Sixth Five-Year Remedy Review Report for Savannah River Site Operable Units with Operating Equipment (U)

Aiken, South Carolina

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DISCLAIMER

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EXECUTIVE SUMMARY

This document presents the results of a technical evaluation of eleven environmental remedies implemented using operating equipment at Savannah River Site (SRS). The remedies are evaluated to determine whether they are functioning as designed, meeting their remedial action objectives, and whether they are protective of human health and the environment. This evaluation is required under Section 121 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986. CERCLA requires that remedial actions that result in any hazardous substances, pollutants, or contaminant remaining at the site be subject to a remedy review every five years.

Previous five-year remedy review reports combined all SRS operable units (OUs) that had implemented a remedial action into a single document. The Fourth Five-Year Remedy Review Report, issued in February 2014, reviewed 52 SRS remedy decision documents. A recommendation was made by SRS in the Fourth Five-Year Remedy Review Report that future reviews should be conducted in phases based on OU groupings with similar remedies. This phased approach not only reduces the volume of future remedy reports, but also is more effective in identifying and resolving issues for similar remedies. For this reason, the Fifth Five-Year Remedy Review Report was the first one conducted in five phases with OUs grouped by the following remedy types: (1) native soil covers and/or land use controls (LUCs); (2) groundwater; (3) engineered cover systems; (4) geosynthetic or stabilization/ solidification systems; and (5) operating equipment. The Sixth Five-Year Remedy Review Report will be conducted in five phases based on remedy type. ~~with t~~This report addresses the fifth phase that ~~evaluating~~ evaluates selected remedial actions with operating equipment as the final remedy.

According to the data reviewed and the site inspections, the remedies evaluated in this report are functioning as intended. The exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection are still valid. No new information has come to light that calls into question the protectiveness of any of the remedies evaluated. The remedies have been determined to be protective of human health and the environment, while the remedy for the A/M Groundwater OU is determined to be protective in the short-term. For the remedy to be

protective in the long-term, final corrective actions to be proposed by SRS and approved by South Carolina Department of Health and Environmental Control under the 2014 Permit Renewal will be implemented.

This report presents the issues and recommendations that have resulted from the remedy review. SRS identified the following recommendations:

- Soil confirmation sampling is recommended at A-Area Burning/Rubble Pits (731-A, 731-1A) and Rubble Pit (731-2A), Miscellaneous Chemical Basin (731-4A) / Metals Burning Pit (731-5A) Operable Unit to evaluate the current soil concentrations against remedial goals (RGs) with the intent to justify shutting down the passive soil vapor extraction (SVE).
- Due to the D-Area Operable Unit Bubble Tower Subunit MicroBlower™ SVE system's minimal removals of contaminants for at least the last four years, SRS proposes to convert the MicroBlower™ SVE system to a passive BaroBall™ SVE system until confirmation soil samples can be collected to determine whether the tetrachloroethylene soil RG has been met (20 µg/kg). If the RG has been achieved, the results will be submitted to the U.S. Department of Energy, U.S. Environmental Protection Agency, and South Carolina Department of Health and Environmental Control for consensus to justify discontinuing operation of the SVE and/or monitoring.
- Since the M-Area Settling Basin Inactive Process Sewer Lines (MIPSL) SVE system has been taken offline and removed, and the LUC boundaries of the MIPSL Operable Unit (OU) and M-Area Operable Unit (MAOU) overlap, SRS recommends ~~moving the M-Area Settling Basin Inactive Process Sewer Lines Operable Unit from the Operating Equipment group to the Native Soil Cover and/or LUCs group~~incorporating the MIPSL into the MAOU to eliminate operations and maintenance costs for the smaller OU. A meeting to discuss the appropriate regulatory path forward for this recommendation is needed. ~~This recommendation would take effect during the Seventh Five-Year Remedy Review Report for the SRS OUs with Native Soil Covers and/or Land Use Controls.~~

- Prevent authorized access
- Prevent unauthorized intrusive activity.
- Maintain the integrity of the cover systems.

Table 2 lists the remedial actions for each of the OUs in this five-year remedy review report. The remedial actions are described in greater detail in the OU-specific appendices (Appendix C through Appendix M). Table 3 provides a summary of the LUC objectives for the OUs with operating equipment.

Status of Implementation

The remedial actions listed in Table 2 have been implemented. LUCs are ongoing at all OUs discussed in this five-year remedy review. The status of all response actions or remedial actions for each of the OUs with operating equipment is discussed in greater detail in the OU-specific appendices (Appendix C through Appendix M).

Systems Operation and Maintenance

A site-wide maintenance program is in place to care for cover systems, signs, monitoring wells, and other infrastructure associated with environmental remediation. The operation and maintenance (O&M) of cover systems consist of, but is not limited to, growing grass, mowing, managing surface stormwater drainage, preventing disturbance from hog activities, inspections, and repair of erosion or subsidence as necessary. In addition, hog fencing was installed at various OUs as an SRS maintenance action to reduce/minimize the damage caused by feral hogs. Identifying signs must remain legible. The O&M of the SVE systems consist of ensuring continual operation (e.g., non-operational units are replaced).

The costs of the O&M activities for the individual OUs have been compiled as part of this five-year remedy review. As part of the process of selecting the most appropriate action for each OU, the cost of implementing each of the remedies was estimated and reported in the respective remedy evaluation and decision documents. Table 4 compares the actual costs incurred at SRS OUs with operating equipment over the period from fiscal year (FY)

2018 to FY2022 to the estimated costs from the remedy decision documents projected for the same period. The review for the actual costs incurred (i.e., 2018 to FY2022) is based on the time-period since the last review for these OUs was conducted in the Fifth Five-Year Remedy Review Report (SRNS 2018c). Specific details concerning costs incurred are included for each OU in Appendix C through Appendix M.

In support of the beneficial reuse of brownfield locations, the U.S. Department of Agriculture Forest Service – Savannah River (USFS-SR) began establishing pollinator habitats in 2019 within the boundaries of previously closed waste units located in M-Area, P-Area, R-Area, and T-Area where they will not interfere with existing cover systems or LUCs. Additionally, the USFS-SR also plants 100 acres of pollinator habitat annually at SRS, primarily along powerline rights-of-way. Other USFS-SR practices include adjusted planning practices to encourage a more diverse plant population, and thinning of 3,500 acres of forest annually, which creates conditions more conducive to pollinator habitat.

III. PROGRESS SINCE LAST REVIEW

For the OUs evaluated in this review, the previous protectiveness statements from the Fifth Five-Year Remedy Review Report (SRNS 2018c) concluded that the remedies for these OUs were found to be protective (Table 5).

Recommendations from the Fifth Five-Year Remedy Review Report that impact the OUs with operating equipment evaluated in this report are as follows:

- The passive system at A-Area Miscellaneous Rubble Pile (731-6A) OU has been successful in treating volatile organic carbon (VOC) contamination. Soil sampling and an updated modeling effort were completed and discussed with USDOE, USEPA, and SCDHEC on December 16, 2020. Based on agreements reached during the meeting, operation of the passive soil vapor extraction (SVE) system was discontinued in 2021. Two groundwater wells (AOB 1 and MSB 31C) are monitored to verify that there are no impacts to the groundwater associated with the discontinued operation of the SVE system. The data from the two wells is reported in the five-year remedy review reports for SRS OUs with operating equipment.~~Soil RGs have likely been achieved and~~

~~operation of the passive soil vapor extraction (SVE) system may no longer be needed for future protection of groundwater.~~

- The D-Area Operable Unit (DAOU) Bubble Tower MicroBlower™ SVE has been successful in treating VOC contamination. Contaminant removal by the MicroBlower™ SVE system has greatly diminished or ceased since 2012 and operation of the SVE system may no longer be needed for future protection of groundwater if the soil RG has been achieved. This recommendation was revised to include conversion of the MicroBlower™ SVE system to a passive BaroBall™ SVE system until soil samples can be collected (refer to Section VI, Issues/Recommendations and Appendix G).

IV. FIVE-YEAR REMEDY REVIEW PROCESS

USDOE has implemented the Sixth Five-Year Remedy Review for SRS OUs with operating equipment. The review specifically evaluated remedies by comparing them to the OU-specific decision documents. The following actions were taken to perform the Sixth Five-Year Remedy Review for this category:

- Submitted a scoping summary to the USDOE, USEPA and SCDHEC on August 9, 2022 and conducted a scoping meeting on August 30, 2022. The USDOE, USEPA and SCDHEC agreed to the scope and schedule of the remedy review report, which is discussed in the scoping summary;
- Published an announcement on October 12, 2022 that the USDOE is conducting the Sixth Five-Year Remedy Review in phases. The announcement stated that the fifth phased submittal will focus on the OUs with operating equipment. The public was notified through mailings of *The Savannah River Site Environmental Bulletin*, a newsletter sent to citizens in South Carolina and Georgia on an extensive mailing list, including landowners adjacent to SRS, which is updated annually in July, and through notices in the *Aiken Standard* (Aiken, SC), *The Augusta Chronicle* (Augusta, GA), *The People Sentinel* (Allendale and Barnwell, SC), and *The State* (Columbia, SC)

newspapers. The Environmental Bulletin and newspaper affidavits of publication are available in the Administrative Record File;

- Reviewed appropriate data, documentation (i.e., including RODs, Early Action RODs [EARODs], Interim RODs [IRODs], Explanation of Significant Differences [ESD]), and LUCIP-required field inspection checklists, etc. The specific data and document references used to review each remedy decision are listed in the OU-specific reports located in Appendix C through Appendix M;
- Confirmed protectiveness of the remedial actions through inspections and interviews. Cognizant personnel were interviewed as to the status and success of the current remedial systems. The results of the inspections and interviews are documented in the Site Inspection Checklist included with the OU-specific reports located in Appendix C through Appendix M;
- Reviewed changes in standards and to-be-considered guidance including federal and state promulgated standards (i.e., chemical specific applicable or relevant and appropriate requirements [ARARs]) that would call into question whether the prescribed remedy was meeting the newer standards or guidance. Any problems or discrepancies are reported in the Section V (Technical Assessment), Section VI (Issues/Recommendations) of the OU-specific appendices; and
- Submitted a draft Fact Sheet to USEPA and SCDHEC for review with Revision 0 of the Sixth Five-Year Remedy Review Report for SRS OUs with Operating Equipment.

Community Notification and Involvement

USDOE will address any comments received from USEPA and SCDHEC and provide a Revision 1 report, if necessary, for USEPA and SCDHEC approval. After the USEPA and SCDHEC approve this report and USDOE, USEPA, and SCDHEC sign this report, a notice of availability will be published in the *Aiken Standard* (Aiken, SC), *The Augusta Chronicle* (Augusta, GA), *The People Sentinel* (Allendale and Barnwell, SC), and *The State* (Columbia, SC) newspapers. Additionally, the availability of the report will be announced in *The Savannah River Site Environmental Bulletin*, which will be sent to the SRS mailing

list. The report will be made available to the public at four information repositories listed in the *Environmental Bulletin*.

Data Review, Site Inspections, and Interviews

According to the data review, the site inspections, and interviews, the remedies selected for the SRS OUs included in this report are functioning as intended by the decision documents. The exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the remedy selection are still valid for all OUs included in this report. No new information has come to light that calls into question the protectiveness of the remedies.

The Revision 0 report ~~will be~~was submitted ~~by~~ on December ~~21~~20, 2022. USEPA and SCDHEC ~~are expected to~~ performed site inspections of OUs with operating equipment ~~prior to submittal of the Revision 1 report~~on March 15, 2023. No problems regarding protection of the remedies for the OUs were identified during the inspections.

V. TECHNICAL ASSESSMENT

The technical assessment of the environmental cleanup program at SRS in general and each of the OU-specific remedies evaluated in this report (Appendices C through M) is described by answers to the following three questions posed by the USEPA.

- Question A: Is the remedy functioning as intended by the decision documents?
- Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs still valid?
- Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

Question A: Is the remedy functioning as intended by the decision documents?

Answer: Yes. SRS remedial systems with operating equipment are functioning as intended as demonstrated below.

- Air stripping and SVE units associated with the A/M-Area Groundwater plume continue to operate reliably and remove VOCs from the groundwater and vadose zone.

- Passive and Low Energy SVE systems, solar powered MicroBlowers™ and barometric pressure-operated BaroBalls™ continue to remove contaminants from subsurface soils contaminated by low concentrations of VOCs
- Thermal treatment of tritium-contaminated soil and debris has been successfully implemented in D-Area.
- Edible oil injection to enhance bioremediation has successfully decreased the size and concentration of the VOC plume in T Area.
- Groundwater data at Monitored Natural Attenuation (MNA) remedy plumes indicates that groundwater concentrations are generally decreasing and plumes are not expanding.
- Contaminated material has been excavated and consolidated or left in place under protective cover systems, breaking the pathway for worker exposure and for the migration of contaminants to groundwater.
- The cover system maintenance program and LUCs have been effective in maintaining the integrity of the cover systems at SRS OUs. The inspection reports indicate no significant deficiencies.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs still valid?

Answer: Yes. The exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection are still valid for all OUs included in this report. An evaluation of changes in chemical and radiological standards including federal and state promulgated standards (i.e., chemical specific ARARs) that were in place when the last five-year remedy review was initiated in 2017 to the standards applicable in 2022 was conducted to determine if there were any changes that would affect the protectiveness of the selected remedies. There were no changes in chemical and radiological specific standards that would affect the protectiveness of the remedies. There were no changes in action-specific or location-specific requirements that would impact any remedy. This evaluation is included in Appendix B and described in the OU-specific appendices.

Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

Answer: No. No other information that could call into question the protectiveness of the selected remedies and no outstanding issues have been identified in this Sixth Five-Year Remedy Review.

For all OUs, current and reasonably anticipated future land use at SRS remains consistent with assumptions in the respective decision documents.

VI. ISSUES/RECOMMENDATIONS

Remedial actions evaluated in this Five-Year Remedy Review for SRS remain protective of human health and the environment and are functioning as intended. The OUs without issues and recommendations are listed in Table 6.

The OUs with issues and recommendation are listed in Table 7 and summarized below.

- Soil confirmation sampling is recommended at A-Area Burning/Rubble Pits (731-A and 731-1A) and Rubble pit (731-2A), Miscellaneous Chemical Basin (731-4A) and Metals Burning Pit (731-5A) OU to evaluate the current soil concentrations against remedial goals with the intent to justify shutting down the passive SVE if the RG has been attained.
- Due to the DAOU Bubble Tower Subunit MicroBlower™ SVE system's minimal removals of contaminants for at least the last four years, SRS proposes to convert the MicroBlower™ SVE system to a passive BaroBall™ SVE system until confirmation soil samples can be collected to determine whether the tetrachloroethylene soil RG has been met (20 µg/kg). If the RG has been achieved, the results will be submitted to the Core Team for consensus to justify discontinuing operation of the SVE and/or monitoring.
- Since the M-Area Settling Basin Inactive Process Sewer Lines (MIPSL) SVE system has been taken offline and removed, and the LUC boundaries of the MIPSL OU and M-Area Operable Unit (MAOU) overlap, SRS recommends ~~moving the M-Area~~

~~Settling Basin Inactive Process Sewer Lines OU from the Operating Equipment group to the Native Soil Cover and/or LUCs group~~ incorporating the MIPSL OU into the MAOU to eliminate operations and maintenance costs for the smaller OU. A meeting to discuss the appropriate regulatory path forward for this recommendation is needed. ~~This recommendation would take effect during the Seventh Five-Year Remedy Review Report for the SRS OUs with Native Soil Covers and/or Land Use Controls.~~

VII. PROTECTIVENESS STATEMENT(S)

The protectiveness statements for each remedy are based on the recommended language from the Comprehensive Five-Year Review Guidance (USEPA 2001), Clarifying the Use of Protectiveness Determinations for Comprehensive Environmental Response, Compensation, and Liability Act Five-Year Reviews (USEPA 2012), and Five-Year Review Recommended Template (USEPA 2016).

For the OUs evaluated in this Five-Year Remedy Review, the remedies with operating equipment have been determined to be protective of human health and the environment (Table 8). However, the remedy for the A/M-Area Groundwater has been determined to be protective in the short-term. To establish long-term protectiveness, final corrective actions to be proposed by SRS and approved by South Carolina Department of Health and Environmental Control under the 2014 Permit Renewal will be implemented.

LUCs are part of all final remedial actions where hazardous substances, pollutants, or contaminants remain on-site above levels that allow for unlimited use and unrestricted exposure. The type of LUCs and implementation and reference to the OU-specific LUCIP is described in detail in Section VII of the OU-specific appendices. For the OUs evaluated in this report, pathways for contaminants to reach human and ecological receptors have been successfully broken by the selected remedies including LUCs.

For the A/M Area Groundwater OU, F-Area Groundwater OU, and H-Area Groundwater OU, the LUC requirements are discussed and approved as part of the closure/post-closure/permit application process and are governed by the RCRA Permit Renewal for the

Table 4. Operation and Maintenance Cost Comparison for SRS OUs with Operating Equipment

Operable Unit	Main Remedy	Remedy Decision Document Year[a]	FY2018-FY2022 O&M Estimated Cost	FY2018-FY2022 O&M Actual Cost	% of Estimate	Comments
A-Area Burning/Rubble Pits (731-A and 731-1A) and Rubble Pit (731-2A), Miscellaneous Chemical Basin (731-4A) and Metals Burning Pit (731-5A) OU	SVE	2007	$313,808	$671,989	214%	Actual costs are higher than expected because the operational life of the active SVE system exceeded the ROD estimated three-year life.
A/M-Area Groundwater OU	Air stripping, SVE	1992	0	$10,174,972	N/A	RCRA documentation does not require estimated costs to be prepared. Therefore, a cost comparison cannot be provided in this remedy review.
A-Area Miscellaneous Rubble Pile (731-6A) OU	SVE	2003	$216,000	$274,856	127%	Actual costs were higher than expected because the operational life of the active SVE system exceeded the ROD estimated five-year life (anticipated end was FY2009).
C-Area Burning/Rubble Pit (131-C) and Old C-Area Burning/Rubble Pit (NBN) OU	SVE, MicroBlowers™	2008	$162,000	$549,995	340%	Actual costs are higher than expected due to the increased costs associated with MNA monitoring and reporting. No unexpected costs have been incurred.
D-Area OU	Soil Cover, LUCs	2011	$119,750	$426,044	356%	Actual costs are higher than expected because D-Area Bubble Tower Subunit costs were not included in the EAROD cost estimate.
F-Area Groundwater OU	Base injection, LUCs	1995	0	$5,680,644	N/A	RCRA documentation does not require estimated costs to be prepared. Therefore, a cost comparison cannot be provided in this remedy review.
H-Area Groundwater OU	Base injection, LUCs	1995	0	$5,950,785	N/A	RCRA documentation does not require estimated costs to be prepared. Therefore, a cost comparison cannot be provided in this remedy review.
M-Area Settling Basin Inactive Process Sewer Lines to Manhole 1 (081-M) OU	SVE	2007	$217,500	$336,648	155%	Actual O&M costs are as expected compared to the estimated O&M costs, until FY2015. Active SVE operations were supposed to end in FY2014 but are continuing to operate. Additional operating equipment repairs were incurred in FY2016/FY2017.

Table 4. Operation and Maintenance Cost Comparison for SRS OUs with Operating Equipment *(continued/end)*

Operable Unit	Main Remedy	Remedy Decision Document Year[a]	FY2018-FY2022 O&M Estimated Cost	FY2018-FY2022 O&M Actual Cost	% of Estimate	Comments
M-Area OU	Cap	2009	$186,000	$810,315	436%	Actual costs are higher than expected because the estimated cost did not include maintenance for the entire MAOU (e.g., mowing).
P-Area Burning/Rubble Pit (131-P) OU	Groundwater Monitoring / Passive SVE	2003	$128,346	$75,190	59%	The actual O&M costs are as expected, with the exception that the ROD estimated every five-year major soil cover repairs have not been necessary (FY2018 and FY2022) and inspections are performed annually instead of monthly as originally estimated.
TNX Area OU	SVE	2004	$1,234,149	$788,860	64%	The actual O&M costs are as expected compared to the estimated O&M costs.

Table 6. Operable Units without Issues and Recommendations in the Sixth Five-Year Remedy Review Report

OU(s) without Issues/Recommendations Identified in the Five-Year Review
SEMS #: 8, 9, 21, 28, 29, 30, 31, 36, 59, 92

Table 7. Issues and Recommendations Identified in the Sixth Five-Year Remedy Review Report

Issues and Recommendations Identified in the Five-Year Review				
A-Area Burning/ Rubble Pits (731-A, 731-1A) and Rubble Pit (731-2A), Miscellaneous Chemical Basin (731-4A) and Metals Burning Pit (731-5A) **SEMS #:** 28	**Issue Category:** Monitoring			
	Issue: Confirmation sampling is needed to justify shutting down the passive SVE.			
	Recommendation: It is recommended that confirmation soil sampling be conducted at ABRP/MCB to evaluate the current soil concentrations against the RGs with the intent to justify shutting down the passive SVE.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	USDOE	USEPA/ SCDHEC	09/30/2024
D-Area Operable Unit **SEMS #:** 63	**Issue Category:** Monitoring			
	Issue: The passive SVE systems have been successful in treating VOC contamination			
	Recommendation: SRS recommends shutdown of the DAOU Bubble Tower MicroBlower™ SVE system if remedial goals have been achieved.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	USDOE	USEPA/ SCDHEC	06/30/2023
M-Area Settling Basin Inactive Process Sewer Lines to manhole 1 (081-M) (MIPSL) OU **SEMS #:** 19	**Issue Category:** Changed Site Conditions			
	Issue: The remediation system has been shut down. Only land use controls remain in place.			
	Recommendation: ~~Move this remedy review to Phase 1 (Native Soil Covers and/or Land Use Controls [LUCs])~~Combine with the MAOU since the LUC boundaries of the two overlap. A meeting to discuss the appropriate path forward for this recommendation is needed.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	USDOE	USEPA/ SCDHEC	12/20/2023

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SIXTH FIVE-YEAR REMEDY REVIEW REPORT PHASED REVIEWS

I. FIVE-YEAR REMEDY REVIEW PHASES

The size of the Savannah River Site (SRS) five-year remedy review reports has grown considerably since the first report was issued in 1997 with respect to the number of operable unit (OU) remedies evaluated and the level of detail required. Beginning with the Fifth Five-Year Remedy Review Report, the U.S. Department of Energy, U.S. Environmental Protection Agency (USEPA), and South Carolina Department of Health and Environmental Control (SCDHEC) agreed to segregate the OUs into five groupings based on remedy similarity with a different group submitted annually on a five-year cycle. This phased approach not only reduces the volume of future remedy reports but is also more effective in identifying and resolving issues for similar remedies.

The SRS OUs are grouped by the following remedy types:

(1) Native Soil Covers and/or Land Use Controls (LUCs);
(2) Groundwater Remedies;
(3) Engineered Cover Systems;
(4) Geosynthetic or Stabilization/Solidification (S/S) Cover Systems; and
(5) Operating Equipment.

The trigger date for submittal of the next five-year remedy review report to the regulatory agencies is based on the USEPA signature date of the previous report. The final signature for the last grouping of the Sixth Five-Year Remedy Review Report is due no later than January 21, 2024. For the sixth five-year remedy review reports, Table A-1 provides a schedule for issuance of the remedy reviews for the five OU remedy groupings to ensure that the five-year limit between decision document reviews in compliance with Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan is not exceeded.

A list of the SRS OUs with remedy decision documents grouped into the five phased reviews is provided in Table A-2. Table A-2 will be updated in future remedy review

reports as additional remedy decision documents are approved and added. A general description of the five remedy types is provided below.

Phase 1: Native Soil Covers and/or LUCs

For purposes of the sixth five-year phased remedy review, SRS OUs with native soil covers and/or LUCs as the selected remedy are grouped under the Native Soil Covers and/or LUCs category.

Native soil covers are often implemented at SRS to protect against human and/or ecosystem exposure to waste or contaminated material left in place. Native soil covers are appropriate when water infiltration and leaching of contaminants to groundwater is not a concern. A typical soil cover is 0.30 m to 0.61 m (12 to 24 in) thick and is usually vegetated to minimize erosion. Native soil covers are usually low in cost and construction materials are readily available from SRS local sources. Native soil covers may be combined with other remedial actions but require LUCs as a component of the remedy. For these units, native soil covers were in place prior to selection of the remedial action. For this reason, only LUCs were required as the final remedial action for the nine OUs with existing soil covers discussed in the Native Soil Covers and/or LUCs report.

LUCs are maintained for all OUs where hazardous substances, pollutants, or contaminants remain on-site or have been left in place above levels that are acceptable for unlimited use and unrestricted exposure. LUCs may be implemented as a stand-alone remedy when active measures are determined not to be practicable or combined with other remedial actions. LUCs involve institutional controls (i.e., administrative controls) and engineering controls and can include monitoring, maintenance, reporting, access restrictions, signage, fencing, and land use restrictions. In older SRS remedy documents, the term "institutional controls" was often used in place of the broader LUC term.

Phase 2: Groundwater Remedies

For purposes of the sixth five-year phased remedy review, SRS OUs that have monitoring activities associated with Monitored Natural Attenuation (MNA) or a Mixing Zone (MZ) permit are grouped in the Groundwater Remedies category.

Table A-6. Summary of No Remedial Actions at SRS OUs

Operable Unit	Remedial Action
No Action/No Further Action	
211-FB Pu-239 Release (081-F)	No Action
716-A Motor Shops Seepage Basin (904-101G)	No Action
Burma Road Rubble Pit (231-4F)	No Action
Central Shops Burning/Rubble Pit (631-6G)	No Action
Central Shops Sludge Lagoon (080-24G)	No Action
C-, F-, K-, and P-Area Coal Pile Runoff Basins (189-C, 289-F, 189-K, and 189-P)	No Further Action
Fire Department Hose Training Facility (904-113G)	No Action
Ford Building Waste Site (643-11G)	No Further Action (Removal)
G-Area Oil Seepage Basin (761-13G)	No Action
Gas Cylinder Disposal Facility (131-2L)	No Further Action
Grace Road Site (631-22G)	No Action
Gunsite 113 Access Road Unit (631-24G)	No Action
Gunsite 218 Rubble Pile (621-23G)	No Action
Gunsite 720 Rubble Pit Unit (631-16G)	No Action
Hydrofluoric Acid Spill (631-4G)	No Action
K-Area and PAR Pond Sludge Land Application Site (761-4G and 761-5G)	No Action
L-Area Burning/Rubble Pit (131-L)	No Further Action
L-Area Hot Shop (717-G)	No Further Action
L-Area Northern Groundwater (NBN)	No Action
L-Area Rubble Pile (131-3L)	No Further Action
M-Area West Unit (631-21G)	No Action
R-Area Acid/Caustic Basin (904-77G)	No Action
Road A Chemical Basin (904-111G)	No Action
SRL Oil Test Site (080-16G)	No Action
Stormwater Outfall A-013 (NBN)	No Action
West of SRL "Georgia Fields" Site (631-19G)	No Action
No Action/No Further Action OUs Associated with OUs Requiring Remedial Action	
108-4R Overflow Basin (108-4R)[1]	No Further Action
489-D Coal Pile Runoff Basin – Southern 75% Subunit[2]	No Further Action
A-Area Burning/Rubble Pit (731-1A)[3]	No Action
A-Area Burning/Rubble Pit (731-A)[3]	No Action
Central Shops Burning/Rubble Pit (631-5G)[34]	No Action
ECODS B-3 and B-5 (NBN)[45]	No Further Action
ECODS G-3 (Adjacent to Gunsite 012) (NBN)[56]	No Action
L-Area Acid/Caustic Basin (904-79G)[67]	No Action
Metals Burning Pit (731-5A)[3]	
Rubble Pile Across from Gunsite 012 (NBN)[56]	No Action
R-Area Rubble Pile (631-25G)[78]	No Action

Table A-6. Summary of No Remedial Actions at SRS OUs (*continued/end)*

Operable Unit	Remedial Action
RCRA Units that are No Further Action under CERCLA	
H-Area Hazardous Waste Management Facility (904-44G, 904-45G, 904-46G, and 904-56G)	No Further Action (Low Permeability Cap)
Tank 105-C Hazardous Waste Management Facility (NBN)	No Further Action
F-Area Hazardous Waste Management Facility (904-41G, 904-42G, and 904-43G)	No Further Action (Low Permeability Cap, In Situ S/S)
Mixed Waste Management Facility (643-28E)	No Further Action (Low Permeability Cap)

1 – Included with R-Reactor Seepage Basins (904-103G, 904-104G, 904-57G, 904-58G, 904-59G, 904-60G)
2 – Included with D-Area Operable Unit
3 – Included with A-Area Burning/Rubble Pits (731-A/731-1A) and Rubble Pit (731-2A), Miscellaneous Chemical Basin (731-4A) and Metals Burning Pit (731-5A)
~~3~~ 4 – Included with Heavy Equipment Wash Basin (NBN)
~~4~~ 5 – Included with B-Area Operable Unit
~~5~~ 6 – Included with Gunsite 012
~~6~~ 7 – Included with L-Area Oil and Chemical Basin (904-83G)
~~7~~ 8 – Included with R-Area Burning/Rubble Pits (131-R, 131-1R)

Table A-7. List of OU Subunits with Remedial Actions

#	OU Subunits[a,b]	SEMS #
1	~~A-Area Burning/Rubble Pit, 731-1A~~	28
	~~A-Area Burning/Rubble Pit, 731-A~~A-Area Ash Pile, 788-2A	
	A-Area Rubble Pit, 731-2A	
	Miscellaneous Chemical Basin, 731-4A	
	~~Metals Burning Pit, 731-5A~~	
2	A-Area Miscellaneous Rubble Pile, 731-6A	30
3	A/M-Area Groundwater	36
4	B-Area Operable Unit	53
5	C-Area Burning/Rubble Pit, 131-C	31
	Old C-Area Burning/Rubble Pit, NBN	
6	C-Area Groundwater	82
7	C-Area Process Sewer Line as Abandoned, NBN	79
	C-Area Reactor Area Cask Car Railroad Tracks as Abandoned, NBN	
	C-Reactor Discharge Canal, NBN	
	ECODS C-1 (Near C-Area Reactor Discharge Canal), NBN	
	Potential Release from C-Area Disassembly Basin, NBN	
	Potential Release from C-Area Reactor Cooling Water System, 186/190-C	
8	C-Area Reactor Seepage Basin, 904-66G	60
	C-Area Reactor Seepage Basin, 904-67G	
	C-Area Reactor Seepage Basin, 904-68G	
9	Central Shops Burning/Rubble Pit, 631-1G	50
	Central Shops Burning/Rubble Pit, 631-3G	
10	CMP Pit, 080-170G	24
	CMP Pit, 080-171G	
	CMP Pit, 080-180G	
	CMP Pit, 080-181G	
	CMP Pit, 080-182G	
	CMP Pit, 080-183G	
	CMP Pit, 080-190G	
11	C-, K-, L-Reactor Complexes	79, 90, 91
12	D-Area Burning/Rubble Pit, 431-D	15
	D-Area Burning/Rubble Pit, 431-1D	
13	D-Area Ash Basin, 488-D	67
	D-Area Rubble Pit, 431-2D	
14	D-Area Oil Seepage Basin, 631-G	27
15	D-Area Coal Pile Runoff Basin, 489-D	63
	D-Area Waste Oil Facility, 484-10D	
	D-Area Asbestos Pit, 080-20G	
	Combined Spills from 483-D and Associated Areas, NBN	
	D-Area Process Sewer Lines as Abandoned, NBN	
	D-Area Ash Basin, 488-1D	
	D-Area Ash Basin, 488-2D	
	D-Area Ash Landfill, 488-4D	
16	E-Area Low Level Waste Facility, 643-26E	86

Table A-7. List of OU Subunits with Remedial Actions *(continued)*

#	OU Subunits[a,b]	SEMS #
17	ECODS L-1, NBN	22
	ECODS P-2, NBN	
	ECODS R-1A, R-1B, R-1C, NBN	
	ECODS N-2, NBN	
18	F-Area Burning/Rubble Pit, 231-1F	14
	F-Area Burning/Rubble Pit, 231-2F	
	F-Area Burning/Rubble Pit, 231-F	
19	F-Area Groundwater Operable Unit	8
20	F-Area Hazardous Waste Management Facility (F-Area Seepage Basin, 904-41G)	6
	F-Area Hazardous Waste Management Facility (F-Area Seepage Basin, 904-42G)	
	F-Area Hazardous Waste Management Facility (F-Area Seepage Basin, 904-43G)	
21	F-Area Retention Basin, 281-3F	23
22	F-Area Tank Farm, Waste Tanks 17 and 20	23
	F-Area Tank Farm, Waste Tanks 18 and 19	
	F-Area Tank Farm, Waste Tanks 5 and 6	
23	Ford Building Seepage Basin, 904-91G	58
24	General Separations Area Consolidation Unit including Old Radioactive Waste Burial Ground(643-E) and Old Solvent Tanks (650-01E through 650-22E)	32
	Warner's Pond, 685-23G and Spill of 3/08/1978 of Unknown Seepage Basin Pipe Leak in H-Area Seepage Basin, NBN and Spill on 02/08/1978 of Unknown H-Area Process Sewer Line Cave-In, NBN	
	H-Area Retention Basin, 281-3H and Spill of 5/01/1956 of Unknown Retention Basin Pipe Leak, NBN	21
	HP-52 Ponds, NBN	
25	H-Area Tank Farm, Waste Tank 12	89
	H-Area Tank Farm, Waste Tank 16	
26	Gunsite 012 Rubble Pile, NBN	78
	~~Rubble Pile across from Gunsite 012, NBN~~	
27	H-Area Groundwater OU	9
28	H-Area Hazardous Waste Management Facility (F-Area Seepage Basin, 904-44G)	7
	H-Area Hazardous Waste Management Facility (F-Area Seepage Basin, 904-46G)	
	H-Area Hazardous Waste Management Facility (F-Area Seepage Basin, 904-45G)	
	H-Area Hazardous Waste Management Facility (F-Area Seepage Basin, 904-56G)	
29	Heavy Equipment Wash Basin, NBN	25
30	K-Area Bingham Pump Outage Pit, 643-1G	20
31	K-Area Burning/Rubble Pit, 131-K	40
	K-Area Rubble Pile, 631-20G	
32	K-Area Reactor Seepage Basin, 904-65G	55
33	L-Area Bingham Pump Outage Pit, 643-2G	26
	L-Area Bingham Pump Outage Pit, 643-3G	
	P-Area Bingham Pump Outage Pit, 643-4G	39
34	L-Area Oil Chemical Basin, 904-83G	17
35	L-Area Reactor Seepage Basin, 904-64G	65
36	L-Area Southern Groundwater, NBN	77
37	M-Area Hazardous Waste Management Facility: Lost Lake, 904-112G	1
	M-Area Hazardous Waste Management Facility: M-Area Settling Basin, 904-51G	

involved the implementation of air sparging with active/passive soil vapor extraction (SVE) system (installed at Rubble Pit 731-2A) to reduce VOCs in the M-Area aquifer contaminated plume. A passive SVE system was installed to reduce VOCs in the vadose zone beneath the trench underlying the Ash Pile. An ABRP monitoring well system was installed to determine the effectiveness of the SVE systems and began operation in September 2001. Based on the results of the first year of operation and subsequent testing of the air sparging system, it was determined that the system had not and likely would not meet the remedial action objectives (RAOs) for the subunit. An Explanation of Significant Differences (ESD) for the ABRP (WSRC 2002) was issued in 2003 to remove the air sparging system and expand the SVE portion of the remedy presented in the ABRP IROD to operate four MicroBlower™-equipped SVE wells at the Trench subunit to remediate VOCs in the vadose zone.

