC ERDMS:Sampling Event 4Q13LASG	20131113	20131113	Volatiles	30
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	SC ERDMS:Sampling Event RXSW1306	20130617	20130617	Radionuclides	4
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	SC ERDMS:Sampling Event RXSW1306	20130617	20130617	Volatiles	24
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	SC ERDMS:Sampling Event RXSW1312	20131113	20131113	Radionuclides	3
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	SC ERDMS:Sampling Event RXSW1312	20131113	20131113	Volatiles	18
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event 1Q15 STREAM WQ	20150113	20150310	Inorganics	15
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event 1Q15 STREAM WQ	20150113	20150310	Metals	33
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event 1Q15 STREAM WQ	20150113	20150310	Other	6
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event 1Q15 STREAM WQ	20150113	20150310	Pesticides/PCBs	26
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event 1Q15 STREAM WQ	20150113	20150310	Semivolatiles	1
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event 1Q15PGW	20150303	20150303	Radionuclides	4
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event 1Q15PGW	20150303	20150303	Volatiles	12
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event 2Q15NPDES	20150428	20150428	Other	1
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event 2Q15-STREAMSURV-SOUTH	20150407	20150602	Radionuclides	38
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event 3Q14PGW	20141103	20141104	Radionuclides	3
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event 3Q14PGW	20141103	20141104	Semivolatiles	15
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event 3Q14PGW	20141103	20141104	Semivolatiles/Volatiles	3
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event 3Q14PGW	20141103	20141104	Volatiles	138
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event 3Q15NPDES	20150818	20150818	Other	1
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event 3Q15-STREAMSURV-SOUTH	20150707	20150909	Radionuclides	26
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event 4Q14LASG	20141103	20141103	Radionuclides	5
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event 4Q14LASG	20141103	20141103	Volatiles	30
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event 4Q15G10	20151005	20151208	Other	9
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event 4Q15LASG	20151117	20151117	Radionuclides	6
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event 4Q15LASG	20151117	20151117	Volatiles	36
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event 4Q15NPDES	20151020	20151020	Other	1
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event 4Q15-STREAMSURV-SOUTH	20151006	20151208	Radionuclides	36
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event IOUSC2015	20150324	20150325	Inorganics	4
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event IOUSC2015	20150324	20150325	Metals	88
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event IOUSC2015	20150324	20150325	Pesticides/PCBs	116
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event IOUSC2015	20150324	20150325	Radionuclides	8
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event IOUSC2015	20150324	20150325	Semivolatiles	260
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event IOUSC2015	20150324	20150325	Semivolatiles/Volatiles	20
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event IOUSC2015	20150324	20150325	Unknown	4
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event IOUSC2015	20150324	20150325	Volatiles	192
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event STREAM-WQ-2Q15	20150414	20150609	Inorganics	15
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event STREAM-WQ-2Q15	20150414	20150609	Metals	33
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event STREAM-WQ-2Q15	20150414	20150609	Other	6
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event STREAM-WQ-2Q15	20150414	20150609	Pesticides/PCBs	26
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event STREAM-WQ-2Q15	20150414	20150609	Semivolatiles	1

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Table 2-1. Data Summary for SC PR6 *(Continued/End)*

Medium	Data Steward	Dataset Name	Study Description	Start Date	End Date	Analyte Type	# Analytical Records
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event STREAM-WQ-3Q15	20150714	20150922	Inorganics	15
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event STREAM-WQ-3Q15	20150714	20150922	Metals	33
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event STREAM-WQ-3Q15	20150714	20150922	Other	6
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event STREAM-WQ-3Q15	20150714	20150922	Pesticides/PCBs	26
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event STREAM-WQ-3Q15	20150714	20150922	Semivolatiles	1
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event STREAM-WQ-4Q15	20151013	20151215	Inorganics	15
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event STREAM-WQ-4Q15	20151013	20151215	Metals	33
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event STREAM-WQ-4Q15	20151013	20151215	Other	6
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event STREAM-WQ-4Q15	20151013	20151215	Pesticides/PCBs	26
Surface Water	SRS Soil and Groundwater Closure Projects	BEIDMS/ERDMS	STCR ERDMS: Sampling Event STREAM-WQ-4Q15	20151013	20151215	Semivolatiles	1
Surface Water	South Carolina Department of Health and Environmental Control	SCDHEC Surface Water NonRadiological Monitoring for 2011	SCDHEC SURFACE WATER NONRAD DATA	20110119	20111207	Inorganics	49
Surface Water	South Carolina Department of Health and Environmental Control	SCDHEC Surface Water NonRadiological Monitoring for 2011	SCDHEC SURFACE WATER NONRAD DATA	20110119	20111207	Metals	110
Surface Water	South Carolina Department of Health and Environmental Control	SCDHEC Surface Water NonRadiological Monitoring for 2011	SCDHEC SURFACE WATER NONRAD DATA	20110119	20111207	Other	57
Surface Water	South Carolina Department of Health and Environmental Control	SCDHEC Surface Water NonRadiological Monitoring for 2011	SCDHEC SURFACE WATER NONRAD DATA	20110119	20111207	Pesticides/PCBs	50
Surface Water	South Carolina Department of Health and Environmental Control	SCDHEC Surface Water NonRadiological Monitoring for 2011	SCDHEC SURFACE WATER NONRAD DATA	20110119	20111207	Volatiles	68
Surface Water	South Carolina Department of Health and Environmental Control	SCDHEC Surface Water NonRadiological Monitoring for 2012	SCDHEC SURFACE WATER NONRAD DATA	20120214	20121205	Inorganics	40
Surface Water	South Carolina Department of Health and Environmental Control	SCDHEC Surface Water NonRadiological Monitoring for 2012	SCDHEC SURFACE WATER NONRAD DATA	20120214	20121205	Metals	90
Surface Water	South Carolina Department of Health and Environmental Control	SCDHEC Surface Water NonRadiological Monitoring for 2012	SCDHEC SURFACE WATER NONRAD DATA	20120214	20121205	Other	49
Surface Water	South Carolina Department of Health and Environmental Control	SCDHEC Surface Water NonRadiological Monitoring for 2012	SCDHEC SURFACE WATER NONRAD DATA	20120214	20121205	Pesticides/PCBs	25
Surface Water	South Carolina Department of Health and Environmental Control	SCDHEC Surface Water NonRadiological Monitoring for 2012	SCDHEC SURFACE WATER NONRAD DATA	20120214	20121205	Volatiles	67
Surface Water	South Carolina Department of Health and Environmental Control	SCDHEC Surface Water Radiological Data 2013	SCDHEC SURFACE WATER RAD DATA 2013	20130102	20131225	Radionuclides	324
Surface Water	South Carolina Department of Health and Environmental Control	SCDHEC Surface Water Radiological Monitoring for 2011	SCDHEC SURFACE WATER RAD DATA	20110105	20111228	Radionuclides	361
Surface Water	South Carolina Department of Health and Environmental Control	SCDHEC Surface Water Radiological Monitoring for 2012	SCDHEC SURFACE WATER RAD DATA	20120104	20121227	Radionuclides	769
							5,315

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Table 2-2. Human Health Benchmark Exceedance Summary for SC PR6

Human Health - Sediment - Onsite Worker																	
IOU Subunit	**Analyte Type**	**Analyte[1]**	**Units**	**Benchmark**	**Max Result**	**Max ~~Ratio~~HQ**	**Mean Detect[2]**	**Mean ~~Ratio~~HQ[3]**	**# Exceed**	**# Analyses**	**Freq Exceed[4] (%)**	**# Detected**	**# Estimated**	**# Non-Detects**	**Max Background**	**Is Detected Mean > Benchmark?[5]**	**Background Location**
SC Upper	Radionuclides	Cesium-137	pCi/g	1.44E+01	1.90E+01	1.32E+00	1.07E+01	7.40E-01	1	2	50.0	2	0	0	0.623	No	BKGDSS001
SC Lower	Radionuclides	Cesium-137	pCi/g	1.44E+01	2.17E+01	1.51E+00	4.84E+00	3.36E-01	1	5	20.0	5	0	0	0.623	No	BKGDSS001
Human Health - Surface Water -Hypothetical Resident																	
IOU Subunit	**Analyte Type**	**Analyte[1]**	**Units**	**Benchmark**	**Max Result**	**Max ~~Ratio~~HQ**	**Mean Detect[2]**	**Mean ~~Ratio~~HQ[3]**	**# Exceed**	**# Analyses**	**Freq Exceed[4] (%)**	**# Detects**	**# Estimated**	**# Non-Detects**	**Max Background**	**Is Detected Mean > Benchmark?[5]**	**Background Location**
SC L-Lake	Radionuclides	Tritium	pCi/L	2.00E+04	1.05E+05	5.25E+00	7.98E+03	3.99E-01	1	48	2.1	24	0	24	2.73E+03	Yes	U3R-1A Treadway Bridge RD 8-1
SC Lower	Metals	Cadmium	mg/L	5.00E-03	4.70E-02	9.40E+00	1.21E-02	2.42E+00	1	58	1.7	4	0	54	4.00E-03	Yes	Tinker Creek at Kennedy Pond
SC Lower	Metals	Lead	mg/L	1.50E-02	4.80E-02	3.20E+00	2.11E-02	1.41E+00	1	58	1.7	3	0	55	2.00E-02	Yes	U3R-1A Treadway Bridge RD 8-1
SC Lower	Inorganics	Thallium	mg/L	2.00E-03	1.66E-02	8.30E+00	1.66E-02	8.30E+00	1	36	2.8	1	0	35	1.63E-02	Yes	Tinker Creek 1
Meyers Branch	Semivolatiles	Benzo[a]pyrene	mg/L	2.00E-04	3.07E-03	1.54E+01	1.81E-03	9.03E+00	2	4	50.0	1	1	2	NDs	---	---
SC Upper	Inorganics	Thallium	mg/L	2.00E-03	1.41E-02	7.05E+00	1.41E-02	7.05E+00	1	12	8.3	0	1	11	1.63E-02	No	Tinker Creek 1, 2006
SC Upper	Volatiles	Trichloroethylene	mg/L	5.00E-03	2.83E-02	5.66E+00	1.11E-02	2.22E+00	7	28	25.0	7	6	15	NDs	---	---
SC Upper	Radionuclides	Tritium	pCi/L	2.00E+04	2.32E+06	1.16E+02	2.56E+05	1.28E+01	64	73	87.7	71	1	1	1.90E+03	Yes	U3R-1A Treadway Bridge RD 8-1
Human Health - Fish - Subsistence Fisherman																	
IOU Subunit	**Analyte Type**	**Analyte[1]**	**Units**	**Benchmark**	**Max Result**	**Max ~~Ratio~~HQ**	**Mean Detect[2]**	**Mean ~~Ratio~~HQ[3]**	**# Exceed**	**# Analyses**	**Freq Exceed[4] (%)**	**# Detects**	**# Estimated**	**# Non-Detect**	**Max Background**	**Is Detected Mean > Benchmark?[5]**	**Background Location**
Meyers Branch	Metals	Mercury	mg/kg	1.47E-01	1.53E-01	1.04E+00	8.01E-02	5.44E-01	1	3	33.33	1	2	0	0.24	No	UTR near SRS Rd F (UTR-01)

Notes:

[1] Shaded boxes indicate the constituent failed the three criteria: mean HQ >1.0, frequency of exceedance >5%, and mean detect value > background.

[2] The Mean Detect is calculated using detected values.

[3] Constituents with a mean detected HQ >1.0 are noted in red. The mean HQ is based on the mean of detected values (Mean HQ = mean of detected values/benchmark).

[4] Constituents with a frequency of exceedance >5% are noted in red (Freq Exceed [%] = # of Exceedances/# Analyses).

[5] Constituents with a mean detected value > background are noted in red. Dashes (---) indicate all results for the constituent were reported as non-detects or background levels are indeterminate.

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Table 2-3. Summary of Ecological Benchmark Exceedances for SC PR6

Ecological – Sediment

IOU Subunit	Analyte Type	Analyte[1]	Units	Bench-mark	Max Result	Max ~~Ratio~~HQ	Mean Detect[2]	Mean ~~Ratio~~HQ[3]	# Exceed	# Analyses	Freq Exceed[4] (%)	# Detected	# Estimated	# Non-Detects	Max Background Level	Mean Detect > Background?[5]	Background Location
Meyers Branch	Metals	Barium	mg/kg	6.00E+01	7.70E+01	1.28E+00	3.24E+01	5.41E-01	1	5	20.00	4	1	0	353	No	L-Lake 55-02
Meyers Branch	Pesticides/PCBs	DDT	mg/kg	7.00E-03	1.69E+00	2.41E+02	4.35E-01	6.21E+01	2	4	50.00	2	2	0	NDs	---	---
Meyers Branch	Pesticides/PCBs	DDD	mg/kg	8.50E-03	1.42E-01	1.67E+01	5.62E-02	6.61E+00	2	4	50.00	3	0	1	NDs	---	---
Meyers Branch	Pesticides/PCBs	DDE	mg/kg	6.80E-03	1.07E+00	1.57E+02	3.79E-01	5.57E+01	3	4	75.00	1	2	1	NDs	---	---
Meyers Branch	Metals	Mercury	mg/kg	4.50E-03	7.24E-02	2.07E+01	5.75E-02	1.28E+01	4	5	80.00	4	0	1	0.021	Yes	Background Upper Three Runs 2
Meyers Branch	Metals	Selenium	mg/kg	1.20E+00	1.73E+00	1.44E+00	1.47E+00	1.23E+00	2	5	40.00	0	2	3	5.65	No	Background Upper Three Runs 2
SC Lower Creek	Metals	Mercury	mg/kg	4.50E-03	1.65E-02	4.71E+00	1.65E-02	3.67E+00	1	4	25.00	0	1	3	0.021	No	Background Upper Three Runs 2