An IROD was approved in December 1999 for MCB/MBP OU (WSRC 1999a) to address elevated levels of aluminum in MBP surface and subsurface soil, elevated levels of polychlorinated biphenyls (PCBs) (i.e., Aroclor 1254 and Aroclor 1260) in MCB surface and subsurface soil, elevated levels of VOCs in MCB vadose zone soils, and elevated levels of VOCs in groundwater. Interim actions at the MCB/MBP OU were taken beginning in 2000 to remove contaminated surface soils exceeding 1,000 µg/kg Aroclor 1254 and 215 µg/kg Aroclor 1260 at MCB and exceeding 11,000 mg/kg aluminum at MBP (considered final actions), and to treat VOC-contaminated vadose zone soils with active and passive SVE. Contaminated surface soils at MCB/MBP were excavated and shipped to a sanitary landfill. Clean fill was backfilled into the excavated areas. At MCB, the area was cleared and remediation equipment (i.e., active SVE followed by passive SVE using BaroBall™ technology) was installed to treat the contaminated vadose zone soils by lowering VOC concentrations to below 50 ppmv. Three banks of airlift recirculation wells (i.e., in situ air stripping) were used to treat contaminated groundwater. Figure C-3 identifies LUC requirements at MCB based on the continued SVE while there are no LUC requirements at the MBP because no further action was required after soil excavation activities.

Basis for Taking Action

No human health, ecological, or contaminant migration (CM) constituents of concern (COCs) have been identified at the Burning/Rubble Pits (731-A, 731-1A), Potential Pit, Depressional Area, and Ash Scatter Area/Ditch subunits. Thus, there is no problem warranting action for these subunits.

Benzo(a)pyrene in surface soil at Rubble Pit 731-2A was identified as a COC for the future industrial worker at concentrations exceeding the remedial goal (RG) of 0.2 mg/kg.

Arsenic and coal-related radionuclides are present at the A-Area Ash Pile subunit (788-2A) at concentrations that exceed the 1E-06 risk for the future industrial worker. Arsenic and selenium are present in concentrations that may be predictive of a potential ecological hazard (hazard quotients > 1). These RGs are listed in Table C-2.

In 2001, before the start of the interim action, the maximum detection of trichloroethylene (TCE) at the Trench subunit was 487,000 µg/kg. TCE concentrations in the vadose zone were present at levels expected to migrate to groundwater above the maximum contaminant level (MCL) of 5 µg/L in less than 10 years (Figure C-4).

At the MCB subunit, PCBs exceeding both the human health RG (1 mg/kg) and the ecological RG (0.215 mg/kg) were present in surface soils. Octachlorodibenzo-p-dioxin (OCDD) was also present as a human health COC but does not pose a risk to future industrial workers.

In the MCB vadose zone, tetrachloroethylene (PCE) and TCE contamination was found at levels that would migrate to groundwater at a concentration above the MCL (5 µg/L) in less than 10 years.

Aluminum concentrations at the MBP subunit exceeded the ecological RG of 11,000 mg/kg at two areas totaling approximately 0.177 hectares (0.436 acres).

IV. Remedial Actions

Remedy Selection

As stated in the ABRP/MCB/MBP OU ROD (WSRC 2007b), the final RAOs are as follows (Table C-4):

A-Area Ash Pile (788-2A) Subunit

- Prevent human exposure to refined COCs that present a risk to future industrial workers.
- Prevent ecological exposure to refined COCs that present a hazard to ecological receptors.

A-Area Trench Subunit

- ~~Treat or remove TCE to the extent practical.~~
- Prevent migration of TCE contamination in soil to groundwater at a concentration above the MCL (5 µg/L).

MCB Vadose Zone

- Prevent migration of TCE and PCE contamination in soil to groundwater at a concentration above the MCL (5 µg/L).

~~As stated in the ABRP OU IROD (WSRC 2000), the final RAO that was addressed by the interim action is as follows:~~

~~A-Area Rubble Pit (731-2A) Surface Soils~~

~~Prevent direct contact with and ingestion of benzo[a]pyrene contaminated surface soil which may present a significant risk (> 1E-06 or hazard index = 1) to current and future workers.~~

~~As stated in the MCB/MBP OU IROD (WSRC 1999a), the final RAO that was addressed by the interim action is as follows:~~

~~MCB/MBP Surface and Vadose Zone Soils~~

~~Prevent direct contact with aluminum, OCDD, Aroclor 1254, and Aroclor 1260 contaminated surface/subsurface soils, such that the COCs are not a continued significant risk to human health or ecological receptors.~~

As stated in the ABRP/MCB/MBP OU ROD (WSRC 2007b~~c~~), the selected final remedial actions to meet the RAOs are listed below. Figures C-5 through C-17 show the ABRP/MCB/MBP OU subunits during operations, prior to and after the final action, and as they look currently.

A-Area Trench Subunit

- Expand the existing interim remedial action SVE system; and
- Institutional controls (i.e., LUCs)

A-Area Ash Pile (788-2A) Subunit

- Installation of a soil cover; and
- Institutional controls (i.e., LUCs).

MCB Vadose Zone

- Continued passive operation of SVE BaroBall™ wells; and
- Institutional controls (i.e., LUCs)

~~***A-Area Trench Subunit***~~

~~- Expand the existing interim remedial action SVE system; and~~
~~- Institutional controls (i.e., LUCs)~~

No action was required for the following subunits; Burning/Rubble Pits 731-A and 731-1A, Depressional Area, Potential Pit, and Ash Scatter Area/Ditch. Final actions have been

completed for the following subunits and no further action is required; Rubble Pit 731-2A and MCB/MBP surface soils.

As stated in the ABRP OU IROD (WSRC 2000), the final RAO and selected remedial alternative are provided below. This RAO was completed as an interim action and is not included in Table C-4.

A-Area Rubble Pit (731-2A) Surface Soils

- RAO – Prevent direct contact with and ingestion of benzo[a]pyrene contaminated surface soil which may present a significant risk (> 1E-06 or hazard index = 1) to current and future workers.
- Remedial Alternative – Installation of a soil cover and institutional controls (i.e., LUCs).

As stated in the MCB/MBP OU IROD (WSRC 1999a), the final RAO and selected remedial alternative are provided below.

MCB/MBP Surface and Vadose Zone Soils

- RAO – Prevent direct contact with aluminum, OCDD, Aroclor 1254, and Aroclor 1260 contaminated surface/subsurface soils, such that the COCs are not a continued significant risk to human health or ecological receptors.
- RAO – Treat VOC-contaminated vadose zone soils with a combination of active and passive treatment with an overall objective to reduce the solvent contaminant mass that would migrate to the water table, resulting in groundwater concentrations exceeding the MCL.
- Remedial Alternatives – Excavation of contaminated soil and offsite disposal for the MBP and MCB Surface/Subsurface Soils. Institutional controls (i.e, LUCs) for the MCB Surface/Subsurface Soils. Installation of active and passive SVE to address VOC contamination for the Vadose Zone Soil.

~~A-Area Rubble Pit (731-2A) Surface Soils~~

- ~~Installation of a soil cover; and~~
- ~~Institutional controls (i.e., LUCs).~~

~~MCB Surface Soil~~

- ~~Excavation of contaminated soil with Aroclor 1260 concentrations above the ecological RG (215 µg/kg) to consist of Soil Removal Areas (SRAs) 3 and 4 to a maximum depth of 0.3 m (1 ft), and Soil Removal Area 5 to maximum depth of 1.2 m (4 ft). Excavation of the 0.3-m (1-ft) interval will also remove all soil contaminated with Aroclor 1260 above the Applicable or Relevant and Appropriate Requirement (ARAR)-based limit of 1,000 µg/kg;~~
- ~~Excavation of contaminated soil with Aroclor 1254 concentrations above the ARAR limit of 1000 µg/kg to a maximum depth of 0.3 m (1 ft) from SRAs 3 and 4 and 1.2 m (4 ft) from SRA 5;~~
- ~~Disposal of excavated soil to a Subtitle D landfill, backfilled with clean fill, vegetation of surface soil; and~~
- ~~Institutional controls (i.e., LUCs).~~

~~MCB Vadose Zone~~

- ~~Continued passive operation of SVE BaroBall™ wells; and~~
- ~~Institutional controls (i.e., LUCs)~~

~~MBP Surface and Subsurface Soil~~

- ~~Excavation of soil containing aluminum in excess of the site-specific maximum background of 11,000 mg/kg to a maximum depth of 1.2 m (4 ft) to consist of SRAs 1 and 2;~~

- ~~Disposal of excavated soil at a Subtitle D landfill, backfilled with clean fill, vegetation of surface soil; and~~

- ~~Institutional controls (i.e., LUCs).~~

Remedy Implementation

The selected final action remedies were implemented to meet the RAOs and included the following activities. Remedial actions completed during the interim action phase are noted below.

A-Area Ash Pile (788-2A) Surface Soils

- In 2008, as the final remedial action, installed a 1-hectare (2.5-acre) soil cover with a minimum of 45 cm (18 in) of compacted common fill and 15 cm (6 in) of topsoil and sod.

A-Area Rubble Pit (731-2A) Surface Soils (completed during the interim action phase)

- In 2001, installed a 2.4-hectare (6-acre) soil cover with a minimum of 30 cm (12 in) of compacted common fill and 7.5 cm (3 in) of topsoil and sod. The soil cover also covered the A-Area Burning/Rubble Pits (731-A and 731-1A) for adequate drainage purposes. This was accepted as part of the final remedial action for the OU.

ABRP Vadose Zone

- In 2001, installed an air sparging system for removal of VOC from the vadose zone contaminated soils. However, air-sparging operations were found to be ineffective due to the presence of impermeable soils just above the water table and, with concurrence of the U.S. Environmental Protection Agency (USEPA), South Carolina Department of Health and Environmental Control (SCDHEC) and USDOE, were discontinued in March of 2003. The wells of the sparging system were converted to passive SVE using BaroBalls™.

- In 2003, under the Interim Action, installed four passive SVE wells (operating with either MicroBlowers™ or BaroBalls™) at the Trench Subunit to remove VOCs from

the ABRP vadose zone contaminated soils. The four passive SVE wells installed were ABV-01, ASH-06, AHT-05, and AHT-06.

- In 2008, in support of the final remedial action, installed an active SVE system, consisting of a vacuum blower, condensate removal system, piping to the well bank, 17 extraction wells, and control instrumentation, to treat 42,000 m^3 (55,000 yd^3) of vadose zone soil. In 2013, due to rising concentrations occurring at extraction well ASH-06, the Core Team agreed to add ASH-06 to the ABRP soil vapor extraction unit (SVEU) extraction well network. Additionally, when the SVEU is down for maintenance, ASH-06, AHT-05, ABV-01 ARV-2D1, ARV-2D2, and ARV-2D3 were operated as MicroBlower™ SVE wells.

MCB/MBP Surface Soil (completed during the interim action phase)

- In 2002, excavation activities removed a total of 7,800 m^3 (10,200 yd^3) of soil. At MCB, 3,060 m^3 (4,000 yd^3) of soil ~~– (3,060 m^3 [4,000 yd^3] at MCB and 4,740 m^3 [6,200 yd^3] at MBP)~~ contaminated with Aroclor 1260 and Aroclor 1254 was removed by excavating to a minimum depth of 0.3 m (1 ft) ~~in SRAs 3 and 4~~ and a maximum depth of 1.2 m (4 ft) ~~in SRAs 1, 2, and 5~~, packaging, and shipping to a Subtitle D landfill. At MBP, 4,740 m^3 [6,200 yd^3] at MBP of soil contaminated with Aluminum was removed by excavating to maximum depth of 1.2 m (4 ft), packaging, and shipping to a Subtitle D landfill. Soil contaminated with OCDD was not targeted during excavation activities since the concentrations do not pose a risk to future industrial workers;

- ~~•~~ Backfilled 0.59 hectares (1.45 acres) of excavated areas to grade with clean native soil and vegetated surface soil after confirmatory sampling verified that RGs were met~~;~~ and

- e~~E~~stablished a maintenance program for 0.59 hectares (1.45-acre) native soil cover at MCB only.

MCB Vadose Zone (completed during the interim action phase)

- Installed an active SVE system, consisting of a vacuum blower, condensate removal system, underground piping to the well bank, five extraction wells, and control

instrumentation, to treat 4,590 m^3 (6,000 yd^3) of vadose zone soils. Active SVE was discontinued in 2004 and the SVE wells were transitioned to passive SVE operation; and

- Installed additional passive SVE wells to continue removing solvent mass from the vadose zone~~supplement the active SVE system~~. The current SVE system consists of two MicroBlower™ SVE wells and 25 BaroBall™ SVE wells. SVE operation will continue at the MCB vadose zone subunit until RAOs are met (Figure C-17).

ABRP/MCB/MBP OU

- In 2008, established LUCs for 4.1 hectares (10.1 acres) including posting eleven warning signs. LUC areas for ABRP are 8.03 acres, and for MCB~~/MBP~~ are 2.10 acres. There are no LUC requirements for MBP.

System Operations/Operation and Maintenance

The ABRP/MCB SVE systems are operational and will continue operations until RGs are achieved for the ABRP/MCB/MBP OU. The SVE systems, with implementation of the interim and final remedies, started operation in 2001 with full implementation at ABRP in 2008.

Due to decreasing concentrations to non-detect levels for several years (Figure C-18), the Core Team concurred in 2015 with the decision to begin transitioning 15 wells from active SVE to passive SVE in the ABRP SVEU. The transition to fully passive SVE started when the ABRP Trench active SVE System ended operations in December 2017. The transition was completed when the last three remaining active SVE wells were converted to MicroBlower™ operation in October 2018.

The active SVE system at ABRP has removed approximately 64.9 kg (143.1 lbs) of TCE while in operation from 2008 to 2017 (Figure C-15). The ABRP passive SVE (MicroBlower™ and BaroBall™) system continues to operate having removed approximately 49.6 kg (109.7 lbs) from 2005 through 2021 (Figure C-17). The active system at MCB removed approximately 77.1 kg (170 lbs) of TCE while in operation from

2001 to 2002. The MCB passive SVE (MicroBlower™ and BaroBall™) system continues to operate having removed approximately 13.7 kg (30.1 lbs) of TCE from 2004 through 2021.

A Performance Evaluation Report (PER) continues to be submitted annually to USEPA and SCDHEC. The PER provides the results of baseline sampling prior to active SVE, passive SVE operation, and all process and performance monitoring during operation.

The following maintenance activities are ongoing:

- Visual inspections for evidence of damage to the cover systems due to erosion or intrusion by burrowing animals are being performed annually as a minimum. The inspections also address upkeep of the vegetative cover and access control barriers (e.g., the warning signs).
- Necessary repairs (e.g., replacing eroded or disturbed soil, sign repair, active SVE system maintenance, etc.) and vegetation management (e.g., mowing, removal of larger vegetation, etc.) are being performed when required.
- ~~Institutional controls (i.e.,~~ LUCs~~)~~ are being enforced to preclude access through the SRS Site Use/ Site Clearance program and SRS site security.
- Table C-3 compares the actual operation and maintenance (O&M) costs for the five-year remedy review period to the estimated direct O&M costs from the ROD (WSRC 2007b). The estimated cost for FY2018 to FY2022 is $313,808 for the SVE systems, soil covers, ~~institutional controls (~~LUCs~~)~~, and five-year remedy reviews. The actual O&M cost for FY2018 to FY2022 is $671,989. The O&M costs from FY2018 to FY2022 are higher than estimated because the operational life of the active SVE system is longer than expected.

V. Progress Since Last Review

The previous protectiveness statement concluded that the remedial actions at ABRP/MCB/MBP OU are expected to be protective and, in the interim, exposure pathways

that could result in unacceptable risks are being controlled by the operation of active/ passive SVE and cover systems along with ~~institutional controls (i.e., LUCs)~~. All systems have been functioning properly.

Since the previous review in support of final remediation activities as set forth in the Corrective Measures Implementation/Remedial Action Implementation Plan (WSRC 2007a), the following actions have been completed:

- Transition of eighteen active SVE wells at the ABRP Trench subunit to a passive SVE system, due to decreasing TCE contamination in the vadose zone soils.

As stated in the PCR (SRNS 2022), the project's recommendation is to perform confirmation soil sampling at ABRP/MCB to evaluate the current soil concentrations against the RGs with the intent to justify shutting down the passive SVE. A Sampling Analysis Plan will be developed and submitted for Core Team approval in fiscal year (FY) 2023. Upon approval, soil sampling will be performed in FY2024. Upon completion of the sampling, a Core Team meeting will be convened to discuss the results of the sampling in context to the remedial goal objectives. Annual performance reviews will continue until the Core Team reaches agreement that the RGs have been met.

VI. Five-Year Review Process

The following tasks were performed as part of the review:

- Reviewed the documents listed in Section XII, Documents Reviewed;
- Confirmed the implementation of the remedial actions;
- Reviewed all process and performance monitoring data provided by the annual PERs and provided a technical assessment of whether the active/passive SVE are functioning as intended by the ROD and whether the shutdown criteria have been achieved;
- Inspected the OU, reviewed the annual site inspection reports, interviewed maintenance personnel, and documented the results on the Inspection Checklist provided in

Attachment C-1 with the purpose of assessing the protectiveness of the remedy and the functionality of the access controls; and

- Reviewed changes in standards and to-be-considered guidance

Data Review

Annual PERs continue to be submitted as scheduled and were reviewed (SRNS 2018, SRNS 2019, SRNS 2020, SRNS 2021, and SRNS 2022). The PERs reported ABRP had a total mass removal of 4.38 lbs TCE and MCB had a total mass removal of 1.62 lbs TCE and 0.77 lbs PCE during the last five years.

Figures C-18 and C-19 depict a large decrease in ABRP TCE production and well exhaust gas concentrations since the implementation of seventeen active SVE wells in 2008. Because of the observed decline in TCE production, the active SVE system at ABRP was completely transitioned to a passive SVE system in 2018. Figures C-20 and C-21 show the TCE production rates and well exhaust gas concentrations of the current ABRP passive SVE system. Figures C-17 and C-18 show a similar decline in the active SVE system. The increase in production results in 2018 is the direct result of adding seventeen new passive SVE wells that was sustained through 2021 (Figure C-17).

At MCB, declining concentrations are an indication that the source of mass in the Upland Unit has been depleted and now is only releasing mass by diffusion. Figures C-22 and C-23 show the PCE and TCE production rates and well exhaust gas concentrations of the current MCB passive SVE system.

As stated in Section V, the project's recommendation is to perform confirmation soil sampling at ABRP/MCB to evaluate the current soil concentrations against the RGs with the intent to justify shutting down the passive SVE.

Summary of Inspections and Interviews

Interviews were conducted with Phil Carter, Savannah River Nuclear Solutions, LLC (SRNS) Environmental Compliance and Area Completion Project (EC&ACP) Post-Closure Lead, and Brian Hanshew, SRNS EC&ACP Post-Closure Lead, on August 30,

2022 at the O&M organization offices. No issues were identified as an outcome of these interviews.

The ABRP/MCB/MBP OU was inspected by SRNS personnel on July 26, 2022. No issues were identified for the ABRP/MCB/MBP OU during this inspection.

A site inspection was conducted by SRNS EC&ACP and USDOE personnel on December 6, 2022. No issues were identified during this inspection.

A regulatory field inspection meeting with USDOE, USEPA, and SCDHEC was held on March 15, 2023. SRNS personnel were also present in the meeting. During the meeting, the participants viewed drone footage of each OU and were provided an opportunity to walk down the individual OUs. The USEPA and SCDHEC elected not to perform a walk down because the drone video provided them better views of the OUs. No significant problems regarding the protection of the remedies for this OU as implemented were identified during the inspection.

Scheduled annual site inspections conducted from FY2018 through FY2022 identified the presence of ant mounds, vegetation blocking waste unit sign, sign replacement, wood debris restricting water flow in drainage ditch, unattached ID well tag, minor depression caused by grass cutting equipment, and fallen tree limbs on road. These findings were documented on the field inspection checklist and resolved soon after discovery. The inspections conducted during this remedy review cycle are listed in Section XII.

Since the MBP ~~and SRA 4~~ subunit~~s~~ ~~are~~ is outside of the established LUC boundary and no further problems warranting action exist in the MBP surface soil subunit ~~and SRA 4~~ (WSRC 2008), inspections were discontinued in 2022.

VII. Technical Assessment

Is the Remedy Functioning as Intended by the Decision Document?

The removal of contaminated soils at MCB/MBP (731-4A / 731-5A surface soil subunits) and the cover systems installed at ABRP (A-Area Rubble Pit [731-2A] and Ash Pile

[788-2A] subunits) are effective in preventing human receptor and ecological exposure to COCs. The MCB/MBP removal action has achieved industrial RGs. The ABRP cover system maintenance program is effective in maintaining the integrity of the cover systems. The annual inspection reports indicate no significant deficiencies.

The passive SVE systems at the ABRP Trench and MCB subunits are effective in preventing the migration of VOC contamination in the vadose zone soils to the groundwater at concentrations above MCLs. Groundwater results indicate that the underlying groundwater VOC concentrations have also been steadily decreasing with time.

As reported in the annual PERs, the passive SVE system operation and well sampling at the ABRP Trench Subunit and the MCB Vadose Zone Subunit will continue until the RGs are achieved as stated in the ROD (WSRC 2007b). Overall soil-gas vapor samples have remained at very low (near the lower laboratory detection limits) asymptotic levels indicating VOCs are nearly depleted and no longer productively being removed (Figures C-20, C-21, C-22, and C-23).

The Land Use Control Implementation Plan for the ABRP/MCB/MBP OU governs LUC implementation, maintenance, monitoring, reporting, and enforcement of LUCs (WSRC 2008). The LUCs that are in place include physical access controls to prevent unauthorized entry to SRS (fences, guards, security patrols, etc.), use restrictions to prevent unauthorized contact, removal or excavation of contaminated soils, restrictions to prevent unauthorized access to or use of groundwater until cleanup levels are met, and restrictions to prevent disturbance of the ABRP soil cover system. Warning signs are in good condition, and no activities were observed that would have violated the LUCs. All LUC objectives are being met.

Are Exposure Assumptions, Toxicity Data, Cleanup Levels, and RAOs still valid?

The exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection are still valid. There have been no changes in the physical conditions at the ABRP/MCB/MBP OU that would affect the protectiveness of the remedy.

Figure C-15. Miscellaneous Chemical Basin (731-4A) Aerial Photo (2022)

Figure C-16. Metals Burning Pit (731-5A)~~iscellaneous Chemical Basin (731-4A)~~ Aerial Photo (2022)

COCs identified in the Interim Record of Decision (IROD) at the ABRP subunit included TCE, PCE, and dichloromethane (Table D-2). Currently, TCE, PCE, and 1,4-dioxane exceed drinking water standards or MCLs in the M-Area Aquifer Zone, the Lost Lake Aquifer Zone, and the Middle Sand Aquifer Zone. TCE is the only ABRP COC observed in the Crouch Branch Aquifer Unit.

COCs identified in the IROD for MCB/MBP subunit included TCE, PCE, carbon tetrachloride and lead (Table D-2). The USDOE, USEPA, and SCDHEC agreed not to treat lead because elevated levels are sporadic and are judged to be caused by natural geologic conditions. Currently, TCE, PCE, and 1,4-dioxane exceed drinking water standards or MCLs at the MCB/MBP subunit. The two aquifer zones impacted above MCLs at the MCB/MBP subunit are the Middle Sand Aquifer Zone and the Lost Lake Aquifer Zone.

IV. Remedial Actions

Three interim remedial actions for the A/M-Area Groundwater OU have been issued. The first was the IROD for the A/M-Area Groundwater OU, dated June 1992 (WSRC 1992). The second IROD, dated December 1999, addressed the groundwater contamination associated with the MCB/MBP subunit (WSRC 1999b). The third IROD, dated April 2000, addressed the groundwater contamination associated with the ABRP subunit (WSRC 2000). Each IROD is discussed below. Corrective action, managed under the RCRA Permit, is associated with the M-Area and Metallurgical Laboratory Hazardous Waste Management Facilities (HWMFs). To administratively manage corrective action in the M-Area HWMF, the contaminated area has been divided into six sectors: Vadose zone, Central, Northern, Southern, Western, and ABRP/MCB/MBP OU. The location and spatial relationship of these ~~area~~sectors are illustrated in Figure D-2, except for the vadose zone. The vadose zone includes all contamination associated with the vadose zone near source areas which tends to overlap with the Central Sector.

The final actions for the A/M-Area Groundwater OU will be documented by modifications to the RCRA permit renewal. These final actions will also be documented in a final ROD for the A/M Groundwater OU at the appropriate time.

Remedy Selection

As stated in the IROD for the A/M-Area Groundwater OU (WSRC 1992), the purpose of the interim action was to:

- Prevent further groundwater plume migration and initiate groundwater restoration while risk assessment activities are being planned and conducted; and
- Obtain further information about the response of the aquifer to remediation.

The preferred interim remedy for groundwater within the A/M-Area Groundwater OU was groundwater recovery with treatment by air stripping.

The components of the remedy included the following:

- Installing strategically located groundwater recovery wells;
- Extracting groundwater and processing it through an air stripper to release VOCs;
- Discharging the treated water to a National Pollutant Discharge Elimination System (NPDES) permitted outfall; and
- Conducting a treatability study to evaluate technologies to control air stripping tower gaseous emissions.

As stated in the IROD for the MCB/MBP (WSRC 1999b), the purpose of the interim action was to:

- Treat contaminated groundwater to prevent further VOC plume growth;
- Demonstrate the effectiveness of in situ air stripping wells in achieving significant contaminant mass removal; and
- Obtain necessary site-specific run data to determine a final remedial goal.

The preferred interim remedy for the MCB/MBP subunit groundwater was in situ air stripping and monitoring. The components of the remedy included the following:

- Installing three series (banks) of in situ air stripping wells located to address groundwater concentrations exceeding 500 µg/L, 200 µg/L, and 50 µg/L, respectively;

- Groundwater monitoring to evaluate and report the effectiveness of the in situ air stripping wells; and
- Conducting a treatability study to evaluate technologies to control air stripping tower gaseous emissions.

As stated in the IROD for ABRP (WSRC 2000), the interim remedial action objectives were to:

- Mitigate any further plume growth;
- Reduce concentration of the contaminant plume within the 100 µg/L VOC contaminant plume isopleth;
- Evaluate the effectiveness of the remedial system and its impact on the aquifer system; and
- Reduce the uncertainty of commingling of plumes between the two aquifer systems.

The preferred interim remedy for the ABRP subunit groundwater was air sparging with soil vapor extraction (SVE). The components of the remedy include the following:

- A two-staged approach with stage one including the installation of ten active air sparging wells, each with three BaroBall^{TM} passive SVE wells to be operated for about 12 months;
- Evaluation of enhanced bioremediation; and
- Stage two will incorporate the operating and effectiveness data obtained from stage one to design a more extensive system to address the > 100 µg/L VOC plume.

Interim and final remedial goals for ABRP and MCB/MBP subunits are shown in Table D-2.

Final remedial action objectives for all A/M-Area groundwater are to prevent exposure to contaminated groundwater above MCLs and restore groundwater to its beneficial use.

Remedy Implementation

A/M-Area Groundwater OU

The remedial action for the A/M-Area Groundwater OU was initiated in Central Sector with the installation and operation of the M-1 Air Stripper and eleven recovery wells in September 1985. Two additional recovery wells were installed near the Met Lab and began supplying groundwater to the M-1 Air Stripper in July 2000. This system was designed to hydraulically contain and capture the high concentration VOC plume predominantly in the Lost Lake Aquifer Zone, with a few of the wells also having screens in the M-Area Aquifer Zone and the Middle Sand Aquifer Zone of the Crouch Branch Confining Unit. Optimization of the recovery well network has occurred with the addition of two recovery wells (i.e., RWM018 and RWM019) to help remove additional VOC mass from the Lost Lake Aquifer Zone and the removal of four recovery wells (i.e., RWM 9, RWM 11, RWM 17B, and RWM 17D) based on diminishing mass removal. Monitoring of air stripper influent and effluent water, recovery well flow rates and concentrations, and groundwater concentrations in nearby monitoring wells is conducted to evaluate the effectiveness of the system. The treated effluent from the air stripper is sampled at NPDES permitted outfalls to comply with the Clean Water Act. The exhaust from the M-1 Air Stripper currently complies with the air emissions permit without additional treatment.