Ecological – Surface Water

IOU Subunit	Analyte Type	Analyte[1]	Units	Bench-mark	Max Result	Max ~~Ratio~~HQ	Mean Detect[2]	Mean ~~Ratio~~HQ[3]	# Exceed	# Analyses	Freq Exceed[4] (%)	# Detected	# Estimated	# Non-Detects	Max Background Level	Mean Detect > Background?[5]	Background Location
SC Upper	Inorganics	Thallium	mg/L	6.00E-03	1.41E-02	2.35E+00	1.41E-02	2.35E+00	1	12	8.33	0	1	11	1.63E-02	No	Tinker Creek 1
SC Upper	Metals	Aluminum	mg/L	8.70E-02	2.72E-01	3.13E+00	1.50E-01	1.72E+00	9	12	75.00	3	8	1	6.06E+00	No	Background Wetland 2
SC Upper	Metals	Lead	mg/L	5.40E-04	6.41E-03	1.19E+01	6.41E-03	1.19E+01	1	12	8.33	0	1	11	2.00E-02	No	U3R-1A Treadway Brdge RD 8-1
Meyers Branch	Metals	Aluminum	mg/L	8.70E-02	2.23E+00	2.56E+01	9.76E-01	1.12E+01	4	4	100.00	2	2	0	6.06E+00	No	Background Wetland 2
Meyers Branch	Metals	Copper	mg/L	2.90E-03	9.33E-03	3.22E+00	9.33E-03	3.22E+00	1	4	25.00	0	1	3	7.00E-02	No	U3R-1A Treadway Brdge RD 8-1
Meyers Branch	Metals	Iron	mg/L	1.00E+00	2.96E+00	2.96E+00	1.53E+00	1.53E+00	2	4	50.00	4	0	0	1.24E+01	No	Background Wetland 2
Meyers Branch	Metals	Lead	mg/L	5.40E-04	5.24E-03	9.70E+00	5.24E-03	9.70E+00	1	4	25.00	0	1	3	2.00E-02	No	U3R-1A Treadway Brdge RD 8-1
Meyers Branch	Metals	Manganese	mg/L	9.30E-02	8.64E-01	9.29E+00	3.46E-01	3.72E+00	3	4	75.00	4	0	0	2.69E+00	No	SR & SC Sed and Water MBH-01 & MB-03
Meyers Branch	Metals	Zinc	mg/L	3.70E-02	1.11E-01	3.00E+00	4.22E-02	1.14E+00	1	4	25.00	3	1	0	1.67E-01	No	U3R-1A Tredway Bridge RD 8-1
Meyers Branch	Semivolatiles	Anthracene	mg/L	2.00E-05	2.28E-03	1.14E+02	2.28E-03	1.14E+02	1	4	25.00	1	0	3	NDs	---	---
Meyers Branch	Semivolatiles	Benzo[a]pyrene	mg/L	6.00E-05	3.07E-03	5.12E+01	1.81E-03	3.01E+01	2	4	50.00	1	1	2	NDs	---	---
Meyers Branch	Semivolatiles	Benzo[b]fluoranthene	mg/L	2.60E-03	3.11E-03	1.20E+00	1.86E-03	7.13E-01	1	4	25.00	1	1	2	NDs	---	---
Meyers Branch	Semivolatiles	Benzo[g,h,i]perylene	mg/L	1.20E-05	3.06E-03	2.55E+02	3.06E-03	2.55E+02	1	4	25.00	1	0	3	NDs	---	---
Meyers Branch	Semivolatiles	Benzo[k]fluoranthene	mg/L	6.00E-05	3.58E-03	5.97E+01	2.09E-03	3.48E+01	2	4	50.00	1	1	2	NDs	---	---
Meyers Branch	Semivolatiles	Fluoranthene	mg/L	8.00E-04	2.28E-03	2.85E+00	2.28E-03	2.85E+00	1	4	25.00	1	0	3	NDs	---	---
Meyers Branch	Semivolatiles	Indeno[1,2,3-cd]pyrene	mg/L	1.20E-05	3.04E-03	2.53E+02	3.04E-03	2.53E+02	1	4	25.00	1	0	3	NDs	---	---
SC Lower	Inorganics	Thallium	mg/L	6.00E-03	1.66E-02	2.77E+00	1.66E-02	2.77E+00	1	36	2.78	1	0	35	1.63E-02	Yes	Tinker Creek 1
SC Lower	Metals	Aluminum	mg/L	8.70E-02	6.44E-01	7.41E+00	1.74E-01	2.01E+00	24	36	66.67	35	0	1	6.06E+00	No	Background Wetland 2
SC Lower	Metals	Cadmium	mg/L	1.00E-04	4.70E-02	4.70E+02	1.21E-02	1.21E+02	4	58	6.90	4	0	54	4.00E-03	Yes	Tinker Creek at Kennedy Rd
SC Lower	Metals	Copper	mg/L	2.90E-03	6.60E-03	2.28E+00	3.06E-03	1.05E+00	3	58	5.17	7	0	51	7.00E-02	No	U3R-1A Treadway Brdge RD 8-1
SC Lower	Metals	Iron	mg/L	1.00E+00	3.41E+00	3.41E+00	5.67E-01	5.67E-01	3	58	5.17	58	0	0	1.24E+01	No	Background Wetland 2
SC Lower	Metals	Lead	mg/L	5.40E-04	4.80E-02	8.89E+01	2.11E-02	3.91E+01	3	58	5.17	3	0	55	2.00E-02	Yes	U3R-1A Treadway Brdge RD 8-1
SC Lower	Metals	Nickel	mg/L	1.60E-02	1.65E-02	1.03E+00	3.53E-03	2.20E-01	1	58	1.72	8	0	50	3.00E-02	No	BKGRDSW003 Meyers Branch
SC Lower	Metals	Zinc	mg/L	3.70E-02	4.17E-02	1.13E+00	1.08E-02	2.93E-01	1	58	1.72	37	0	21	1.67E-01	No	U3R-1A Tredway Bridge RD 8-1

Notes:

[1] Shaded boxes indicate the constituent failed the three criteria: mean HQ >1.0, frequency of exceedance >5%, and mean detect value > background.

[2] The Mean Detect is calculated using detected values.

[3] Constituents with a mean detected HQ >1.0 are noted in red. The mean HQ is based on the mean of detected values (Mean HQ = mean of detected values/benchmark).

[4] Constituents with a frequency of exceedance >5% are noted in red (Freq Exceed [%] = # of Exceedances/# Analyses).

[5] Constituents with a mean detected value > background are noted in red. Dashes (---) indicate all results for the constituent were reported as non-detects or background levels are indeterminate.

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3.0 DATA NEEDS AND EARLY ACTIONS

3.1 Identification of Data Needs

The results of the benchmark evaluations conducted in Section 2.1 provide the rationale and justification for data needs to support the ongoing assessment of the SC IOU. Table 3-1 lists IOU identified data needs and sampling conducted to address the data needs for the SC IOU.

The PR6 evaluation revealed a lack of recent fish data for Steel Creek/L-Lake, with the last field collections in 2007. Monitoring contaminant levels over time is a useful in assessing potential contaminants threats. Passive diffusive gradients in thin films (DGT) samplers will be deployed in the SC IOU to provide screening data to estimate bioavailable concentrations of metal constituents to support future HH and the ecological screening. DGT samplers target bioavailable fractions of contaminants to help identify contaminants of interest that may pose a risk to ecological receptors, and in turn HH exposures such as fishing. DGT samplers have been deployed in UTR and have had various deployments here at SRS for various investigations. The data obtained from passive samplers will provide consistent and comparable data allowing for spatial comparison and trending among and within the IOUs since the semipermeable medium is consistently prepared and deployed. ~~As t~~The DGT sampling data ~~is~~ will be comparatively assessed with existing fish data. This evaluation will identify any other warranted data that would supplement~~ed~~ the DGT data. Additional future data collection efforts will likely include ~~with~~ surface water and other biological data/tissue to support refinement of the DGT approach,~~samples,~~ and to demonstrate the comparability of the DGT sampler approach to traditional biological data collection~~s~~ efforts such as fish sampling ~~will be demonstrated.~~ The DGT data collected will be used to begin the process of refining the approach for assessing contaminant threats for the IOU program. These data will be reported in a future ~~PR~~ report.

3.2 Early Actions

The need for early actions for all or portions of the SC IOU is assessed as part of this PR. The need to consider an early action is based on results of the HH and ecological benchmarking process

(Section 2.1). If results of these evaluations indicate that early action may be warranted, then the area(s) of concern are assessed for the possibility of conducting an early action. The early action strategy follows the decision-making flow diagram titled the "SRS Environmental Restoration RI/FS Early Action Strategy for the Units Listed on FFA Appendix C, RCRA/Comprehensive Environmental Response, Compensation, and Liability Act Units" as presented in the *Remedial Investigation Work Plan for the Steel Creek Integrator Operable Unit* (WSRC 2000).

No constituents were retained for early action consideration based on the HH evaluation or the ecological assessment presented in Section 2. Therefore, there are no early actions warranted for any portion of the SC IOU based on evaluation of PR6 data.

Data will continue to be compiled annually for periodic assessments. These data, typically consisting of IOU sampling efforts, OU investigations, annual environmental monitoring conducted by SRS and SCDHEC, and special studies that may be conducted by various data stewards will be used to continue the assessment of the SC IOU as Phase II of the IOU program continues.

Table 3-1. Summary of Steel Creek IOU Sampling and Data Needs

Location	Media	Data Need Identified in Work Plan	Sampling Conducted to Address Data Needs
Upper Steel Creek			
Steel Creek Headwaters	Sediment and Sediment/soil	Confirm human health and ecological benchmark exceedances and define lateral extent.	Screening along two perpendicular transects and one parallel transect. Samples for full-suite lab analysis collected at six locations. Additional lab sample collected at SC-2.
	Surface Water	None. Existing data sufficient.	Lab sample collected at SC-2.
	Fish	None. Existing data to be evaluated in *SRS IOU Bioassessment Survey Report.*	None.
L Lake (L-Lake Canal to Dam)			
L-Area Diversion Canal	Sediment	No existing sediment data in areas where particle tracks converge. Define nature and extent of contamination	Screening at ten locations along the canal. Samples for full-suite analysis collected at three locations.
	Surface Water	No existing data. Investigate impact from L-Area effluent where Outfalls L-7 and L-8 discharge.	One full suite lab sample at the head of discharge canal.
	Fish	None. Fish sampling to be further evaluated in Phase II.	None.
L Lake	Sediment	No existing sediment data in areas where particle tracks converge. Define nature and extent of contamination	Screening at ten locations along the discharge point of the canal and along the north shoreline. Samples for full-suite analysis collected at three locations.
	Surface Water	Investigate potential impacts from surface runoff and shallow groundwater.	One full-suite lab sample at the confluence of the canal and lake.
	Fish	None. Fish sampling to be further evaluated in Phase II.	None.
Wetlands	Sed/SW/Biota	None. Pending results from L-Area Southern Groundwater Investigation.	Sampling results from L-Area Groundwater does not indicate impact.
Lower Steel Creek (L Lake Dam to Steel Creek Delta)			
Steel Creek at SC-4	Sediment and Sediment/Soil	Define nature and extent of contamination in stream corridor perpendicular to flow.	Perpendicular transect at former dam location just north of SC-4; screening level data and one confirmatory sediment sample.
	Surface Water	Evaluate existing EMS data suite.	One full-suite lab sample collocated with confirmatory sediment sample.
	Fish	None. Current sampling under EMS program believed sufficient. Existing data to be evaluated under SRS IOU Bioassessment Report.	None.

Table 3-1. Summary of Steel Creek IOU Sampling and Data Needs *(Continued)*

Location	Media	Data Need Identified in Work Plan	Sampling Conducted to Address Data Needs
Lower Steel Creek (L Lake Dam to Steel Creek Delta) *(cont'd)*			
Steel Creek Swamp Discharge	Sediment and Sediment/Soil	Need data transecting the delta where cesium-137 isorad contours show elevated activity.	Screening along transect perpendicular to stream channel. One confirmatory full-suite lab sample.
	Surface Water	Evaluate existing EMS data suite.	One full-suite lab sample collocated with confirmatory sediment sample.
	Fish	None. Current sampling under EMS program believed sufficient. Existing data to be evaluated under SRS IOU Bioassessment Report.	None.
SR/Steel Creek			
Delta and Creek Plantation	Sediment and Sediment/Soil	No existing data in delta. Define nature and extent of contamination in delta (onsite) and at Creek Plantation (offsite). Determine if principle threat source material is present at depth.	Screening data along three transects across the width of the delta. One surface sample from each transect submitted for full-suite analysis. Soil borings at four locations along each transect. Partial-suite lab analysis for select SW samples all soil boring samples.
	Surface Water	No existing SW data.	Two samples for full-suite analysis.
	Fish	None. Currently sampled under EMS program. Additional sampling needs to be further evaluated in Phase II.	None.
Steel Creek Boat Landing and Little Hell Landing			
	Sediment	No existing data at highly used public areas.	Screening data (metals only) at ten locations at Steel Creek Landing and five locations at Little Hell Landing.
Meyers Branch			
	Sediment	No existing data at headwaters where particle tracts converge.	Samples for full-suite analysis collected at two locations.
	Surface Water	No existing data at headwaters where particle tracts converge.	Samples for full-suite analysis collected at two locations.
	Fish	None. Currently sampled under EMS program. Additional sampling needs to be further evaluated in Phase II.	None.

Table 3-1. Summary of Steel Creek IOU Sampling and Data Needs *(Continued)*

Location	Media	Data Need Identified in PR1	Sampling Conducted to Address Data Needs
Upper Steel Creek			
Steel Creek Headwaters	Sediment and Sediment/Soil	Confirm nonvolatile beta screening results where trigger level exceeded.	Samples for radiological speciation collected at USC-01-02 and USC-02-03 and submitted for laboratory analysis.
	Surface Water	None. Existing data sufficient.	None.
	Fish	None. Existing data to be evaluated in *SRS IOU Bioassessment Report.*	None.
L Lake (L-Lake Canal to Dam)			
L-Area Diversion Canal	Sediment	None. Existing data sufficient. Continue evaluation of data from OU/SE characterizations and ongoing surveys.	None.
	Surface Water	None. Existing data sufficient. Continue evaluation of data from OU/SE characterizations and ongoing surveys.	None.
	Fish	None. Fish sampling to be further evaluated in Phase II.	None.
L-Lake	Sediment	None. Existing data sufficient. Continue evaluation of data from OU/SE characterizations and ongoing surveys.	None.
	Surface Water	None. Existing data sufficient. Continue evaluation of data from OU/SE characterizations and ongoing surveys.	None.
	Fish	None. Fish sampling to be further evaluated in Phase II.	None.
Wetlands	Sed/SW/Biota	None. Continue evaluations of data from L-Area Southern Groundwater for potential impact to the wetland.	None.
Lower Steel Creek (L-Lake Dam to Steel Creek Delta)			
Steel Creek at SC-4	Sediment and Sediment/Soil	None. Existing data sufficient.	None.
	Surface Water	Confirm gross alpha screening results where trigger level exceeded.	Sample for radiological speciation collected at LSC-04 and submitted for laboratory analysis.
	Fish	None. Current sampling under EMS program believed sufficient. Existing data to be evaluated under *SRS IOU Bioassessment Survey Report*.	None.

Table 3-1. Summary of Steel Creek IOU Sampling and Data Needs *(Continued)*

Location	Media	Data Need Identified in PR1	Sampling Conducted to Address Data Needs
Lower Steel Creek (L-Lake Dam to Steel Creek Delta) *(cont'd)*			
Steel Creek Swamp Discharge	Sediment and Sediment/Soil	None. Existing data sufficient.	None.
	Surface Water	None. Existing data sufficient.	None.
	Fish	None. Current sampling under EMS program believed sufficient. Existing data to be evaluated under *SRS IOU Bioassessment Survey Report*.	None.
Meyers Branch			
	Sediment/Soil	No existing radiological speciation data at locations downgradient of P Area.	Sample for radiological speciation collected at MB-03 and MB-04 and submitted for laboratory analysis.
	Surface Water	None. Existing data sufficient.	None.
	Fish	None. Additional sampling needs to be further evaluated in Phase II.	None.

Location	Media	Data Need Identified in PR2	Sampling Conducted to Address Data Needs
Upper Steel Creek			
Steel Creek Near SC-2A	Sediment/Soil	Independent study indicates cesium-137 contamination in depositional area near SC-2A.	Field screening for cesium-137 using sodium iodide detector with confirmatory lab spectroscopy.

Location	Media	Data Need Identified in PR3	Sampling Conducted to Address Data Needs
Upper Steel Creek			
	Sediment/Soil	Confirm nonvolatile beta and gross alpha screening results where trigger level exceeded.	Spectroscopy at USC-05A and USC-07A for non-volatile beta and USC-05A, USC-06A, and USC-07A for gross alpha trigger exceedances
	Biota	Habitat Evaluation/Reconnaissance	Habitat Reconnaissance
Upper, L Lake, Lower Steel Creek Subunits			
	Fish	Periodic assessment of fish tissue in Steel Creek	Fish tissue collected for laboratory analyses
	Biota	Fish assemblage and macroinvertebrate surveys	Fish IBI and macroinvertebrate surveys conducted
	Biota	Trophic modeling to identify constituents of interest	Trophic modeling based on site-specific data

Table 3-1. Summary of Steel Creek IOU Sampling and Data Needs *(Continued/End)*

Location	Media	Data Need Identified in PR4	Sampling Conducted to Address Data Needs
Meyers Branch			
	Fish	Fish data from background location.	Fish tissue collected in Meyers Branch

Location	Media	Data Need Identified in PR5	Sampling Conducted to Address Data Needs
Meyers Branch			
	All	Conduct walk-down of Dunbarton Rail Road Yard	Walk-down completed for sampling locations for outfalls
	Sediment, Surface Water	Sampling at Dunbarton Rail Road Yard discharge points that potentially discharge to the IOU	Collected sediment and SW associated with outfalls with potentially complete pathways to the IOU
	Sediment	Sediment/Soil and sediment (if available) data for selected metals and radionuclides from side channel of main branch	Collected sediment samples from Meyers Branch
Upper, L Lake, Lower			
	Biota	Crayfish and fish tissue for Phase III metals for trophic modeling	Will be collected if needed for Phase III ERA refinement
Lower			
	Sediment	Sediment/Soil and sediment (if available) data for cyanide, silver, and thallium in Lower SC	Collected from Lower SC and Meyers Branch (sediment)

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4.0 REFERENCES

FFA, 1993. Federal Facility Agreement for the Savannah River Site, Administrative Docket No. 89-05-FF (Effective Date: August 16, 1993)

Paller, M.H., M.J.M. Reichert, and J.M. Dean, 1996. *The Use of Fish Communities to Assess Environmental Impacts in South Carolina Coastal Plain Streams*, Transactions of the American Fisheries Society 125:633-644

Paller, M.H., F.D. Martin, L.D. Wike, and W.L. Specht, 2007. *Factors Influencing the Accuracy of a Macroinvertebrate Bioassessment Protocol in South Carolina Coastal Plain Streams*, Journal of Freshwater Ecology, 22:1, 23-32, DOI: 10.1080/02705060.2007.9664142

Paller, M.H. and S.A. Blas, 2017. *Bioassessment of Streams on the Savannah River Site*, 1996 to 2017, SRNS-STI-2018-00492, Savannah River Nuclear Solutions, Savannah River Site, Aiken, SC

SCDHEC, 2014. Water Classifications & Standards, R. 61-68, Bureau of Water, S.C. Department of Health and Environmental Control, Columbia, SC

SRNS, 2014. Periodic Report 5 for the Steel Creek Integrator Operable Unit, SRNS-RP-2013-00136, Rev. 1.1, Savannah River Nuclear Solutions, Savannah River Site, Aiken, SC

SRNS, 2017. Remedial Investigation/Baseline Risk Assessment for the Lower Three Runs IOU, SRNS-RP-2017-00139, Rev. 1, Savannah River Nuclear Solutions, Savannah River Site, Aiken, SC

SRNS, 2018. *Sampling and Analysis Plan Addendum for the P-Area Groundwater Operable Unit*, SRNS-RP-2018-00261, Rev. 0, Savannah River Nuclear Solutions, Savannah River Site, Aiken, SC

USEPA, 2018. Region 4 Ecological Risk Assessment Supplemental Guidance, March 2018 Update, United States Environmental Protection Agency, Scientific Support Section, Superfund Division, Washington, DC

USFS, 2009. United States Department of Agriculture, Forest Service, Pacific Northwest Research Station, Savannah River Site 20009 LIDAR Project, FY09 Final Report, Pacific Northwest Research Station, University of Washington, Box 352100, Seattle, WA

WSRC, 1997. SRS Ecology, Environmental Information Document, WSRC-TR-97-0223, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC

WSRC 2000. Remedial Investigation Work Plan for the Steel Creek Integrator Operable Unit, WSRC-RP-99-4151, Rev. 1.1, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC

WSRC, 2003. An Updated Regional Water Table of the Savannah River Site and Related Coverages, WSRC-TR-2003-00250, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC

APPENDIX A

Human Health and Ecological Benchmarks for SC PR6

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HUMAN HEALTH ONSITE WORKER — SEDIMENT							
Matrix Name	**Analyte CAS Number**	**Analyte Name**	**Benchmark Value**	**Units**	**Benchmark Type**	**Benchmark Name**	**Benchmark Reference**
Sediment	83-32-9	Acenaphthene	225,900	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	67-64-1	Acetone	3,360,000	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	7429-90-5	Aluminum	5,610,000	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	120-12-7	Anthracene	1,131,000	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	7440-36-0	Antimony	2,337	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	7440-38-2	Arsenic	624	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	7440-39-3	Barium	1,083,000	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	56-55-3	Benzo[a]anthracene	129	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	50-32-8	Benzo[a]pyrene	439	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	205-99-2	Benzo[b]fluoranthene	4,390	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	207-08-9	Benzo[k]fluoranthene	43,900	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	7440-41-7	Beryllium	11,460	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	75-00-3	Chloroethane	283,500	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	7440-47-3	Chromium	8,760,000	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	218-01-9	Chrysene	439,000	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	7440-48-4	Cobalt	1,734	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	7440-50-8	Copper	233,700	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	57-12-5	Cyanide	738	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	72-54-8	DDD	1,990	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	72-55-9	DDE	1,930	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	50-29-3	DDT	1,780	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	84-74-2	Dibutylphthalate	411,000	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	206-44-0	Fluoranthene	150,600	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	86-73-7	Fluorene	150,600	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	7439-89-6	Iron	4,080,000	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	7439-92-1	Lead	800	mg/kg	HH	On-Site Worker	From LTR BRA based on Industrial Worker, USEPA RSL November 2017 Version

HUMAN HEALTH ONSITE WORKER — SEDIMENT							
Matrix Name	**Analyte CAS Number**	**Analyte Name**	**Benchmark Value**	**Units**	**Benchmark Type**	**Benchmark Name**	**Benchmark Reference**
Sediment	7439-96-5	Manganese	128,100	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	7439-97-6	Mercury	228	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	78-93-3	Methyl ethyl ketone	966,000	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	75-09-2	Methylene chloride	212,000	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	7440-02-0	Nickel	111,900	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	11096-82-5	PCB-1260	206	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	129-00-0	Pyrene	113,100	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	7782-49-2	Selenium	29,190	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	12789-03-6	technical-Chlordane	1,600	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	7440-61-1	Uranium	1,167	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	7440-61-1	Uranium, Total	1,167	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	7440-62-2	Vanadium	9,720	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	75-01-4	Vinyl chloride	350	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	7440-66-6	Zinc	1,752,000	mg/kg	HH	On-Site Worker	USEPA RSL November 2017 Version
Sediment	14331-83-0	Actinium-228	3.2	pCi/g	HH	On-Site Worker	USEPA PRG January 2018 Version
Sediment	14596-10-2	Americium-241	17.5	pCi/g	HH	On-Site Worker	USEPA PRG January 2018 Version
Sediment	10045-97-3	Cesium-137	14.4	pCi/g	HH	On-Site Worker	USEPA PRG January 2018 Version
Sediment	15092-94-1	Lead-212	5.01	pCi/g	HH	On-Site Worker	USEPA PRG January 2018 Version
Sediment	15067-28-4	Lead-214	4.26	pCi/g	HH	On-Site Worker	USEPA PRG January 2018 Version
Sediment	13981-16-3	Plutonium-238	4.22	pCi/g	HH	On-Site Worker	USEPA PRG January 2018 Version
Sediment	15117-48-3	Plutonium-239	15.1	pCi/g	HH	On-Site Worker	USEPA PRG January 2018 Version
Sediment	15117-48-3	Plutonium-239 and Plutonium-240	15.1	pCi/g	HH	On-Site Worker	USEPA PRG January 2018 Version
Sediment	13966-00-2	Potassium-40	45.6	pCi/g	HH	On-Site Worker	USEPA PRG January 2018 Version
Sediment	10098-97-2	Strontium-89 and Strontium-90	1,410	pCi/g	HH	On-Site Worker	USEPA PRG January 2018 Version
Sediment	10098-97-2	Strontium-90	1,410	pCi/g	HH	On-Site Worker	USEPA PRG January 2018 Version
Sediment	7440-29-1	Thorium-228	4.96	pCi/g	HH	On-Site Worker	USEPA PRG January 2018 Version
Sediment	14269-63-7	Thorium-230	4.23	pCi/g	HH	On-Site Worker	USEPA PRG January 2018 Version

HUMAN HEALTH ONSITE WORKER — SEDIMENT							
Matrix Name	**Analyte CAS Number**	**Analyte Name**	**Benchmark Value**	**Units**	**Benchmark Type**	**Benchmark Name**	**Benchmark Reference**
Sediment	7440-29-1	Thorium-232	3.18	pCi/g	HH	On-Site Worker	USEPA PRG January 2018 Version
Sediment	7440-61-1	Uranium-233 and Uranium-234	4.22	pCi/g	HH	On-Site Worker	USEPA PRG January 2018 Version
Sediment	13966-29-5	Uranium-234	4.22	pCi/g	HH	On-Site Worker	USEPA PRG January 2018 Version
Sediment	15117-96-1	Uranium-235	15.2	pCi/g	HH	On-Site Worker	USEPA PRG January 2018 Version
Sediment	7440-61-1	Uranium-238	4.16	pCi/g	HH	On-Site Worker	USEPA PRG January 2018 Version

PRG = Preliminary Remedial Goal
RSL = Refinement Screening Level

HUMAN HEALTH HYPOTHETICAL RESIDENT — SURFACE WATER							
Matrix Name	**Analyte CAS Number**	**Analyte Name**	**Bench-mark Value**	**Units**	**Bench-mark Type**	**Benchmark Name**	**Benchmark Reference**
Surface Water	79-00-5	1,1,2-Trichloroethane	0.005	mg/L	HH	Hypothetical Resident	MCL, USEPA RSL November 2017 Version
Surface Water	7440-39-3	Barium	2	mg/L	HH	Hypothetical Resident	MCL, USEPA RSL November 2017 Version
Surface Water	50-32-8	Benzo[a]pyrene	0.0002	mg/L	HH	Hypothetical Resident	MCL, USEPA RSL November 2017 Version
Surface Water	7440-41-7	Beryllium	0.004	mg/L	HH	Hypothetical Resident	MCL, USEPA RSL November 2017 Version
Surface Water	117-81-7	Bis[2-ethylhexyl]phthalate	0.006	mg/L	HH	Hypothetical Resident	MCL, USEPA RSL November 2017 Version
Surface Water	7440-43-9	Cadmium	0.005	mg/L	HH	Hypothetical Resident	MCL, USEPA RSL November 2017 Version
Surface Water	7440-47-3	Chromium	0.1	mg/L	HH	Hypothetical Resident	MCL, USEPA RSL November 2017 Version
Surface Water	156-59-2	cis-1,2-Dichloroethylene	0.07	mg/L	HH	Hypothetical Resident	MCL, USEPA RSL November 2017 Version
Surface Water	7440-50-8	Copper	1.3	mg/L	HH	Hypothetical Resident	MCL, USEPA RSL November 2017 Version
Surface Water	7439-92-1	Lead	0.015	mg/L	HH	Hypothetical Resident	MCL, USEPA RSL November 2017 Version
Surface Water	7439-97-6	Mercury	0.002	mg/L	HH	Hypothetical Resident	MCL, USEPA RSL November 2017 Version
Surface Water	14797-55-8	Nitrate (as Nitrogen)	10	mg/L	HH	Hypothetical Resident	MCL, USEPA RSL November 2017 Version
Surface Water	14797-65-0	Nitrite	1	mg/L	HH	Hypothetical Resident	MCL, USEPA RSL November 2017 Version
Surface Water	127-18-4	Tetrachloroethene	0.005	mg/L	HH	Hypothetical Resident	MCL, USEPA RSL November 2017 Version
Surface Water	7440-28-0	Thallium	0.002	mg/L	HH	Hypothetical Resident	MCL, USEPA RSL November 2017 Version
Surface Water	108-88-3	Toluene	1	mg/L	HH	Hypothetical Resident	MCL, USEPA RSL November 2017 Version
Surface Water	79-01-6	Trichloroethylene	0.005	mg/L	HH	Hypothetical Resident	MCL, USEPA RSL November 2017 Version
Surface Water	75-01-4	Vinyl chloride	0.002	mg/L	HH	Hypothetical Resident	MCL, USEPA RSL November 2017 Version
Surface Water	14596-10-2	Americium-241	15	pCi/L	HH	Hypothetical Resident	MCL USEPA PRG Website January 2018 Version
Surface Water	10045-97-3	Cesium-137	200	pCi/L	HH	Hypothetical Resident	MCL USEPA PRG Website January 2018 Version
Surface Water	15117-48-3	Plutonium-239	0.015	pCi/L	HH	Hypothetical Resident	MCL Pu-239, USEPA PRG website January 2018 Version
Surface Water	15117-48-3	Plutonium-239 and Plutonium-240	15	pCi/L	HH	Hypothetical Resident	MCL Pu-239, USEPA PRG website January 2018 Version

HUMAN HEALTH HYPOTHETICAL RESIDENT — SURFACE WATER							
Matrix Name	**Analyte CAS Number**	**Analyte Name**	**Bench-mark Value**	**Units**	**Bench-mark Type**	**Benchmark Name**	**Benchmark Reference**
Surface Water	10098-97-2	Strontium-89 and Strontium-90	8	pCi/L	HH	Hypothetical Resident	MCL Sr90, USEPA PRG website January 2018 Version
Surface Water	10098-97-2	Strontium-90	8	pCi/L	HH	Hypothetical Resident	MCL USEPA PRG website January 2018 Version
Surface Water	10028-17-8	Tritium	20,000	pCi/L	HH	Hypothetical Resident	MCL USEPA PRG website January 2018 Version
Surface Water	7440-61-1	Uranium-233 and Uranium-234	186.887942	pCi/L	HH	Hypothetical Resident	MCL USEPA PRG website January 2018 Version
Surface Water	13966-29-5	Uranium-234	186.887942	pCi/L	HH	Hypothetical Resident	MCL USEPA PRG website January 2018 Version
Surface Water	15117-96-1	Uranium-235	64.76236529	pCi/L	HH	Hypothetical Resident	MCL USEPA PRG website January 2018 Version
Surface Water	7440-61-1	Uranium-238	10.07114255	pCi/L	HH	Hypothetical Resident	MCL USEPA PRG website January 2018 Version

MCL = maximum contaminant level
PRG = Preliminary Remedial Goal
RSL = Refinement Screening Level

HUMAN HEALTH SUBSISTENCE FISHERMAN — FISH							
Matrix Name	**Analyte CAS Number**	**Analyte Name**	**Bench-mark Value**	**Units**	**Bench-mark Type**	**Benchmark Name**	**Benchmark Reference**
Fish	7429-90-5	Aluminum	1473	mg/kg	HH	Subsistence Fisherman	USEPA RSL Tables November 2017 Version
Fish	7440-36-0	Antimony	0.588	mg/kg	HH	Subsistence Fisherman	USEPA RSL Tables November 2017 Version
Fish	7440-39-3	Barium	294.6	mg/kg	HH	Subsistence Fisherman	USEPA RSL Tables November 2017 Version
Fish	7440-50-8	Copper	58.8	mg/kg	HH	Subsistence Fisherman	USEPA RSL Tables November 2017 Version
Fish	57-12-5	Cyanide	0.882	mg/kg	HH	Subsistence Fisherman	USEPA RSL Tables November 2017 Version
Fish	7439-89-6	Iron	1032	mg/kg	HH	Subsistence Fisherman	USEPA RSL Tables November 2017 Version
Fish	7439-96-5	Manganese	206.1	mg/kg	HH	Subsistence Fisherman	USEPA RSL Tables November 2017 Version
Fish	7439-97-6	Mercury	0.1473	mg/kg	HH	Subsistence Fisherman	Methy Mercury, USEPA RSL Tables November 2017 Version
Fish	7782-49-2	Selenium	7.35	mg/kg	HH	Subsistence Fisherman	USEPA RSL Tables November 2017 Version
Fish	7440-66-6	Zinc	441	mg/kg	HH	Subsistence Fisherman	USEPA RSL Tables November 2017 Version