In Northern Sector, ~~T~~the A-2 Air Stripper and recovery well system was installed to capture the northern portion of the VOC groundwater plume, which is associated with historical solvent use and disposal in laboratory facilities. The A-2 Air Stripper and six recovery wells were installed to restrict migration of VOC contamination within the Lost Lake Aquifer Zone and the Middle Sand Aquifer Zone of the Crouch Branch Confining Unit, thereby preventing future downward migration into the deeper aquifer system. The A-2 Air Stripper began operations in 1996. ~~The six recovery wells are screened in the Lost Lake Aquifer Zone and the Middle Sand Aquifer Zone of the Crouch Branch Confining Unit.~~ Due to diminished mass removal rates at the six recovery wells, the A-2 Air Stripper was shut down in October 2012 after SCDHEC approved a temporary authorization (TA) (SCDHEC 2012). Based on sampling results collected during shutdown, contaminant

migration from the Lost Lake Aquifer Zone into the underlying Middle Sand Aquifer Zone of the Crouch Branch Confining Unit and the Crouch Branch Aquifer Unit was not occurring. Monitoring wells ASB 8C, MSB113B, and recovery well RWM 14C indicate that the greater than 1,000 µg/L TCE plume extends southwest toward the Savannah River National Laboratory (SRNL). Although additional corrective actions may be needed to address the > 1,000 µg/L TCE plume, the A-2 Air Stripper and recovery well network is not currently positioned to effectively capture that portion of the plume. Therefore, the SRS proposed the permanent shutdown of the A-2 Air Stripper in the 2013 RCRA Permit Renewal Application for the M-Area and Met Lab HWMFs Postclosure (SRNS-IM-2012-00002, Volume III) in January 2020 and SCDHEC approved the proposal on November 30, 2021 (SCDHEC 2014). The A-2 Air Stripper was permanently shut down on December 15, 2021. Additional corrective action to address the 1,000 µg/L TCE plume will be identified, as needed, in a Corrective Measures Study and the final Corrective Action Plan for Northern Sector.

The groundwater recovery well systems have been complemented with the use of SVE technology to address known source areas in the vadose zone. Four sites with elevated concentrations of PCE and TCE in the vadose zone were initially chosen for vadose zone remediation using vacuum extraction: the abandoned process sewer line leading to the M-Area Settling Basin, the M-Area Settling Basin, the A-014 Outfall, and the former 321-M Solvent Storage Tank Area. The SVE units (SVEUs) are connected to vertical and/or horizontal SVE wells, effectively reducing the VOC mass in the vadose zone preventing future impacts to the groundwater. In the A-014 Outfall area, residual VOCs in lower permeability soils were addressed by soil hydraulic fracturing at seven locations, which allowed for improved rates of mass removal using a high vacuum SVE unit (Figure D-5) for those wells.

As contaminant levels have decreased in the vadose zone, several of the larger active systems have reached shutdown criteria as established in the M-Area and Met Lab HWMFs RCRA permit renewal application. To continue to provide mass removal, the SVE wells associated with these units are often transitioned to passive SVE wells. Recent strategies

have employed renewable energy (solar) powered blowers (MicroBlowers™) or passive barometric pumping using BaroBalls™. These passive technologies are proving beneficial in aiding cleanup when contaminant removal becomes limited by the rate of diffusion from fine-grained sediments.

Recognizing that a significant amount of solvents remains trapped in the subsurface in the form of DNAPLs, SRS has evaluated and implemented DNAPL specific remedies where appropriate. The most effective DNAPL specific remedy used within the A/M-Area Groundwater OU has been the use of thermal heating using the Dynamic Underground Stripping (DUS) process. Under this process, steam is injected into the subsurface using multiple injection wells with the objective to provide a total steam flood throughout the DNAPL source zone. The steam flood promotes the enhanced removal of volatile compounds using vapor and groundwater extraction wells.

DUS was first deployed at the 321-M Solvent Storage Tank Area beginning in September 2000 and ending in September 2001. Approximately 31,750 kg (70,000 lbs) of VOCs were removed from the 30 m x 30 m x 48 m (100 ft x 100 ft x 160 ft) deep target area during the 12 months of operation. The second deployment of DUS targeted DNAPL beneath the closed M-Area Settling Basin to address the main source of the groundwater contamination in this area. The second DUS project commenced operation in August 2005 and operated through September 2009. An estimated 207,485 kg (457,426 lbs) of chlorinated solvents were removed from the subsurface at M-Area Settling Basin DUS from August 2005 (operational start) through 2012. Since termination of DUS, all further SVE and groundwater remediation near the M-Area Settling Basin have been renamed to~~are now associated with~~ the Western Sector Treatment System (WSTS) (SRNS 2012). ~~An estimated 207,485 kg (457,426 lbs) of chlorinated solvents were removed from the subsurface at M-Area Settling Basin DUS from August 2005 (operational start) through 2012.~~ After 2012, the 782-6M SVEU continued operation removing an additional 1,295.5 kg (2,856 lbs) before it was shut down in 2019. Between 2013 and 2018, the SVEU at the M-Area Settling Basin (i.e., 782-6M) was evaluated through a series of rebound tests, and the SVE wells were sampled individually to identify which wells contributed the highest

vapor concentrations to the 782-6M SVEU. The SVE wells with the highest concentrations remained connected to the SVEU while some wells were transitioned to MicroBlowers™ and the SVE wells with the lowest concentrations were abandoned. In August 2019, the 782-6M SVEU was permanently shut down. Currently, 16 MicroBlowers™ are operational and 18 SVE wells have been abandoned. In total, the 16 MicroBlowers™ removed 92 kg (203 lbs) of solvent in 2021. The MicroBlowers™ at the WSTS have removed a total of 499 kg (1,100 lbs) of solvent since 2015 indicating there is residual mass in the vadose zone surrounding the former DUS treatment zone.

The southeastern portion of the plume, known as Southern Sector, is associated with discharges from the A-014 Outfall and along its un-named tributary. The plume, which covers an area of approximately 325 hectares (800 acres), was being treated by a series of twelve in situ air stripping wells (airlift recirculation wells [ARW]) that were brought online in 1996. Due to high contaminant concentrations in the plume on the north end of the ARW line, multi-stage in-well aerators were installed in four of the twelve wells (i.e., SSR009 through SSR012) to enhance removal efficiency from 70% to 90% in 2001. In 2011, eight of the ARWs (i.e., SSR001 through SSR007, and SSR010) were shut down due to low VOC removal rates after SCDHEC approved a TA (SCDHEC 2011a). Shut down criteria was established for the remaining wells in the 2000 RCRA Part B Permit Renewal Application for M-Area and Met Lab HWMFs Postclosure (WSRC-IM-98-30, Volume III). This shutdown criterion was approved by SCDHEC in the 2014 RCRA Permit Renewal (SCDHEC 2014). Based on this criterion (i.e., less than 9.1 kg/year (20 lbs/year) for two consecutive years), SSR011 and SSR012 were shut down in September 2017. SSR008 and SSR009 achieved the shutdown criteria in 2019 and were shut down in February 2020.

A field scale study investigating enhanced attenuation using humate amendments began in Southern Sector to target the source plume using the existing ARW, SSR001. In 2017, the injection of humate into the Lost Lake Aquifer Zone started at SSR001. Quickly after injections started, declining injection rates and difficulties injecting humate into the subsurface caused delays in the project. From 2017 to 2020, the injection system was

redesigned to add additional injection wells and the injection chemistry was altered to reduce foaming. In 2020, due to COVID-19 precautions, SRS requested approval to temporarily discontinue the bi-weekly inspections of the M-Area HWMF Southern Sector Humate System (SRNS 2020). The SCDHEC approved the request on April 3, 2020 (SCDHEC 2020). The system has been placed in a safe configuration until it is operational again. There are currently no plans to resume operation of this system.

Additionally, in situ chemical oxidation (ISCO) was applied to the high concentration portion of the plume near the A-014 Outfall. ISCO was demonstrated twice under separate TAs (SCDHEC 2009 and SCDHEC 2011b). Although some VOC destruction was observed, ISCO (using persulfate) was determined to not be the most effective corrective action option for this area.

The western plume, known as Western Sector, is associated with contaminant migration from the M-Area Settling Basin and the 321-M Solvent Storage Tank Area. Three separate TAs were conducted between 2018 and 2022 to help remediate areas of high VOC concentrations associated with Western Sector. The first TA (SCDHEC 2016a) installed an additional M-1 Air Stripper recovery well, RWM018, and deployed ISCO into ~~to capture~~ the greater than 10,000 µg/L VOC plume that was located outside of the original recovery well zone of capture. RWM018 was installed in 2017 and became operational in 2018. ISCO was deployed upgradient of RWM018, utilizing the enhanced hydraulic gradient created by the operation of RWM018 to help distribute oxidant over a larger area. The first ISCO injection started in 2018 and successfully injected 151,416 L (40,000 gallons) of potassium permanganate and 151,416 L (40,000 gallons) of sodium persulfate. Results were positive but revealed only two of four targeted injection horizons were affected by the oxidant injections. A second ISCO injection started in 2020 to target the two horizons least affected by oxidant during the first injection. RWM018 was shut down in March 2020 since it is believed that oxidant entering the M-1 Air Stripper, via RWM018, is interfering with a mercury remediation system. A plan to restart RWM018 while sampling for the presence of oxidant and its side-affects will be executed in 2023. The second TA (SCDHEC 2018b) installed a new recovery well, RWM019, on the southeast

side of the M-Area Settling Basin to capture high concentration VOCs in the Lost Lake Aquifer. RWM019 was installed in 2019 and became operational in 2020 and has had some of the highest VOC concentrations observed at the recovery wells. The third TA (SCDHEC 2021) injected emulsified zero valent iron (EZVI) into the upper Lost Lake Aquifer Zone and the anticipated travel path of DNAPL from the M-Area Settling Basin out toward Western Sector. Approximately 151,416 L (40,000 gallons) of EZVI was injected via hydraulic fracturing in April 2022. Results of this study are currently being collected and will be summarized in the next five-year review.

Two process water production wells (PW 20A and PW 53A), which are screened in the deeper Crouch Branch Aquifer Unit, are operated to provide water for the SRNL key essential services such as chilled water, steam, cooling water, and for SRNL's Nuclear Safety Class fire water system. When operated, ~~T~~these wells ~~are operated to~~ capture a portion of the groundwater plume within the Crouch Branch Aquifer Unit downgradient of the SRNL complex. Groundwater from these production wells is not treated. On January 5, 2016, the SRS requested a "contained-in determination" for the groundwater contaminated with RCRA-listed wastes (F001/F002) that is used as process water throughout the A/M Area (SRNS 2016). On December 7, 2016, the SCDHEC approved a "contained-in determination" for production wells, PW 20A and PW 53A, establishing limits of 161 µg/L for TCE and 27 µg/L for PCE (SCDHEC 2016b). To determine compliance with these limits, samples are collected from the two production wells a minimum of once per quarter. In addition, TCE and PCE is also analyzed at NPDES permitted outfalls to verify no impacts to surface water.

MCB/MBP Subunit

The remedial action for the groundwater portion of the MCB/MBP subunit was implemented through the following activities:

- Treating the plume using an in situ air stripping system consisting of eleven wells arranged in three banks, with five wells in the first bank and three wells in each of the next two banks. These ARWs became operational in February 2002. The vertical and horizontal flow fields modeled during the operation of these wells was predicted to

result in a 90% contaminant concentration reduction in one pass through the well field at 151 L/min (40 gpm). Seventeen new and existing monitoring wells were identified to assist in determining the effectiveness of the system. Monitoring of ARW off-gas was conducted to assess the effectiveness of the ARW system.

- Between 2002 and 2011, the eleven ARWs only removed a total of 174 L (46 lbs) of VOCs from the Lost Lake Aquifer. MIS-001 through MIS-005 were installed to target the >500 µg/L TCE plume, a concentration that has not been observed since after start-up in 2002. The removal rates in the Lost Lake Aquifer had declined over time, which was an indication that active remediation of the vadose zone had cut off the majority of contaminant migration to the groundwater at the MCB/MBP OU. In 2011, the eleven ARWs (i.e., MIS001 through MIS011) were shut down after SCDHEC approved a TA (SCDHEC 2011a). Since the shutdown, new monitoring wells have been installed to observe VOC contaminant plume migration and establish regional groundwater flow directions. A schedule for the final corrective action at MCB/MBP Subunit will be incorporated into the Corrective Action Plan for the ABRP/MCB/MBP OU as defined in the 2013 RCRA Permit Renewal Application for M-Area and Met Lab HWMFs Postclosure (SRNS-IM-2012-00002, Volume III). The corrective action schedule was incorporated into the 2014 RCRA Permit Renewal (SCDHEC 2014). On October 9, 2017 SRS proposed to dismantle and removal (D&R) all equipment requiring maintenance associated with the eleven ARWs to include the air compressor, air receiver tank, pressure indicators, well packers, etc. (SRNS 2017). SCDHEC approved the D&R activities on May 4, 2018 (SCDHEC 2018a). The D&R activities were completed in August 2019. In addition to the D&R activities, SRS requested approval to abandon eight of the ARWs (i.e., MIS001 through MIS008) in November 2018 (SRNS 2018), since there are no future plans to use these wells. SCDHEC approved the request in February 2019 (SCDHEC 2019a). During the abandonment activities of the eight ARWs, SRS decided that the three remaining ARWs (i.e., MIS009 through MIS011) were not needed for potential future corrective action. SRS requested approval to abandon MIS009 through MIS011 in July 2019 (SRNS 2019). SCDHEC

are operating as designed. SVE wells equipped with MicroBlowers™ or BaroBalls™ are present near the SRNL, Solvent Storage Tank Area, A-014 Outfall, M-Area Abandoned Process Sewer Line, M-Area Settling Basin, and near Building 717-A.

The in situ air stripping wells are no longer operational.

Routine and preventative maintenance is conducted on all operating systems, along with comprehensive monitoring of groundwater, effluent discharge, and off-gas associated with the treatment systems.

~~Institutional controls (i.e., land use controls [~~LUCs~~])~~ have been implemented through the SRS Site Use/Site Clearance program to preclude inadvertent access or use of contaminated groundwater.

Costs associated with the selected remedy for A/M Groundwater include operation and maintenance (O&M) costs of air strippers, SVE units, and ~~institutional controls (i.e., ~~LUCs~~)~~. The actual O&M cost during Fiscal Year (FY) 2018 to FY2022 is $10,174,972. RCRA documentation does not require estimated project costs to be prepared. Therefore, a cost comparison cannot be provided in this remedy review.

V. Progress since Last Review

The previous protectiveness statement concluded that the interim remedial actions at A/M-Area Groundwater OU are expected to be protective, and in the interim, exposure pathways that could result in unacceptable risks are being prevented by existing SRS Site Use/Site Clearance requirements. Containment and remediation by several treatment systems are monitored by the groundwater monitoring network which has been functioning properly.

Data from point of compliance, background, plume definition, airlift recirculation, and recovery wells, as applicable, are used to assess the effectiveness of the corrective action program. Point of compliance wells are located in close proximity to the waste units and are monitored for compliance with groundwater quality protection standards. Background and plume definition wells monitor the horizontal and vertical extent of groundwater contamination and groundwater quality. Recovery wells pump contaminated groundwater

to air strippers, which remove VOCs from the water before it is discharged to the appropriate outfall. ARWs perform in situ air stripping to reduce VOC mass in the plume.

A summary of the operation and performance data over the last five years for the various remediation systems associated with the A/M-Area Groundwater OU and MCB/MBP subunit is presented in Table D-3.

VI. Five-Year Review Process

The following tasks were performed as part of the review:

- Reviewed the documents listed in Section XII, Documents Reviewed;
- Confirmed the implementation of the remedial actions;
- Reviewed all process and performance monitoring data provided by the annual groundwater monitoring and corrective action reports and provided a technical assessment of whether the treatment systems are functioning as intended by the ABRP and MCB/MBP IRODs and whether the shutdown criteria have been achieved;
- Inspected the OU, interviewed maintenance personnel and documented the results on the Inspection Checklist provided in Attachment D-1; and
- Assured that all actions required under the RCRA Permit Renewal were implemented.

Data Review

M-1 Air Stripper and Recovery Wells

The M-1 Air Stripper and associated recovery wells have removed 28,451 kg (62,723 lbs) of VOCs over the last five years, with an increase in mass of about 44% between the last and first year of the period. During 2021, the average monthly influent VOC concentration was 10,617 µg/L. The average monthly effluent total VOC concentration was 0.04 µg/L or less than the detection limit for TCE and PCE. The M-1 Air Stripper has removed a cumulative total of approximately 259,186 kg (571,407 lbs) of VOCs since the beginning of operation in 1984.

Closure Lead, and Brian Hanshew, SRNS EC&ACP Post-Closure Lead, on August 30, 2022 at the O&M organization offices. No issues were identified as an outcome of these interviews.

The A/M-Area Groundwater OU was inspected by SRNS personnel on July 13, 2022. No issues were identified during this inspection.

A site inspection was conducted by SRNS EC&ACP and USDOE personnel on December 6, 2022. No issues were identified during this inspection.

A regulatory field inspection meeting with USDOE, USEPA, and SCDHEC was held on March 15, 2023. SRNS personnel were also present in the meeting. During the meeting, the participants viewed drone footage of each OU and were provided an opportunity to walk down the individual OUs. The USEPA and SCDHEC elected not to perform a walk down because the drone video provided them better views of the OUs. No significant problems regarding the protection of the remedies for this OU as implemented were identified during the inspection.

VII. Technical Assessment

Is the Remedy Functioning as Intended by the Decision Document?

Each of the three interim remedies effectiveness in meeting the interim remedial action objectives is described below:

A/M-Area Groundwater OU

The zone of influence of the M-1 Air Stripper and associated recovery well network was designed to capture the high concentration regions of the TCE/PCE plumes present, thus preventing significant plume migration. The system has been effective, removing 259,186 kg (571,407 lbs) of VOCs since 1984. In the last five years, annual mass removal rates increased at the M-1 Air Stripper with the addition of RWM018 in 2018 and RWM019 in 2020. In addition to adding wells to the recovery well network, recovery wells RWM 9, RWM 11, and RWM 17B were removed from the network due to diminishing mass removal rates. Continued optimization of the recovery well network

helps to maximize annual mass removal rates of the M-1 Air Stripper. RWM018 was turned off in March 2020 and remained off through 2021 since it is believed that oxidant entering the M-1 Air Stripper, via RWM018, is interfering with a mercury remediation system. The recovery wells are primarily screened in the Lost Lake Aquifer Zone; however residual contamination within the M-Area Aquifer Zone would ultimately also be captured by these wells. Any contamination in the Crouch Branch Aquifer is not affected by this system.

The active SVEU systems at the A/M Area Groundwater OU remain operational until VOC removal is 18 kg/week (40 lbs/week) or less for each SVEU. The 782-6M SVEU was shut down in 2019. MicroBlowers™ remain at the WSTS to remove residual mass remaining near the M-Area Settling Basin. The two SVEUs at the A-014 Outfall have also achieved the shutdown criteria but will remain active until a current evaluation of these SVEUs can be completed. The evaluation will help determine if the SVE wells near the A-014 Outfall can be transitioned to low energy or passive systems.

MCB/MBP Subunit

The recirculation wells were placed in service in February 2002 and were shut down in November 2011. During operation, the eleven recirculation wells removed a total of 21 kg (46 lbs) of VOCs. The ARWs were abandoned in 2019 based on agreements with SCDHEC RCRA personnel due to declining VOC concentrations and low mass removal rates. The ARWs had not achieved the RAOs specified in the IROD (WSRC 1999b) prior to their abandonment, and groundwater monitoring and characterization are ongoing under the RCRA Permit Renewal. The results from these activities are reported annually in the M-Area and Metallurgical Laboratory Hazardous Waste Management Facilities Groundwater Monitoring and Corrective Action Report and will aid in identifying new corrective actions for the groundwater plume associated with the MCB/MBP subunit.

An approved corrective action schedule is included in the 2013 RCRA Permit Renewal Application for M-Area and Met Lab HWMFs Postclosure (SRNS-IM-2012-00002, Volume III). The corrective action schedule was incorporated into the 2014 RCRA Permit Renewal (SCDHEC 2014).

Has any Other Information Come to Light that Could Call into Question the Protectiveness of the Remedy?

No new information has come to light that could call into question the protectiveness of the remedy.

VIII. Issues

There are no issues related to current site conditions, or activities that currently prevent the remedy from being protective.

IX. Recommendations and Follow-up Actions

There are no recommendations or follow-up actions for this OU under CERCLA. Groundwater monitoring, characterization, and corrective actions are conducted under RCRA. SRS has submitted corrective action schedules, which propose corrective action technologies to treat the higher concentration parts of the plume, in the 2013 RCRA Permit Renewal Application for M-Area and Met Lab HWMFs Postclosure (SRNS-IM-2012-00002, Volume III). These corrective action technologies were approved by SCDHEC in the 2014 RCRA Permit Renewal (SCDHEC 2014).

X. Protectiveness Statement(s)

The remedies at the A/M-Area Groundwater OU currently protect human health and the environment because groundwater removal and treatment, in situ treatment, and contaminant source treatment have been successful in removing VOC contamination in groundwater and exposure pathways that could result in unacceptable risks are being controlled through ~~institutional controls (i.e., LUCs)~~. However, ~~for the remedy to be protective in the long-term,~~ optimization of the M-1 Air Stripper recovery system and/or other corrective action technologies must be implemented to treat the high concentration part of the plume located outside of the recovery well system zone of capture.

Currently, long-term protectiveness is achieved through controls to prevent exposure to or ingestion of contaminated groundwater includinge physical access controls to prevent

unauthorized entry to SRS (fences, guards, security patrols, etc.), administrative controls that maintain the A/M-Area Groundwater OU for industrial use only (SRS is a secured government facility with land use restrictions) and use restrictions via the SRS Site Use/Site Clearance Program.

XI. Next Review

As shown in Appendix A, Table A-1, the next five-year review for SRS OUs with Operating Equipment is scheduled for January 2029.

XII. Documents Reviewed

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

SCDHEC, 2009. Letter, R. Haynes (SCDHEC) to G. Hayford (SRNS), *Re: Treatability Study Test Plan for Demonstration of In Situ Chemical Oxidation for the Degradation of Residual VOCs at the M-Area Chemical Oxidation (MACO) Site*, WSRC-RP-2008-4074, Rev. 0, Sept. 2008, Savannah River Site (SRS) SC1 890 008 989, Aiken County, South Carolina Department of Health and Environmental Control, Columbia, SC

SCDHEC, 2011a. Letter, R. Haynes (SCDHEC) to G. Hayford (SRNS), *Re: Temporary Authorization Request for the AM-Area HWMF: Modification of the Corrective Action Systems at the Southern Sector and A-Area Burning/Rubble Pits and Rubble Pile/ Miscellaneous Chemical Basin/Metals Burning Pit Operable Unit (ABRP/MCB/MBP OU) Letter Hayford to Haynes – dated October 14, 2011 Savannah River Site (SRS) SC1 890 008 989*, SRNS-OS-2011-00239, dated November 11, 2011, South Carolina Department of Health and Environmental Control, Columbia, SC

SCDHEC, 2011b. Letter, R. Haynes (SCDHEC) to G. Hayford (SRNS), *Re: Treatability Study Test Plan for Demonstration of In Situ Chemical Oxidation (ISCO) for the Degradation of Residual VOCs at the M-Area Chemical Oxidation (MACO) Site Phase II: Shallow Water Table Treatability Study*, SRNS-RP-2010-01393, Rev. 1, January 2011)

Table D-3. Summary of Remediation Performance for 2018–2022 (lbs of VOCs Removed)

	2018	2019	2020	2021	2022
Groundwater Recovery & Treatment					
M-1 Air Stripper	10,597	9,464	10,467	15,293	16,902
A-2 Air Stripper	7~~3~~	8~~7~~	10~~8~~	12~~10~~	~~12~~0
Groundwater Recirculation Wells					
Southern Sector ARWs	48	34	27	3	0
MCB ARWs	0	0	0	0	0
Soil Vapor Extraction					
A-014 Outfall (3M)	486	502	426	519	265
A-014 High Vacuum (Mobile #3)	495	410	512	329	152
Solvent Storage Tank (DUS-1)	273	314	349	417	327
M-Area Settling Basin (6M)	236	295	247	0	0
WSTS/M-Area Settling Basin (MicroBlower™)	243	143	43	131	203
M-Area Process Sewer Line (MicroBlower™)	-	-	-	95	205
Savannah River National Laboratory (MicroBlower™)	19	42	24	18	4
MRS-34 (MicroBlower™)	-	-	-	1	15

- No results since MicroBlowers were not operating.

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Attachment D-1. Five-Year Review Site Inspection Checklist – A/M-Area Groundwater *(continued/end)*

XI. OVERALL OBSERVATIONS
A. Implementation of the Remedy
Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emissions, etc.). The remedies at the A/M Area Groundwater OU currently protect human health and the environment because groundwater removal and treatment, in situ treatment, and contaminant source treatment have been successful in removing VOC contamination in groundwater and exposure pathways that could result in unacceptable risks are being controlled through ~~institutional controls (i.e., LUCs~~). However, in order for the remedy to be protective of the environment in the long-term, the M-1 Air Stripper recovery system should be optimized and/or other corrective action technologies must be implemented to treat the high concentration part of the plume located outside of the recovery well system zone of capture. After successfully reducing VOC concentrations in the main source area of the plume, the highest dissolved concentrations of VOCs currently are located outside (west) of the zone of capture zone of the recovery system.
B. Adequacy of O&M
Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy. The O&M procedures consisting of site inspections and site maintenance and site controls (SRS Site Use and Site Clearance Programs) have been implemented. O&M programs are well established and functioning to ensure that the remedial systems remain in effective service.
C. Early Indicators of Potential Remedy Failure
Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs that suggest that the protectiveness of the remedy may be compromised in the future. N/A
D. Opportunities for Optimization
Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy. SRS has submitted corrective action schedules in the 2013 RCRA Permit Renewal Application for M-Area and Met Lab HWMFs Postclosure (SRNS-IM-2012-00002, Volume III), which proposes to optimize the M-1 Air Stripper recovery well system to treat the higher concentration parts of the plume, as well as corrective actions for the lower concentrations of the distal plumes.

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System Operation/Operation and Maintenance

At the AMRP OU Trench Area, full scale operation of the seven active SVE wells began on April 26, 2004. The seven active SVE wells were alternated between the odd and even numbered wells, monthly, to optimize the mass removal from the subunit. Compliance, performance, and process monitoring was conducted quarterly at the seven active SVE wells and twelve monitoring wells. The seven active SVE operated until they were physically disconnected from the 782-3M soil vapor extraction unit (SVEU) on March 14, 2017. No operational process monitoring data was collected after March 2017 because the system was under modifications to transition from active to passive SVE. The seven SVE wells and twelve monitoring wells were connected to MicroBlowers™ and operated between June 14, 2017 and April 30, 2021.

The following maintenance activities have been implemented for both the Ash Area and the Trenches Area:

- Visual inspections for evidence of damage to the cover system due to erosion or intrusion by burrowing animals and to address upkeep of the vegetative cover and access control barriers (e.g., the warning signs) are performed annually.
- Necessary repairs (e.g., replacing eroded or disturbed soil, sign repair, etc.) and vegetation management (e.g., mowing, removal of larger vegetation, etc.) are being performed when required.

Table E-3 compares the actual operation and maintenance (O&M) costs for the five-year remedy review period to the estimated direct O&M costs from the ROD (WSRC 2003). The estimated cost for Fiscal Year (FY) 2018 to FY2022 is $216,000 for the soil cover and LUCs. The actual O&M cost for FY2018 to FY2022 is $274,856. The O&M cost estimate was based on five years of active SVE operation. After thirteen years, the active SVE ended operations in FY2017 as documented in the *Explanation of Significant Differences (ESD) for the Revision 1.3 A-Area Miscellaneous Rubble Pile (731-6A) Operable Unit Record of Decision (U)* (SRNS 2014). The O&M costs from FY2018 to FY2022 are higher than estimated because the operational life of the active SVE systems was longer than

expected and the cost to operate the 782-3M SVEU is no longer shared by the A-014 Outfall project.

V. Progress Since Last Review

The previous protectiveness statement concluded that the remedial actions at AMRP OU are expected to be protective, and in the interim, exposure pathways that could result in unacceptable risks are being controlled by ~~institutional controls (i.e., LUCs)~~ that have been functioning properly.

Recommendations from the Fifth Five Year Remedy Review Report for SRS OUs with Operating Equipment, Appendix E included the following: The passive system at A-Area Miscellaneous Rubble Pile (731-6A) OU has been successful in treating VOC contamination. Soil RGs have likely been achieved and operation of the passive SVE system may no longer be needed for future protection of groundwater.

Soil data was collected in July 2018 and results were used to update a fate and transport model for the AMRP OU in 2019. Conclusions from the modeling effort identified longer contaminant transport times through the vadose zone and were used to determine that residual PCE and TCE contamination beneath the Trenches Area soil cover no longer pose a contaminant migration concern. Based on these conclusions, the passiveSVE was discontinued in 2021.~~There were no recommendations or follow-up actions from the last five-year review.~~

VI. Five-Year Review Process

The following tasks were performed as part of the review:

- Reviewed the documents listed in Section XII, Documents Reviewed;
- Confirmed the implementation of the remedial action;
- Reviewed all process and performance monitoring data provided by the annual performance evaluation reports (PERs) and provided a technical assessment of whether

the SVE system is functioning as intended by the ROD and the shutdown criteria has been achieved;

- Inspected the OU, interviewed maintenance personnel and documented the results on the Inspection Checklist provided in Attachment E-1 with the purpose of assessing the protectiveness of the remedy and the functionality of the access controls; and
- Reviewed changes in standards and to-be-considered guidance.

Data Review

The transition from active SVE to passive SVE was completed on June 14, 2017. The passive SVE well network consists of 19 MicroBlowers™ connected to the seven SVE wells and 12 monitoring wells. The data collected from the passive SVE system is reported annually in a PER (SRNS 2018a, SRNS 2019a, and SRNS 2020). Since SVE operation began, mass removal rates fluctuated during active SVE and decreased after passive SVE began operation (Figure E-7 and Figure E-8). The system operated as designed to remove mass from the subsurface. During active SVE operations (2004-2017), the cumulative mass removed is estimated to be 64.3 kg (142 lbs) of VOCs (Figure E-8). During passive SVE operation (MicroBlowers^{TM}) (2017-2021), the cumulative mass removed is estimated to be 6.4 kg (14.0 lbs) of VOCs.

In accordance with the approved *Sampling and Analysis Plan for the A-Area Miscellaneous Rubble Pile (731-6A) Operable Unit (U)* (SRNS 2015), additional characterization of the ash layer and vadose zone soils located beneath the Trenches Area soil cover was conducted in July 2018 to evaluate if the VOCs are partitioned in the hydraulic/cutting oils and to provide information on the remaining VOC concentration in soil and ash. The soil results were included in the *Performance Evaluation Report for the A-Area Miscellaneous Rubble Pile (731-6A) Operable Unit: April 2019 to April 2020 (U)* (SRNS 2020). In 2019, the nearly 20-year old fate and transport model for the AMRP OU was updated using the 2018 characterization data. Conclusions from the modeling effort identified longer contaminant transport times through the vadose zone and indicates that

TCE and PCE at the AMRP OU Trenches Area no longer pose a threat to human health and the environment (SRNS 2019b).

On December 16, 2020, the USDOE, U. S. Environmental Protection Agency (USEPA), and South Carolina Department of Health and Environmental Control (SCDHEC) reached agreement to discontinue operation of the passive SVE system based upon the yearly empirical data reported in the annual PERs, as well as the favorable modeling analysis as reported in the *Evaluation of Contaminant Migration and Remedial Goals for the A-Area Miscellaneous Rubble Pile (731-6A) Operable Unit Trenches Area (U)* (SRNS 2019b). As part of this agreement, monitoring data from groundwater wells AOB 1 and MSB 31C will be reported in the five-year remedy review reports in support of this decision. The groundwater data is used to verify the effectiveness of the SVE remedial action by observing potential impacts to the groundwater beneath the AMRP. In 2021, passive SVE operation was shut down based on low soil vapor concentrations observed at the passive SVE wells, the lack of rebounding VOC concentrations during the transition from ASVE to passive SVE indicating that VOC mass identified during the 2018 soil sampling is bound to the organic content of the ash, and a favorable modeling effort that determined the AMRP OU VOC source present pose no threat to groundwater (SRNS 2019b). An ~~second~~ addendum to the Post-Construction Report (SRNS 2018b) documented the shutdown of the passive SVE wells and established that groundwater would be monitored at AOB 1 and MSB 31C (Figure E-9) in this Appendix of the Five-Year Remedy Review Report for the AMRP OU.