RSL = Refinement Screening Level

ECOLOGICAL – SEDIMENT							
Matrix Name	**Analyte CAS Number**	**Analyte Name**	**Bench-mark Value**	**Units**	**Bench-mark Type**	**Bench-mark Name**	**Benchmark Reference**
Sediment	83-32-9	Acenaphthene	4.91	mg/kg	ECO	RSV	USEPA Region 4 Table 2C Region 4 Freshwater Sediment RSV
Sediment	67-64-1	Acetone	38.133	mg/kg	ECO	RSV	USEPA Region 4 Table 2b Region 4 Freshwater Sediment RSV
Sediment	5103-71-9	alpha-Chlordane	0.018	mg/kg	ECO	RSV	USEPA Region 4 Table 2a Freshwater Sediment RSV for "Chlordane" (not specified as Alpha or Gamma)
Sediment	7429-90-5	Aluminum	58,000	mg/kg	ECO	RSV	USEPA Region 4 Table 2a Freshwater Sediment RSV
Sediment	7429-90-5	Aluminum	58,000	mg/kg	ECO	RSV	USEPA Region 4 Table 2a Freshwater Sediment RSV
Sediment	120-12-7	Anthracene	5.94	mg/kg	ECO	RSV	USEPA Region 4 Table 2c Freshwater Sediment RSV
Sediment	7440-36-0	Antimony	25	mg/kg	ECO	RSV	USEPA Region 4 Table 2a Freshwater Sediment RSV
Sediment	7440-38-2	Arsenic	33	mg/kg	ECO	RSV	USEPA Region 4 Table 2a Freshwater Sediment RSV
Sediment	7440-39-3	Barium	60	mg/kg	ECO	RSV	USEPA Region 4 Table 2a Freshwater Sediment RSV
Sediment	56-55-3	Benzo[a]anthracene	8.41	mg/kg	ECO	RSV	USEPA Region 4 Table 2c Freshwater Sediment RSV
Sediment	50-32-8	Benzo[a]pyrene	9.65	mg/kg	ECO	RSV	USEPA Region 4 Table 2c Freshwater Sediment RSV
Sediment	205-99-2	Benzo[b]fluoranthene	9.79	mg/kg	ECO	RSV	USEPA Region 4 Table 2c Freshwater Sediment RSV
Sediment	191-24-2	Benzo[g,h,i]perylene	10.9	mg/kg	ECO	RSV	USEPA Region 4 Table 2c Freshwater Sediment RSV
Sediment	207-08-9	Benzo[k]fluoranthene	9.81	mg/kg	ECO	RSV	USEPA Region 4 Table 2c Freshwater Sediment RSV
Sediment	7440-41-7	Beryllium	25	mg/kg	ECO	RSV	USEPA Region 4 Table 3 Soil ESV x 10
Sediment	7440-43-9	Cadmium	5	mg/kg	ECO	RSV	USEPA Region 4 Table 2a Freshwater Sediment RSV
Sediment	7440-47-3	Chromium	111	mg/kg	ECO	RSV	USEPA Region 4 Table 2a Freshwater Sediment RSV (Total)
Sediment	218-01-9	Chrysene	8.44	mg/kg	ECO	RSV	USEPA Region 4 Table 2c Freshwater Sediment RSV
Sediment	7440-48-4	Cobalt	500	mg/kg	ECO	RSV	USEPA Region 4 Table 2a Freshwater Sediment ESV x10
Sediment	7440-50-8	Copper	149	mg/kg	ECO	RSV	USEPA Region 4 Table 2a Freshwater Sediment RSV
Sediment	57-12-5	Cyanide	1	mg/kg	ECO	RSV	USEPA Region 4 Table 3 Soil ESV x 10
Sediment	72-54-8	DDD	0.0085	mg/kg	ECO	RSV	USEPA Region 4 Table 2a Freshwater Sediment RSV
Sediment	72-55-9	DDE	0.0068	mg/kg	ECO	RSV	USEPA Region 4 Table 2a Freshwater Sediment RSV
Sediment	50-29-3	DDT	0.007	mg/kg	ECO	RSV	USEPA Region 4 Table 2a Freshwater Sediment RSV (aquatic life)

ECOLOGICAL – SEDIMENT							
Matrix Name	**Analyte CAS Number**	**Analyte Name**	**Bench-mark Value**	**Units**	**Bench-mark Type**	**Bench-mark Name**	**Benchmark Reference**
Sediment	53-70-3	Dibenz[a,h]anthracene	11.2	mg/kg	ECO	RSV	EPA Region 4 Table 2c Freshwater Sediment RSV
Sediment	84-74-2	Dibutylphthalate	0.319	mg/kg	ECO	RSV	USEPA Region 4 Table 2b Region 4 Freshwater Sediment RSV
Sediment	206-44-0	Fluoranthene	7.07	mg/kg	ECO	RSV	USEPA Region 4 Table 2c Freshwater Sediment RSV
Sediment	86-73-7	Fluorene	5.38	mg/kg	ECO	RSV	USEPA Region 4 Table 2c Freshwater Sediment RSV
Sediment	7439-89-6	Iron	40,000	mg/kg	ECO	RSV	USEPA Region 4 Table 2a RSV freshwater Sediment RSV
Sediment	7439-92-1	Lead	128	mg/kg	ECO	RSV	USEPA Region 4 Table 2a Freshwater Sediment RSV
Sediment	7439-96-5	Manganese	1,100	mg/kg	ECO	RSV	USEPA Region 4 Table 2a Freshwater Sediment RSV
Sediment	7439-97-6	Mercury	0.0045	mg/kg	ECO	RSV	USEPA Region 4 Table 2a Freshwater Sediment RSV wildlife based
Sediment	78-93-3	Methyl ethyl ketone	22.707	mg/kg	ECO	RSV	USEPA Region 4 Table 2b Freshwater Sediment RSV
Sediment	7440-02-0	Nickel	48.6	mg/kg	ECO	RSV	USEPA Region 4 Table 2a RSV Freshwater RSV
Sediment	11096-82-5	PCB-1260	0.676	mg/kg	ECO	RSV	USEPA Region 4 Table 2a RSV freshwater Sediment RSV
Sediment	85-01-8	Phenanthrene	5.96	mg/kg	ECO	RSV	USEPA Region 4 Table 2c Freshwater ~~Sdiment~~Sediment RSV
Sediment	129-00-0	Pyrene	6.97	mg/kg	ECO	RSV	USEPA Region 4 Table 2c Freshwater Sediment RSV
Sediment	7782-49-2	Selenium	1.2	mg/kg	ECO	RSV	USEPA Region 4 Table 2a RSV Freshwater Sediment RSV wildlife based
Sediment	12789-03-6	technical-Chlordane	0.018	mg/kg	ECO	RSV	USEPA Region 4 Table 2a Freshwater Sediment RSV for "Chlordane" (not specified as Alpha or Gamma)
Sediment	7440-61-1	Uranium	1,000	mg/kg	ECO	RSV	USEPA Region 4 Table 2a RSV Freshwater Sediment RSV
Sediment	7440-62-2	Vanadium	78	mg/kg	ECO	RSV	USEPA Region 4 Table 3 Soil ESVx10
Sediment	7440-66-6	Zinc	459	mg/kg	ECO	RSV	USEPA Region 4 Table 2a Freshwater Sediment RSV
Sediment	14596-10-2	Americium-241	680,000	pCi/g	ECO	RSV	Sediment BCGs Aquatic Animal 2018 (Jannik)
Sediment	10045-97-3	Cesium-137	49,300	pCi/g	ECO	RSV	Sediment BCGs Aquatic Animal 2018 (Jannik)
Sediment	13981-16-3	Plutonium-238	3,950,000	pCi/g	ECO	RSV	Sediment BCGs Aquatic Animal 2018 (Jannik)
Sediment	15117-48-3	Plutonium-239	7,050,000	pCi/g	ECO	RSV	Pu-239 BDAC Table ~~i~~1B value, Sediment BCG
Sediment	15117-48-3	Plutonium-239 and Plutonium-240	7,050,000	pCi/g	ECO	RSV	Pu-239 Sediment BCGs Aquatic Animal 2018 (Jannik)

ECOLOGICAL – SEDIMENT							
Matrix Name	**Analyte CAS Number**	**Analyte Name**	**Bench-mark Value**	**Units**	**Bench-mark Type**	**Bench-mark Name**	**Benchmark Reference**
Sediment	13966-00-2	Potassium-40	57,900	pCi/g	ECO	RSV	Sediment BCGs Aquatic Animal 2018 (Jannik)
Sediment	10098-97-2	Strontium-89 and Strontium-90	34,600	pCi/g	ECO	RSV	BDAC Aquatic Animal, Sediment BCG, Sr-90
Sediment	7440-29-1	Thorium-228	2,900	pCi/g	ECO	RSV	LANL Low Effect ESL Sediment
Sediment	14269-63-7	Thorium-230	2,740,000	pCi/g	ECO	RSV	Sediment BCGs Aquatic Animal 2018 (Jannik)
Sediment	7440-29-1	Thorium-232	3,230,000	pCi/g	ECO	RSV	Sediment BCGs Aquatic Animal 2018 (Jannik)
Sediment	7440-61-1	Uranium-233 and Uranium-234	3,030,000	pCi/g	ECO	RSV	U-234, Sediment BCGs Aquatic Animal 2018 (Jannik)
Sediment	13966-29-5	Uranium-234	43,200	pCi/g	ECO	RSV	Sediment BCGs Aquatic Animal 2018 (Jannik)
Sediment	15117-96-1	Uranium-235	110,000	pCi/g	ECO	RSV	Sediment BCGs Aquatic Animal 2018 (Jannik)
Sediment	7440-61-1	Uranium-238	42,900	pCi/g	ECO	RSV	Sediment BCGs Aquatic Animal 2018 (Jannik)

BCG = Biota Concentration Guide
BDAC = Biota Dose Assessment Committee
ECO = Ecological
ESL = Ecological Screening Level
ESV = Ecological Screening Value
RSV = Refinement Screening Value

ECOLOGICAL – SURFACE WATER							
Matrix Name	**Analyte CAS Number**	**Analyte Name**	**Benchmark Value**	**Units**	**Bench-mark Type**	**Benchmark Name**	**Benchmark Reference**
Surface Water	75-35-4	1,1-Dichloroethene	0.13	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	83-32-9	Acenaphthene	0.015	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	67-64-1	Acetone	1.7	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	7429-90-5	Aluminum	0.087	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	120-12-7	Anthracene	0.00002	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	7440-36-0	Antimony	0.19	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	7440-38-2	Arsenic	0.15	mg/L	ECO	Chronic Exposure	SCDHEC R.61-68 Freshwater Aquatic Life CCC
Surface Water	7440-39-3	Barium	0.22	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	56-55-3	Benzo[a]anthracene	0.0047	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	50-32-8	Benzo[a]pyrene	0.00006	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	205-99-2	Benzo[b]fluoranthene	0.0026	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	191-24-2	Benzo[g,h,i]perylene	0.000012	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	207-08-9	Benzo[k]fluoranthene	0.00006	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	7440-41-7	Beryllium	0.011	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	117-81-7	Bis[2-ethylhexyl]phthalate	0.008	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	85-68-7	Butylbenzylphthalate	0.023	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	7440-43-9	Cadmium	0.0001	mg/L	ECO	Chronic Exposure	SCDHEC R.61-68 Freshwater Aquatic Life CCC
Surface Water	7440-70-2	Calcium	116	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	7440-47-3	Chromium	0.028	mg/L	ECO	Chronic Exposure	SCDHEC R.61-68 Freshwater Aquatic Life CCC
Surface Water	16065-83-1	Chromium III	0.028	mg/L	ECO	Chronic Exposure	SCDHEC R.61-68 Freshwater Aquatic Life CCC
Surface Water	18540-29-9	Chromium VI	0.011	mg/L	ECO	Chronic Exposure	SCDHEC R.61-68 Freshwater Aquatic Life CCC
Surface Water	218-01-9	Chrysene	0.0047	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	156-59-2	cis-1,2-Dichloroethylene	0.62	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	10061-01-5	cis-1,3-Dichloropropene	0.0017	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	7440-48-4	Cobalt	0.019	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic

ECOLOGICAL – SURFACE WATER							
Matrix Name	**Analyte CAS Number**	**Analyte Name**	**Benchmark Value**	**Units**	**Bench-mark Type**	**Benchmark Name**	**Benchmark Reference**
Surface Water	7440-50-8	Copper	0.0029	mg/L	ECO	Chronic Exposure	SCDHEC R.61-68 Freshwater Aquatic Life CCC
Surface Water	115-29-7	Endosulfan	0.000056	mg/L	ECO	Chronic Exposure	SCDHEC R.61-68 Freshwater Aquatic Life CCC
Surface Water	959-98-8	Endosulfan I	0.00006	mg/L	ECO	Chronic Exposure	SCDHEC R.61-68 Freshwater Aquatic Life CCC
Surface Water	33213-65-9	Endosulfan II	0.00006	mg/L	ECO	Chronic Exposure	SCDHEC R.61-68 Freshwater Aquatic Life CCC
Surface Water	206-44-0	Fluoranthene	0.0008	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	86-73-7	Fluorene	0.019	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	193-39-5	Indeno[1,2,3-cd]pyrene	0.000012	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	7439-89-6	Iron	1	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	7439-92-1	Lead	0.00054	mg/L	ECO	Chronic Exposure	SCDHEC R.61-68 Freshwater Aquatic Life CCC
Surface Water	7439-95-4	Magnesium	82	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	7439-96-5	Manganese	0.093	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	7439-97-6	Mercury	0.00091	mg/L	ECO	Chronic Exposure	SCDHEC R.61-68 Freshwater Aquatic Life CCC
Surface Water	22967-92-6	Methylmercury, Total	0.0000028	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	7440-02-0	Nickel	0.016	mg/L	ECO	Chronic Exposure	SCDHEC R.61-68 Freshwater Aquatic Life CCC
Surface Water	14797-65-0	Nitrite	0.02	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	UNKNOWN	Nitrogen-Nitrite	0.02	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	85-01-8	Phenanthrene	0.0023	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	7440-09-7	Potassium	53	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	129-00-0	Pyrene	0.0046	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	7440-23-5	Sodium	680	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	127-18-4	Tetrachloroethene	0.053	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	7440-28-0	Thallium	0.006	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	108-88-3	Toluene	0.062	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	79-01-6	Trichloroethylene	0.22	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	7440-62-2	Vanadium	0.027	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	108-05-4	Vinyl Acetate	0.016	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic

ECOLOGICAL – SURFACE WATER							
Matrix Name	**Analyte CAS Number**	**Analyte Name**	**Benchmark Value**	**Units**	**Bench-mark Type**	**Benchmark Name**	**Benchmark Reference**
Surface Water	75-01-4	Vinyl chloride	0.93	mg/L	ECO	Chronic Exposure	USEPA Region 4 Table 1a Freshwater Screening Values, Chronic
Surface Water	7440-66-6	Zinc	0.037	mg/L	ECO	Chronic Exposure	SCDHEC R.61-68 Freshwater Aquatic Life CCC
Surface Water	14596-10-2	Americium-241	731	pCi/L	ECO	Chronic Exposure	BDAC Table IIB Value water BCG
Surface Water	10045-97-3	Cesium-137	7,680	pCi/L	ECO	Chronic Exposure	BDAC Table IIB Water BCG
Surface Water	15757-87-6	Curium-243 and Curium-244	5,530	pCi/L	ECO	Chronic Exposure	Cm-244, Water BCGs Aquatic Animal 2017 (Jannik)
Surface Water	13981-15-2	Curium-244	5,530	pCi/L	ECO	Chronic Exposure	Water BCGs Aquatic Animal 2017 (Jannik)
Surface Water	15117-48-3	Plutonium-239	6,230	pCi/L	ECO	Chronic Exposure	Water BCGs Aquatic Animal 2017 (Jannik)
Surface Water	15117-48-3	Plutonium-239 and Plutonium-240	6,230	pCi/L	ECO	Chronic Exposure	Pu-239 Water BCGs Aquatic Animal 2018 (Jannik)
Surface Water	13966-00-2	Potassium-40	249	pCi/L	ECO	Chronic Exposure	BDAC riparian animal water BCG
Surface Water	10098-97-2	Strontium-89 and Strontium-90	5,080,000	pCi/L	ECO	Chronic Exposure	Sr-90 Water BCBs Aquatic Animal 2018 (Jannik)
Surface Water	10098-97-2	Strontium-90	5,080,000	pCi/L	ECO	Chronic Exposure	Water BCGs Aquatic Animal 2017 (Jannik)
Surface Water	10028-17-8	Tritium	2,290,000,000	pCi/L	ECO	Chronic Exposure	Water BCGs Aquatic Animal 2017 (Jannik)
Surface Water	7440-61-1	Uranium-233 and Uranium-234	210,000	pCi/L	ECO	Chronic Exposure	U-234, Water BCGs Aquatic Animal 2018 (Jannik)
Surface Water	13966-29-5	Uranium-234	210,000	pCi/L	ECO	Chronic Exposure	Water BCGs Aquatic Animal 2017 (Jannik)
Surface Water	15117-96-1	Uranium-235	226,000	pCi/L	ECO	Chronic Exposure	Water BCGs Aquatic Animal 2017 (Jannik)
Surface Water	7440-61-1	Uranium-238	232,000	pCi/L	ECO	Chronic Exposure	Water BCGs Aquatic Animal 2017 (Jannik)

BCG = Biota Concentration Guide
BDAC = Biota Dose Assessment Committee
CAS = Chemical Abstracts Service (Registry Number [F.Y.I., a unique number for each chemical])
CCC = Criteria Continuous Concentration
ECO = Ecological

APPENDIX B

Literature Based Wildlife Survey

2004-2017
Update of the Literature-Based Wildlife Survey
Abstracts

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1. Bryan Jr., A.L., J.W. Snodgrass, H.A. Brant, C.S. Romanek, C.H. Jagoe, G.L. Mills and I.L. Brisbin Jr., 2014. *Precipitation Influences on Uptake of a Global Pollutant by a Coastal Avian Species*. Environmental Toxicology and Chemistry 33(12): 2711-2715.

   Climatic variation, including precipitation amounts and timing, has been linked to abundance and breeding success of many avian species. Less studied, but also of significance, is the consequence of climatic variability on the exposure and uptake of nutrients and contaminants by wildlife. The authors examined mercury (Hg) concentrations in nestling wood stork feathers in a coastal setting over a 16-year (yr) period to understand the influence of rainfall amounts on Hg transfer by parental provisioning relative to habitat use, assuming differential bioavailability of Hg within freshwater and saltwater habitat types. Coastal Hg uptake by stork nestlings was linked to freshwater habitat use, as indicated by stable carbon isotope ($\delta^{13}C$) analyses. Cumulative rainfall amounts exceeding 220 cm in the 23 months (mos,) preceding the breeding seasons resulted in greater use of freshwater wetlands as foraging habitat and greater Hg accumulation by nestling storks.

2. Bryan Jr., A.L., C.N. Love, G.L. Mills, R.R. Borkhataria, and S.L. Lance, 2015. *Testing for Associations Between Hematozoa Infection and Mercury in Wading Bird Nestlings*. Journal of Wildlife Diseases 51(1): 222-226.

   Several wading bird species in the southeastern United States (U.S.) have a history of infection by hematozoa/avian malaria as well as Hg accumulation through their diet, and thus may be exposed to two, generally sublethal, yet chronic, stressors. We analyzed nestling wading birds (n=171) of varying size and trophic position from the southeastern US, and a smaller sample (n=23) of older, free-ranging birds, to look for potential interrelationships between infection by hematozoa and Hg uptake. Only one nestling was PCR positive for hematozoa (Plasmodium/Haemoproteus) whereas nine (39 percent [%]) of the older wading birds were positive. Sequencing indicated that both nestling and adult positives were infected with Plasmodium. Given the low infection rate of the nestlings, there was no association between Hg and malaria. The older birds exhibited a possible malaria/Hg association, but it may be confounded by their greater potential exposure period and large-scale movements.

3. Cooper, Z., R. Bringolf, R. Cooper, K. Loftis, A.L. Bryan Jr., and J.A. Martin, 2017. *Heavy Metal Bioaccumulation in Two Passerines with Differing Migration Strategies*. Science of the Total Environment 592(2017): 25-32.

   Various anthropogenic activities have resulted in concentration of heavy metals and contamination of surrounding environments. Historically, heavy metal contamination at the Savannah River Site (SRS) in South Carolina has resulted from accidental releases of stored waste generated from nuclear weapon production in the early 1950s. Songbirds inhabiting and using resources from these areas have the potential to bioaccumulate metals but there is limited information on metal concentration levels in areas suspected of contamination as well as uncontaminated sites. Nonlethal tissues samples from avian blood and feathers provide a reliable approach for determining the bioavailability of these pollutants (arsenic [As], cadmium [Cd], Chromium [Cr], copper [Cu], Hg, Nickel [Ni], Lead [Pb], Selenium [Se], and Zinc [Zn]).

The objectives of this study were to survey terrestrial heavy metal contamination at the SRS on potentially bioavailable contaminated sites through blood and feather samples from resident Northern Cardinals (Cardinalis cardinalis) and migratory Great Crested Flycatchers (Myiarchus crinitus) and quantify sex-specific concentrations within species. Samples were collected April to June of 2016. Cardinals had lower blood concentrations of Hg (beta [β] = -0.17, 85% CL = -0.26, -0.09) and Se (β = -0.33, 85% CL = -0.50, -0.16) than flycatchers. Cr feather concentrations were less in cardinals (β = -1.46, 85% CL = -2.44, -0.49) and all feathers of both species from reference locations had significantly less Zn (β = -67.92, 85% CL = -128.71, -7.14). Results indicate flycatchers were exposed to differing heavy metal levels during feather formation on their wintering grounds as compared to their recent exposure (through bloods samples) on their breeding grounds. Sex of individuals did not have a significant impact on bioaccumulation in either species. Overall, metal concentration levels in both species indicate minimal risk for acute toxicity; however, there is limited research on wild passerine populations with similar concentration levels. Therefore, further research on reproductive success of these birds should be explored.

4. Deryabina, T.G., S.V. Kuchmel, L.L. Nagorskaya, T.G. Hinton, J.C. Beasley, A. Lerebours, and J.T. Smith, 2015. *Long-Term Census Data Reveal Abundant Wildlife Populations at Chernobyl*. Current Biology 25: R824-R826.

   Following the 1986 Chernobyl accident, 116,000 people were permanently evacuated from the 4,200 square kilometers Chernobyl exclusion zone. There is continuing scientific and public debate surrounding the fate of wildlife that remained in the abandoned area. Several previous studies of the Chernobyl exclusion zone indicated major radiation effects and pronounced reductions in wildlife populations at dose rates well below those thought to cause significant impacts. In contrast, our long-term empirical data showed no evidence of a negative influence of radiation on mammal abundance. Relative abundances of elk, roe deer, red deer and wild boar within the Chernobyl exclusion zone are similar to those in four (uncontaminated) nature reserves in the region and wolf abundance is greater than seven times higher. Additionally, our earlier helicopter survey data show rising trends in elk, roe deer and wild boar abundances from one to ten years post-accident. These results demonstrate for the first time that, regardless of potential radiation effects on individual animals, the Chernobyl exclusion zone supports an abundant mammal community after nearly three decades of chronic radiation exposures.

5. Edwards, P.G., K.F. Gaines, A.L. Bryan Jr., J.M. Novak, and S.A. Blas, 2014. *Trophic dynamics of U, Ni, Hg and Other Contaminants of Potential Concern on the Department of Energy's Savannah River Site*. Environmental Monitoring and Assessment 2014(186): 481-500.

   The U.S. Department of Energy's (USDOE) SRS is a former nuclear weapon material production and current research facility located in South Carolina, USA. Wastewater discharges from a fuel and nuclear reactor target manufacturing facility released depleted and natural uranium (U), as well as other metals into the Tims Branch-Steed Pond water system. We investigated the current dynamics of this system for the purposes of environmental monitoring and assessment by examining metal concentrations, bioavailability, and trophic

transfer of contaminants in seven ponds. Biofilm, detritus, and Anuran and Anisopteran larvae were collected and analyzed for stable isotopes (δ^{15} nitrogen [N], δ^{13} carbon [C]) and contaminants of potential concern (COPC) with a focus on Ni, U, and Hg, to examine metal mobility. Highest levels of Ni and U were found in biofilms U (147 and 332 mg/kg^{-1} deionized water [DW], respectively), while highest Hg levels were found in tadpoles (1.1 mg/kg^{-1} DW). We found intraspecific biomagnification of COPCs as expressed through stable isotope analysis. Biofilms were the best indicators for contamination and Anuran larvae with the digestive tract removed were the best indicators of the specific bioavailability of the focal metals. Monitoring data showed that baseline $\delta^{15}N$ values differed between ponds, but within a pond, values were stable throughout tadpole Gosner stage, strengthening the case to use this species for monitoring purposes. It is likely that there still is risk to ecosystem integrity as COPC metals are being assimilated into lower trophic organisms and even low levels of this mixture has shown to produce deleterious effects to some wildlife species.

6. Edwards, P.G., K.F. Gaines, A.L. Bryan, Jr., J.M. Novak, and S.A. Blas, 2014. *Are U, Ni, and Hg an Environmental Risk within a RCRA/Comprehensive Environmental Response, Compensation, and Liability Act Unit on the U.S. Department of Energy's Savannah River Site*? Human and Ecological Risk Assessment 20(2014): 1565-1589.

   The USDOE SRS is a former nuclear weapon production facility. From 1954–1985, releases of Aluminium (Al), Cu, Cr, Hg, Ni, Pb, U, and Zn were discharged into the Tims Branch-Steed Pond water system. This study investigates whether metal concentrations in Tims Branch's sediment, biofilm, and other biota exceed screening level risk calculations to determine if remedial actions should be pursued for the COPC (U, Ni, Hg). Transfer factors (TFs) were calculated to determine metal concentration changes throughout lower trophic levels and results were compared with sediment benchmarks to create hazard quotients (HQs) to assess risk and a scientific-management decision point. Most TFs for Ni and U from lower to higher trophic level biota were <1, suggesting no biomagnifications; however, HQs >1 and cumulative distributions showed the majority of the samples exceeded action levels. Elevated TFs and HQs >1 in the upper trophic levels for Hg indicated a high degree of bioavailability and biomagnification. Monte Carlo resampling analyses supported these empirical results. This system should continue to be closely monitored to ensure that contamination does not move off the SRS.

7. Finger Jr., J.W., M.T. Hamilton, T.C. Glenn, and T.D. Tuberville, 2017. *Dietary Selenomethionine Administration in the American Alligator (Alligator Mississippiensis): Hepatic and Renal Se Accumulation and its Effects on Growth and Body Condition*. Archives of Environmental Contamination and Toxicology 72(3): 439-448.

   Se is an essential trace nutrient, but in excess, it can induce toxicity. Incomplete combustion of coal produces coal combustion wastes (CCW), which are enriched in Se and often disposed of in aquatic basins. While a multitude of studies have investigated Se accumulation in vertebrates, few studies have examined its effects on longer-lived top trophic carnivores, such as the American alligator (Alligator mississippiensis). In this study, alligators were fed one of three Dietary Treatments: mice injected with water (controls) or water supplemented with

1,000 or 2,000 parts per million (ppm) selenomethionine (SeMet). Dietary Treatment significantly affected Se levels in both the liver ($p < 0.0001$; raw mean plus/minus (±) standard error (SE): 1,000 ppm group, 35.20 ± 6.32 ppm; 2,000 ppm group, 49.97 ± 4.00 ppm) and kidney ($p < 0.0001$; raw mean ± SE: 1,000 ppm group, 101.60 ± 8.64 ppm; 2,000 ppm, 96.38 ± 5.81 ppm), which were significantly higher in alligators fed SeMet than in controls. Post-treatment head length, used to control for size variation, was negatively related to both kidney ($p = 0.0142$) and liver ($p = 0.0010$) Se concentrations. Dietary treatment with SeMet significantly reduced body condition (1,000 ppm, $p < 0.0029$; 2,000 ppm, $p = 0.0075$), but it significantly increased growth (1,000 ppm, $p < 0.0001$; 2,000 ppm, $p = 0.0316$). Body condition and growth remained unchanged in control alligators ($p > 0.05$). Our results demonstrate alligators are capable of accumulating high levels of Se through trophic transfer. The positive effects of accumulation on growth may demonstrate Se essentiality, whereas the negative effects on condition may demonstrate toxicity. Accumulation also was associated with mortality, further demonstrating toxicity. Future studies should further investigate the physiological effects of Se accumulation in long-lived, toptrophic carnivores.

8. Finger Jr., J.W., M.T. Hamilton, B.S. Metts, T.C. Glenn, and T.D. Tuberville, 2016. *Chronic Ingestion of Coal Fly-Ash Contaminated Prey and Its Effects on Health and Immune Parameters in Juvenile American Alligators (Alligator Mississippiensis)*. Archives of Environmental Contamination and Toxicology 71(3): 347-358.

   Coal-burning power plants supply approximately (~) 37% of the electricity in the U.S. However, incomplete combustion produces ash wastes enriched with toxic trace elements that have historically been disposed of in aquatic basins. Organisms inhabiting such habitats may accumulate these trace elements; however, studies investigating the effects on biota have been primarily restricted to shorter-lived, lower-trophic organisms. The American alligator (Alligator mississippiensis), a long-lived, top-trophic carnivore, has been observed inhabiting these basins, yet the health or immune effects of chronic exposure and possible accumulation remains unknown. In this study, we investigated how chronic dietary ingestion of prey contaminated with CCWs for 25 mos., and subsequent accumulation of trace elements present in CCWs, affected juvenile alligator immune function and health. Alligators were assigned to one of four dietary-treatment groups including controls and those fed prey contaminated with CCWs for one, two, or three times a week. However, no effect of Dietary Treatment ($p > 0.05$) was observed on any immune parameter or hematological or plasma analyte we tested. Our results suggest that neither exposure to nor accumulation of low doses of CCWs had a negative effect on certain aspects of the immune and hematological system. However, future studies are required to elucidate this further.

9. Fletcher, D.E., A.H. Lindell, G.K. Stillings, G.L. Mills, S.A. Blas, and J.V. McArthur, 2014. *Variation in Trace-Element Accumulation In Predatory Fishes from a Stream Contaminated By Coal Combustion Waste*. Archives of Environmental Contamination and Toxicology 66(3): 341-360.