Groundwater concentrations for PCE and TCE at AOB 1 and MSB 31C are provided in Figure E-10 and E-11, respectively. At AOB 1, PCE and TCE concentrations have been below detection limits during the last five or more years of sampling. At MSB 31C, PCE concentrations have been slightly lower than 100 µg/L during the last five years of sampling and TCE concentrations have been less than the MCL since 2014. PCE and TCE contamination at this well is related to the groundwater contaminant plume associated with the discharges to the A-014 Outfall.

The USEPA standards and toxicity values have been updated since the last five-year remedy review as shown in Appendix B. The changes to the values for COCs at the AMRP OU were not significant, and the RAOs continue to be met by the remedial action. No new standards or to-be-considered guidance have been identified that call into question the protectiveness of the remedy.

Fact sheets provided on the USEPA webpage (https://www.epa.gov/fedfac/emerging-contaminants-and-federal-facility-contaminants-concern) regarding emerging contaminants were reviewed for applicability to this site. This webpage provides a link to specific fact sheets for each of the following contaminants: 1,2,3-trichloropropane (TCP), 1,4-dioxane, 2,4,6-trinitrotoluene (TNT), 2,4-dinitrotoluene (DNT), hexahydro-1,3,5-tri-nitro-1,3,5-triazine (RDX), nanomaterials, N-nitroso-dimethylamine (NDMA), perchlorate, perfluorooctane sulfonic acid (PFOS) and other per- and polyfluoroalkyl substances (PFAS), polybrominated biphenyls, polybrominated diphenyl ethers (PBDEs) and tungsten. None of the listed emerging contaminants were identified as applicable to this OU.

Has any Other Information Come to Light that Could Call into Question the Protectiveness of the Remedy?

No new information has come to light that could call into question the protectiveness of the remedy.

VIII. Issues

No issues were identified during this remedy review.

IX. Recommendations and Follow-up Actions

No recommendations or follow-up were identified during this remedy review.

X. Protectiveness Statement(s)

The remedy at the AMRP OU is protective of human health and the environment.

Exposure pathways that could result in unacceptable risks were~~are being~~ controlled by the SVE system and are being controlled by the soil cover over the Trenches Area and ~~institutional controls (i.e., LUCs)~~ to prevent exposure to or ingestion of contaminated media. All threats to contaminated media at the AMRP OU have been addressed through implementation of the SVE system, physical access controls to prevent unauthorized entry to SRS (fences, guards, security patrols, etc.), administrative controls that maintain this site for industrial use only (SRS is a secured government facility with land use restrictions), and warning signs and use restrictions via the SRS Site Use/Site Clearance Program.

XI. Next Review

As shown in Appendix A, Table A-1, the next five-year review for SRS OUs with Operating Equipment is scheduled for January 2029.

XII. Documents Reviewed

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

SRNS, 2014. Explanation of Significant Differences (ESD) for Rev. 1.3 for the A-Area Miscellaneous Rubble Pile (731-6A) Operable Unit Record of Decision (U), SRNS-RP-2014-00443, Revision 0, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken SC

SRNS, 2015. *Sampling and Analysis Plan for the A-Area Miscellaneous Rubble Pile (731-6A) Operable Unit (U)*, SRNS-RP-2015-00007, Revision 1, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC

SRNS, 2018a. Performance Evaluation Report for the A-Area Miscellaneous Rubble Pile (731-6A) Operable Unit: April 2017 to April 2018 (U), SRNS-RP-2018-00541, Revision 0, Savanah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC

Table E-1. Chronology of OU Events

Event	Date
RFI/RI Field Start	November 10, 1997
Record of Decision (ROD) issuance	August 11, 2003
Remedial Action Construction Start / Complete	September 8, 2003/ June 30, 2004
Remedial Action Operations Start	April 26, 2004
Previous Five-Year Reviews Issuance	January 29, 2009 / February 4, 2014 / December 5, 2018

Table E-2. Remedial Goals for OU Soil under Industrial Land Use

Subunit	Refined COCs	Type of COC			RG (mg/kg)	Basis
		ARAR	HH	CM		
Piles Area	Arsenic		X		4.4	2X average background
	Lead		X		400	USEPA TBC criteria
	Aroclor1254	X			1	TSCA action level
	Benzo[a]pyrene		X		0.052	1E-06 risk level*
Ash Area	Arsenic		X		4.4	2X average background
Trenches Area	Arsenic		X		4.4	2X average background
	Benzo[a]anthracene		X		2.56	1E-06 risk level
	Benzo[a]pyrene		X		0.256	1E-06 risk level
	Benzo[b]fluoranthene		X		2.56	1E-06 risk level
	Dibenzo[a,h]anthracene		X		0.256	1E-06 risk level
	Trichloroethylene (TCE)			X	0.0877	CM soil clean up level
	Tetrachloroethylene (PCE)			X	0.656	CM soil clean up level

ARAR – Applicable or Relevant and Appropriate Requirements
CM – contaminant migration
COC – constituent of concern
HH – human health
RG – remedial goal
TBC – to be considered
TSCA - Toxic Substances Control Act, 1976
*The 1E-06 risk level is based on a resident, consistent with unrestricted use in the Piles Area

Table E-3. Actual versus Estimated O&M Costs

	FY2018	FY2019	FY2020	FY2021	FY2022	Five-Year Total
Total Actual O&M Costs ($)	61,172	43,619	71,985	73,176	24,904	274,856
Total ROD Estimated Direct O&M Costs ($)	33,200	33,200	33,200	33,200	83,200	216,000

Attachment E-1. Five-Year Review Site Inspection Checklist – A-Area Miscellaneous Rubble Pile (731-6A) Operable Unit *(continued)*

VIII. VERTICAL BARRIER WALLS ☐ **Applicable** ☒ **N/A**	
IX. GROUNDWATER/SURFACE WATER REMEDIES ☐ Applicable ☒ N/A	
X. OTHER REMEDIES	
If there are remedies applied at the site, which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction.	
A. Soil Vapor Extraction System ☒ Applicable ☐ N/A	
1. Blowers, Wellhead Plumbing, and Electrical: ☒ Good Condition ☒ All required wells located ☐ Needs maintenance ☐ N/A Remarks: SVE system is no longer service. The MicroBlowers™ were shutdown on April 30, 2021.	
2. Extraction System Pipelines, Valves, Valve Boxes and Other Appurtenances: ☒ Good Condition ☐ Needs maintenance Remarks:	
3. Spare Parts and Equipment: ☒ Readily Available ☒ Good Condition ☐ Requires Upgrade ☐ Needs to be provided Remarks:	

Attachment E-1. Five-Year Review Site Inspection Checklist – A-Area Miscellaneous Rubble Pile (731-6A) Operable Unit *(continued/end)*

XI. OVERALL OBSERVATIONS

A. Implementation of the Remedy

Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emissions, etc.).

The remedial action for the Piles Area is removal and disposal to remove all unacceptable risk (PTSM) from small-localized hot spots of lead and PCB/PAH. The remedial action chosen for the Ash Area is ~~institutional controls (i.e., LUCs)~~ to protect future industrial workers and potential residents from exposure to elevated levels of arsenic. ~~Institutional controls (i.e., LUCs)~~ have been established for this subunit. The remedial action chosen for the Trenches Area is active SVE to permanently remove TCE and PCE from the soil and ~~institutional controls (i.e., LUCs)~~ and a soil cover to protect remedial workers and future industrial workers from unacceptable exposure to arsenic and PAHs (benzo[a]pyrene) in the surface soil. The active SVE system was transitioned to a passive system in June 2017 and shutdown in 2020. Annual PERs demonstrate that these actions are effective and that the remedies are functioning as designed.

B. Adequacy of O&M

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

The O&M procedures consisting of annual site inspections and site maintenance (repair of erosion damage, cover maintenance, and warning signs) and site controls (SRS Site Use and Site Clearance Programs, which restrict invasive and permanent installation activities at the OU) have been implemented. The O&M procedures are adequately maintaining the integrity of the SVE system, which in turn maintains the effectiveness of the SVE system to mitigate leaching. There are no issues requiring corrective actions.

C. Early Indicators of Potential Remedy Failure

Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs that suggest that the protectiveness of the remedy may be compromised in the future.

N/A

D. Opportunities for Optimization

Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy.

N/A

- Prohibit the development and use of property for residential housing, elementary schools, childcare facilities, and playgrounds; and
- Prevent construction of inhabitable buildings without an evaluation of indoor air quality to address vapor intrusion.

Remedy Implementation

The selected final remedy for the CBRP OU is a combination of the preferred alternatives for each of the subunits that provide the greatest level of protection to human and ecological receptors. As part of the Declaration for the issued Record of Decision (ROD), the interim actions for the soil cover cap, the active soil vapor extraction and the air sparging were accepted as a final remedial action. The final remedy documented in the ROD (WSRC 2008) includes the following:

- Continued maintenance of the installed 0.24 hectares (0.6-acre), 1E-05 cm/s soil cover system installed during the interim remedial action;
- Continued operation of the four active MicroBlower™ SVE wells installed during the interim remedial action;
- Installation of a groundwater monitoring network to support MNA consisting of eighteen monitoring wells, twelve MNA monitoring wells, and five surface water stations;
- Abandonment of the no longer needed SVE and AS wells from the interim remedial action in accordance with SRS procedures and R.61-71, South Carolina Well Standards. Three AS wells were not abandoned due to their geologically significant location relative to plume geometry and the waste unit; and
- Expanded LUCs to 57.1 hectares (141.2 acres) to include the groundwater plume area (Figure F-8) consisting of general site access controls, groundwater use restrictions, the SRS Site Use/Site Clearance program, and deed restrictions and notifications.

System Operations/Operations and Maintenance

The following system operations are ongoing:

- Operation and Maintenance (O&M) of the MicroBlower™ SVE system will continue until the vadose zone source is no longer a threat to increase groundwater contamination levels above MCLs(Figure F-5).

The following maintenance activities are ongoing:

- Annual sampling of the wells and surface water stations. Sampling will continue until MCLs have been attained, the MNA has achieved its RAOs and the remedial action is complete. In 2011, an agreement was reached to decrease reporting to biennially. The MNA remedy will be evaluated biennially based on groundwater monitoring data as defined in the approved Corrective Measures Implementation/Remedial Action Implementation Plan for the CBRP OU (WSRC 2009a). The MNA remedy is expected to reduce groundwater concentrations to below MCLs within a reasonable timeframe (70 years).
- Annual site inspections and site maintenance (repair of erosion damage, cover system [Figure F-6] maintenance, and warning signs [Figure F-7]).
- Site controls and land use restrictions via the SRS Site Use and Site Clearance Programs, which restrict invasive and permanent installation activities at the CBRP OU.

Table F-3 compares the actual O&M costs for the five-year remedy review period to the estimated direct O&M costs from the ROD (WSRC 2008). The estimated cost for fiscal year (FY) 2018 to FY2022 is $162,000 for the SVE systems, soil cover, ~~institutional controls (i.e.,~~ LUCs~~)~~, and five-year remedy reviews. The actual O&M cost for FY2018 to FY2022 is $549,995. The O&M costs from FY2018 to FY2022 are higher than estimated due to the increased cost associated with MNA monitoring, including retaining annual sampling, adding additional monitoring wells and contaminant analyses, and reporting.

Sampling, analytical, data management, and validation additions caused the increase in costs.

V. Progress since Last Review

The previous protectiveness statement concluded that the remedial actions at the CBRP OU are expected to be protective of human health and the environment. Exposure pathways that could result in unacceptable risks are being addressed through the low permeability soil cover system with low-energy SVE, MNA, and ~~institutional controls (i.e.,~~ LUCs~~)~~.

There were no recommendations or follow-up actions from the last five-year review.

VI. Five-Year Review Process

The following tasks were performed as part of the review:

- Reviewed documents listed in Section XII. References
- Reviewed the groundwater monitoring data (Table F-4);
- Confirmed implementation of the remedial action;
- Inspected the OU, interviewed maintenance personnel, and documented the results on the Inspection Checklist provided in Attachment F-1, with the purpose of assessing the protectiveness of the remedy and the functionality of the access controls; and
- Reviewed changes in standards and to-be-considered guidance.

Data Review

The Interim Action for the CBRP OU s started in January 1999 and included a soil cover cap over the disposal pit, installation of an SVE system and installation of an air sparging system. The final ROD issued in July 2008 suspended the air sparge system, but continued the SVE system (MicroBlowers™ only), inspections of the soil cover, and added MNA for the groundwater plume. The last five years of available data (SRNS 2017, SRNS 2019, SRNS 2021) show the MicroBlowers™ system has removed an annual average of

approximately 14.1 kg/yr (31.2 lbs/yr) of TCE, which exceeds the minimal recovery rate necessary to prevent migration of TCE to the groundwater (0.8 kg/yr [1.8 lbs/yr]) (Figure F-9).

The MNA wells and surface water sampling show decreasing contaminants over time except for two wells (CRW 10C and CRW010CU), and CRW010CU displays concentrations exceeding the TCE trigger level. Figure F-10 and Figure F-11 demonstrate the decrease in TCE groundwater concentrations from 2000 to 2020 as the plume has migrated from the CBRP OU pit towards Fourmile Branch. The figures show the TCE source to groundwater from the CBRP OU pit has been cut off. TCE degradation products (i.e., cDCE, VC and ethylene) are observed in monitoring wells and are proof of a MNA degradation scheme, especially in the wetlands of Twin Lakes.

Summary of Inspections and Interviews

Interviews were conducted with Phil Carter, Savannah River Nuclear Solutions, LLC (SRNS) Environmental Compliance and Area Completion Project (EC&ACP) Post-Closure Lead, and Brian Hanshew, SRNS EC&ACP Post-Closure Lead, on August 30, 2022 at the O&M organization offices. No issues were identified as an outcome of these interviews.

The CBRP OU was inspected by SRNS on July 13, 2022. No issues were identified during this inspection.

A site inspection was conducted by SRNS EC&ACP and USDOE personnel on December 6, 2022. No issues were identified during this inspection.

A regulatory field inspection meeting with USDOE, U.S. Environmental Protection Agency (USEPA), and South Carolina Department of Health and Environmental Control (SCDHEC) was held on March 15, 2023. SRNS personnel were also present in the meeting. During the meeting, the participants viewed drone footage of each OU and were provided an opportunity to walk down the individual OUs. The USEPA and SCDHEC

dioxane, 2,4,6-trinitrotoluene (TNT), 2,4-dinitrotoluene (DNT), hexahydro-1,3,5-tri-nitro-1,3,5-triazine (RDX), nanomaterials, N-nitroso-dimethylamine (NDMA), perchlorate, perfluorooctane sulfonic acid (PFOS) and other per- and polyfluoroalkyl substances (PFAS), polybrominated biphenyls, polybrominated diphenyl ethers (PBDEs) and tungsten. None of the listed emerging contaminants were identified as applicable to this OU.

Has any Other Information Come to Light that Could Call into Question the Protectiveness of the Remedy?

No new information has come to light that could call into question the protectiveness of the remedy.

VIII. Issues

There are no issues related to current site conditions or activities that currently prevent the remedy for CBRP OU from being protective.

IX. Recommendations and Follow-up Actions

There are no recommendations or follow-up actions for CBRP OU.

X. Protectiveness Statement(s)

The remedy at CBRP OU is protective of human health and the environment.

Exposure pathways that could result in unacceptable risks are being controlled by ~~institutional controls (i.e.,~~ LUCs~~)~~ to prevent exposure to or ingestion of contaminated groundwater and soil media. Contamination at the CBRP OU is being addressed through implementation of the soil cover, MNA, physical access controls to prevent unauthorized entry to SRS (fences, guards, security patrols, etc.), administrative controls that maintain the CBRP OU for industrial use only, and warning signs and use restrictions via the SRS Site Use/Site Clearance Program.

XI. Next Review

Table A-1, the next five-year review for SRS OUs with Operating Equipment is scheduled for January 2029.

XII. Documents Reviewed

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

SRNS, 2017. *Biennial Effectiveness Monitoring Report (EMR) for Monitored Natural Attenuation (MNA) at the C-Area Burning/Rubble Pit (131-C) and Old C-Area Burning/Rubble Pit (NBN) Operable Unit (U), January 2015 through December 2016,* SEMS Number: 31, SRNS-RP-2017-00229, Revision 0, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC

SRNS, 2019. *Biennial Effectiveness Monitoring Report (EMR) for Monitored Natural Attenuation (MNA) at the C-Area Burning/Rubble Pit (131-C) and Old C-Area Burning/Rubble Pit (NBN) Operable Unit (U), January 2017 through December 2018,* SEMS Number: 31, SRNS-RP-2019-00327, Revision 0, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC

SRNS, 2021. *Biennial Effectiveness Monitoring Report (EMR) for Monitored Natural Attenuation (MNA) at the C-Area Burning/Rubble Pit (131-C) and Old C-Area Burning/Rubble Pit (NBN) Operable Unit (U), January 2019 through December 2020,* SEMS Number: 31, SRNS-RP-2021-03749, Revision 0, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC

USDOE, 1996. *Savannah River Site Future Use Project Report*, U.S. Department of Energy, Savannah River Operations Office, Savannah River Site, Aiken, SC

WSRC, 1998. *Interim Record of Decision for the C-Area Burning/Rubble Pit Operable Unit (131-C) (U)*, WSRC-RP-98-4039, Revision 0, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC

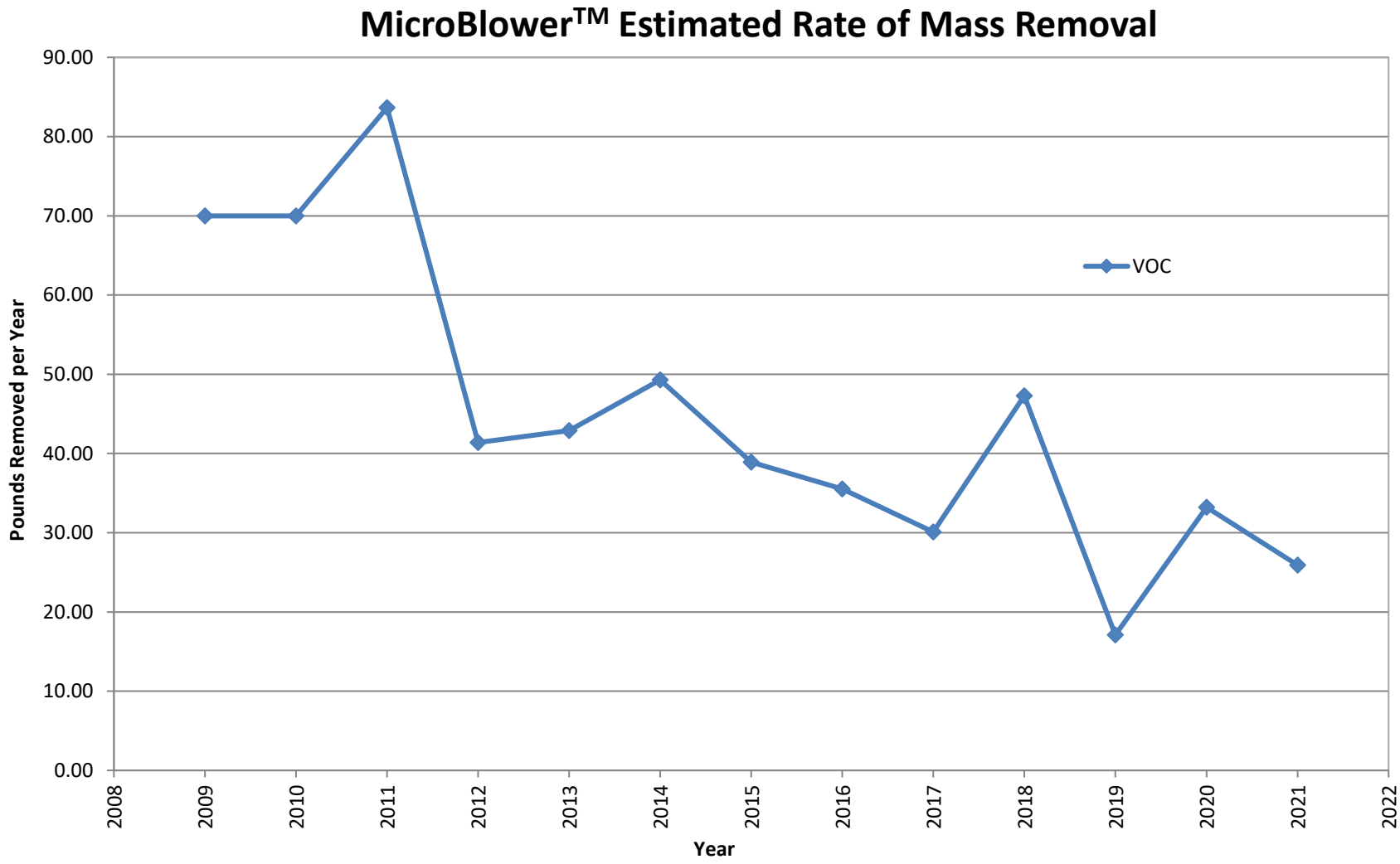

Figure F-9. Estimated Rate of Mass Removal by MicroBlowers™ at CBRP OU

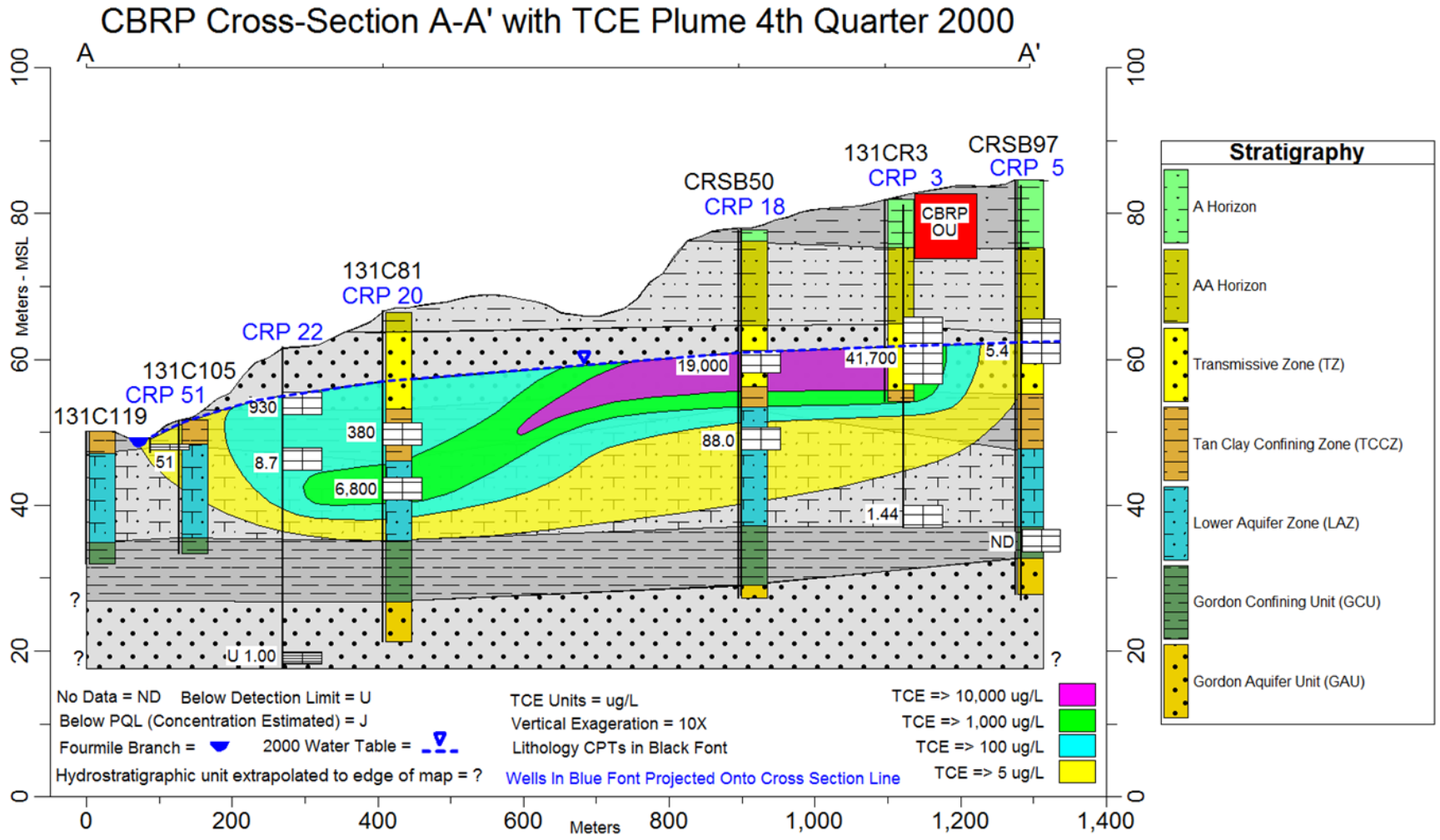

Figure F-10. CBRP Plume Cross Section, Fourth Quarter 2020

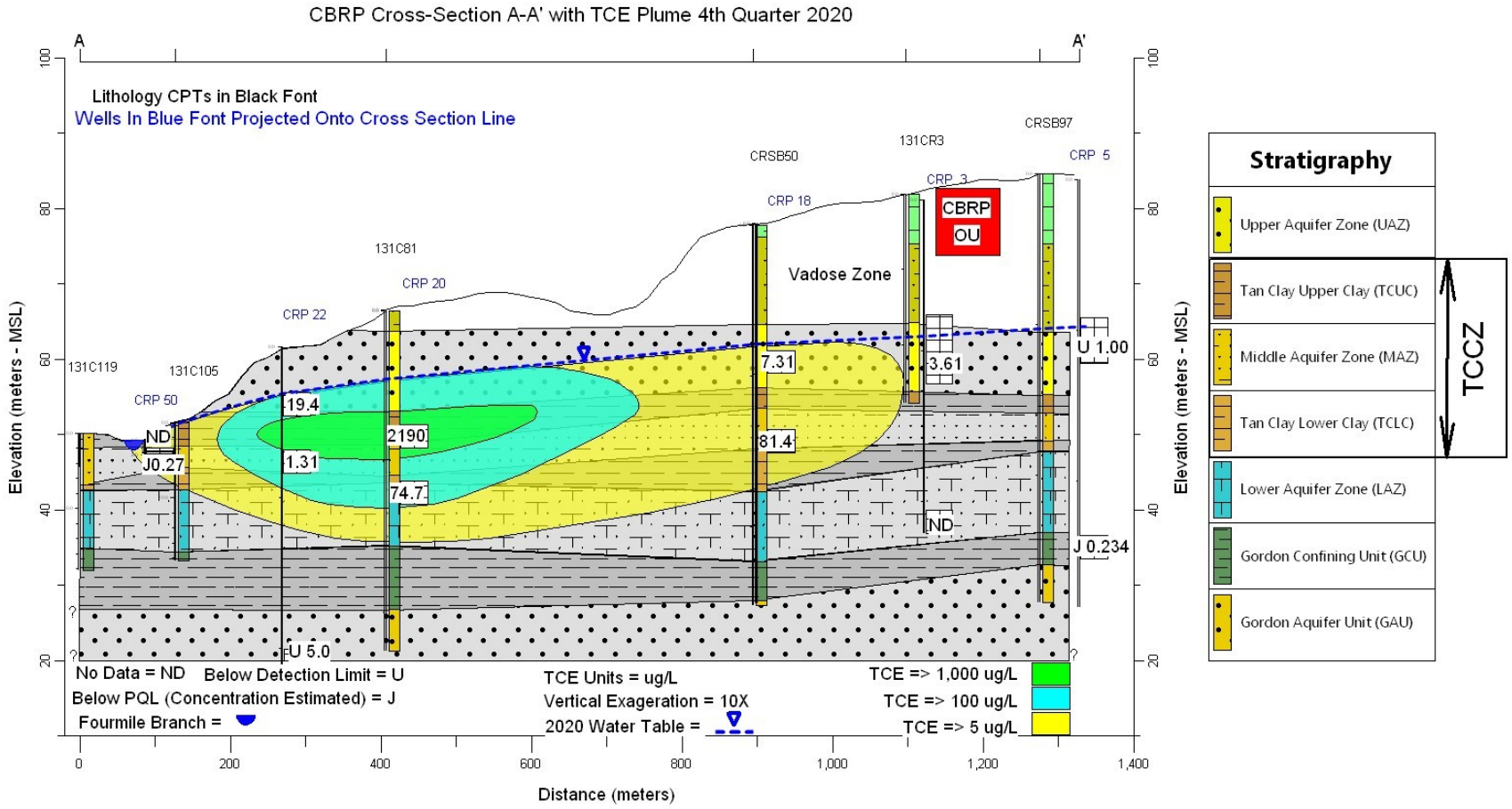

Figure F-11. CBRP Plume Cross Section, Fourth Quarter 2020

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Attachment F-1. Five-Year Review Site Inspection Checklist – C-Area Burning/ Rubble Pit (131-C) and Old C-Area Burning/Rubble Pit (NBN) Operable Unit *(continued)*

III. ONSITE DOCUMENTS & RECORDS VERIFIED *(Continued)*

2. Health and Safety Plans (HASPs):

☐ Site-Specific Health and Safety Plans	☐ Readily Available	☐ Up to Date	☒ N/A
☐ Contingency Plan/Emergency Response Plan	☐ Readily Available	☐ Up to Date	☒ N/A

Remarks: Routine O&M activities do not require a site-specific health and safety plan (SSHASP) under 29 CFR 1910.120120 HAZWOPER. A SSHASP will be prepared if needed.

3. O&M and OSHA Training Records: ☒ Readily Available ☒ Up to Date ☐ N/A

Remarks: Training Records are complete and up to date per EC&ACP training matrix.

4. Permits and Service Agreements:

☒ Air Discharge Permit	☒ Readily Available	☒ Up to Date	☐ N/A
☐ Effluent Discharge	☐ Readily Available	☐ Up to Date	☒ N/A
☐ Waste Disposal; POTW	☐ Readily Available	☐ Up to Date	☒ N/A
☐ Other Permits	☐ Readily Available	☐ Up to Date	☒ N/A

Remarks:

5. Gas Generation Records: ☐ Readily Available ☐ Up to Date ☒ N/A

Remarks:

6. Settlement Monument Records: ☐ Readily Available ☐ Up to Date ☒ N/A

Remarks:

7. Groundwater Monitoring Records: ☒ Readily Available ☒ Up to Date ☐~~☒~~ N/A

Remarks: The last Biennial Effectiveness Monitoring Report for MNA at the CBRP OU was submitted to USEPA and SCDHEC in June 2021. The next report is scheduled for June 2023.

8. Leachate Extraction Records: ☐ Readily Available ☐ Up to Date ☒ N/A

Remarks:

9. Discharge Compliance Records:

☒ Air	☒ Readily Available	☒ Up to Date	☐ N/A
☐ Water (Effluent)	☐ Readily Available	☐ Up to Date	☒ N/A

Remarks:

10. Daily Access/Security Logs: ☐ Readily Available ☐ Up to Date ☒ N/A

Remarks:

Attachment F-1. Five-Year Review Site Inspection Checklist – C-Area Burning/ Rubble Pit (131-C) and Old C-Area Burning/Rubble Pit (NBN) Operable Unit *(continued)*

IV. O&M COSTS

1. O&M Organization:

☐ State In-House ☐ Contractor for State
☐ PRP In-House ☐ Contractor for PRP
☒ Other: SRS

2. O&M Cost Records:

☐ Readily Available ☐ Up to Date ☐ Funding mechanism/agreement in place
☒ Other: Project cost data is summarized in Section IV of this OU-specific review.

Total annual cost by year for review period, if available

From: (Date)	To: (Date)	(Total Cost)	
			☐ Breakdown attached
			☐ Breakdown attached
			☐ Breakdown attached
			☐ Breakdown attached
			☐ Breakdown attached

3. Unanticipated or Unusually High O&M Costs During Review Period

Describe costs and reasons: ____

V. ACCESS AND INSTITUTIONAL CONTROLS ☒ Applicable ☐ N/A

A. Fencing

1. Fencing Damage: ☐ Location shown on site map ☐ Gates secured ☒ N/A
Remarks: OU-specific fencing is not required by the remedial action.