   Extensive and critical evaluation can be required to assess contaminant bioaccumulation in large predatory fishes. Species differences in habitat use, resource use, and trophic level, often

influenced by body form, can result in diverging contaminant bioaccumulation patterns. Moreover, the broad size ranges inherent with large-bodied fish provide opportunity for trophic and habitat shifts within species that can further influence contaminant exposure. We compared contaminant bioaccumulation in four fish species, as well as two herbivorous invertebrates, from a CCW contaminated stream. Muscle, liver, and gonad tissue were analyzed from fish stratified across the broadest size ranges available. Effects of trophic position ($\delta^{15}N$), carbon sources ($\delta^{13}C$), and body size varied among and within species. Hg and cesium (Cs) concentrations were lowest in the invertebrates and increased with trophic level both among and within fish species. Other elements, such as vanadium, cadmium, barium, nickel, and lead, had greater levels in herbivorous invertebrates than in fish muscle. Sequestration by the fish livers averted accumulation in muscle. Consequently, fish liver tissue appeared to be a more sensitive indicator of bioavailability, but exceptions existed. Despite liver sequestration, within fishes, muscle concentrations of many elements still tended to increase by trophic level. Notable variation within some species was observed. These results illustrate the utility of stable isotope data in exploring differences of bioaccumulation within taxa. Our analyses suggest a need for further evaluation of the underlying sources of this variability to better understand contaminant bioaccumulation in large predatory fishes.

10. Fletcher, D.E., A.H. Lindell, G.K. Stillings, S.A. Blas, and J.V. McArthur, 2017. T*race Element Accumulation in Lotic Dragonfly Nymphs: Genus Matters*. PLos ONE 12(2): 1-27.

    Constituents of CCW expose aquatic organisms to complex mixtures of potentially toxic metals and metalloids. Multi-element trace element analyses were used to distinguish patterns of accumulation among eight genera of dragonfly nymphs collected from two sites on a CCW contaminated coastal plain stream. Dragonfly nymphs are exceptional for comparing trace element accumulation in syntopic macroinvertebrates that are all predators within the same order (Odonata) and suborder (Anisoptera), but differ vastly in habitat use and body form. Sixteen trace element (beryllium [Be], Vanadium [V], Cr, Ni, Cu, Zn, As, Se, Strontium [Sr], Cd, Antimony [Sb], Cs, Barium [Ba], Hg, Thallium [Tl], and Pb) were analyzed and trophic position and basal carbon sources assessed with stable isotope analyses (C and N). Trophic positions varied within relatively narrow ranges. Size did not appear to influence trophic position. Trophic position rarely influenced trace element accumulation within genera and did not consistently correlate with accumulation among genera. Patterns between $\delta^{13}C$ and trace element accumulation were generally driven by differences between sites. An increase in trace element accumulation was associated with a divergence of carbon sources between sites in two genera. Higher trace element concentrations tended to accumulate in nymphs from the upstream site, closer to contaminant sources. Influences of factors such as body form and habitat use appeared more influential on trace element accumulation than phylogeny for several elements (Ni, Ba, Sr, V, Be, Cd, and Cr) as higher concentrations accumulated in sprawler and the climber-sprawler genera, irrespective of family. In contrast, As and Se accumulated variably higher in burrowers, but accumulation in sprawlers differed between sites. Greater variation between genera than within genera suggests genus as an acceptable unit of comparison in dragonfly nymphs. Overall, taxonomic differences in trace element accumulation can be substantial, often exceeding variation between sites. Our results underscore the element and taxa-specific nature of trace element accumulation, but we provide

evidence of accumulation of some trace elements differing among dragonflies that differ in body form and utilize different sub-habitats within a stream reach.

11. Fletcher, D.E., A.H. Lindell, G.K. Stillings, G.L. Mills, S.A. Blas, and J.V. McArthur, 2014. *Spatial and Taxonomic Variation in Trace Element Bioaccumulation in Two Herbivores from a Coal Combustion Waste Contaminated Stream*. Ecotoxicology and Environmental Safety 101(2014): 196-204.

    Dissimilarities in habitat use, feeding habits, life histories, and physiology can result in syntopic aquatic taxa of similar trophic position bioaccumulating trace elements in vastly different patterns. We compared bioaccumulation in a clam, Corbicula fluminea and mayfly nymph Maccaffertium modestum from a CCW contaminated stream. Collection sites differed in distance to contaminant sources, incision, floodplain activity, and sources of flood event water and organic matter. Contaminants variably accumulated in both sediment and biofilm. Bioaccumulation differed between species and sites with C. fluminea accumulating higher concentrations of Hg, Cs, SR, Se, As, Be, and Cu, but M. modestum higher Pb and V. Stable isotope analyses suggested both spatial and taxonomic differences in resource use with greater variability and overlap between species in the more physically disturbed site. The complex but essential interactions between organismal biology, divergence in resource use, and bioaccumulation as related to stream habitat requires further studies essential to understand impacts of metal pollution on stream systems.

12. Haskins, D.L., M.T. Hamilton, A.L. Jones, J.W. Finger Jr., R.B. Bringolf, and T.D. Tuberville, 2017. *Accumulation of Coal Combustion Residues and Their Immunological Effects in the Yellow-Bellied Slider (Trachemys scripta scripta)*. Environmental Pollution 224(2017): 810-819.

    Anthropogenic activities such as industrial processes often produce copious amounts of contaminants that have the potential to negatively impact growth, survival, and reproduction of exposed wildlife. Coal combustion residues (CCRs) represent a major source of pollutants globally, resulting in the release of potentially harmful trace elements such as As, Cd, and Se into the environment. In the U.S., CCRs are typically stored in aquatic settling basins that may become attractive nuisances to wildlife. Trace element contaminants, such as CCRs, may pose a threat to biota yet little is known about their sublethal effects on reptiles. To assess the effects of CCR exposure in turtles, we sampled 81 yellow-bellied sliders (*Trachemys scripta scripta*) in 2014 to 2015 from CCR-contaminated and uncontaminated reference wetlands located on the SRS (Aiken, SC, USA). Specific aims were to 1) compare the accumulation of trace elements in T. s. scripta claw and blood samples between reference and CCR-contaminated site types; 2) evaluate potential immunological effects of CCRs via bacterial killing assays and phytohaemagglutinin (PHA) assays; and 3) quantify differences in hemogregarine parasite loads between site types. Claw As, Cd, Cu, and Se (all $p \leq 0.001$) and blood As, Cu, Se, and Sr ($p \leq 0.015$) were significantly elevated in turtles from CCR-contaminated wetlands compared to turtles from reference wetlands. Turtles from reference wetlands exhibited lower bacterial killing ($p = 0.015$) abilities than individuals from contaminated sites but neither PHA responses ($p = 0.566$) nor parasite loads ($p = 0.980$) differed by site type. Despite relatively

high CCR body burdens, sliders did not exhibit apparent impairment of immunological response or parasite load. In addition, the high correlation between claw and blood concentrations within individuals suggests that nonlethal tissue sampling may be useful for monitoring CCR exposure in turtles.

13. Haskins, D.L., M.T. Hamilton, N.I. Stacy, J.W. Finger Jr., and T.D. Tuberville, 2017. *Effects of Selenium Exposure on the Hematology, Innate Immunity, tnd Metabolic Rate of Yellow-Bellied Sliders (Trachemys Scripta Scripta)*. Ecotoxicology 26(8): 1134-1146.

    Se is a naturally-occurring essential element that can be toxic to vertebrates at high concentrations. Despite studies that have documented that wild reptile species can accumulate copious amounts of Se, little is known regarding specific toxicologic effects of Se. In this study, 70 juvenile yellow-bellied sliders (*Trachemys scripta scripta*) were exposed to one of three seleno-L-methionine (SetMet) treatments (control, n = 24; 15 mg/kg, n = 23; and 30 mg/kg, n = 23) via weekly oral gavage for five weeks. At the conclusion of the experiment, kidney, liver, muscle, and blood samples were collected for quantitative Se analysis. Turtles in the SeMet treatment groups accumulated significantly higher amounts of Se in all tissue types relative to controls (all $p < 0.001$). Turtles in the 30 mg/kg SeMet group also accumulated significantly higher amounts of Se compared to the 15 mg/kg group (all $p < 0.001$). Although toxicity thresholds for reptiles have not been established, Se concentrations in liver tissue from both SeMet treatment groups exceeded reported avian toxicity thresholds for liver tissue. Neither oxygen consumption nor innate bactericidal capacity were impacted by SeMet exposure. However, turtles in the 30 mg/kg SeMet group exhibited anemia, which has been reported in other vertebrates exposed to Se. Furthermore, juvenile T. s. scripta in the 30 mg/kg SeMet group experienced 17% mortality compared to 0% in the 15 mg/kg treatment and control groups. To our knowledge, this study is the first to report dose-dependent Se-associated anemia and mortality in a chelonian species.

14. Hernandez, F., R.E. Oldenkamp, S. Webster, J.C. Beasley, L.L. Farina, and S.M. Wisely, 2017. *Raccoons (Procyon lotor) as Sentinels of Trace Element Contamination and Physiological Effects of Exposure to Coal Fly Ash*. Archives of Environmental Contamination and Toxicology 72(2): 235-246.

    Anthropogenic pollutants disrupt global biodiversity, and terrestrial sentinels of pollution can provide a warning system for ecosystem-wide contamination. This study sought to assess whether raccoons (Procyon lotor) are sentinels of local exposure to trace element contaminants at a coal fly ash site and whether exposure resulted in health impairment or changes in the intestinal helminth communities. We compared trace element accumulation and the impact on health responses and intestinal helminth communities of raccoons inhabiting contaminated and reference sites of the USDOE's SRS (South Carolina, USA). Data on morphometry, hematology, histopathology, helminth community and abundance, and liver trace element burdens were collected from 15 raccoons captured adjacent to a coal fly ash basin and 11 raccoons from a comparable uncontaminated site nearby. Of eight trace elements analyzed, Cu, As, Se, and Pb were elevated in raccoons from the contaminated site. Raccoons from the contaminated site harbored higher helminth abundance than animals from the reference site

and that abundance was positively associated with increased Cu concentrations. While we found changes in hematology associated with increased Se exposure, we did not find physiological or histological changes associated with higher levels of contaminants. Our results suggest that raccoons and their intestinal helminths act as sentinels of trace elements in the environment associated with coal fly ash contamination.

15. Hinton, T.G., M.E. Byrne, S.C. Webster, and J.C. Beasley, 2015. *Quantifying the Spatial and Temporal Variation in Dose from External Exposure to Radiation: A New Tool for Use on Free-Ranging Wildlife*. Journal of Environmental Radioactivity 145(2015): 58-65.

    Inadequate dosimetry is often the fundamental problem in much of the controversial research dealing with radiation effects on free-ranging wildlife. Such research is difficult because of the need to measure dose from several potential pathways of exposure (i.e., internal contamination, external irradiation, and inhalation). Difficulties in quantifying external exposures can contribute significantly to the uncertainties of dose-effect relationships. Quantifying an animal's external exposure due to spatial–temporal use of habitats that can vary by orders of magnitude in radiation levels is particularly challenging. Historically, wildlife dosimetry studies have largely ignored or been unable to accurately quantify variability in external dose because of technological limitations. The difficulties of quantifying the temporal–spatial aspects of external irradiation prompted us to develop a new dosimetry instrument for field research. We merged two existing technologies (Global Positioning Systems [GPS]) and electronic dosimeters) to accommodate the restrictive conditions of having a combined unit small enough to be unobtrusively worn on the neck of a free-ranging animal, and sufficiently robust to withstand harsh environmental conditions. The GPS–dosimeter quantifies the spatial and temporal variation in external dose as wildlife traverse radioactively contaminated habitats and sends, via satellites, an animal's location and short term integrated dose to the researcher at a user-defined interval. Herein we describe: 1) the GPS–dosimeters; 2) tests to compare their uniformity of response to external irradiation under laboratory conditions; 3) field tests of their durability when worn on wildlife under natural conditions; and 4) a field application of the new technology at a radioactively contaminated site. Use of coupled GPS–dosimetry will allow, for the first time, researchers to better understand the relationship of animals to their contaminated habitats and better assess animal responses to the stress of radiological exposures.

16. Kennamer, R.A., R.E. Oldenkamp, J.C. Leaphart, J.D. King, A.L. Bryan Jr., and J.C. Beasley, 2017. *Radiocesium in Migratory Aquatic Game Birds Using Contaminated U.S. Department of Energy Reactor-Cooling Reservoirs: A Long-Term Perspective*. Journal of Environmental Radioactivity 171(2017): 189-199.

    Low-level releases of radiocesium into former nuclear reactor cooling-reservoirs on the USDOE's SRS in South Carolina, USA, dating primarily to the late 1950s and early 1960s, have allowed examination of long-term contaminant attenuation in biota occupying these habitats. Periodic collections of migratory game birds since the 1970s have documented ^{137}Cs (radiocesium) activity concentrations in birds of SRS reservoirs, including mainly PAR Pond and Pond B. In this study, during 2014 and 2015 we released wild-caught American coots

(Fulica americana) and ring-necked ducks (Aythya collaris) onto Pond B. We made lethal collections of these same birds with residence times ranging from 32 to 173 days to examine radiocesium uptake and estimate the rate of natural attenuation. The two species achieved asymptotic whole-body activity concentrations of radiocesium at different times, with ring-necked ducks requiring almost three times longer than the 30 to 35 days needed by coots. We estimated ecological half-life (Tellurium [Te]) for Pond B coots over a 28-yr period as 16.8 yr (95% Chlorine = 12.9 to 24.2 yr). Pond B coot Te was nearly four times longer than Te for coots at nearby PAR Pond where radiocesium bioavailability had been constrained for decades by pumping of potassium-enriched river water into that reservoir. Te could not be estimated from long-term data for radiocesium in Pond B diving ducks, including ring-necked ducks, likely because of high variability in residence times of ducks on Pond B. Our results highlight the importance: 1) for risk managers to understand site-specific biogeochemistry of radiocesium for successful implementation of countermeasures at contaminated sites and 2) of residence time as a critical determinant of observed radiocesium activity concentrations in highly mobile wildlife inhabiting contaminated habitats.

17. Kosnicki, E., S.A. Sefick, M.H. Paller, M.S. Jerrell, B.A. Prusha, S.C. Sterrett, T.D. Tuberville, and J.W. Feminella, 2016. *A Stream Multimetric Macroinvertebrate Index (MMI) for the Sand Hills Ecoregion of the Southeastern Plains, USA*. Environmental Management 58(4): 741-751.

    A multimetric macroinvertebrate index (MMI) is an effective tool for assessing the biological integrity of streams. However, data collected under a single protocol may not be available for an entire region. We sampled macroinvertebrates from the full extent of the Sand Hills ecoregion Level IV of the Southeastern Plains with a standard protocol during the summers of 2010 – 2012. We evaluated the performance of 94 metrics through a series of screening criteria and built 48 MMI with combinations of the best performing metrics, representing richness, habit, functional feeding guild, sensitivity, and community composition. A series of narrative-response tests for each MMI was used to find the best performing MMI which we called the Sand Hills MMI. The Sand Hills MMI consisted of the measures Biotic Index, % Shredder taxa, Clinger taxa2/total taxa, Plecoptera and Trichoptera richness, and Tanytarsini taxa2/Chironomidae taxa. Comparison of the Sand Hills MMI with existing assessment tools calculated with our data indicated that the Sand Hills MMI performs at a high level with regards to identifying degraded sites and in its response to stress gradients.

18. Koster van Groos, P., D.I. Kaplan, H. Chang, J.C. Seaman, D.Li, A.D. Peacock, K.G. Scheckel, and P.R. Jaffé, 2016. *Uranium Fate in Wetland Mesocosms: Effects of Plants at Two Iron Loadings with Different pH Values*. Chemosphere 163(2016): 116-124.

    Small-scale continuous flow wetland mesocosms (~0.8 liters [L]) were used to evaluate how plant roots under different Fe loadings affect U mobility. When significant concentrations of ferrous Fe were present at circumneutral pH values, U concentrations in root exposed sediments were an order of magnitude greater than concentrations in root excluded sediments. Micro X-ray absorption near-edge structure (μ-XANES) spectroscopy indicated that U was associated with the plant roots primarily as U(VI) or U(V), with limited evidence of U(IV).