B. Signs

1. Signs and Other Security Measures: ☐ Location shown on site map ☐ N/A
Remarks: Signs are in good condition.

Attachment F-1. Five-Year Review Site Inspection Checklist – C-Area Burning/ Rubble Pit (131-C) and Old C-Area Burning/Rubble Pit (NBN) Operable Unit *(continued)*

IX. GROUNDWATER/SURFACE WATER REMEDIES ☒ Applicable ☐ N/A	
A. Groundwater Extraction Wells, Pumps, and Pipelines ☐ Applicable ☒ N/A	
B. Surface Water Collection Structures, Pumps, and Pipelines ☐ Applicable ☒ N/A	
C. Treatment System ☐ Applicable ☒ N/A	
D. Monitoring Data ☒ Applicable ☐ N/A	
1. Monitoring Data: ☒ Is routinely submitted on time ☒ Is of acceptable quality	
2. Monitoring Data: ☐ Groundwater plume is effectively contained ☒ Contaminant concentrations are declining	
E. Monitored Natural Attenuation ☒ Applicable ☐ N/A	
1. Monitoring Wells *(natural attenuation remedy)***:** ☒ Properly secured/locked ☒ Functioning ☒ Routinely sampled ☒ Good condition ☐ All required wells located ☐ Needs maintenance ☐ N/A Remarks:_____	
X. OTHER REMEDIES	
If there are remedies applied at the site, which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction.	
A. Soil Vapor Extraction System ☒ Applicable ☐ N/A	
1. Blowers, Wellhead Plumbing, and Electrical: ☒ Good Condition ☒ All required wells located ☐ Needs maintenance ☐ N/A Remarks:_____	
2. Extraction System Pipelines, Valves, Valve Boxes and Other Appurtenances: ☒ Good Condition ☐ Needs maintenance Remarks:_____	
3. Spare Parts and Equipment: ☒ Readily Available ☒ Good Condition ☐ Requires Upgrade ☐ Needs to be provided Remarks:_____	

Attachment F-1. Five-Year Review Site Inspection Checklist – C-Area Burning/ Rubble Pit (131-C) and Old C-Area Burning/Rubble Pit (NBN) Operable Unit *(continued/end)*

XI. OVERALL OBSERVATIONS
A. Implementation of the Remedy
Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emissions, etc.). The remedy for the CBRP OU is maintaining the integrity of the soil cover system, operating the existing active MicroBlowers™, implementing ~~institutional controls (i.e., LUCs)~~, and MNA for groundwater. The remedy is fully established and functioning as designed.
B. Adequacy of O&M
Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy. The protectiveness of the remedy is maintained through effective containment source removal by soil vapor extraction and prevention of contaminant leachate by minimizing infiltration through the contaminants by a low permeability soil cover system. Institutional controls (i.e., LUCs) effectively prevent unauthorized access to the OU: physical access controls to SRS (fences, guards, security patrols, etc.); administrative controls (SRS is a secured government facility with land use restrictions); and warning signs and use controls (SRS Site Use/Site Clearance Program).
C. Early Indicators of Potential Remedy Failure
Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs that suggest that the protectiveness of the remedy may be compromised in the future. N/A
D. Opportunities for Optimization
Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy. N/A

Basin and 488-4D Ash Landfill of the Powerhouse Subunit) pose contaminant migration risks.

- Ecological Risk: Coal-related contaminants beneath the engineered cover systems at the eastern end of the 488-1D Ash Basin and the 488-4D Ash Landfill pose a risk to ecological receptors if direct exposure were to occur.

IV. Remedial Actions

Remedy Selection

Regulatory decisions (i.e., early removal actions) were previously made for the Bubble Tower Subunit, the Moderator Processing Subunit, the Powerhouse Subunit, and Miscellaneous Units and documented in the Removal Site Evaluation Report (RSER) /Engineering Evaluation/Cost Analysis (EE/CA) documents (SRNS 2009a, SRNS 2009b, SRNS 2009c). Cleanup goals established for the DAOU subunits (including goals identified for the early removal actions) are based on industrial land use. Therefore, hazardous substances will remain at the DAOU at levels that pose a threat to human health and prevent unrestricted land use. The remedial action of LUCs selected in the EAROD (SRNS 2011a) and Second EAROD (SRNS 2020a) for a portion of the DAOU will prevent land disturbance activities and protects against unrestricted (i.e., residential) use. This will facilitate protecting the public health or welfare of the environment from actual or threatened releases of hazardous substances into the environment.

In September 2010, SCDHEC identified a problem with proceeding with a final ROD for DAOU given that the D-Area Powerhouse (484-D) would still be operational after approval of the ROD. Therefore, USDOE, USEPA, and SCDHEC agreed to pursue an EAROD to allow the DAOU project to remain on track and achieve the targeted footprint reduction. Once the 484-D Powerhouse was no longer in use, additional subunits were included in the Second EAROD in 2020.

The RCOCs and RGs for the subunits, as identified in the EAROD (SRNS 2011a) and Second EAROD (SRNS 2020a) are provided in Table G-2.

The remedial action objectives (RAOs) identified in the EAROD (SRNS 2011a) and Second EAROD (SRNS 2020a) for the DAOU after completion of the removal actions are as follows:

- Protect industrial workers from exposure to asbestos-containing waste in subsurface soil at the D-Area Asbestos Pit;
- Maintain the engineered cover system in the eastern end of the 488-1D Ash Basin and the 488-4D Ash Landfill to eliminate or control all routes of exposure to contaminants beneath the cover exceeding 1E-06 risk to future industrial workers and exceeding HQ >1 to ecological receptors and/or presenting a CM concern,
- Maintain the engineered cover system at the 488-1D Ash Landfill to prevent migration of contaminants to groundwater that could exceed groundwater protection standards,
- Protect hypothetical future residents from exposure to residual contamination in soil in the western end of the 488-1D Ash Basin exceeding 1E-06 risk,
- Protect hypothetical future residents from exposure to residual contamination in the 488-2D Ash Basin soils exceeding 1E-06 risk, and
- Ensure protection against unrestricted (i.e., residential) land use at the DAOU.

The removal actions that have been accepted as final actions within the DAOU, and their associated RAOs, are as follows:

- Reduce the potential leaching of PCE in the Bubble Tower Subunit vadose zone soils that would result in an MCL exceedance in groundwater (SRNS 2009a);
- Reduce the potential leaching of tritium in the Moderator Processing subunit vadose zone soils and concrete slabs that would result in an MCL exceedance in groundwater (SRNS 2009b),
- Prevent exposure of industrial workers to arsenic contaminated soil at D-Area WOF, D-Area Powerhouse (484-D) and ecological receptors to contaminated soil at the 489-D CPRB (SRNS 2009c),

erosion, settlement or intrusion by burrowing animals are being performed annually. The inspections also address upkeep of the vegetative cover and access control barriers (e.g., the warning signs);

- Necessary repairs (e.g., replacing eroded or disturbed soil, sign repair, etc.) and vegetation management (e.g., mowing, removal of larger vegetation, etc.) are being performed when required; and
- ~~Institutional controls (i.e., LUCs)~~ are being enforced to preclude access through the SRS Site Use/ Site Clearance program and SRS site security.

Table G-3 compares the actual operation and maintenance (O&M) costs for the five-year remedy review period to the estimated direct O&M costs from the EAROD (SRNS 2011a) and Second EAROD (SRNS 2020a). The estimated cost for Fiscal Year (FY) 2018 to FY2022 is $119,750 for the SVE systems, soil cover, ~~institutional controls (i.e., LUCs)~~, and five-year remedy reviews. The actual O&M cost for FY2018 to FY2022 is $426,044. The O&M costs from FY2018 to FY2022 are higher than estimated because O&M costs for the SVE system at the D-Area Bubble Tower Subunit costs were not included in the EAROD cost estimate. Additionally, the 488-1D Ash Basin, 488-2D Ash Basin, and the 488-4D Landfill costs were added to the estimate beginning in FY2020 (i.e., addition of access controls) and inclusion of O&M costs beginning in FY2021. The five-year remedy review cost for DAOU was included in the FY2022.

V. Progress since Last Review

The remedy at DAOU is protective of human health and the environment.

Exposure pathways that could result in unacceptable risks are being controlled by ~~institutional controls (i.e., LUCs)~~ to prevent exposure to or ingestion of contaminated groundwater and soil media. Contamination at the DAOU is being addressed through removal of contaminated media, implementation of the soil cover, physical access controls to prevent unauthorized entry to SRS (fences, guards, security patrols, etc.), administrative controls that maintain the DAOU for industrial use only, and warning signs and use restrictions via the SRS Site Use/Site Clearance Program.

VI. Five-Year Review Process

The following tasks were performed as part of the review:

- Reviewed the documents listed in Section XII, Documents Reviewed;
- Confirmed the implementation of the remedial action;
- Reviewed the data associated with the SVE system for the Bubble Tower subunit and the detritiation for the Moderator Processing subunit (discussed below);
- Inspected the OU, interviewed maintenance personnel and documented the results on the Inspection Checklist provided in Attachment G-1 with the purpose of assessing the protectiveness of the remedy and the functionality of the access controls; and
- Reviewed changes in standards and to-be-considered guidance.

Data Review

DAOU Bubble Tower Subunit

The remedy for the PCE contaminated vadose zone soils of the Bubble Tower Subunit is operation of a network of MicroBlower™ SVE units. This network facilitates breaking of the transport pathway from the source to the groundwater. The approved Removal Action Report (RAR) for the DAOU Bubble Tower Subunit (SRNS 2011c) requires the monitoring results from the SVE system be reported in the five-year remedy review report. Attachment G-2 provides the detailed data associated with the operation of this system. The system has been operating near 100% for the last five years (2017 through 2021). During that period, the MicroBlower™ system has removed approximately 0.14 kg (0.31 lbs) of PCE and 0.017 kg (0.037 lbs) of trichloroethylene (TCE). Most contaminants were removed between 2011 and 2013 with minimal annual removal amounts since then.

Moderator Processing Subunit

The remedy for the tritium-contaminated soils of the Moderator Processing Subunit was treatment by on-site detritiation units. The RAR (SRNS 2011d) provides detail on the construction and operation of these units. The RGs for soil (120 pCi/g) and concrete

Table G-4. Summary of Confirmatory Sampling for On-Site Thermal Detritiation Treatment of Soils and Concrete associated with the Moderator Processing Subunit (SRNS 2011d)

Event #	Treatment Cell #	Media	# of Records	Maximum Concentration (pCi/g)	Minimum Concentration (pCi/g)
DAOU-HR-TS	2	Soil	5	72.9	31.2
	3	Concrete	2	724	640
	4	Concrete	2	29.7	19.9
		Soil	2	39.2	35.1
	1	Concrete	11	17.4	ND
		Soil	4	38.4	9.88
DAOU-HR-TS10	4	Soil	5	104	77.2
DAOU-HR-TS11	1	Concrete	7	189	10.3
	1	Soil	5	55.1	17.5
	3	Soil	5	ND	ND
	2	Soil	5	15.9	7.79 (J)
	4	Soil	5	67.7	22.6
	1	Soil	5	64.3	21.9
	2	Soil	5	7.14 (J)	5.1 (J)
	3	Soil	4	5.48	4.4
DAOU-HR-TS2	1	Soil	4	54.4	12
DAOU-HR-TS3	1	Soil	5	29.3	15.2
DAOU-HR-TS4	2	Soil	~~5~~4	~~133~~109	68.3
DAOU-HR-TS5	1	Soil	5	40.2	19.7
DAOU-HR-TS9	3	Soil	3	69.8	45.3
		Concrete	2	48.9	40.7
	1	Concrete	2	541	119
	2	Soil	4	~~142~~102	102

Note: Sampling events occurred over multiple dates. Thus, multiple listing of a treatment cell for a single media within a single event indicates separate sampling events.

Table G-5. Recommendations and Follow-up Actions for DAOU

Issue	Recommendations/ Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness? (Y/N)	
					Current	Future
Contaminant removal from the DAOU Bubble Tower MicroBlower™ SVE wells has greatly diminished or ceased since 2012 and operation of the SVE system may no longer be needed for future protectiveness if the CM RG has been achieved.	Due to the DAOU Bubble Tower Subunit MicroBlower™ SVE system's minimal removals of contaminants for at least the last four years (Figure G-2-2, Attachment G-2), SRS proposes to convert the MicroBlower™ SVE system to a passive BaroBall™ SVE system until confirmation soil samples can be collected to determine whether the PCE CM RG has been met (20 µg/kg). If the CM RG has been achieved, the results will be submitted to the Core Team for consensus to justify discontinuing operation of the SVE and/or monitoring.	USDOE	SCDHEC/ USEPA	June 2023	N	N

Attachment G-1. Five-Year Review Site Inspection Checklist – D-Area Operable Unit *(continued/end)*

XI. OVERALL OBSERVATIONS
A. Implementation of the Remedy
Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emissions, etc.). The remedial action for the DAOU Bubble Tower Subunit is SVE with MicroBlowers™ to prevent the migration of VOCs from the contaminated soils to groundwater above the MCLs, a 1-foot soil cover to protect remedial workers and future industrial workers from unacceptable exposure to VOCs and ~~institutional controls (i.e., LUCs)~~. The SVE system is operating at the Bubble Tower Subunit and is functioning as expected. The remedial actions for the DAOU Powerhouse Subunit include geosynthetic cover systems over the 488-1D Ash Basin and 488-4D Ash Landfill with ~~institutional controls (i.e., LUCs)~~ to prevent the migration of coal and ash related contaminants to groundwater above MCLs and to prevent industrial workers and ecological receptors from exposure to contaminated soils and ash.
B. Adequacy of O&M
Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy. The O&M procedures are adequately maintaining the integrity of the Bubble Tower Subunit SVE system and the 488-1D Ash Basin and 488-4D Ash Landfill cover systems. The O&M procedures consisting of annual site inspections and site maintenance (cover system and warning signs) and site controls (SRS Site Use and Site Clearance Programs, which restrict invasive and permanent installation activities at the OU) have been implemented. There are no issues requiring corrective actions
C. Early Indicators of Potential Remedy Failure
Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs that suggest that the protectiveness of the remedy may be compromised in the future. N/A
D. Opportunities for Optimization
Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy. Recommendations provided in the OU-specific review report (Table G-5).

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uppermost groundwater aquifer. Several of the contaminants exceeded regulatory limits and were targeted for remediation.

Basis for Taking Action

The maximum detected levels of several contaminants (e.g., tritium, iodine-129, and strontium-90) in the F-Area groundwater currently exceed the National Primary Drinking Water Standards and state standards (i.e., maximum contaminant levels [MCLs]). However, potential exposures to the general public are minimized by the distance from the OU to the site boundary, natural attenuation and radionuclide decay, ~~institutional controls (i.e., land use controls [~~LUCs~~])~~, and dilution in receiving streams. The remediation of the F-Area Groundwater OU was designed to meet, as far as practicable, the groundwater protection standards (GWPS) outlined in the 1992 SRS RCRA Permit Renewal.

The constituents for which monitoring is required are shown in Table H-2. These constituents are identified in the current SRS RCRA Permit Renewal (SCDHEC 2021) and listed in the Interim Action Record of Decision (IROD) (WSRC 1995).

IV. Remedial Actions

Remedy Selection

An IROD for the F-Area Groundwater OU was issued in April 1995 (WSRC 1995). A final Record of Decision (ROD) for the F-Area Groundwater OU has not been issued. The final action for this media-specific OU will be documented by modifications to the RCRA permit renewal.

The selected interim action under CERCLA is no further action beyond that required by the corrective action as identified in the SRS RCRA Permit Renewal. As specified in the SRS RCRA Permit Renewal, the goal of remediation of the F-Area Groundwater Operable Unit is to lower contaminant concentrations in the groundwater associated with the F-Area HWMF to levels specified in the RCRA permit renewal and to minimize the discharge of contaminants to the adjacent stream. Under RCRA, the corrective action for the F-Area HWMF commenced in 1989, was certified closed in February 1991, and certification of

closure was approved by SCDHEC in April 1991 (WSRC 1995). The remedial action objectives (RAOs) of the interim remedial action are to address the potential ecological impacts at the seeplines along Fourmile Branch and to address the ambient water quality standards in Fourmile Branch by remediating this OU (WSRC 1995).

The SRS RCRA Permit Renewal set forth a phased approach to remediating the groundwater that required documented evaluations of the performance of the system to determine effectiveness toward meeting the RAOs. The Phase 1 remedy involved groundwater recovery and hydraulic control with treatment of mobile hazardous constituents and radionuclides (except tritium and nitrates) and injection of treated water into the shallow aquifer at the upgradient extent of the plume. The evaluation of this remedy (WSRC 2001) facilitated the following phased success measures to reach the RAOs that are in the current SRS RCRA Permit Renewal (SCDHEC 2021):

- Phase 1) Objectives met:
    - Implement a groundwater extraction and injection system to capture and remediate those portions of the contaminant plume delineated by the 10,000 pCi/mL tritium isoconcentration contour.
    - Prevented portions of the plumes from further migration and discharge to Fourmile Branch. The groundwater extraction and injection system is no longer operating.
- Phase 2a) Objectives met:
    - Reduced the mass flux (Curies/year) of tritium discharging from the F-Area plume to Fourmile Branch by 70%.
    - Reduced the concentration of the remaining ~~Appendix IVB-A~~Table H-2 constituents in Fourmile Branch (except tritium and I-129) to levels that are less than the GWPS.

- Phase 2b) before January 14, 2032:
  - Reduce the discharge from the F-Area plume of all ~~Appendix IVB-A~~Table H-2 constituents in the surface water at the seepline to concentrations that are less than the GWPS (except tritium).
  - Reduce the concentration of I-129 in Fourmile Branch to levels that are less than the GWPS.
- Phase 3):
  - Submit a Phase 3 corrective action plan that, upon approval, will capture and remediate the entire contaminant plume (including tritium) above those concentrations listed in the GWPS and/or evaluate the applicability of Alternate Concentration Limits (ACL) and/or a Mixing Zone.

Remedy Implementation

Consistent with the phased approach of the RCRA permit renewal, the implementation of the remedy was structured to prevent the plumes from further migration and discharge to Fourmile Branch, treat and/or attenuate the contaminant plumes at and approaching the OU boundary (Fourmile Branch), and treat and/or attenuate all contaminants within the OU. Except for the initial treatment (pump-treat-reinjection), the permit identifies that development work would be needed to select and implement technologies to address the unique conditions presented at this OU. While the treatments that are and have been part of the remedy for this OU are presented chronologically in the following paragraphs, they work synergistically to address the permit requirements and RAOs.

Active Treatment with Pump – Treat - Reinjection

In 1997, SRS designed and built a pump-and-treat system using a water treatment unit (WTU) with a network of injection and extraction wells. The remediation system extracted groundwater downgradient of the seepage basins, passed it through the WTU to remove metals and radionuclides, and re-injected the treated water upgradient to maintain the recirculation loop. To reduce the migration of tritium to Fourmile Branch, the system

lengthened the tritium pathway in the extraction/reinjection loop, which allowed more time for tritium decay prior to discharging to Fourmile Branch. Over the course of pump-and-treat operations, due to increased water volume and gradient from injection of treated water and annual rainfall, the effectiveness of the system on reducing tritium flux to Fourmile Branch had diminished. This prompted termination of operations and implementation of new corrective actions (subsurface barriers and gates, and base injection). Operation of the pump and treat system was suspended October 2003 upon receipt of conditional approval by SCDHEC.

Passive Control of Water Table Gradients and pH Treatment

After successful completion of a small-scale pilot study to demonstrate that raising the pH value of the F-Area groundwater will immobilize metals and metallic radionuclides, a subsurface barrier and gate system and base (alkaline) solution injection system were constructed, replacing the groundwater pump-and-treat unit. In June 2005, the operation of the base injection system commenced. Base injection operations are currently ongoing and active injection occurs as needed to maintain desired pH levels greater than 5.0 in the treatment zone. During June 2008, the base injection system was expanded to treat groundwater beneath the wetlands by injecting base through a series of injection wells. The engineered groundwater barriers were expanded in 2010 to add an additional gate and footage of wall. Operations in the new gate commenced in 2011.

The barriers were constructed across the preferential groundwater flow paths leading to the wetlands adjacent to Fourmile Branch. The subsurface barrier and gate system reduces the groundwater flow velocity (allowing more time for radioactive decay) and controls the flux of contaminants to Fourmile Branch. Within the gates, base injection is operated to immobilize metals and metallic radionuclides. With the expansion of the system, the barrier, composed of low permeability amendments, consists of four walls totaling 750 m (2,500 ft) in length and three gates/funnels. Construction utilized an in-situ soil mixing technique to blend acid resistant pozzolan cement and attapulgite clay with native soils. A small percentage of caustic was also added to the cement to facilitate curing. Upon hardening, the resulting soil/cement mixture formed a low permeability (less than

1E-06 cm/s [2.83E-03 ft/day]) subsurface barrier approximately 0.75 m (2.5 ft) thick on average. Vertically the wall was installed from just below ground surface to the base of the upper aquifer zone. The location of the original barrier, the extension, and the injection wells are shown in Figure H-2.

A silver chloride injection field pilot study began in March 2009 to test the potential to capture iodine-129 and form stable, insoluble silver iodide. The pilot study was effective, and a field scale demonstration was implemented in the small central gate. SCDHEC approved a permit modification allowing full-scale operation effective July 20, 2011. SRS injected half of the permitted and purchased quantity in 2011 and injected the remaining quantity on hand in 2015. In 2018, a UIC Permit was approved for the third deployment of silver chloride at the central gate. The third deployment of silver chloride was executed at the central gate to augment previous silver chloride injections and increase robustness through further development of a permeable in situ treatment zone. SRS is implementing silver chloride technology to reduce the concentration of iodine-129 in groundwater at F-Area HWMF and in FMB and continues to evaluate the need for additional silver chloride injection(s) in the future.

System Operations/Operation and Maintenance

Remedial activities are still in progress that require operations and maintenance (O&M).

Since 2005, the base injection system that stabilizes the pH in the target zone has operated with periodic injections of base to maintain pH downgradient of the barrier to support sorption of the metals and metallic radionuclides. Since 2005, 390.3 million L (103.1 million gal) of base solution were injected through the barrier wall gates. Beginning in 2008, 215.0 million L (56.8 million gal) of base solution have been injected through individual injection ports in the wetlands. A total of 605.3 million L (159.9 million gal) of base solution have been injected into the subsurface.

The injection of silver chloride into the plume at the central gate to stabilize iodine-129 as silver iodide occurred in 3 injection campaigns (2011, 2015 and 2018). Approximately 1,563,375 L (413,000 gal) of the ultra-fine ground silver chloride suspension (water +

silver chloride amendment) was placed into the subsurface during the three deployments. Based on the pilot test and the three rounds of injection at the central gate, silver chloride has been demonstrated effective at sequestering iodine-129 in situ. Variations in the degree of reduction have been observed during each deployment. Monitoring data at several well locations have shown that the 2018 silver chloride injection campaign was effective in reducing iodine-129 concentrations. In one of the wells (FSB 146D) close to the injection points, a reduction of approximately 58 – 75 percent in iodine-129 concentration occurred after the injection period and has persisted for over two years (Figure H-3). Wells FSB 143D and FSB 130D also saw attenuation of iodine-129 after the injection period with reductions in iodine concentration between 63 – 69 percent and 58 – 69 percent, respectively (Figure H-3). Monitoring points closest to the injection show the greatest reduction in concentration and wells further away show less of an impact (Figure H-4). SRS is continuing to evaluate the effectiveness of the permeable in situ treatment zone and continues to evaluate the need for additional silver chloride injection(s) in the future.

Costs associated with the selected interim remedy for F-Area Groundwater include O&M costs of the WTU, base injection, and ~~institutional controls (i.e., LUCs)~~. The actual O&M cost during FY2018 to FY2022 is $5,680,644. RCRA documentation does not require estimated project costs to be prepared. Therefore, none are included in this remedy review.

V. Progress since Last Review

The previous protectiveness statement concluded that the interim remedial actions at the F-Area Groundwater OU are expected to be protective, and in the interim, exposure pathways that could result in unacceptable risks are being maintained by engineered subsurface barriers and a base injection treatment system and are monitored by the groundwater and surface water monitoring networks, which have all been functioning properly.

There were no recommendations and follow-up actions from the last five-year review.

The following actions have been completed:

- Silver chloride injection - Conducted a third deployment at the central gate and concluded that the silver chloride effectively sequesters iodine-129 and the silver chloride particles do not migrate a significant distance away from the treatment zone.
- Base injection operations are continuing as needed.

VI. Five-Year Review Process

The following tasks were performed as part of the review:

- Reviewed the documents listed in Section XII. Documents Reviewed;
- Confirmed the implemented remedial actions are ongoing. Figures H-~~3~~ 5 through H-7 provide~~s~~ current photographs of the remedial actions;
- Reviewed all process and performance monitoring data provided by the annual groundwater monitoring and corrective action reports and provided a technical assessment of whether the treatment systems are functioning as intended by the IROD and whether the shutdown criteria have been achieved;
- Inspected the OU, interviewed maintenance personnel and documented the results on the Inspection Checklist provided in Attachment H-1 with the purpose of assessing the protectiveness of the remedy and the functionality of the access controls and provided current photos of the treatment system (Figure H-~~3~~5);
- Ensured that all actions required under the RCRA Permit Renewal were implemented; and
- Reviewed changes in standards and to-be-considered guidance.

Data Review

This OU has a unique set of subsurface conditions, facilitated in part by the carrier fluid for the process waste that was discharged to the seepage basins (groundwater contaminant source). This low pH liquid (acid) leached to the subsurface over a 30-plus year period creating a groundwater plume of low pH that has impacted the geochemistry of the subsurface soils, leaching natural metals and minerals, and minimizing the retardation of

contaminants. As recognized by SRS, the pH must be addressed to have success in reaching the RAOs and RCRA permit renewal requirements. Because of the properties of the individual metal and radionuclide contaminants, one remedy will not address all the contaminants. In addition, the only viable approach to tritium, a main contaminant at this site, is increased travel time to receptors to allow for radioactive decay. Thus, the remedial approach implemented at SRS attempts to address all these facets. This technical assessment was conducted to assess progress in addressing the RAOs as per the IROD (WSRC 1995).

Ecological Studies

Ecological studies associated with the F-Area Groundwater OU are conducted as part of the Fourmile Branch Integrator Operable Unit (IOU). These studies include ecological benchmark comparisons that compare ecological screening values (ESVs) to sediment, sediment/soil, and surface water media constituent concentrations. The ESVs are derived from ecologically relevant criteria and standards such as National Ambient Water Quality Criteria. Review of the fifth periodic report for the Fourmile Branch IOU indicates that in terms of community level effects there is no evidence that metals discharged from F Area have degraded fish or macroinvertebrate communities in Fourmile Branch. Aluminum, barium, and mercury may pose a potential threat to wildlife. Aluminum and barium showed a potential threat to wildlife upgradient of SRS operations. Only mercury is a potential issue in lower and middle Fourmile Branch, but there is little evidence that this is associated with discharges from SRS operational areas (i.e., F-Area, H-Area) (SRNS 2016).

The decrease in pH of the groundwater due to the introduction of the low pH fluid became evident in the wetland areas in the form of a tree-kill zone. The ongoing base injection operations appear to be positively impacting this area. From a visual survey, vegetation in the tree-kill zone appears to be recovering.

Groundwater and Surface Water Data

This data review encompassed a review of concentration data, contaminant plume maps (SRNS 2018, SRNS 2019, SRNS 2020, SRNS 2021, SRNS 2022), and time trend data for sampling locations within the F-Area Groundwater OU.

As a condition of the RCRA permit renewal for the F-Area HWMF groundwater, SRS annually calculates and reports the tritium flux to Fourmile Branch. As shown in Table H-3, tritium flux discharges have been reduced by 70%.

A review of surface water data from stations FMC002H, FMC002HD, FM2BD, and FMC002F from 1997 to 2021 was conducted to assess the effect of the F-Area Groundwater OU treatment systems on Fourmile Branch (Figure H-8). Table H-4 presents the contaminants that at any time during the review period were detected above the GWPS or MCL. The base injection went into operation in 2005. The data in Table H-4 provides evidence that the base injection operations are having a positive influence on the concentrations of all constituents except for iodine-129. The concentrations of the constituents are decreasing or are below the GWPS and/or MCL. SRS recognizes that iodine-129 will not be treated by the base injection system and thus is investigating and implementing other approaches to remediate the iodine (as discussed below). The data provides evidence that the remedial activities are having a positive impact on the groundwater and Fourmile Branch surface water (Tables H-3 and H-4, respectively). Because all constituents have not reached acceptable levels in the surface water, corrective action activities will continue.

A review of the seepline groundwater data from initial sampling in 2001 to 2021 was conducted to assess the effect of the F-Area Groundwater OU treatment systems on the seeplines. Table H-5 provides a summary of constituents from the seepline sampling locations that have exceeded the GWPS or MCL at any time during the period beginning in 2001 and ending December 31, 2021. Review of the seepline data indicates a downward trend in contaminant levels for the majority of constituents. Of the three constituents identified in the ecological studies as potential threats to wildlife, only mercury was

detected above standard with concentrations decreasing after the barrier and gate system with base injection became operational.

While Table H-5 presents a list of contaminants detected above standards in groundwater at the seepline, the RCRA corrective action recognizes that there are four challenging contaminants of concern with respect to mitigating the migration/discharge of GWPS constituents from outcropping in the surface water at the seepline. These contaminants include iodine-129, strontium-90, tritium, and uranium-238. For these contaminants time series were analyzed for concentration trends at all 17 of the seepline groundwater piezometers over the past 10 years. Table H-6 presents the trend summary for each of the four contaminants listed above.

Groundwater concentrations for strontium-90 were non-detect at 7 locations and less than the GWPS at ten locations. The remaining locations had decreasing concentration trends except for one location where the trend was stable. Uranium-238 was not detected at seven locations and was less than the GWPS at 16 of the 17 locations. Only one location had an increasing trend for Uranium-238. Iodine-129 was below the GWPS and not detected at two locations. The trend for iodine-129 was increasing at only one location; the remaining locations had decreasing or stable trends. Tritium was decreasing at all seepline locations except for one which had a stable trend and was less than the GWPS at four locations.

Summary of Inspections and Interviews

Interviews were conducted with Phil Carter, O&M staff member, on August 30, 2022 and Brian Hanshew, O&M Site Manager, on August 30, 2022 at the O&M organization offices. No issues were identified for the F-Area Groundwater OU during this interview.

The F-Area Groundwater OU was inspected by Savannah River Nuclear Solutions, LLC (SRNS) and USDOE personnel on November 22, 2022. No issues were identified for the F-Area Groundwater OU during this inspection.

A regulatory field inspection meeting with USDOE, USEPA, and SCDHEC was held on March 15, 2023. SRNS personnel were also present in the meeting. During the meeting, the participants viewed drone footage of each OU and were provided an opportunity to

The GWPS set forth in the SRS RCRA Permit Renewal (SCDHEC 2021) for the monitored constituents were compared against MCLs, where available. The comparison found that when available, the MCL is the same as the GWPS. The comparison found two constituents where the GWPS differed from the MCL (Table H-~~6~~7). The GWPS is more protective than the MCL for carbon-14, and cobalt-60; thus, SRS is adhering to a more stringent standard.

Fact sheets provided on the USEPA webpage (https://www.epa.gov/fedfac/emerging-contaminants-and-federal-facility-contaminants-concern) regarding emerging contaminants were reviewed for applicability to this OU. This webpage provides a link to specific fact sheets for each of the following contaminants: 1,2,3-trichloropropane (TCP), 1,4-dioxane, 2,4,6-trinitrotoluene (TNT), 2,4-dinitrotoluene (DNT), hexahydro-1,3,5-tri-nitro-1,3,5-triazine (RDX), nanomaterials, N-nitroso-dimethylamine (NDMA), perchlorate, perflurorooctane sulfonic acid (PFOS), Perfluorooctanoic acid (PFOA) and other per- and polyfluoroalkyl substances (PFAS), polybrominated biphenyls, polybrominated diphenyl ethers (PBDEs) and tungsten. The only emerging contaminant identified as applicable to this OU is 1,4-dixoane.

Due to the widespread usage of chlorinated solvents at SRS and the use of 1,4-dioxane as a stabilizer in chlorinated solvents, paint strippers, greases, and waxes, SRS began sampling for this constituent at selected wells within the F-Area Groundwater OU in 2007. Of the 196 records reviewed from twenty wells, only one sample detected 1,4-dioxane (31 J ug/L) at background well HSB 85A, providing evidence that 1,4-dioxane is not a constituent of concern for the F-Area Groundwater OU.

Has any Other Information Come to Light that Could Call into Question the Protectiveness of the Remedy?

No new information has come to light that could call into question the protectiveness of the remedy.

VIII. Issues

There are no issues related to current operations, site conditions or activities that currently prevent the remedy from being protective.

IX. Recommendations and Follow-up Actions

There are no recommendations or follow-up actions for F-Area Groundwater OU.

X. Protectiveness Statement(s)

The remedy at the F-Area Groundwater OU is currently protective of human health and the environment because exposure pathways that could result in unacceptable risks are being controlled by the barrier wall, base injection treatment systems, silver chloride injections, groundwater monitoring, and implementation of LUCs including physical access controls to prevent unauthorized entry to SRS (fences, guards, security patrols, etc.), and administrative controls that restrict site use to industrial use only (via the SRS Site Use/Site Clearance Program). Protectiveness of the remedial action will be verified by continued groundwater and surface water monitoring.

XI. Next Review

As shown in Appendix A, Table A-1, the next five-year review for SRS OUs with Operating Equipment is scheduled for January 2029.

XII. Documents Reviewed

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

SCDHEC, 2014. South Carolina Department of Health and Environmental Control Hazardous and Mixed Waste Permit, Permit Number SC1 890 008 989, 2014 RCRA Permit Renewal for the Savannah River Site, issued on February 11, 2014, Module III - Postclosure Care and Module IV – Groundwater Requirements, Section B, F-Area Hazardous Waste Management Facility, South Carolina Department of Health and

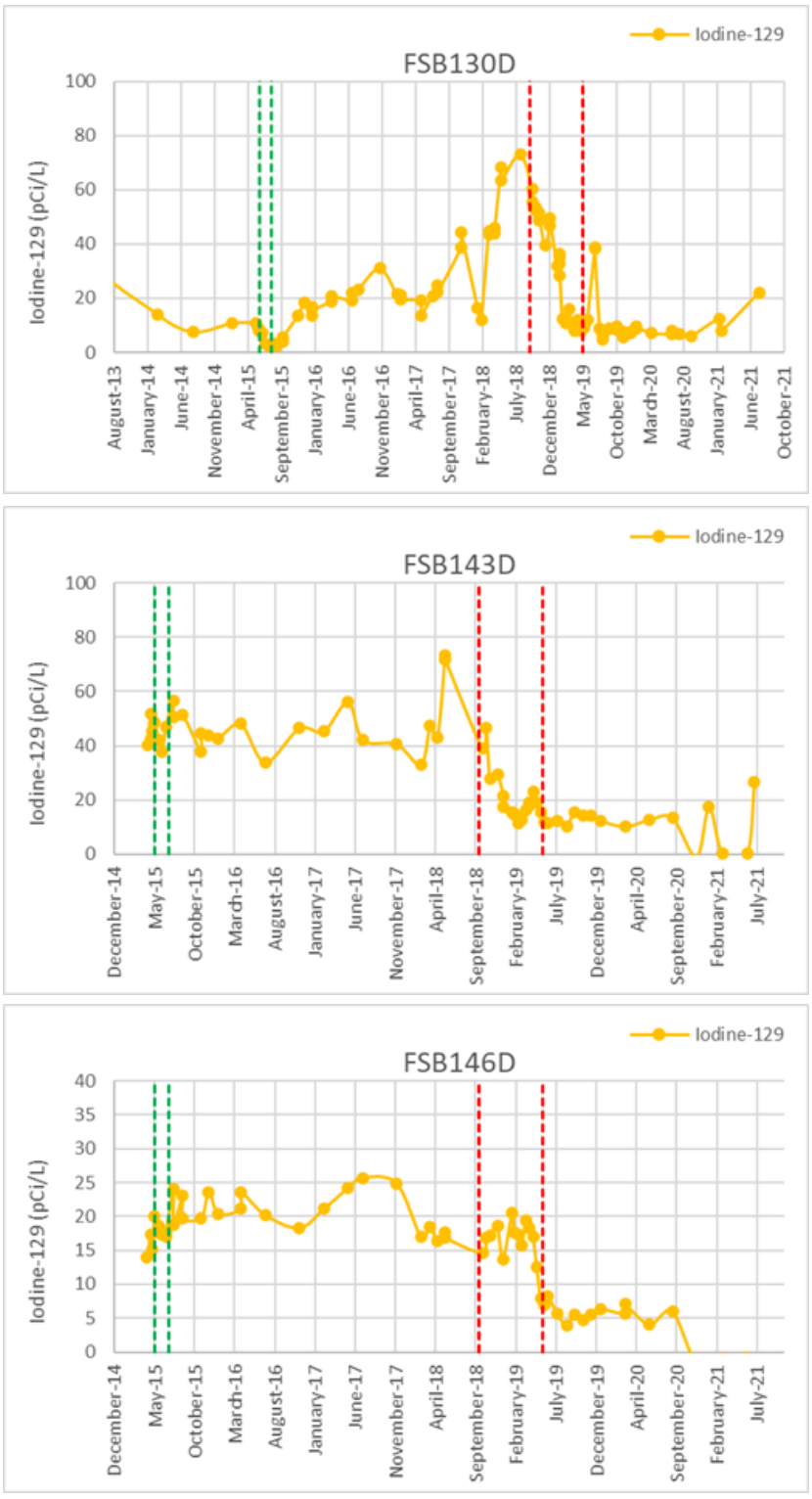

Figure H-3. Time Trends of Iodine-129 Concentrations at wells FSB 146D, FSB 143D and FSB 130D

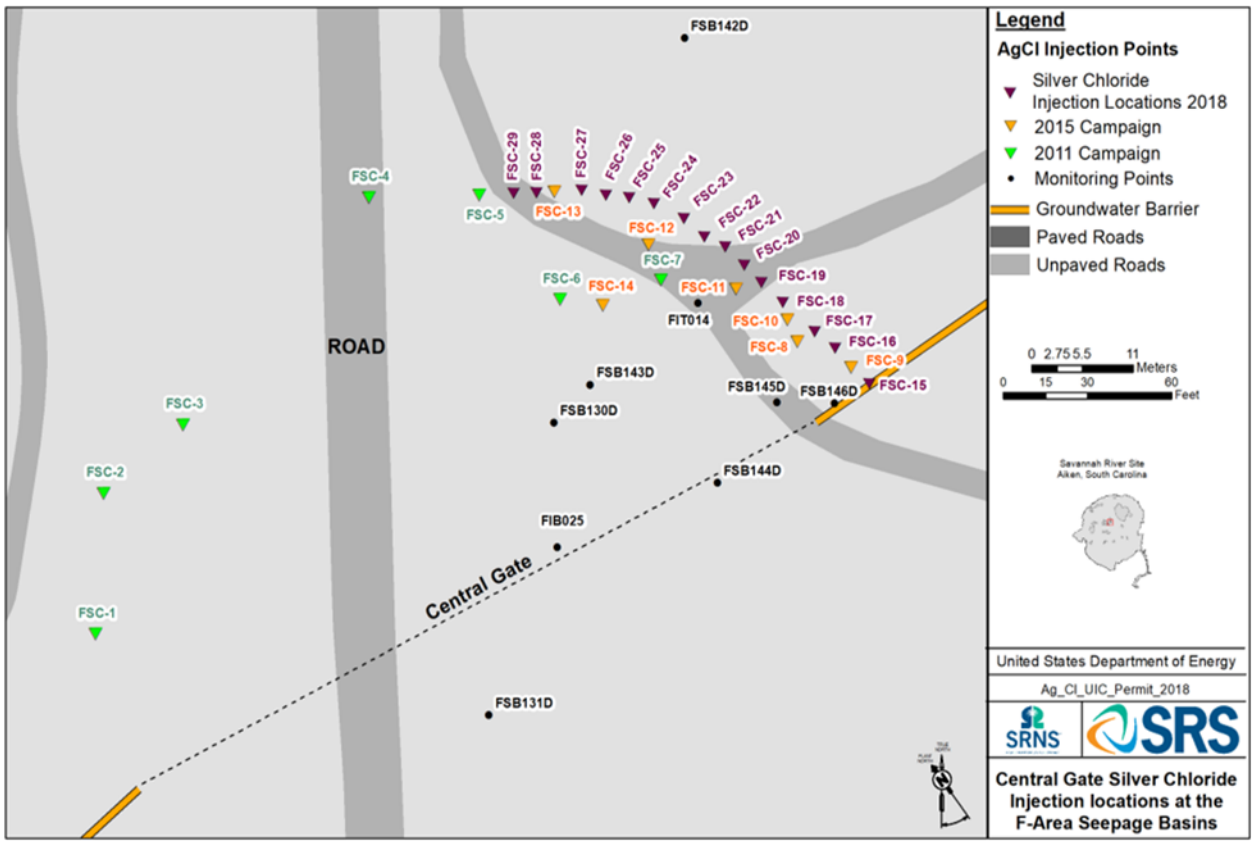

Figure H-4. F-Area Hazardous Waste Management Facility Silver Chloride Injection Layout

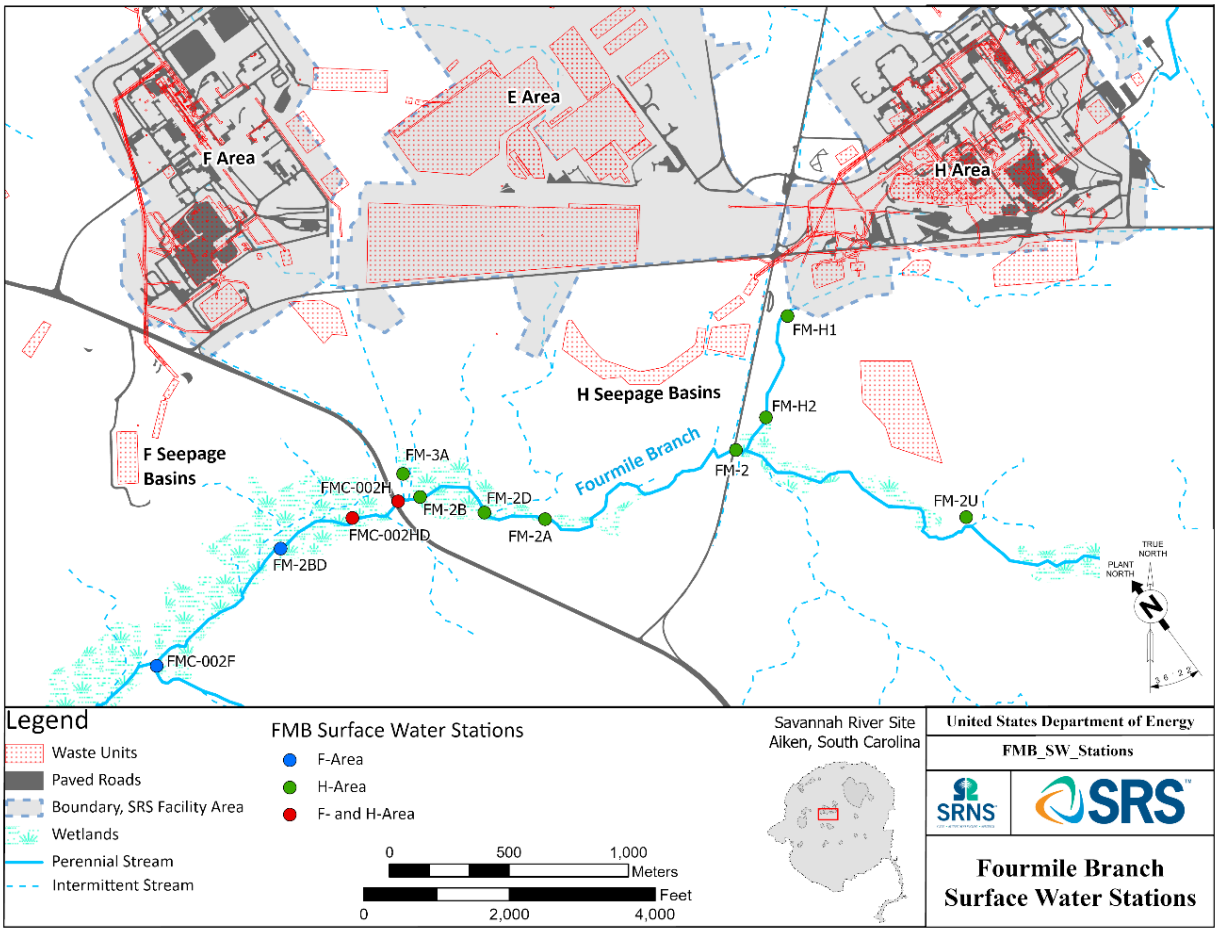

Figure H-8. Fourmile Branch Surface Water Stations

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Table H-4. Summary of Constituents from the F-Area Groundwater OU Surface Waters of Fourmile Branch Detected Above Standards

Constituent	Unit	GWPS or MCL[1]	Maximum Concentration [# of samples]				
			2nd Remedy Review (1997-2001)	3rd Remedy Review (2002–2006)	4th Remedy Review (2007–2011)	5th Remedy Review (2012–2016)	6th Remedy Review (2017–2021)
Carbon-14	pCi/L	50					57.8 [22] [2]
Cesium-137	pCi/L	50	110 [12]	12.7 [27]	16.1 (J) [40]	11.2 (J) [10]	ND [10]
Cobalt	µg/L	3	4.71 (J) [14]	1.3 [27]	1.22 [21]	4.07 (J) [36]	12 [47]
Gross alpha	pCi/L	15	155 [19]	2.71 [51]	2.3 [53]	4.72 (J) [50]	5.04 (J) [50]
Iodine-129	pCi/L	1	0.642 [10]	5.88 [22]	14.5 [53]	10.1 [58]	7.26 [54]
Nitrate	µg/L	10,000	665 [23]	4,260 [55]	7,480 [51]	1,120 [44]	920 [52]
Nonvolatile beta	pCi/L	50	207 [19]	26.2 [51]	23.6 [53]	14.8 [50]	14.7 [50]
Phenols	µg/L	5,800	ND [10]	ND [21]	58 (J) [11]	ND [10]	154 [10] [3]
Radium, total	pCi/L	5	30.3 [15]	0.66 [30]	0.59 [31]	1.35 [22]	1.81 [22]
Radium-226	pCi/L	5	28.7 [15]	0.64 [38]	0.49 [31]	1.12 [28]	1.11 [22]
Radium-228	pCi/L	5	22.1 [16]	4.93 [34]	4.08 [24]	1.3 (J) [13]	0.59 (J) [11]
Strontium-90	pCi/L	8	13.2 [17]	5.5 [18]	5.6 [41]	4.66 (J) [31]	6.28 (J) [28]
Tritium	pCi/L	20,000	506,000 [25]	625,000 [261]	337,000 [298]	340,000 [335][4]	169,000 [340]

1 The more conservative of the MCL or GWPS was used for comparison.

2 All other records were below the MCL

3 Exceedances are sporadic. Of the 47 measurements taken, only 5 were above the MCL.

4~~3~~ Of the 10 records, 8 were non-detects and only one value was over the practical quantitation limit.

5~~4~~ FMC-002H had two anomalous results with concentrations of 2,160,000 pCi/L and 1,220,000 pCi/L. The average concentration for the 5th Remedy Review period was 64,000 pCi/L.

ND – Non-detect

J – Estimated Value

Table H-5. Summary of Constituents from the F-Area Groundwater OU Seepline Groundwater Detected Above Standards

Constituent	Unit	GWPS or MCL[1]	Maximum Concentration [# of samples]				
			2nd Remedy Review (1997-2001)	3rd Remedy Review (2002–2006)	4th Remedy Review (2007–2011)	5th Remedy Review (2012–2016)	6th Remedy Review (2017–2021)
Beryllium	µg/L	4	21.9 [7]	22.3 [254]	10.8 [283]	3.02 [94]	2.69 [113]
Cadmium	µg/L	5	14.2 [7]	26.8 [268]	22 [355]	10.8 [367]	6.97 [376}
Cobalt	µg/L	3	36.7 [7]	373 [264]	294 [337]	96.8 [275]	67.9 [376]
Gross alpha	pCi/L	15	543 [5]	143 [371]	90.1 [369]	89.9 [379]	77.1 [370]
Iodine-129	pCi/L	1	1620 [7]	926 [302]	392 [397]	227 [404]	358 [418]
Mercury	µg/L	2	ND [7]	5.89 [272]	2.3 [357]	4.47 [363]	3.82 [239]
Nitrate	µg/L	10,000	173,000 [6]	259,000 [351]	201,000 [385]	170,000 [370]	108,000 [365]
Nonvolatile beta	pCi/L	50	1070 [5]	1730 [371]	1870 [369]	613 [379]	477 [370]
Radium, total	pCi/L	5	83.8 [6]	98.4 [254]	90.2 [194]	47.6 [377]	18.3 [368]
Radium-226	pCi/L	5	77.9 [5]	100.2 [298]	56.3 [370]	39.4 [406]	11.3 [381]
Radium-228	pCi/L	5	28.3 [6]	417 [294]	279 [369]	181 [402]	13.1 [379]
Strontium-90	pCi/L	8	393 [6]	802 [174]	392 [380]	256 [378]	192 [414]
Technetium-99	pCi/L	900	791 [5]	403 [308]	146 [266]	123 [369]	107 [374]
Tritium	pCi/L	20,000	5,190,000 [7]	6,530,000 [501]	3,650,000 [564]	1,940,000 [532]	1,090,000 [675]
Uranium-233/234	pCi/L	15	238 [6]	113 [307]	48.2 [380]	34.2 [365]	37.3 [349]
Uranium-238	pCi/L	15	430 [6]	201 [307]	66.4 [380]	45.1 [384]	51.5 [355]

Note: Analytical data reporting began in 2001.

[1] The more conservative of the GWPS or MCL was used for comparison purposes

Table H-6. Summary of Concentration Trends for Iodine-129, Strontium-90, Tritium, and Uranium-238 at the F-Area Groundwater OU Seepline Groundwater.

GWPS Concentration	20 pCi/mL	1 pCi/L	8 pCi/L	15 pCi/L
F Area Location	Tritium	Iodine-129	Strontium-90	Uranium-238
FPZ 2A	↔	↔	ND	ND
FPZ 3A	↓	↔	↓	ND
FPZ 4A	↓	↓	ND	↔
FPZ 6A	↓	↓	↓	↓
FPZ 6B	↓	↔	↓	↓
FPZ 7A	↓	↓	↓	↓
FPZ 7B	↓	↑	ND	↑
FPZ 8AR	↓	↓	↓	↓
FPZ 8BR	↓	↓	ND	↓
FSP 2A	↓	ND	ND	ND
FSP 2B	↓	ND	↔	ND
FSP 47A	↓	↓	ND	↔
FSP-12A	↓	↓	ND	↔
FSP204A	↓	↓	↓	↔
FSP226A	↓	↔	↓	ND
FSP249A	↓	↓	↓	ND
FSP249B	↓	↓	↓	ND

Notes:
ND indicates contaminant was not detected
↓ indicates a decreasing concentration trend
↑ indicates an increasing concentration trend
↔ indicates a stable concentration trend
Green shading indicates concentration is below the Groundwater Protection Standard (GWPS)

Table H-7~~6~~. Comparison of Permitted GWPS for the H-Area Groundwater OU versus MCLs

Contaminant	Unit	GWPS	MCL
Carbon-14	pCi/L	50	2000
Cobalt-60	pCi/L	50	100

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In 1992, South Carolina Department of Health and Environmental Control (SCDHEC) issued to SRS a RCRA Permit that specified ongoing groundwater monitoring requirements and a Corrective Action Plan to remediate the contaminated portions of the uppermost groundwater aquifer. Several contaminants exceeded regulatory limits and were targeted for remediation.

Basis for Taking Action

The maximum detected levels of several contaminants (e.g., tritium, mercury, and strontium-90) in the H-Area groundwater currently exceed the National Primary Drinking Water Standards and state standards (i.e., maximum contaminant levels [MCLs]). However, potential exposures to the general public are minimized by the distance from the OU to the site boundary, natural attenuation and radionuclide decay, institutional controls (i.e. land use controls [LUCs]), and dilution in receiving streams. The remediation of the H-Area Groundwater OU was designed to meet, as far as practicable, the Groundwater Protection Standards (GWPS) outlined in the 1992 SRS RCRA Permit.

The contaminants requiring monitoring are shown in Table I-2. These contaminants are identified in the current SRS RCRA Permit Renewal (SCDHEC 2021) and listed in the Interim Action Record of Decision (IROD) (WSRC 1995).

IV. Remedial Actions

Remedy Selection

An IROD for the H-Area Groundwater OU was issued in April 1995 (WSRC 1995). A Final ROD has not been issued. The final action for this media-specific OU will be documented by modifications to the RCRA permit renewal.

The selected interim action under CERCLA is no further action beyond that required by the corrective action as identified in the SRS RCRA Permit. As described in the SRS RCRA Permit Renewal, the goal of remediation of the H-Area Groundwater OU is to lower contaminant concentrations in the groundwater associated with the H-Area HWMF to levels specified in the RCRA permit renewal and to minimize the discharge of

contaminants to the adjacent stream (WSRC 1995). The remedial action objectives (RAOs) of the interim remedial action are to address the potential ecological impacts at the seeplines along Fourmile Branch and to address the ambient water quality standards in Fourmile Branch by remediating this OU (WSRC 1995).

The SRS RCRA Permit Renewal set forth a phased approach to remediating the groundwater that required documented evaluations of the performance of the system to determine effectiveness toward meeting the RAOs. The Phase 1 remedy was groundwater recovery and hydraulic control with treatment of mobile hazardous constituents and radionuclides (except tritium and nitrates) and injection of treated water into the shallow aquifer at the upgradient extent of the plume. The evaluation of this remedy (WSRC 2001) facilitated the following phased success measures to reach the RAOs that are in the current SRS RCRA Permit Renewal (SCDHEC 2021):

- Phase 1) Objectives met:
    - Implement a groundwater extraction and injection system to capture and remediate those portions of the contaminant plume delineated by the 10,000 pCi/mL tritium isoconcentration contour.
    - Captured the mercury plume emanating from the H-3 basin.
    - Prevented portions of the plumes from further migration and discharge to Fourmile Branch. The groundwater extraction and injection system are no longer operating.
- Phase 2a) Objectives met:
    - Reduced the mass flux (Curies/year) of tritium discharging from the H-Area plume to Fourmile Branch by 70%.
    - Reduced the concentration of the remaining ~~Appendix IVC-A~~Table I-2 constituents in Fourmile Branch (except tritium and I-129) to levels that are less than GWPS.
- Phase 2b) before January 14, 2032:
    - Reduce the discharge from the H-Area plume of all ~~Appendix IVC-A~~Table I-2 constituents in the surface water at the seepline to concentrations that are less than the GWPS (except tritium).

- Phase 3):
    - Submit a Phase 3 corrective action plan that, upon approval, will capture and remediate the entire contaminant plume (including tritium) above those concentrations listed in the GWPS and/or evaluate the applicability of Alternate Concentration Limits (ACL) and/or a Mixing Zone.

Remedy Implementation

Consistent with the phased approach of the RCRA permit renewal, the implementation of the remedy was structured to prevent the plumes from further migration and discharge to Fourmile Branch, treat and/or attenuate the contaminant plumes at and approaching the OU boundary (Fourmile Branch), and finally to treat and/or attenuate all contaminants within the OU. Except for the initial treatment (pump-treat-reinjection), the permit identifies that development work would be needed to select and implement technologies to address the unique conditions presented at this OU. While the treatments that are and have been part of the remedy are presented chronologically in the following paragraphs, they work synergistically to address the permit requirements and RAOs.

Active Treatment with Pump - Treat - Reinjection

In 1997, SRS designed and built a pump-and-treat system using a water treatment unit (WTU) with a network of injection and extraction wells. The remediation system extracted groundwater downgradient of the seepage basins, passed it through a WTU to remove metals and radionuclides, and re-injected the treated water upgradient to maintain the recirculation loop. To reduce the migration of tritium to Fourmile Branch, the system lengthened the tritium pathway in the extraction/reinjection loop. This was expected to provide more time for decay prior to discharge to Fourmile Branch. The length of the tritium pathway between injection and extraction was not sufficient to support decay and significant breakthrough (due to increased water volume and gradient from the injection of treated effluent and annual rainfall), which prompted the termination of operations. Operation of the pump-and-treat system was suspended October 2003 upon receipt of conditional approval by SCDHEC.

Passive Treatment with Subsurface Barrier System

In 2004, two groundwater barriers were installed. One barrier was placed upgradient of Basin H-4 and a second barrier was placed downgradient of the basin for a total length of 948 m (3,160 ft). The subsurface barrier and gate system reduces the groundwater flow velocity (allowing more time for radioactive decay) and controls the flux of contaminants to Fourmile Branch. Construction utilized an in-situ soil mixing technique to blend acid resistant pozzolan cement and attapulgite clay with native soils. A small percentage of caustic was also added to the cement to facilitate curing. Upon hardening, the resulting soil/cement mixture formed a low permeability (less than 1E-06 cm/s) subsurface barrier approximately 0.75 m (2.5 ft) thick on average. Vertically the wall was installed from just below ground surface to the base of the upper aquifer zone. Placement of the barrier walls altered groundwater levels near the walls (groundwater gradient), thus altering groundwater flow paths and increasing groundwater travel times to surface water and seeplines.

In June 2010, a base injection system, comprised of injection wells, pumping station, and chemical metering system, was constructed to inject an alkaline solution approximately at a pH of 10 into the aquifer to immobilize metals. Figure I-3 shows the locations of the injectors that are placed downgradient of the barrier walls and upgradient of the seepline. The base injection system operates periodically as needed to add alkalinity to the aquifer where the injection wells are located. The injected solution alters the geochemistry by raising the pH of both the pore water and aquifer sediments to provide favorable conditions for sorption of cationic contaminants. The base injection system at H Area has operated for two separate injection campaigns. The initial campaign started in September 2010 and was completed in June of 2013. A second injection campaign began in July 2019 and was completed in May 2020. SRS is observing the effects of previous base injection at H Area, prior to potentially injecting additional base.

System Operations/Operation and Maintenance

Remedial activities are still in progress that require operations and maintenance (O&M).

- Since operation of the base injection system began in 2010, the pH in the target zone has stabilized. Since 2010, ~~P~~periodic injections ~~are ongoing to maintain~~have been performed to adjust the pH in the target zone of the plume. H Area Base injection was not operated in 2017, 2018 or 2021 because pH levels remained within the target were greater than 5.0 in the injection well zone. Through the end of 2021, 227.9 million L (60.2 million gal) of base solution have been injected (Table I-3).

In 2011, enhancements were made to the cover system over the H-Area HWMF basins. Specifically, the drainage system, consisting of concrete-lined swales, was re-graded and new concrete was installed. Also, modifications to tie the drainage layer from the cap to the swales were completed.

Costs associated with the selected interim remedy for H-Area Groundwater OU include O&M costs of WTU, base injection, and LUCs. The actual O&M cost during fiscal year (FY) 2018 to FY2022 is $5,680,644. RCRA documentation does not require estimated project costs to be prepared. Therefore, none are included in this remedy review.

V. Progress since Last Review

The previous protectiveness statement concluded that the interim remedial actions at the H-Area Groundwater OU are expected to be protective, and in the interim, exposure pathways that could result in unacceptable risks are being maintained by the barrier walls and base injection treatment system which have been functioning properly based on groundwater monitoring data.

There were no recommendations and follow-up actions from the last five-year review. Base injection operations are continuing as needed.

VI. Five-Year Review Process

The following tasks were performed as part of the review:

- Reviewed the documents listed in Section XII. Documents Reviewed;

- Confirmed the implementation of the remedial action. Figures I-4 ~~-~~5 and I-6 provides current photographs of the remedial actions;
- Reviewed all process and performance monitoring data provided by the annual groundwater monitoring and corrective action reports and provided a technical assessment of whether the treatment systems are functioning as intended by the IROD and whether the shutdown criteria have been achieved;
- Inspected the OU, interviewed maintenance personnel and documented the results on the Inspection Checklist provided in Attachment I-1 with the purpose of assessing the protectiveness of the remedy and the functionality of the access controls;
- Ensured that all actions required under the RCRA Permit Renewal were implemented; and
- Reviewed changes in standards and to-be-considered guidance.

Data Review

The H-Area Groundwater OU and underlying geology have been impacted by the volumes of acidic waste discharged to the basins. The carrier fluid for the process waste to the seepage basins (groundwater contaminant source) was low pH acid that leached to the subsurface over a 30-plus year period creating a groundwater plume of low pH that has impacted the geochemistry of the subsurface soils, leached natural metals and minerals, and minimized the retardation of contaminants. As recognized by SRS, the pH must be addressed to have success in reaching the RAOs and RCRA permit requirements. Because of the properties of the individual metal and radionuclide contaminants, one remedy will not address all the contaminants. The only viable approach to tritium, a main contaminant at this site, is to decrease the rate of release from sources and slow the migration rates through the water table to the receptors. Thus, the remedial approach implemented at SRS attempts to address these facets. This technical review was conducted to assess progress in addressing the RAOs as per the IROD (WSRC 1995).

Ecological Studies

Ecological studies associated with the H-Area Groundwater OU are conducted as part of the Fourmile Branch Integrator Operable Unit (IOU). These studies include ecological benchmark comparisons that compare ecological screening values (ESVs) to sediment, sediment/soil, and surface water media constituent concentrations. The ESVs are derived from ecologically relevant criteria and standards such as National Ambient Water Quality Criteria. Review of the fifth periodic report for the Fourmile Branch IOU indicates that in terms of community level effects there is no evidence that metals discharged from H Area have degraded fish or macroinvertebrate communities in Fourmile Branch (SRNS 2016). Aluminum, barium, and mercury may pose a potential threat to wildlife. Aluminum and barium showed a potential threat to wildlife upgradient of SRS operations. Only mercury is a potential issue in lower and middle Fourmile Branch, but there is little evidence that this is associated with discharges from SRS operational areas (i.e., F Area, H Area) (SRNS 2016).

Groundwater and Surface Water Data

This data review encompassed a review of concentration data, contaminant plume maps (SRNS 2018, SRNS 2019, SRNS 2020, SRNS 2021, SRNS 2022), and time trend data for sampling locations within the H-Area Groundwater OU.

As a condition of the RCRA permit renewal for the H-Area HWMF groundwater, SRS annually calculates and reports the tritium flux to Fourmile Branch. As shown in Table I-4, tritium flux discharges have been reduced by > 70 %.

A review of the surface water data from stations FM-2U, FM-H1, FM-H2, FM-2, FM-2A, FM-2D, FM-2B, FM-3A, FMC-002H and FMC-002HD was conducted to evaluate the impact of the H-Area Groundwater OU on Fourmile Branch (Figure I-7). Table I-5 presents the contaminants that at any time during the review period were detected above the GWPS or MCL. The data in Table I-5 provides evidence that the subsurface barriers and base injection operations are having a positive influence on the concentrations of all constituents. H Area Base injection was not operated in 2017, 2018 or 2021. The 2019

total volume injected was 51.5 million L (13.6 million gal) and the 2020 total volume injected was 52.2 million L (13.8 million gal). The concentrations of the constituents are decreasing or are below the GWPS and/or MCL.

A review of the seepline groundwater data from initial sampling in 2001 to 2021 was conducted to assess the effect of the H-Areas Groundwater OU treatment systems on the seeplines. Table I-6 provides a summary of constituents from the seepline sampling locations that have exceeded the GWPS or MCL at any time during the period beginning in 2001 (initial sampling) and ending December 2021. Review of the seepline data indicates decreasing concentrations over time for all constituents except iodine-129. SRS recognizes that iodine-129 will not be treated by the base injection system and thus is investigating other approaches to remediate the iodine.