Micro X-ray fluorescence (μ-XRF) of plant roots suggested that for high Fe loading at circumneutral pH, U was co-located with Fe, perhaps co-precipitated with root Fe plaques, while for low Fe loading at a pH of ~4 the correlation between U and Fe was not significant, consistent with previous observations of U associated with organic matter. Quantitative PCR analyses indicated that the root exposed sediments also contained elevated numbers of Geobacter spp., which are likely associated with enhanced Fe cycling, but may also reduce mobile U(VI) to less mobile U(IV) species.

19. Li, D., J.C. Seaman, H. Chang, P.R. Jaffe, P.Koster van Groos, D. Jiang, N. Chen, J. Lin, Z. Arthur, Y. Pan, K.G. Scheckel, M. Newville, A. Lanxirotti, and D.I. Kaplan, 2014. *Retention and Chemical Speciation of Uranium in an Oxidized Wetland Sediment from the Savannah River Site*. Journal of Environmental Radioactivity 131(2014): 40-46.

    Uranium speciation and retention mechanisms onto SRS wetland sediments was studied using batch (ad)sorption experiments, sequential extraction, U L3-edge X-ray absorption near-edge structure (XANES) spectroscopy, fluorescence mapping and μ-XANES. Under oxidized conditions, U was highly retained by the SRS wetland sediments. In contrast to other similar but much lower natural organic matter (NOM) sediments, significant sorption of U onto the SRS sediments was observed at pH <4 and pH >8. Sequential extraction indicated that the U species were primarily associated with the acid soluble fraction (weak acetic acid extractable) and organic fraction (Na-pyrophosphate extractable). U L3-edge XANES spectra of the U-bound sediments were nearly identical to that of uranyl acetate. Based on fluorescence mapping, U and Fe distributions in the sediment were poorly correlated, U was distributed throughout the sample and did not appear as isolated U mineral phases. The primary oxidation state of U in these oxidized sediments was U(VI), and there was little evidence that the high sorptive capacity of the sediments could be ascribed to abiotic or biotic reduction to the less soluble U(IV) species or to secondary mineral formation. Collectively, this study suggests that U may be strongly bound to wetland sediments, not only under reducing conditions by reductive precipitation, but also under oxidizing conditions through NOM-uranium bonding.

20. Lindell, A.H., R.C. Tuckfield, and J.V. McArthur, 2016. *Differences in the Effect of Coal Pile Runoff (Low Ph, High Metal Concentration) Versus Natural Carolina Bay Water (Low pH, Low Metal Concentration) on Plant Condition and Associated Bacterial Epiphytes of Salvinia Minima*. Bulletin of Environmental Contamination and Toxicology 96(5): 602-607.

    Numerous wetlands and streams have been impacted by acid mine drainage (AMD) resulting in lowered pH and increased levels of toxic heavy metals. Remediation of these contaminated sites requires knowledge on the response of microbial communities (especially epiphytic) and aquatic plants to these altered environmental conditions. We examined the effect of coal pile runoff waters as an example of AMD in contrast to natural water from Carolina Bays with low pH and levels of metals on Salvinia minima, a non-native, metal accumulating plant and associated epiphytic bacteria. Treatments included water from two Carolina Bays, one AMD basin and Hoagland's Solution at two pH levels (natural and adjusted to 5.0 – 5.5). Using controlled replicated microcosms (N = 64) we determined that the combination of low pH and high metal concentrations has a significant negative impact ($p < 0.05$) on plant condition and

epiphytes. Solution metal concentrations dropped indicating removal from solution by S. minima in all microcosms.

21. Mathews, T.J., B.B. Looney, A.L. Bryan, J.G. Smith, C.L. Miller, G.R. Southworth, M.J. Peterson, 2015. *The Effects of a Stannous Chloride-Based Water Treatment Systems in a Mercury Contaminated Stream*. Chemosphere 138(2015)190-196.

    We assessed the impacts of an innovative Hg water treatment system on a small, industrially-contaminated stream in the southeastern U.S. The treatment system, installed in 2007, removes Hg from wastewater using Sn (II) chloride followed by air stripping. Hg concentrations in the receiving stream, Tims Branch, decreased from >100 to ~10 mg/L in the four years following treatment, and Hg body burdens in redfin pickerel (Esox americanus) decreased by 70% at the most contaminated site. Sn concentrations in water and fish increased significantly in the tributary leading to Tims Branch, but concentrations remain below levels of concern for human health or ecological risks. While other studies have shown that Sn may be environmentally methylated and methyltin can transfer its methyl group to Hg, results from our field studies and sediment incubation experiments suggest that the added Sn to the Tims Branch watershed is not contributing to methylmercury (MeHg) production or bioaccumulation in this system. The stannous chloride treatment system installed at Tims Branch was effective at removing Hg inputs and reducing Hg bioaccumulation in the stream, but future studies are needed to assess longer term impacts of Sn on the environment.

22. McArthur, J.V., C.A. Dicks, A.L. Bryan Jr., and R.C. Tuckfield, 2017. *The Effects of Low-Level Ionizing Radiation and Copper Exposure on the Incidence of Antibiotic Resistance in Lentic Biofilm Bacteria*. Environmental Pollution 228(2017): 390-397.

    Environmental reservoirs of antibiotic resistant bacteria are poorly understood. Understanding how the environment selects for resistance traits in the absence of antibiotics is critical in developing strategies to mitigate this growing menace. Indirect or co-selection of resistance by environmental pollution has been shown to increase antibiotic resistance (AR). However, no attention has been given to the effects of low-level ionizing radiation or the interactions between radiation and heavy metals on the maintenance or selection for AR traits. Here we explore the effect of radiation and Cu on AR. Bacteria were collected from biofilms in two ponds – one impacted by low-level radiocesium and the other an abandoned farm pond. Through laboratory-controlled experiments, we examined the effects of increasing concentrations of Cu on the incidence of AR. Differences were detected in the resistance profiles of the controls from each pond. Low levels (0.01 mM) of copper sulfate increased resistance but 0.5 mM concentrations of copper sulfate depressed the AR response in both ponds. A similar pattern was observed for levels of multiple AR per isolate. The first principal component response of isolate exposure to multiple antibiotics showed significant differences among the six isolate treatment combinations. These differences were clearly visualized through a discriminant function analysis, which showed distinct AR response patterns based on the six treatment groups.

23. McArthur, J.V., R.C. Tuckfield, D.E. Fletcher, and A.H. Lindell, 2017. *Effect of Heavy Metal Pollution on the Incidence of Antibiotic Resistance in Aeromonas Hydrophila Isolates Obtained from the Surface of Fish*. Aquatic Microbial Ecology 79(3): 197-207.

A large collection of aquatic Aeromonas obtained from the surfaces of five species of fish in two streams with different contamination histories were examined to test hypotheses on the effects of contaminant history, stream habitat and longitudinal location on the incidence of AR) towards six antibiotics and levels of multiple antibiotic resistance (MAR). Fish species included an open-water species (Micropterus salmoides), two mid-water species of centrarchids (Lepomis auritus and L. punctatus) and two species of bottom-dwelling fish (Ameiurus natalis and A. platycephalus). Metal analysis of the sediments indicated that there was a strong downstream contamination gradient in one stream but not in the other. However, we found that the average MAR level was similar between the two streams. Comparisons among fish species found the highest levels of resistance in bacteria isolated from bottom-dwelling fish in the least contaminated stream. However, there were clear differences in levels of resistance between bacteria isolated from the two bottom-dwelling fish, with those isolated from A. natalis having significantly higher levels than those isolated from A. platycephalus. We suggest that these differences relate to higher concentrations of metals and other contaminants in habitats where A. natalis is normally found. For some antibiotics, there was a clear pattern of decreasing resistance among bacteria isolated from bottom-dwelling, mid-water and open-water fish. Unlike culturable sediment bacteria from the same streams in previous studies, these commensal aeromonads did not show the same expected patterns of increasing AR in metal-contaminated vs. uncontaminated streams.

24. Oldenkamp, R.E., A.L. Bryan Jr., R.A. Kennamer, J.C. Leaphart, S.C. Webster, and J.C. Beasley, 2017. *Trace Elements and Radiocesium in Game Species Near Contaminated Sites*. Journal of Wildlife Management 81(8): 1338-1350.

Hg, Se, and As found in CCW and radionuclides released from anthropogenic activities present potential environmental and human health concerns. Despite the widespread harvest and consumption of wildlife by recreational hunters, game species are not subject to the same safety testing as commercially marketed livestock; thus, there are few data available regarding contaminant concentrations in many commonly harvested wildlife. We sampled feral pigs (Sus scrofa; invasive wild pigs), gray squirrels (Sciurus carolinensis), and waterfowl from relatively uncontaminated habitats and areas of contamination to quantify levels of trace elements and radiocesium (^{137}Cs) in muscle and liver tissues for assessment of potential human health risks from the consumption of game. Species collected at a CCW ash basin consistently had levels of selected trace elements, particularly Se, above concentrations considered toxic to waterfowl, suggesting CCW may be an important pathway for wildlife, and subsequently human exposure to this element. Similarly, we observed elevated concentrations of ^{137}Cs in wildlife collected in or near aquatic ecosystems with histories of operational releases of radionuclides. The majority of tissue samples analyzed were below elemental levels known to adversely affect wildlife health and ^{137}Cs levels were below European Economic Community limits for human consumption established following the 1986 Chernobyl accident. Waterfowl, however, had levels of several elements of interest (Se and Hg) that could be of health concern

to the birds, especially individuals collected from areas with known contamination, or human consumers of the birds. Given the high levels of trace element burdens we observed in waterfowl collected from ash basins, and the common occurrence of similar surface impoundments throughout much of the globe, wide-scale sampling for contaminants in waterfowl within or across migratory flyways appear to be greatly needed to better understand routes of contaminant movement and potential areas (or species) with elevated contamination risk to waterfowl and hunters.

25. Rumrill, C.T., D.E. Scott, and S.L. Lance, 2016. *Effects of Metal and Predator Stressors in Larval Southern Toads (Anaxyrus Terrestris)*. Ecotoxicology 25(2016): 1278-1286.

    Natural and anthropogenic stressors typically do not occur in isolation; therefore, understanding ecological risk of contaminant exposure should account for potential interactions of multiple stressors. Realistically, common contaminants can also occur chronically in the environment. Because parental exposure to stressors may cause transgenerational effects on offspring, affecting their ability to cope with the same or novel environmental stressors, the exposure histories of generations preceding that being tested should be considered. To examine multiple stressor and parental exposure effects we employed a 2 x 2 x 2 factorial design in outdoor 1,000-L mesocosms (n = 24). Larval southern toads (Anaxyrus terrestris), bred from parents collected from reference and metal-contaminated sites, were exposed to two levels of both an anthropogenic (Cu – 0, 30 µg/L) and natural (predator cue - present/absent) stressor and reared to metamorphosis. Toads from the metal-contaminated parental source population were smaller at metamorphosis and had delayed development; i.e., a prolonged larval period. Similarly, larval Cu exposure also reduced size at metamorphosis and prolonged the larval period. We, additionally, observed a significant interaction between larval Cu and predator-cue exposure on larval period, wherein delayed emergence was only present in the 30-µg/L Cu treatments in the absence of predator cues. The presence of parental effects as well as an interaction between aquatic stressors on commonly measured endpoints highlight the importance of conducting multistressor studies across generations to obtain data that are more relevant to field conditions in order to determine population-level effects of contaminant exposure.

26. Soteropoulos, D.L., S.L. Lance, R.W. Flynn, and D.E. Scott, 2014. *Effects of Copper Exposure on Hatchling Success and Early Larval Survival in Marbled Salamanders, Ambystoma Opacum*. Environmental Toxicology and Chemistry 33(7): 1631-1637.

    The creation of wetlands, such as urban and industrial ponds, has increased in recent decades, and these wetlands often become enriched in pollutants over time. One metal contaminant trapped in created wetlands is Cu (Cu2+). Cu concentrations in sediments and overlying water may affect amphibian species that breed in created wetlands. The authors analyzed the Cu concentration in dried sediments from a contaminated wetland and the levels of aqueous Cu released after flooding the sediments with different volumes of water, mimicking low, medium, and high pond-filling events. Eggs and larvae of Ambystoma opacum Gravenhorst, a salamander that lays eggs on the sediments in dry pond beds that hatch on pond-filling, were exposed to a range of Cu concentrations that bracketed potential aqueous Cu levels in created

wetlands. Embryo survival varied among clutches, but increased Cu levels did not affect embryo survival. At Cu concentrations of 500 µg/L or greater; however, embryos hatched earlier, and the aquatic larvae died shortly after hatching. Because Cu concentrations in sediments increase over time in created wetlands, even relatively tolerant species such as A. opacum may be affected by Cu levels in the posthatching environment.

27. SREL, 2015. *Chemical and Radiological Analysis of Sediment and Biological Samples Collected from McQueens Branch*, Final Report, R-15-003, Ver. 1.0, June 22, 2015, Savannah River Ecology Laboratory, Aiken, SC

The objective of the current study was to evaluate contaminant levels present in sediment and biota samples collected from a section of McQueens Branch downstream from the Saltstone Facility before and after the 2013 spillway discharge from Z-Area Sedimentation Basin No. 4 to Storm Water Outfall Z-01. Sediments within the basin have elevated levels of ^{137}Cs and other radionuclides originating from the Saltstone Disposal Facility. Sediment and macroinvertebrate samples were fortuitously collected from the McQueens Branch stream just prior to the 2013 discharge event as part of a larger effort to evaluate the impact of SRS operations on streams and watersheds. A second set of McQueens Branch samples were collected in 2014 for comparison. In addition, another set of sediment samples was collected in 2014 from a beaver pond located upstream on McQueens Branch from the Saltstone Facility.

The radionuclide levels observed for the 2013 and 2014 McQueens Branch sediment samples suggest that very little if any additional radioactivity can be attributed to the Z-Area Sedimentation Basin No. 4 discharge event that occurred in 2013. The ^{137}Cs levels for all sediment samples collected in 2013 and 2014 from the McQueens Branch study site were <1 pCi/g^{-1}. Although ^{137}Cs makes up a large portion of the radioactivity associated with the saltwaste materials and present in the Z-Area Sedimentation Basin No. 4, there was no increase in ^{137}Cs levels measured in sediments from the McQueens Branch study site following the 2013 discharge event. Gross alpha/beta levels were a bit higher for the McQueens Branch sediment samples in 2014, but not high enough to differentiate from background variability. Similar trends were observed with respect to radionuclides in the biological samples. In general, the levels of ^{137}Cs and gross alpha/non-volatile beta were quite low for all biological tissues (in most cases below the minimum detectable activity [MDA]) for ^{137}Cs), with somewhat higher levels observed in the 2014 samples. However, the high level of variability observed for biological samples collected within a given year suggests that such differences are not significant.

Analyzing contaminant accumulation in macroinvertebrates enhances the assessment of contamination in McQueens Branch by verifying which contaminants detected in the sediments are bioavailable and actually entering the stream community. Macroinvertebrates are known to accumulate a variety of contaminants and represent trophic links between primary production and higher trophic level vertebrates. We selected three groups of aquatic macroinvertebrates as biomonitors for the current study: dragonfly nymphs, crane fly larvae and crayfish. Dragonfly nymphs are predators that utilize a wide range of stream habitats. Crane fly larvae feed on decaying leaves and consequently biofilm that is known to accumulate

high concentrations of contaminants. Crayfish inhabit depositional zones where highest contaminant concentrations were found. Additionally, as omnivores, crayfish can be exposed trophically via many potentials comprised by the genus) of some sensitive dragonfly genera decreased moderately while the particularly tolerant genus Progomphus increased in relative abundance between 2013 and 2014. Macroinvertebrate Tolerance Values (TVs) are indices ranging from 0-10 indicating how tolerant taxa are to poor water quality. The average over all TVs for dragonflies collected in 2013 vs. 2014 only increased 0.4 points from 7.4 to 7.8. Consequently, based on the dragonfly community composition, there was no evidence of an extreme community shift indicating a severe stream degradation following discharge from the Z-Area Sedimentation Basin No. 4.