While SRS acknowledges that base injection is not effective for treating iodine-129, the migration of iodine-129 from the source area beneath the basins is being controlled by the low permeability caps and the subsurface engineered barriers at basin H-4. There are no industry standard technologies available for the treatment of iodine-129 in groundwater. Since 2011, SRS has been implementing and evaluating a new technology at the F-Area Groundwater OU to immobilize iodine-129 in situ using an injectable silver chloride amendment. The permeable reactive treatment zone has been effective at reducing the concentration of iodine-129 in groundwater. It is appropriate to establish this technology at F Area because iodine-129 groundwater concentrations are an order of magnitude higher than at H Area."

"Concurrently with the development of silver chloride technology, SRS has been investigating materials that can effectively sorb iodine-129 and are safe to implement in the ecologically sensitive wetland environment. If an appropriate material or combination of materials is identified, SRS will evaluate whether implementation at the H Area wetlands is both feasible and warranted. At H Area, current concentrations of iodine-129 in surface water in Fourmile Branch are non-detect and in surface water at the seepline less than 20 pCi/L. Sorbent development progress is summarized in the annual corrective action report.

While showing decreasing concentrations over time, there are several contaminants that remain above their standards. These contaminants are associated with existing plumes and are located downgradient of these plumes. Of the three constituents identified in the ecological studies as potential threats to wildlife, only mercury was detected above standard with concentrations decreasing to below the GWPS during the fifth five-year review cycle.

While Table I-6 presents a list of contaminants detected above standards in groundwater at the seepline, the RCRA corrective action recognizes that there are four challenging contaminants of concern with respect mitigating the migration/discharge of GWPS constituents outcropping in surface water at the seepline. These contaminants include iodine-129, strontium-90, tritium, and uranium-238. For these contaminants time series were analyzed for concentration trends at all 10 of the seepline groundwater piezometers over the past 10 years. Table I-7 presents the trend summary for each of the four contaminants listed above.

Groundwater concentrations for strontium-90 at all locations were non-detect and less than the GWPS. Uranium-238 concentrations were less than the GWPS at all locations and not detected at all but one location which had a stable trend. Iodine-129 was below the GWPS and not detected at 5 of the locations. At the remaining locations iodine-129 exhibited a decreasing trend at four locations and a stable trend at one location. Tritium was decreasing at all seepline locations and was less than the GWPS at two locations.

Summary of Inspections and Interviews

Interviews were conducted with Phil Carter, O&M staff member, on August 30, 2022 and Brian Hanshew, O&M Site Manager, on August 30, 2022 at the O&M organization offices. No issues were identified for the H-Area Groundwater OU during these interviews.

The H-Area Groundwater OU was inspected by Savannah River Nuclear Solutions, LLC (SRNS) and USDOE personnel on November 22, 2022. No issues were identified for the H-Area Groundwater OU during this inspection

A regulatory field inspection meeting with USDOE, USEPA, and SCDHEC was held on March 15, 2023. SRNS personnel were also present in the meeting. During the meeting, the participants viewed drone footage of each OU and were provided an opportunity to walk down the individual OUs. The USEPA and SCDHEC elected not to perform a walk down because the drone video provided them better views of the OUs. No significant problems regarding the protection of the remedy for this OU as implemented were identified during the inspection.

VII. Technical Assessment

Is the Remedy Functioning as Intended by the Decision Document?

The review of documents, Applicable or Relevant and Appropriate Requirements (ARARs), risk assumptions, and the results of site inspections indicate that the remedy is functioning as intended by the IROD. The IROD identifies no further action beyond that required by the SRS RCRA Permit Renewal but stipulates the corrective action will address the potential ecological impacts at the seeplines along Fourmile Branch and will also serve to address the ambient water quality standards in Fourmile Branch by remediating this OU. The implemented treatment strategy is addressing the goal of the remediation, as described in the SRS RCRA Permit Renewal by lowering contaminant concentrations in the groundwater associated with the H-Area HWMF to levels specified in the RCRA permit renewal and by minimizing the discharge of contaminants to the adjacent stream. SRS has met the Phase 1 and Phase 2a goals outlined in the SRS RCRA Permit Renewal and are actively implementing corrective actions to meet the remaining goals.

Ecological assessment of Fourmile Branch indicates no impact from the H-Area HWMF. However, aluminum, barium, and mercury are potential threats to wildlife in Fourmile Branch in the area impacted by H-Area operations. As part of the Fourmile Branch IOU program, studies of ecological impacts to the branch will be ongoing. Based on the results of the ecological studies to date, the RAOs of the IROD are being met. The groundwater requirements of the RCRA permit renewal, which the IROD identified must also be satisfied, have not been met. However, the treatment approach is making positive progress

towards those requirements. The effective implementation of institutional controls has prevented exposure to, or ingestion of, contaminated groundwater.

According to the data reviewed, the site inspections, and the interviews, the remedy is functioning as intended by the IROD. There have been no changes in the physical conditions of the site that would affect the protectiveness of the remedy.

On February 11, 2014, the SCDHEC originally issued the 2014 RCRA Permit Renewal for the SRS (SCDHEC 2014). The SCDHEC modified the 2014 RCRA Permit Renewal on November 30, 2021, which became effective on December 15, 2021 (SCDHEC 2021).

The LUC requirements are discussed and approved as part of the closure/post-closure/permit application process and are governed by the RCRA Permit Renewal for the SRS (SCDHEC 2021). Therefore, a Land Use Control Implementation Plan is not required for this OU. The institutional controls (i.e., LUCs) that are in place to prevent exposure to or ingestion of contaminated groundwater include physical access controls to prevent unauthorized entry to SRS (fences, guards, security patrols, etc.), administrative controls that maintain the H-Area Groundwater OU for industrial use only (SRS is a secured government facility with land use restrictions) and use restrictions via the SRS Site Use/Site Clearance Program. No activities were observed that would have violated the institutional controls (i.e., LUCs).

Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and Remedial Action Objectives Still Valid?

The exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection are still valid. There have been no changes in the physical conditions at the H-Area Groundwater OU that would affect the protectiveness of the remedy.

The action specific ARARs have been met with the shutting down and dismantling of the groundwater pump-and-treat system. The chemical specific ARARs and location specific ARARs associated with groundwater remediation must still be met and have been evaluated.

The GWPS set forth in the SRS RCRA Permit Renewal (SCDHEC 2021) for the constituents that were identified as present above those standards were compared against MCLs, where available. The comparison found two constituents where the GWPS differed from the MCL (Table I-~~7~~8). The GWPS is more protective than the MCL for carbon-14, and cobalt-60; thus, SRS is adhering to a more stringent standard.

Fact sheets provided on the USEPA webpage (https://www.epa.gov/fedfac/emerging-contaminants-and-federal-facility-contaminants-concern) regarding emerging contaminants were reviewed for applicability to this OU. This webpage provides a link to specific fact sheets for each of the following contaminants: 1,2,3-trichloropropane (TCP), 1,4-dioxane, 2,4,6-trinitrotoluene (TNT), 2,4-dinitrotoluene (DNT), hexahydro-1,3,5-tri-nitro-1,3,5-triazine (RDX), nanomaterials, N-nitroso-dimethylamine (NDMA), perchlorate, perflurorooctane sulfonic acid (PFOS), Perfluorooctanoic acid (PFOA) and other per- and polyfluoroalkyl substances (PFAS), polybrominated biphenyls, polybrominated diphenyl ethers (PBDEs) and tungsten. The only emerging contaminant identified as applicable to this OU is 1,4-dixoane.

1,4-dioxane is a potential contaminant at this unit as it is found at sites where chlorinated solvents are present. The groundwater data for the H-Area wells that are monitored as per the RCRA permit renewal were evaluated for the period January 2000 through December 2021 for 1,4-dioxane. Four hundred and ninety-seven 1,4-dioxane records were reviewed from this period. There were 19 detected results from 4 wells (HSB-85A, 85B, 111D and 120C) with a maximum of 58 µg/L and an average value of 28 µg/L. SRS will continue to monitor for 1,4-dioxane as a potential contaminant for the H-Area Groundwater OU.

There have been no changes in MCLs (versus GWPS) that would impact the remedy. The remedy is progressing as expected.

Has any Other Information Come to Light that Could Call into Question the Protectiveness of the Remedy?

No new information has come to light that could call into question the protectiveness of the remedy.

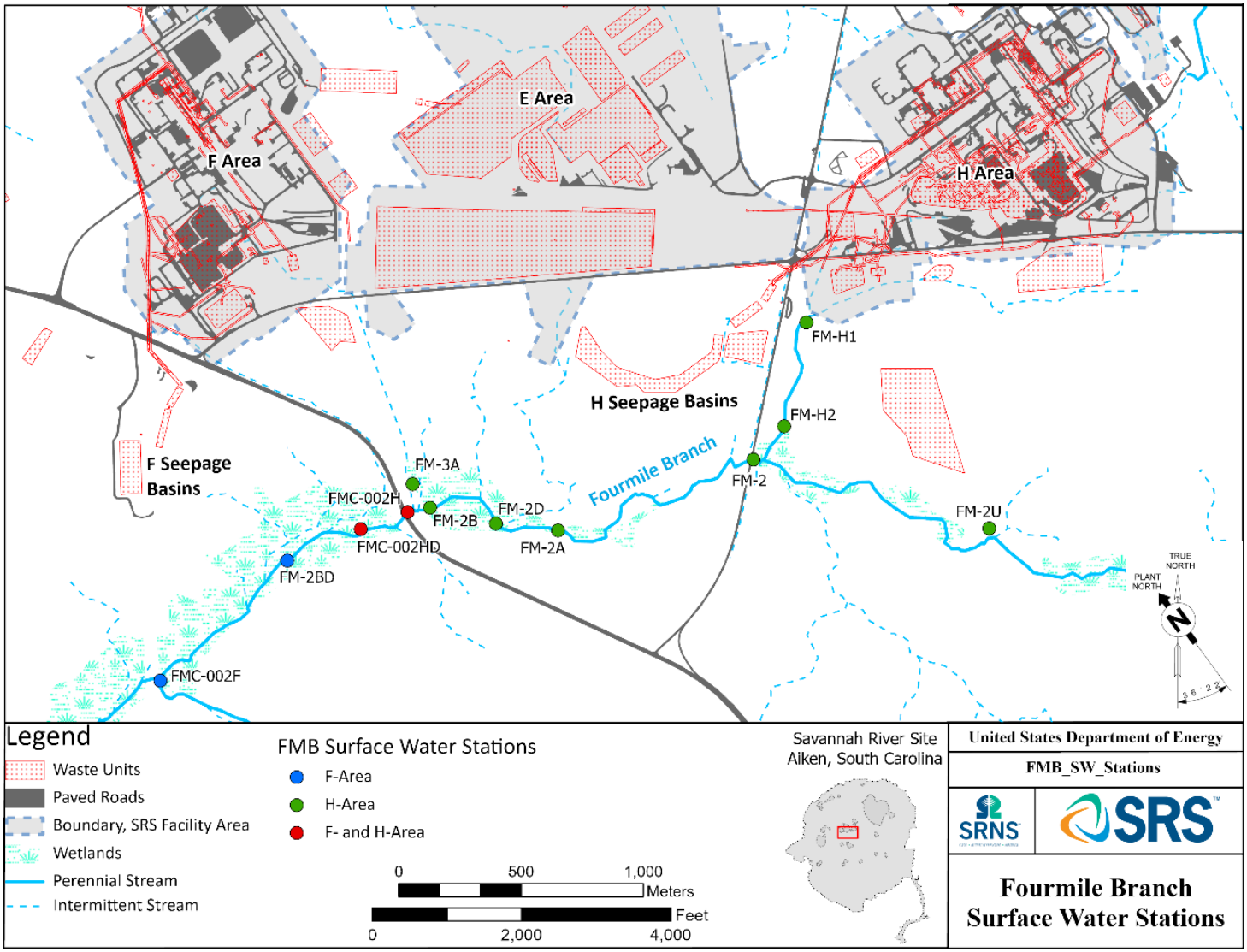

Figure I-7. Current Photo of H-Area Groundwater Injection System (2022)

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Table I-5. Summary of Constituents from the H-Area Groundwater OU Surface Waters of Fourmile Branch Detected Above Standards

Constituent	Unit	GWPS or MCL[1]	Maximum Concentration [# of Samples]				
			2nd Remedy Review (1997-2001)	3rd Remedy Review (2002-2006)	4th Remedy Review (2007-2011)	5th Remedy Review (2012-2016)	6th Remedy Review (2017-2021)
Antimony	µg/L	6	10 [49]	2.7 [93]	0.21 [65]	All ND [38]	All ND [63]
Arsenic	µg/L	10	6 [55]	3.12 [105]	27.1 [65]	8.54 (J) [38]	11.7 (J) [63][1]
Carbon-14	pCi/L	50	11.2 [66]	162 [142]	1140 [88]	59.7 (J) [72]	57.8 [62][1]
Cobalt	µg/L	3	6.27 [52]	15.7 [93]	5.69 [65]	8.25 [77]	1.22 [147]
Gross alpha	pCi/L	15	46.8 [68]	7.06 [174]	128 [207]	12.5 [129]	4.7 (J) [197]
Iodine-129	pCi/L	1	All ND [59]	4.69 [70]	9 [206]	3.44 (J) [134]	3.32 (J) [201]
Non-volatile Beta	pCi/L	50	192 [68]	142 [174]	268 [207]	42 [129]	30.7 [197]
Total radium	pCi/L	5	13.5 [64]	4.16 [94]	7.44 [82]	4.95 [38]	2.4 [62]
Radium-226	pCi/L	5	12 [65]	2.68 [134]	5.55 [85]	4.97 (J) [58]	1.12 [65]
Radium-228	pCi/L	5	3.22 [66]	6.05 [113]	8.4 [69]	1.74 (J) [29]	0.97 (J) [45]
Strontium-90	pCi/L	8	9.54 [67]	7.96 [57]	18.1 [135]	9.45 (J) [53]	10.1 [87][2]
Thallium	µg/L	2	10 [43]	7.95 [93]	2.52 [65]	0.2 (J) [38]	15.3 (J) [152][1]
Tin	µg/L	2.6	10 [57]	8.37 [87]	0.62 [65]	All ND [31]	All ND [63]
Tritium	pCi/L	20,000	312,000 [66]	4,810,000 [455]	2,760,000 [585]	179,000 [266]	890,000 [543]
Vanadium	µg/L	4	10.8 [52]	4.09 [93]	30.9 [65]	14.6 (J) [38]	17.9 (J) [63][1]

1 All other records were below the GWPS or MCL

2 Of the 87 records, only 2 were above the GWPS/MCL and only 1 was above the PQL.

ND = Non-detect
J = Estimated value

Table I-6. Summary of Constituents from the H-Area Groundwater OU Seepline Detected Above Standards

Constituent	Unit	GWPS or MCL[1]	Maximum Concentration [# of Samples]				
			2nd Remedy Review (1997-2001)	3rd Remedy Review (2002-2006)	4th Remedy Review (2007-2011)	5th Remedy Review (2012-2016)	6th Remedy Review (2017-2021)
Arsenic	µg/L	10	ND [8]	59.8 [117]	20.6 (J) [48]	ND [51]	ND [61]
Beryllium	µg/L	4	1.55 (J) [8]	9.87 [177]	0.63 [101]	2.74 [51]	0.92 [61]
Carbon-14	pCi/L	50	221 [8]	798.4 [197]	268 [195]	665 [173]	399 [199]
Chromium	µg/L	100	73.5 [8]	659 [172]	40.9 [48]	66.7 (J) [51]	32 [61]
Cobalt	µg/L	3	9.8 [8]	36.2 [181]	4.4 [132]	3.46 (J) [107]	3.92 [184]
Methylene Chloride	µg/L	5	8.31 [9]	16 [65]	ND [38]	4.02 (J) [49]	ND [50]
Gross Alpha	pCi/L	15	48.5 [7]	188 [199]	40.1 [236]	7.78 [212]	21.3 [227]
Iodine-129	pCi/L	1	39.6 [9]	50.7 [180]	22.1 [241]	77.4 [233]	442 [239]
Lead	µg/L	15	1920 [8]	460 [173]	9.01 [48]	29.6 [62]	31.6 [164]
Mercury	µg/L	2	ND [8]	2.33 [180]	1.1 [231]	1.22 [210]	1.57 [209]
Nickel	µg/L	390	29.7 [8]	267 [184]	62 [68]	16.2 [51]	12.2 [61]
Nickel-63	pCi/L	50	ND [8]	63.3 [70]	21.4 [70]	7.72 (J) [56]	ND [56]
Nitrate-Nitrite as N	mg/L	10	8.45 [8]	60.2 [207]	80.2 [234]	35 [215]	33.3 [206]
Non-Volatile Beta	pCi/L	50	86.1 [7]	302 [199]	107 [236]	100 [212]	102 [229]
Total Radium	pCi/L	5	8.04 [7]	133 [167]	7.51 [102]	2.73 [53]	10 [129]
Radium-226	pCi/L	5	13.3 [7]	11.3 [198]	1.98 [133]	3.95 [52]	1.6 [56]
Radium-228	pCi/L	5	18.1 [7]	3.2 [198]	6.74 [133]	2.21 [55]	3.29 (J) [57]
Technetium-99	pCi/L	900	34.7 [7]	1080 [202]	196 [162]	159 [208]	118 [207]
Tin	µg/L	2.6	1340 [8]	49.8 [118]	ND	3.37 (J) [73]	1.3 (J) [61]
Tritium	pCi/L	20,000	5,900,000 [9]	5,470,000 [204]	2,930,000 [235]	2,330,000 [218]	1,380,000 [221]
Uranium-233/234	pCi/L	15	5.76 [7]	16.8 [199]	0.87 [135]	0.383 [57]	1.21 [67]
Uranium-238	pCi/L	15	2.77 [7]	20.5 [199]	0.87 [135]	0.326 [57]	1.44 [67]
Vanadium	µg/L	4	81.1 [8]	733 [146]	10.5 [48]	72.5 [146]	81.3 [205]

J = Estimated value

Table I-7. Summary of Concentration Trends for Iodine-129, Strontium-90, Tritium, and Uranium-238 at the H-Area Groundwater OU Seepline Groundwater.

GWPS Concentration	20 pCi/mL	1 pCi/L	8 pCi/L	15 pCi/L
H Area Location	Tritium	Iodine-129	Strontium-90	Uranium-238
HPZ 1A	↓	↓	ND	ND
HPZ 3A	↓	ND	ND	ND
HPZ 3B	↓	ND	ND	ND
HPZ 5A	↓	ND	ND	ND
HPZ 5B	↓	↓	ND	↔
HPZ 6AR	↓	↔	ND	ND
HSP 60A	↓	↓	ND	ND
HSP 60B	↓	↓	ND	ND
HSP 76A	↓	ND	ND	ND
HSP 76B	↓	ND	ND	ND

Notes:
ND indicates contaminant was not detected
↓ indicates a decreasing concentration trend
↑ indicates an increasing concentration trend
↔ indicates a stable concentration trend
Green shading indicates concentration is below the Groundwater Protection Standard (GWPS)

Table I-~~8~~7. Comparison of Permitted GWPS for the H-Area Groundwater OU versus MCLs

Contaminant	Unit	GWPS	MCL
Carbon-14	pCi/L	50	2000
Cobalt-60	pCi/L	50	100

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wells, followed by 0.3 m (1 ft) of clean seeded common fill (i.e., vegetative cover) over the FML.

Remedy Implementation

The selected remedies met the RAOs at MAOU by implementing the following activities:

- Grouting of manholes to prevent access to the inactive process sewer lines.
- Installing four passive SVE wells at 313-M, 320-M, and Manhole 4A with depths between 10.7 and 15.2 m (35 and 50 ft).
- Constructing two VOC treatment cells (i.e., the 321-M Cell and the Passive SVE Cell) with a passive SVE treatment system using BaroBall^{TM} wells to treat 841 m^3 (1,100 yd^3) (321-M) and 2,500 m^3 (3,250 yd^3) (passive SVE) of VOC contaminated soils. Average PCE soil concentrations were 6.6 mg/kg. Placement of an FML infiltration control barrier over the soils/concrete media at the 321-M and Passive SVE Cell followed by 0.3 m (1 ft) of clean seeded common fill (i.e., vegetative cover). The configurations of two cells can be seen in the Post Construction Report (PCR) (SRNS 2011) and/or in Figures J-2-8 through J-2-11 (Attachment J-2).
- Established LUCs (including restricting worker access to contaminated media, manholes, and pipelines, prohibiting public and residential development and use of the property, maintaining the integrity of any SVE systems or monitoring wells, and preventing access to or use of the groundwater until cleanup levels are met) for approximately 28.7 hectares (70.9 acres). This area excludes the MIPSL OU LUC area of 0.69 hectares (1.7 acres) (SRNS 2009b).

System Operations/Operation and Maintenance

The following system operations are ongoing:

As of December 6, 2022, the passive SVE wells are still in operation. Operation of passive SVE wells started on June 16, 2010. The BaroBall^{TM} system is anticipated to operate until RGs are achieved (Table J-2).

Only LUCs including inspection and maintenance activities are required at MAOU as follows:

- Visual inspections for evidence of damage to the vegetative cover at the 321-M and Passive SVE due to erosion, settlement, or intrusion by burrowing animals are performed annually. The inspections also address upkeep of the passive SVE units, and access control barriers (e.g., the warning signs).
- Necessary repairs (e.g., replacing eroded or disturbed soil, sign repair, etc.) and vegetation management (e.g., mowing, removal of larger vegetation, etc.) are performed when required.
- Access controls and use restrictions are enforced to preclude access through the SRS Site Use/Site Clearance program and SRS site security.

Table J-3 compares the actual operation and maintenance (O&M) costs for the five-year remedy review period to the estimated direct O&M costs from the ROD (WSRC 2008a). The estimated O&M cost for Fiscal Year (FY) 2018 to FY2022 is $186,000 for the soil cover, passive SVE units, ~~institutional controls (i.e.,~~ LUCs~~)~~, and five-year remedy reviews. The actual cost for FY2018 to FY2022 is $810,315. The O&M costs from FY2018 to FY2022 are higher than estimated because the ROD estimate did not include the maintenance of the entire MAOU (e.g., mowing, etc.).

V. Progress Since Last Review

The previous protectiveness statement satisfies the current conditions at the MAOU.

VI. Five-Year Review Process

The following tasks were performed as part of the review:

- Reviewed the documents listed in Section XII, Documents Reviewed;
- Confirmed the implementation of the remedial action;

Attachment J-1. Five-Year Review Site Inspection Checklist – M-Area Operable Unit *(continued/end)*

XI. OVERALL OBSERVATIONS
A. Implementation of the Remedy
Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emissions, etc.). The remedial action for the MAOU is Passive SVE to prevent the migration of VOCs from the contaminated soils to groundwater above the MCLs, vegetative soil cover, and ~~institutional controls~~LUCs to protect remedial workers and future industrial workers from unacceptable exposure to VOCs. As reported in Section VII, the Passive SVE operations demonstrate that these actions are effective and that the remedies are functioning as designed.
B. Adequacy of O&M
Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy. The O&M procedures are adequately maintaining the integrity of the Passive SVE Systems. The O&M procedures consisting of annual site inspections and site maintenance (vegetative cover and warning signs) and site controls (SRS Site Use and Site Clearance Programs, which restrict invasive and permanent installation activities at the OU) have been implemented. There are no issues requiring corrective actions.
C. Early Indicators of Potential Remedy Failure
Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs that suggest that the protectiveness of the remedy may be compromised in the future. N/A
D. Opportunities for Optimization
Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy. N/A

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Remedy Implementation

The selected final remedy for the MIPSL OU provides the greatest level of protection to human health and ecological receptors. The remedy included the following:

- Installed four fractured wells at each of the four manhole locations for SVE. Hydraulic fracturing was used to improve the permeability of the fine-grained soils ("Upland Unit") where residual contamination remains. One deep SVE well was installed at the center of each fracture well area. A threshold value of 10 ppmv was recognized as appropriate for transition from active SVE to passive SVE;
- Grouted the process sewer connections at all the manholes and the sewer discharge point at the A-014 Outfall was plugged; and
- Established LUCs for 2.14 hectares (5.29 acres) (Figure K-6) to include the following:
    - Providing access controls for on-site workers via the Site Use/Site Clearance Program. Other administrative controls to ensure worker safety include work controls, worker training, and worker briefings of health, safety requirements, and identification of signs located at the waste unit boundaries;
    - Notifying U.S. Environmental Protection Agency (USEPA) and SCDHEC in advance of any changes in land use or excavation of waste:
    - Providing access controls against trespassers, as described in the 2013 RCRA Permit Renewal Application, Volume I, Section F.1, which describes the security procedures and equipment, 24-hour surveillance system, artificial or natural barriers, control entry systems, and warning signs in place at the SRS boundary.
    - In the long term, if the property or any portion thereof, is ever transferred from USDOE, notice of the type and quantity of any hazardous substances that were known to have stored (for more than one year), released, or disposed of on the property will be provided. In addition, if the property or any portion thereof, is every transferred by deed, the U.S. Government will satisfy the requirements of

CERCLA 120(h)(3) to include a description of the remedial action taken, a covenant, and an access clause.

System Operations/Operation and Maintenance

The following system operation was discontinued in July 2020 and consisted of:

- A portable soil vapor extraction unit (SVEU) and
- 5 Microblowers™, 16 fracture wells, and 6 pressure monitoring wells.
- The MIPSL OU SVE system removed 4,445 and 1,105 lbs of PCE and TCE, respectively, throughout its operational life between 2008 and 2020 (Figures K-5 and K-6).

The following maintenance activities are ongoing:

- Annual site inspections and site maintenance; and
- Site controls and land use restrictions via the SRS Site Use/Site Clearance program, which restricts invasive and permanent installation activities at the MIPSL OU.

Table K-3 compares the actual operation and maintenance (O&M) costs for the five-year remedy review period to the estimated direct O&M costs from the ROD (WSRC 2006). The estimated cost for Fiscal Year (FY) 2018 to FY2022 is $217,500 for O&M of the SVE system, MicroBlowers™, ~~institutional controls (i.e., LUCs)~~, and five-year remedy reviews. The actual O&M cost for FY2018 to FY2022 is $336,648. The actual O&M costs from FY2018 to FY2022 are as expected.

V. Progress Since Last Review

The previous protectiveness statement concluded that the remedial action at MIPSL OU is expected to be protective of human health and the environment. Exposure pathways that could result in unacceptable risks have been controlled through ~~institutional controls (i.e., LUCs)~~. There were no recommendations or follow-up actions from the last five-year remedy review.

VI. Five-Year Review Process

The following tasks were performed as part of the review:

- Reviewed the documents listed in Section XII, Documents Reviewed;
- Confirmed the implementation of the remedial action;
- Reviewed all process and performance monitoring data provided by the annual performance evaluation reports (PERs) (SRNS 2018, SRNS 2019, and SRNS 2020) and provided a technical assessment that the SVE system achieved shutdown criteria;
- Inspected the OU, interviewed maintenance personnel and documented the results on the Inspection Checklist provided in Attachment K-1 with the purpose of assessing the protectiveness of the remedy and the functionality of the access controls; and
- Reviewed changes in standards and to-be-considered guidance.

Data Review

The data and results presented in the 2019 PER were reviewed (SRNS 2020).

The active SVE system at the MIPSL OU started operations in 2008. The contamination exists primarily within fine-grained sediments of the Upland Formation; therefore, the active SVE system will only operate for short periods of time before the mobile contaminants are exhausted. Hydraulic fracturing was used to increase the surface area available for vapor extraction and improve permeability.

A portable active SVEU was cycled between the four manhole (MH) locations (i.e., MH-01, MH-11, MH-12, and MH-13) to better match the depletion and rebound behavior of soil vapor in the Upland Formation. At each MH, there are four fractured wells, one conventional SVE well, and one or two pressure monitoring wells. When the MHs were not undergoing active SVE a MicroBlower™ was connected to the conventional SVE well and the four fractured wells.

The last 3 years of operation (2017-2019) the active SVE system at the MIPSL OU was only connected to the wells at MH-01 and removed 848 lbs of PCE and 228 lbs of TCE (Figure K-5) and the MicroBlowers™ have removed 87.7 lbs of PCE and 18.6 lbs of TCE. Cumulative amounts of VOC removed are shown in Figure K-6.

Beginning in October 2019, the MIPSL SVEU was temporarily shutdown for soil-sampling between October 7, 2019 and December 5, 2019. No rebound was demonstrated after the SVEU was not operated for fifty-nine consecutive days in this time period. No rebound is demonstrated by both the sample results from individual wells and the SVEU stack collected in the late November and early December time frame.

The 2019 soil sampling event collected vadose zone soil samples at MH-01, MH-11, MH-12, and MH-13 ~~(SRNS 2018b)~~ and the results revealed that the RGs for TCE and PCE have been met with the MIPSL SVE system. Recommendations to discontinue operation of the MIPSL SVE system were included in the 2019 PER (SRNS 2020). The soil sampling locations and the soil results are provided in the 2019 PER (SRNS 2000). The highest PCE and TCE concentrations were observed at MISPL01SB1 which is located near MH-01. The maximum PCE concentration was 0.12 mg/kg and the maximum TCE concentration was 0.00701 mg/kg, which are less than the soil RGs of 0.307 mg/kg for PCE and 0.0408 mg/kg for TCE. In a meeting with the Core Team in June 2020, the proposal for permanent shutdown of the SVE system at MIPSL was presented. Approval of the proposal was provided by USEPA and SCDHEC in July 2020 and the SVE system was shut down.

Summary of Inspections and Interviews

Interviews were conducted with Phil Carter, Savannah River Nuclear Solutions, LLC (SRNS) Environmental Compliance and Area Completion Projects (EC&ACP) Post-Closure Lead, and Brian Hanshew, SRNS EC&ACP Post-Closure Lead, on August 30, 2022 at the O&M organization offices. No issues were identified as an outcome of these interviews.

The MIPSL OU was inspected by Savannah River Nuclear Solutions, LLC (SRNS) personnel on July 13, 2022. No issues were identified for the MIPSL OU during these inspections.

IX. Recommendations and Follow-up Actions

Recommendations for the MIPSL OU are provided in Table K-4.

X. Protectiveness Statement(s)

The remedy at MIPSL OU is protective of human health and the environment.

Exposure pathways that could result in unacceptable risks are being controlled by ~~institutional controls (i.e.~~ LUCs~~)~~ to prevent exposure to or ingestion of contaminated groundwater and soil media. All threats to contaminated vadose zone soil at the MIPSL OU ~~are being~~were addressed through ~~SVE systems and~~ implementation of physical access controls to prevent unauthorized entry to SRS (fences, guards, security patrols, etc.), administrative controls that maintain the MIPSL OU for industrial use only, and warning signs and use restrictions via the SRS Site Use/Site Clearance Program.

XI. Next Review

As shown in Appendix A, Table A-1, the next five-year review for SRS OUs with Operating Equipment is scheduled for January 2029.