The concentration of several metals was found to be higher in the 2014 McQueens Branch stream sediments, particularly for depositional samples, compared to the 2013 McQueens Branch sediments and other comparable SRS data sets. However, the 2014 metal levels are similar to those found in sediments collected in 2014 from a beaver pond up-stream from the Saltstone Facility. This increase in metals coincides with a significant increase in organic matter, from ≈ 1 % in 2013 to ≈ 28% in 2014, observed for the depositional 2014 McQueens Branch samples. These results suggest that the buildup in metals for the 2014 samples is associated with the increase in allochthonous organic matter in depositional regions of the stream, and not related to storm water discharge from the Saltstone Facility.

Although considerable variation was evident among taxa, trace element concentrations also were found to be higher in 2014 McQueens Branch biota. Despite the increased concentrations in biota between years, the Biota-Sediment Accumulation Factor of most elements decreased between years across all taxa. This pattern results from concentrations increasing in the biota at a lower rate than measured in the sediment.

Identification of recently collected caddisfly adults is still in progress. Comparison of recently collected adults to those collected over 25 years ago is finding both: species collected recently but not in the early collection, and species absent in current collections that were previously recorded. The SCDHEC macroinvertebrate procedure indicated a site on Mill Creek and the lower reaches of McQueens Branch to be of similar condition when the 2014 collections were made. This is an encouraging indicator that the lower reaches of McQueens Branch have not been severely degraded.

28. SREL, 2016. *Annual Technical Progress Report of Ecological Research for FY 16, Final Report,* December 2016, for the Period of October 1, 2015 – September 30, 2016, H-02 Constructed Wetland Studies: Amphibian Ecotoxicity, Savannah River Ecology Laboratory, Aiken, SC

    Objectives

    Our research at the H-02 constructed wetland complex focuses on several questions related to these treatment wetlands: 1) Over time, what amphibians have become established in the wetlands? 2) Do the elevated trace metal (e.g., Cu and Zn) levels in the wetlands affect amphibian reproductive success, disease ecology, and population dynamics? 3) How do the

amphibian diversity and numbers compare to more natural, wetlands? and 4) As the constructed wetlands age, how will the amphibian community respond?

Summary of Research Activities: This report summarizes our amphibian studies related to the H-02 treatment wetlands from October 2015 to September 2016. We used aquatic trapping to characterize biota of the treatment wetlands. We completed a third field season examining the influence of wetland hydroperiod on the prevalence of two amphibian diseases, chytridiomycosis and ranavirus. We also expanded that study to include community structure and water quality surveys of 20 wetlands. To more directly examine the effect of Cu on disease susceptibility we conducted an experimental challenge. To do this we reared southern toad and eastern narrowmouth toad larvae under conditions of no and low levels of Cu. After seven days, we exposed them to known concentrations of ranavirus and then reared them for an additional ten days. We completed studies examining the interactive effects of exposure to both Cu and Zn in three species of amphibians and lab studies examining the effects of Cu on three larval ambystomatid salamander species. We initiated studies examining effects of contamination on methylation patterns in southern toads and southern leopard frogs and to investigate how distance from a contaminated wetland influences tolerance to Cu. We combined natural history data with copper toxicity results from prior experiments to model the potential combined effects of Cu contamination and climate change on reproductive success in toads and leopard frogs. We also analyzed long-term data from Rainbow Bay (RB) in the context of nutrient flux between aquatic and terrestrial habitats. RB and other isolated wetlands serve as comparison sites for the H-02 amphibian studies. We completed the 38th year of monitoring at RB, and have begun analyzing the data in the context of community shifts in response to environmental change and altered hydrology.

Conclusions

1) Southern toad juveniles exposed to ranavirus had reduced growth rates, but Cu did not affect viral loads.
2) Over time there has been a shift in nutrient flux from a net flow to the terrestrial environment to a flow into the aquatic environment that is likely tied to climate change.
3) Exposure to ranavirus causes a decline in growth rate.
4) Larval ambystomatids were highly sensitive to Cu with 50% mortality at 18.7, 35.3, and 47.9 ppb for three species. Cu also caused reduced growth rates in A. talpoideium.
5) Amphibians inhabiting reference wetlands are less tolerant to a novel metal stressor than those from metal impacted wetlands.
6) The amphibian community at RB has shifted from long- to short-hydroperiod species over three decades in response to drought and associated shortened wetland hydroperiods. The RB data are useful to build a conceptual model of the impact of climate change on southeastern isolated wetlands. Initial models showed that Cu toxicity alone did not result in significant extinction risk for two species unless toxicity was >50% for survival parameters, whereas shortened hydroperiods could greatly increase the chance of local extinction.

Major Impact(s) of Research

1) Our continued time series of metal concentrations in the H-02 system (in sediments, water, and biota) will enable informed assessment of how this type of constructed treatment wetland functions, and whether it provides suitable wildlife habitat in addition to enhancing water quality. We have found that the levels of Zn in the wetlands do not pose a threat to amphibians.

2) Our lab and mesocosm studies demonstrate the importance of looking a) at multiple stressors, b) beyond the larval period, and c) at multiple source populations.

3) Our disease studies are ongoing but are demonstrating the complexity of variables involved with disease incidence and prevalence in amphibians. The nature of the wetland – metal-contaminated vs. clean, permanent vs. ephemeral, and constructed treatment wetland vs. natural–impacts disease prevalence and variables are confounded with each other.

4) Ranavirus exposure can cause serious sub-lethal effects such as growth rate, and more studies are required to determine if these effects can influence population dynamics.

5) Our understanding of the factors that drive the population dynamics of amphibians in natural systems, based on the long-term RB study, will allow predictions of the effects of climate change on isolated wetlands and provide insights to land managers who may need to design protective measures for rare species.

29. SRNL, 2015. *2015 Assessment of Mercury in the Savannah River Site Environment and Responses to the Agency for Toxic Substances and Disease Registry 2012 Report of Assessment of Biota Exposure to Mercury Originating from the Savannah River Site*, SRNL-STI-2015-00393, Rev. 0, August 2015, Savannah River National Laboratory, Savannah River Nuclear Solutions, Savannah River Site, Aiken, SC

    The purpose of the report is to 1) update previous SRNL assessment reports on the fate of Hg in SRS environment and 2) address comments and recommendations from the review of SRS by the Agency for Toxic Substances and Disease Registry (ATSDR) concerning the evaluation of exposures to contaminants in biota originating from the SRS. The ATSDR reviewed and evaluated data from SRS, SCDHEC and the Georgia Department of Natural Resources concerning the non-radioactive contaminant Hg. This report will provide a response and update to conclusions and recommendations made by the ATSDR.

    In an effort to address the implications of the ATSDR report, the Hg in biota of the SR originated from SRS activities, a review of existing literature, monitoring data, and a comprehensive accounting of the mass balance of Hg usage and deposition from offsite sources to the SRS was conducted. A recent review by the U.S. Geological Survey (USGS) in 2014 was included in this report on Hg status and implications in our nation's streams. The USGS report highlights the unique environmental factors of forested wetlands, that are prominent features of the southeast, and the higher rainfall totals as primary keys to understanding the higher MeHg tissue concentrations in higher trophic level fish as compared to the rest of the

nation. Nearly 22% of the total land area of the SRS consists of forested wetlands which drain into five primary streams and ultimately to the SR.

Little information was provided in the ATSDR report on the long historical inputs of Hg to the SR from industries located upstream of SRS (i.e., Olin Corporation Chlor-Alkali Plant). It is documented that the Olin Corporation discharged 12-lb per day into the SR from August 1965 to August 1970. During this time period, the SRS was pumping water directly from the SR onto the site to cool reactors. The cooling water was pumped through the reactor cooling systems and then to holding ponds and subsequently to the site streams or directly to site streams. Reviews conducted by the Risk Assessment Corporation on behalf of the Centers for Disease Control and Prevention investigated Hg usage at SRS from 1954 to 1992 and concluded the Hg levels in sediment of creeks known to have Hg inputs from SRS activities have not resulted in appreciable Hg releases to the SR. Additionally, high Hg concentrations were measured in fish caught onsite in SRS streams and ponds that directly received reactor cooling effluent. Hg would not have been used in or produced as a byproduct of reactor operations; therefore, the input of Hg originating from the Olin Corporation releases into the SRS is the likely source.

A comprehensive review of the mass balance of Hg inputs and deposition to the SRS and the SR indicates that ~1.1 kg/yr of Hg enters the SR from SRS stream outfalls. This value is small compared to the upstream sources of Hg that input ~12.0 kg/yr from known sources, and ~3.8 kg/yr from unknown sources, resulting in 16.9 kg/yr in the river effluent below the SRS.

Comparison of largemouth bass tissue concentrations for the SRS streams, the SR and other streams in South Carolina showed that average concentrations were similar among all sites. Largemouth bass are known to bioaccumulate MeHg and are a popular choice among sport fisherman so continued monitoring of this species is required.

A list of several projects describing efforts to mitigate impacts from residual Hg captured in bottom and bank sediments by employing a strategy to minimize Hg methylation through the use of stannous chloride, and projects initiated by SRS through the University of Georgia's, SREL to address concerns of Hg uptake in biota are presented.

Section 4.7.2 of the SRNL report is specific to Hg in fish. Concentrations of Hg in Fish Caught On-Site at SRS Versus Off-Site in the SR. Fish data reported in the 1971 to 1991 annual environmental monitoring reports were evaluated and compared with fish collected from a control location upriver from the SRS (Thurmond Lake). Average Hg concentrations measured in fish from Thurmond Lake and the SR at locations above, adjacent to, and below the SRS showed no statistically significant differences. This was not consistent with the fact that Olin Corporation discharges to the SR are well downriver from the Thurmond Reservoir, and concentrations of Hg in the fish from Thurmond Lake would not be expected to be the same as fish from the SR. Fish evaluated in the study (Bream, Bass, Catfish and other) were of similar size and length.

Conclusions made from the review of available data indicated:

- Evaluations of average Hg concentrations in fish for on-site and SR locations from 1971 to 1991 showed that concentrations appear to be a factor of two greater in onsite fish.
- There is little evidence to suggest that Hg from F-Area and H-Area Seepage Basins has resulted in elevated fish concentration in Four Mile Creek or any other onsite stream.
- The highest concentrations appear to be in SRS streams and reservoirs that have received reactor cooling effluent. It is unlikely that cooling effluent would contain Hg resulting from reactor operations, and it appears that the primary source of Hg at the SRS has been the continuous pumping of SR water for use as a reactor coolant.
- Several studies have reported elevated Hg concentrations in fish (approaching and exceeding concentrations measured in onsite fish) collected from South Carolina and Georgia reservoirs lacking a known Hg point source of contamination."

30. Tuberville, T.D., D.E. Scott, B.S. Metts, J.W. Finger Jr., and M.T. Hamilton, 2016. *Hepatic and Renal Trace Element Concentrations in American Alligators (Alligator Mississippiensis) Following Chronic Dietary Exposure to Coal Fly Ash Contaiminated Prey*. Environmental Pollution 214(2016): 680-689.

    Little is known about the propensity of crocodilians to bioaccumulate trace elements as a result of chronic dietary exposure. We exposed 36 juvenile alligators (Alligator mississippiensis) to one of four dietary treatments that varied in the relative frequency of meals containing prey from CCW-contaminated habitats vs. prey from uncontaminated sites, and evaluated tissue residues and growth rates after 12 mos. and 25 mos. of exposure. Hepatic and renal concentrations of As, Cd and Se varied significantly among dietary treatment groups in a dose dependent manner and were higher in kidneys than in livers. Exposure period did not affect Se or As levels but Cd levels were significantly higher after 25 mos. than 12 mos. of exposure. Kidney As and Se levels were negatively correlated with body size but neither growth rates nor body condition varied significantly among dietary treatment groups. Our study is among the first to experimentally examine bioaccumulation of trace element contaminants in crocodilians as a result of chronic dietary exposure. A combination of field surveys and laboratory experiments will be required to understand the effects of different exposure scenarios on tissue residues, and ultimately link these concentrations with effects on individual health.

31. Weir, S.M., R.W. Flynn, D.E. Scott, S. Yu, and S. L. Lance, 2016. *Environmental Levels of Zn Do Not Protect Embryos from Cu Toxicity in Three Species of Amphibians*. Environmental Pollution 214(2016): 161-168

    Contaminants often occur as mixtures in the environment, but investigations into toxicity usually employ a single chemical. Metal contaminant mixtures from anthropogenic activities such as mining and coal combustion energy are widespread, yet relatively little research has been performed on effects of these mixtures on amphibians. Considering that amphibians tend to be highly sensitive to Cu and that metal contaminants often occur as mixtures in the environment, it is important to understand the interactive effects that may result from multiple

metals. Interactive effects of Cu and Zn on amphibians have been reported as antagonistic and, conversely, synergistic. The goal of our study was to investigate the role of Zn in Cu toxicity to amphibians throughout the embryonic developmental period. We also considered maternal effects and population differences by collecting multiple egg masses from contaminated and reference areas for use in four experiments across three species. We performed acute toxicity experiments with Cu concentrations that cause toxicity (10 to 200 µg/L) in the absence of other contaminants combined with sublethal concentrations of Zn (100 and 1,000 µg/L). Our results suggest very few effects of Zn on Cu toxicity at these concentrations of Zn. As has been previously reported, we found that maternal effects and population history had significant influence on Cu toxicity. The explanation for a lack of interaction between Cu and Zn in this experiment is unknown but may be due to the use of sublethal Zn concentrations when previous experiments have used Zn concentrations associated with acute toxicity. Understanding the inconsistency of amphibian Cu/Zn mixture toxicity studies is an important research direction in order to create generalities that can be used to understand risk of contaminant mixtures in the environment.

32. Xu, C., M. Athon, Y.F. Ho, H.S. Chang, S. Zhang, D.I. Kaplan, K.A. Schwehr, N. DiDonato, P.G. Hatcher, and P.H. Santschi, 2014. *Plutonium Immobilization and Remobilization by Soil Mineral and Organic Matter in the Far-Field of the Savannah River Site*, U.S. Environmental Science and Technology 48(6): 3186-3195.

    To study the effects of NOM on plutonium (Pu) sorption, Pu(IV) and (V) were amended at environmentally relevant concentrations (10 to 14 millions) to two soils of contrasting particulate NOM concentrations collected from the F-Area of the SRS. More Pu(IV) than (V) was bound to soil colloidal organic matter (COM). A de-ashed humic acid (i.e., metals being removed) scavenged more Pu(IV,V) into its colloidal fraction than the original HA incorporated into its colloidal fraction, and an inverse trend was thus observed for the particulate-fraction-bound Pu for these two types of HAs. However, the overall Pu binding capacity of HA (particulate + colloidal-Pu) decreased after de-ashing. The presence of NOM in the FArea soil did not enhance Pu fixation to the organic-rich soil when compared to the organic-poor soil or the mineral phase from the same soil source, due to the formation of COM-bound Pu. Most importantly, Pu uptake by organic-rich soil decreased with increasing pH because more NOM in the colloidal size desorbed from the particulate fraction in the elevated pH systems, resulting in greater amounts of Pu associated with the COM fraction. This is in contrast to previous observations with low-NOM sediments or minerals, which showed increased Pu uptake with increasing pH levels. This demonstrates that despite Pu immobilization by NOM, COM can convert Pu into a more mobile form.