XII. Documents Reviewed

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

SRNS, 2018. *Performance Evaluation Report of 2017 for the M-Area Inactive Process Sewer Lines (MIPSL) (081-M) Operable Unit (OU) (U) January through December 2017*, SRNS-RP-2018-00161, Revision 0, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC

SRNS, 2019. *Performance Evaluation Report of 2018 for the M-Area Inactive Process Sewer Lines (MIPSL) (081-M) Operable Unit (OU) (U) January through December 2018*, SRNS-RP-2019-00066, Revision 0, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC

SRNS, 2020. *Performance Evaluation Report of 2019 for the M-Area Inactive Process Sewer Lines (MIPSL) (081-M) Operable Unit (OU) (U) January through December 2019*,

SRNS-RP-2020-00046, Revision 0, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC

USDOE, 1996. *Savannah River Site Future Use Project Report*, U.S. Department of Energy, Savannah River Operations Office, Savannah River Site, Aiken, SC

WSRC, 1999. *Land Use Control Assurance Plan for the Savannah River Site*, WSRC-RP-98-4125, Revision 1.1, latest revision, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC

WSRC, 2003. *M-Area Inactive Process Sewer Lines (MIPSL) and 313-M Area Inactive Process Sewer (313-MIPS) Manhole Overflow Evaluation (U)*, ERD-EN-2003-0169, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC

WSRC, 2005. *RCRA Facility Investigation/Remedial Investigation (RFI/RI) Work Plan, RFI/RI Report with Baseline Risk Assessment, and Corrective Measures Study/Feasibility Study (CMS/FS) for the M Area Inactive Process Sewer Lines (081-M) (U)*, WSRC-RP-2004-4214, Revision 1.1, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC

WSRC, 2006. *Record of Decision Remedial Alternative Selection for the M-Area Inactive Process Sewer Lines Operable Unit (U)*, WSRC-RP-2006-4001, Revision 1, Washington Savannah River Company, Savannah River Site, Aiken, SC

WSRC, 2007a. *Land Use Control Implementation Plan (LUCIP) for the M-Area Inactive Process Sewer Lines Operable Unit (081-M) (U)*, WSRC–RP–2006-4068, Revision 1, Washington Savannah River Company, Savannah River Site, Aiken, SC

Various - Inspection Data Sheets – *Field Inspection Checklist, M-Area Inactive Process Sewer Lines (U)*, ER-IDS-019-050, Inspection period 2018 through 2022 (annually)

Table K-1. Chronology of OU Events

Event	Date
Characterization Field Start	July 28, 2003
ROD Issuance	April 26, 2007
Remedial Action Construction Start / Completion	June 25, 2007 / April 30, 2008
Remedial Action Operations Start / Complete	January 1, 2008 / ~~ongoing~~July 21, 2020
Previous Five-Year Reviews Issuance	February 4, 2009 / February 4, 2014 / December 5, 2018

Table K-2. MIPSL RCOCs with Final Remedial Goals

Medium	RCOC	Type of COC	RG (mg/kg)	Basis
Soil	Tetrachloroethylene (PCE)	CM	3.07E-01	CM soil clean up level
	Trichlorethylene (TCE)	CM	4.08E-02	CM soil clean up level

RCOC – refined COC

Table K-3. Actual versus Estimated O&M Costs ($)

	FY2018	FY2019	FY2020	FY2021	FY2022	Five-Year Total
Total Actual O&M Costs ($)	73,463	88,106	137,484	14,776	22,818	336,648
Total ROD Estimated Direct O&M Costs ($)	40,500	40,500	40,500	40,500	55,500	217,500

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Table K-4. Recommendations and Follow-up Actions for the MIPSL OU

Issue	Recommendations/ Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness? (Y/N)	
					Current	Future
MIPSL OU no longer has equipment operating a remedial system.	Since the MIPSL SVE system has been taken offline and removed, and the LUC boundaries of the MIPSL OU and M-Area OU overlap. SRS recommends ~~moving the MIPSL OU from the Operating Equipment group to the Native Soil Cover and/or LUCs group~~incorporating the MIPSL OU into the M-Area OU to eliminate O&M cost for the smaller OU. A meeting to discuss the appropriate regulatory path forward for this recommendation is needed. ~~This recommendation would take effect during the Seventh Five-Year Remedy Review Report for the SRS OUs.~~	USDOE	SCDHEC/ USEPA	December 2023	N	N

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Groundwater also poses a threat to human health. Groundwater was determined to be contaminated with 1,1-dichloroethene (1,1-DCE) and TCE above the MCLs of 7 µg/L and 5 µg/L, respectively.

The small drainage ditch near PBRP, the seepline located along an embankment of Steel Creek, and the segment of Steel Creek adjacent to the OU were determined to not be impacted by PBRP OU. Although Steel Creek is contaminated, the contamination did not originate from the PBRP OU, but from an unrelated upgradient source in P-Area. Contamination in Steel Creek is being addressed separately under the Integrator Operable Unit program.

IV. Remedial Actions

Remedy Selection

In 2002, a final ROD was issued to address the soil and groundwater contamination at PBRP (WSRC 2002). As stated in the ROD, the remedial action objectives (RAOs) are as follows:

- Protect current workers from the exposure to benzo[a]pyrene in surface soil at concentrations that exceed 53.3 mg/kg
- Protect hypothetical future industrial workers from exposure to benzo[a]anthracene (2.56 mg/kg), benzo[a]pyrene (0.256 mg/kg), benzo[b]fluoranthene (2.56 mg/kg), benzo[k]fluoranthene (25.6 mg/kg), dibenzo[a,h]anthracene (0.256 mg/kg), and indeno[1,2,3-c,d]pyrene (2.56 mg/kg) in surface and subsurface soils at concentrations that exceed target risk levels.
- Protect hypothetical future industrial workers from exposure to 1,1-DCE (7.0 µg/L) and TCE (5.0 µg/L) in groundwater at concentrations that exceed MCLs.
- Protect groundwater resources from contaminant migration of antimony (4.588 mg/kg), chromium (35.22 mg/kg), copper (40.8 mg/kg), nickel (11.432 mg/kg), zinc (1,110 mg/kg), dibenzofuran (0.195 mg/kg), PCE (0.00338 mg/kg), TCE (0.00153

mg/kg), and Aroclor 1242 (0.00843 mg/kg) in PBRP soil that would impact the groundwater above MCLs or RBCs.

As stated in the ROD, the selected remedial actions for the PBRP OU are as follows:

- Engineered cover system with BaroBalls™;
- Institutional controls (i.e., land use controls [LUCs]);
- Natural biodegradation; and
- Continued groundwater monitoring and reporting.

In 2013, 1,4-dioxane was also added to the analyte list based on a recommendation in the Fourth Five-Year Remedy Review Report for the SRS (SRNS 2014). 1,4-Dioxane does not have an MCL; therefore, the U.S. Environmental Protection Agency (USEPA) tap water RSL (0.46 µg/L) has been applied.

Remedy Implementation

The implementation of the final remedial action included the following activities:

- Constructing a 0.24-hectares (0.6-acres) engineered cover system (e.g., native soil cover with a hydraulic conductivity of approximately 1E-05 cm/sec) over PBRP to (1) prevent exposure to contaminants in surface soil, (2) reduce rainwater infiltration and resulting leaching, and (3) slow the rate of contaminant migration through the soil to groundwater so that there is more time for natural processes such as biodegradation to reduce the leachability risk;
- Installing four passive soil venting wells (BaroBall™) to allow volatile organic compounds (VOCs) in the soil to vent to the atmosphere instead of leaching to groundwater;
- Monitoring the groundwater quality to confirm that a discernible groundwater plume above MCLs does not develop; and

- Implementing 0.36 hectares (0.89 acres) LUCs (i.e., site maintenance, warning signs, and institutional controls) to prevent unauthorized intrusion into the buried contamination (Figure L-5).

System Operations/Operation and Maintenance

The following operation at the PBRP OU is now complete.

- The vapor phase monitoring of the BaroBall™ wells (PSV-10, PSV-11, PSV-12, and PSV-13) was discontinued in 2006 as concentrations dropped to below the remedial goal (RG) of 10 parts per million vapors. The wells were left in place to continue passive operation until groundwater objectives are met. The location of the BaroBall™ wells is shown on Figure L-6.

The following activities are ongoing:

- Groundwater monitoring for three wells (PRP 5, PRP 6, and PRP 7) (Figure L-6). As stated in the approved Record of Decision (WSRC 2002), groundwater ~~S~~sampling will continue until MCLs have been attained for three consecutive years. The 2013 and 2014 USEPA guidance (USEPA 2013, USEPA 2014) will also be taken into consideration when evaluating groundwater cleanup. The results were reported via annual Environmental Monitoring Reports since 2004. Starting in 2008, the monitoring results for PBRP OU were combined with the K-Area Burning/Rubble Pit (131-K) and K-Area Rubble Pile (631-20G) OU and L-Area Burning/Rubble Pit (131-L) / Gas Cylinder Disposal Facility (131-2L) / L-Area Rubble Pile (131-3L) OU monitoring reports into a single abbreviated annual groundwater data summary, with full detailed reports every five years (WSRC 2008). The second five-year detailed report was submitted in June 2017. The third five-year detailed report was submitted in June 2022 (SRNS 2022).
- Annual site inspections and site maintenance (repair of erosion damage, cover maintenance, and warning signs).

- Site controls (SRS Site Use and Site Clearance Programs, which restrict invasive and permanent installation activities at the waste unit).

Table L-3 compares the actual operation and maintenance (O&M) costs for the five-year remedy review period to the estimated direct O&M costs from the ROD (WSRC 2002). The estimated cost for Fiscal Year (FY) 2018 to FY2022 was $128,346 for O&M of the passive SVE system, soil cover, groundwater monitoring, ~~institutional controls (i.e.,~~ LUCs~~)~~, and five-year remedy reviews. The actual O&M cost for FY2018 to FY2022 was $75,190. The actual O&M costs from FY2018 to FY2022 are lower than estimated because soil cover repairs expected every five years have not been necessary and inspections are performed annually instead of monthly as originally estimated.

V. Progress Since Last Review

The previous protectiveness statement concluded that the remedy of a soil cover at the PBRP OU with ~~institutional controls (i.e.~~ LUCs~~)~~ and groundwater monitoring are protective of human health and the environment. This continues to be true as the soil cover and LUCs eliminate the exposure path to the contaminated soil and groundwater at the PBRP OU. However, improvements to the groundwater monitoring network at the PBRP OU are being made to address concerns regarding the triangulation and extent of contamination within the OU. To better define the groundwater flow direction beneath the PBRP OU, seven wells will be used to help evaluate the potentiometric surface/groundwater flow in the area (Figure L-7). To better define the extent of contamination at the PBRP OU and to ensure that concentrations sourced from the unit are not adversely affecting Steel Creek, additional surface-water sampling for 1,4-dioxane ~~will be~~was conducted at surface-water stations SC-02 and SC-03 (Figure L-7) in 3Q2022.

VI. Five-Year Review Process

The following tasks were performed as part of the review:

- Reviewed the documents listed in Section XII, Documents Reviewed;
- Confirmed implementation of the remedial action;

when water levels increased to historically high levels. The more recent increase in water elevations near historic levels may have mobilized some residual contamination within the capillary fringe into the water table. If 1,1-DCE or TCE exceed the recent 2020 maximums at well PRP 6 during the fourth quarter 2022 sampling event, the sampling frequency will be increased to semi-annual at PRP 6 and PRP 7. 1,4-Dioxane concentrations continue to be at a steady state in all wells indicating no observed trend of increasing or decreasing concentrations but exhibit concentrations above the RSL (Figure L-10). The background well, PRP 5, remains non-detect for all VOC analyses. Figure L-6 shows the location of the wells with listed contaminant concentrations, the areas of elevated concentrations, and the potentiometric surface at PBRP.

The above remedial activities are meeting the RGs established for the PBRP OU, as discussed in Section IV, by eliminating or controlling all routes of exposure to human health.

The Land Use Control Implementation Plan for the PBRP OU is located in Appendix E of the Post-Construction Report and governs LUC implementation, maintenance, monitoring, reporting, and enforcement (WSRC 2004). The LUCs that are in place include physical access controls to prevent unauthorized entry to SRS (fences, guards, security patrols, etc.), use restrictions to prevent unauthorized contact, removal or excavation of contaminated soils, restrictions to prevent unauthorized access to or use of groundwater until cleanup levels are met, and restrictions to prevent disturbance of the engineered cover system. Warning signs are in good condition, and no activities were observed that would have violated the LUCs. All LUC objectives are being met.

Are Exposure Assumptions, Toxicity Data, Cleanup Levels, and Remedial Action Objectives still valid?

The exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection are still valid. There have been no changes in the physical conditions at the PRBP OU that would affect the protectiveness of the remedy.

The USEPA standards and toxicity values have been updated since the last five-year remedy review as shown in Appendix B. The changes to the values for COCs at the PBRP OU were not significant, and the RAOs continue to be met by the remedial action. No new standards or to-be-considered guidance have been identified that call into question the protectiveness of the remedy.

Fact sheets provided on the USEPA webpage (https://www.epa.gov/fedfac/emerging-contaminants-and-federal-facility-contaminants-concern) regarding emerging contaminants were reviewed for applicability to this site. This webpage provides a link to specific fact sheets for each of the following contaminants: 1,2,3-trichloropropane (TCP), 1,4-dioxane, 2,4,6-trinitrotoluene (TNT), 2,4-dinitrotoluene (DNT), hexahydro-1,3,5-tri-nitro-1,3,5-triazine (RDX), nanomaterials, N-nitroso-dimethylamine (NDMA), perchlorate, perflurorooctane sulfonic acid (PFOS) and other per- and polyfluoroalkyl substances (PFAS), polybrominated biphenyls, polybrominated diphenyl ethers (PBDEs) and tungsten. The only listed emerging contaminant identified as applicable to this OU is 1,4-dioxane.

Has any Other Information Come to Light that Could Call into Question the Protectiveness of the Remedy?

No new information has come to light that could call into question the protectiveness of the remedy.

VIII. Issues

There are no issues related to the PBRP OU since the previous Five-Year Remedy Review.

IX. Recommendations and Follow-up Actions

There are no recommendations and/or follow-up actions for the PBRP OU since the previous Five-Year Remedy Review.

X. Protectiveness Statement(s)

The remedy at the PBRP OU is protective of human health and the environment.

Exposure pathways that could result in unacceptable risks are being controlled by ~~institutional controls (i.e.,~~ LUCs~~)~~ to prevent exposure to, or the ingestion of, contaminated soil and groundwater. All threats to contaminated soil at the PBRP OU have been addressed through implementation of the soil cover, physical access controls to prevent unauthorized entry to SRS (fences, guards, security patrols, etc.), administrative controls that maintain the PBRP OU for industrial use only, and warning signs and use restrictions via the SRS Site Use/Site Clearance Program.

XI. Next Review

As shown in Appendix A, Table A-1, the next five-year review for SRS OUs with Operating Equipment is scheduled for January 2029.

XII. Documents Reviewed

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

SRNS, 2014. *Fifth Five-Year Remedy Review Report for the Savannah River Site Operable Units with Operating Equipment (U)*, SRNS-RP-2017-00567, Revision 1, Savannah River Site, Aiken, SC

SRNS, 2022. *K-Area Burning/Rubble Pit and Rubble Pile (131-K and 631-20G) (KBRP), L-Area Burning/Rubble Pit and Rubble Pile (131-L, 131-3L, and 131-2L) (LBRP), and P-Area Burning/Rubble Pit (131-P) (PBRP) Operable Units (OUs) Detailed Combined Groundwater Monitoring Report (U)*, SRNS-RP-2022-00253, Revision 0, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken SC

USDOE, 1996. *Savannah River Site Future Use Project Report*, U.S. Department of Energy, Savannah River Operations Office, Savannah River Site, Aiken, SC

USEPA, 2013. *Guidance for Evaluating Completion of Groundwater Restoration Remedial Actions,* Office of Solid Waste and Emergency Response (OSWER) 9355.0-129, Washington D.C.

USEPA, 2014. *Recommended Approach for Evaluating Completion of Groundwater Restoration Remedial Actions at a Groundwater Monitoring Well and the Groundwater Statistics Tool*, Office of Solid Waste and Emergency Response (OSWER) 9283.1-44, Washington D.C.

WSRC, 1999. *Land Use Control Assurance Plan for the Savannah River Site*, WSRC-RP-98-4125, Revision 1.1, latest revision Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC

WSRC, 2001. *RFI/RI/BRA for the P-Area Burning/Rubble Pit (131-P) (U)*, WSRC-RP-98-4174, Revision 1.1, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC

WSRC, 2002. *Record of Decision Remedial Alternative Selection for the P-Area Burning/Rubble Pit (131-P) (U)*, WSRC-RP-2000-4197, Revision 1, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC

WSRC, 2004. *Post-Construction Report for the P-Area Burning/Rubble Pit (131-P) (U)*, WSRC-RP-2004-4051, Revision 1, Westinghouse, Savannah River Company, Savannah River Site, Aiken, SC

WSRC, 2008. *Proposal to Standardize Sampling and Reporting Requirements of Groundwater Data for P, L, and K Area Burning/Rubble Pit Operable Units*, ACP-08-133, Revision 0, Washington Savannah River Company, Savannah River Site, Aiken, SC

Various - *Inspection Data Sheets – Field Inspection Checklist P-Area Burning/Rubble Pits (U)*, ER-IDS-019-030, Inspection period 2018 through 2022 (annually)

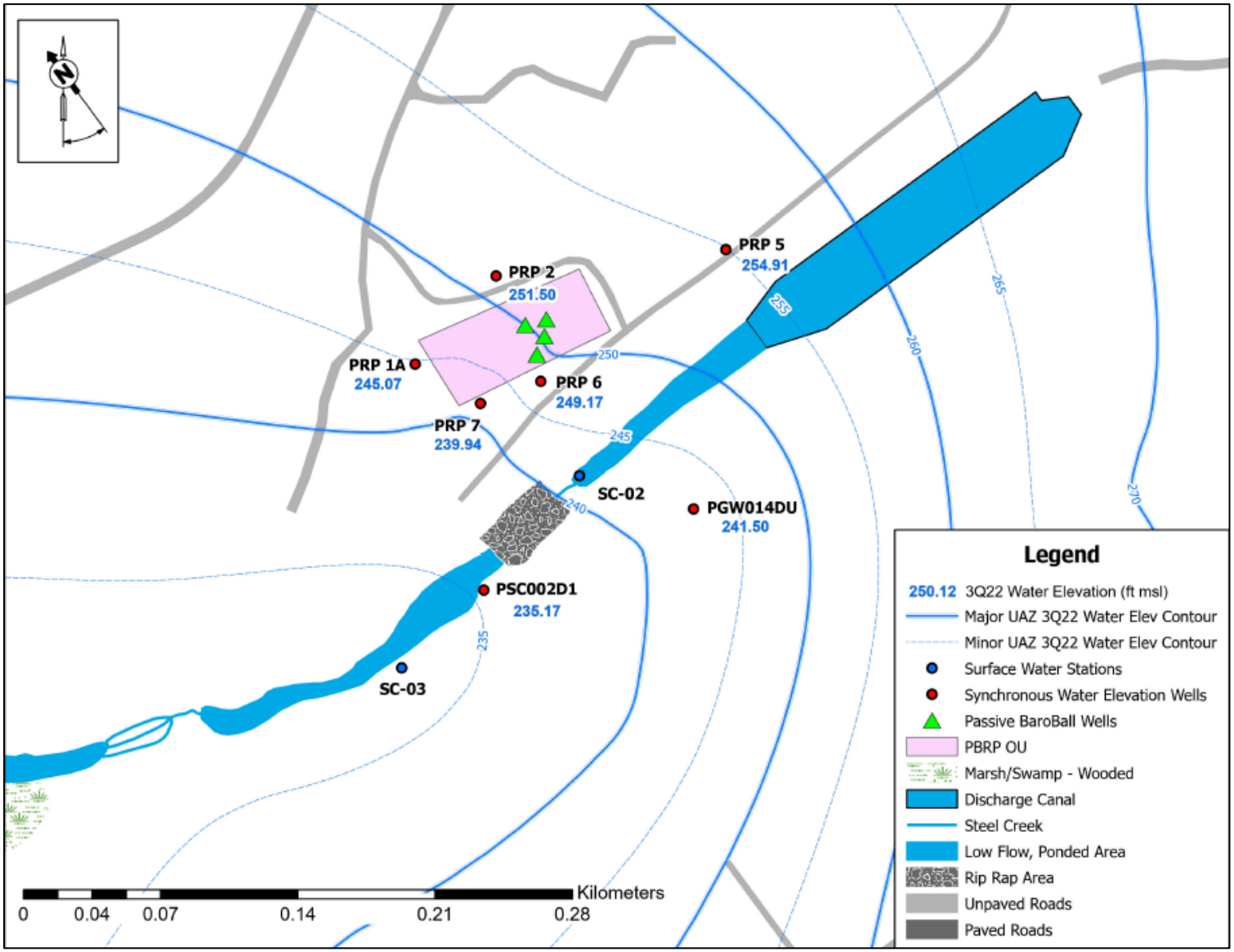
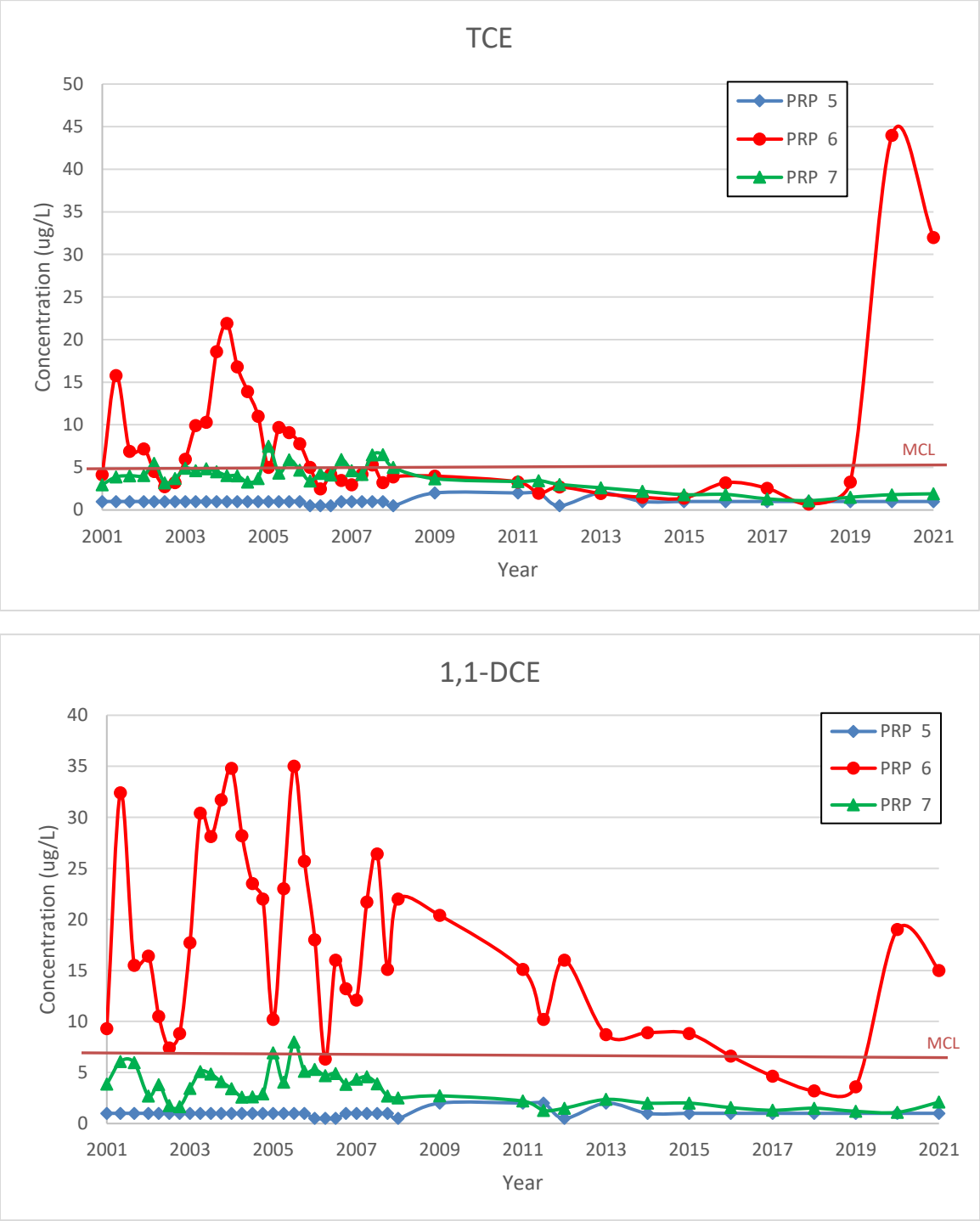


Figure L-7. 2022 PBRP OU Optimized Monitoring Network



Non-detects are plotted as 0.5 µg/L (PRP 5 values)

Figure L-8. Time-series plots of 1,1-DCE and TCE at wells PRP 5, PRP 6, and PRP 7

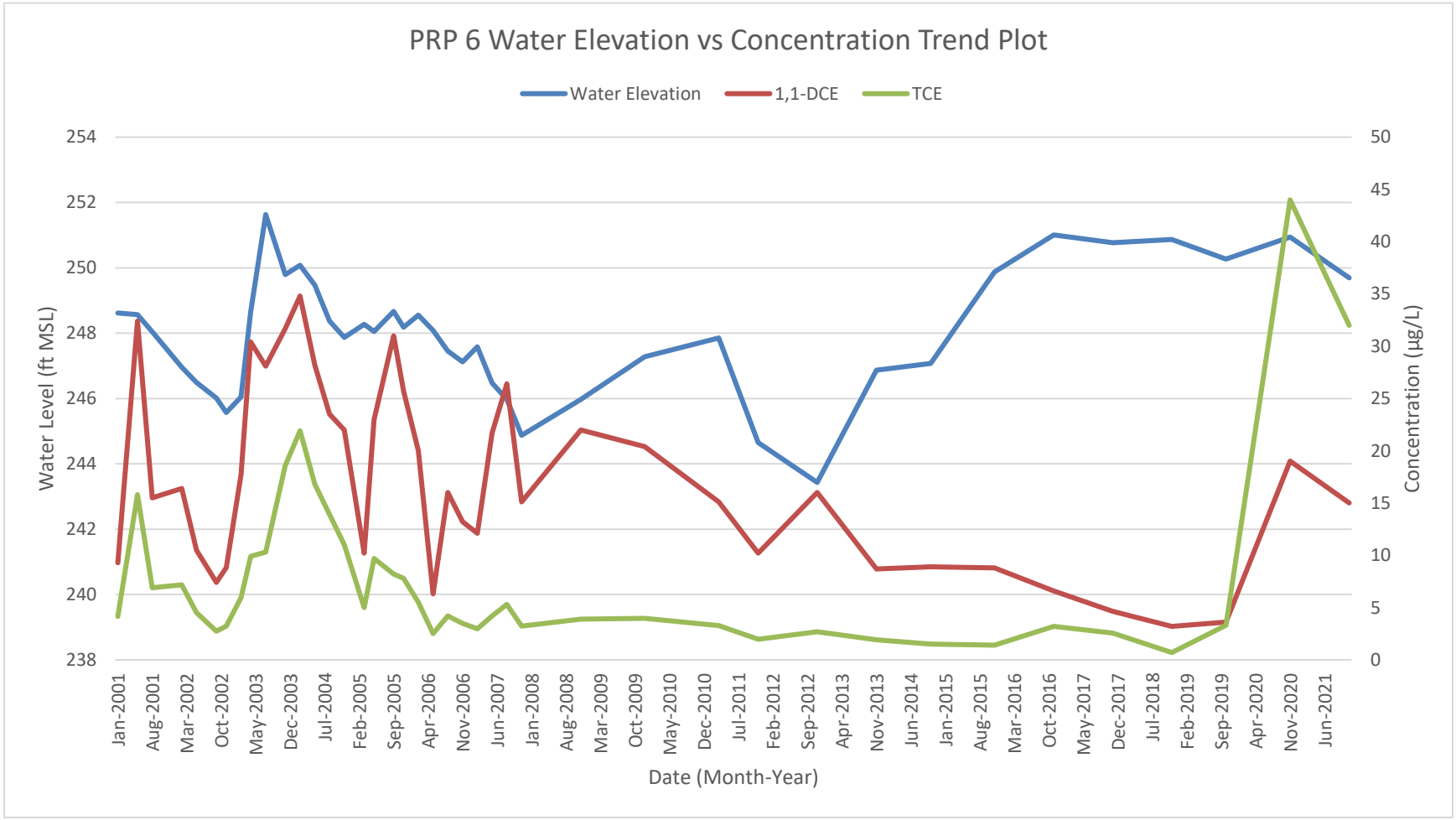


Figure L-9. PRP 6 Water Elevation vs Concentration Trend Plot

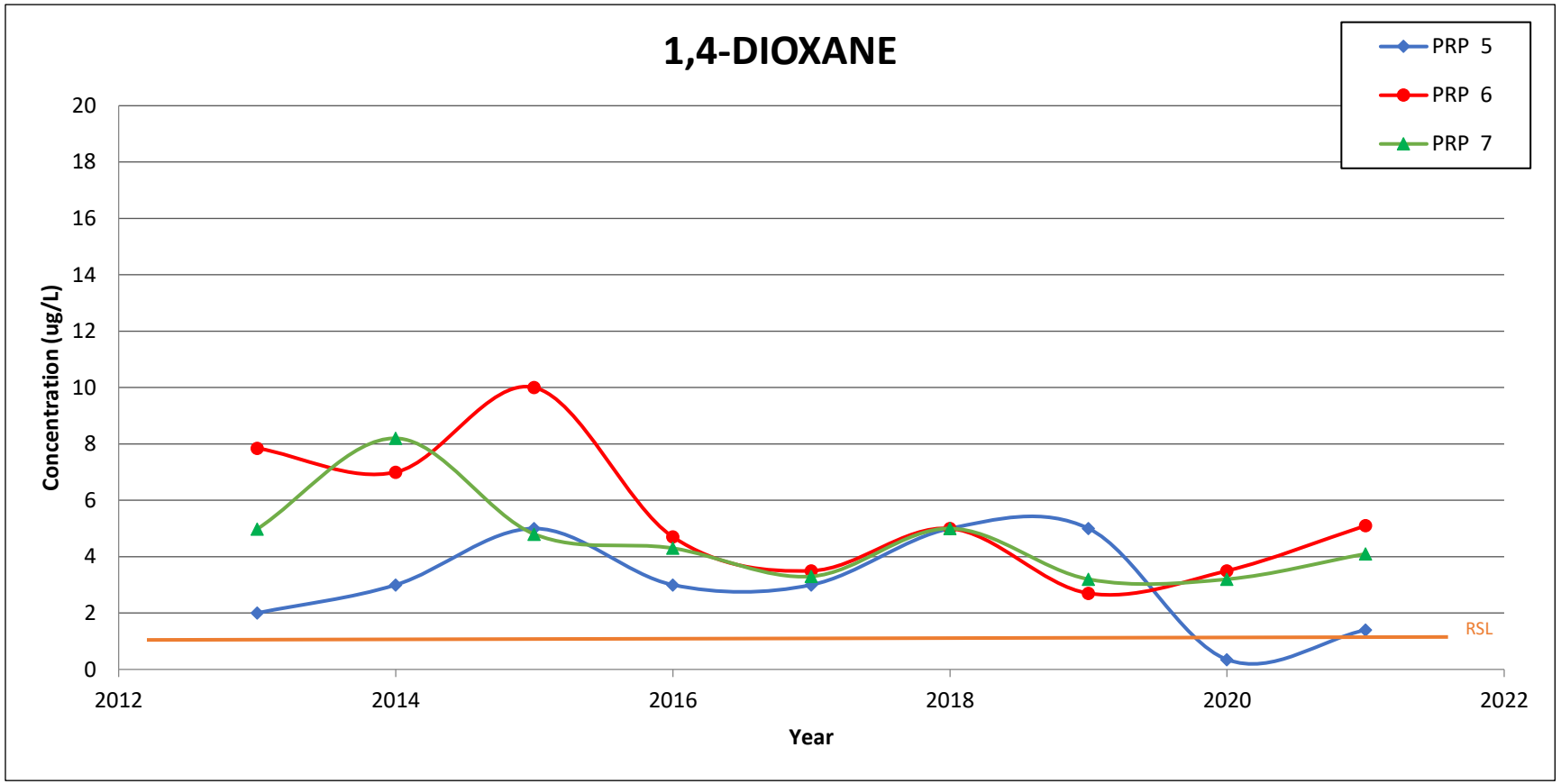


Figure L-10. Time Series Plot of 1,4-Dioxane at wells PRP 5, PRP 6, PRP 7

of fill materials.

- Groundwater remediation efforts began in 1996 with installation of a pump-and-treat system consisting of four recovery wells feeding an air stripper (WSRC 1994). In 2007, the pump and treat system was shutdown to allow a treatability study of edible oils to treat the residual VOCs in the source (vadose zone/groundwater interface and near source groundwater). In 2013, edible oil became the remedial action reducing the treatment time to achieve MCLs by approximately 20 years. Edible oil treatment is ongoing and most monitoring wells within the treatment zone have VOC concentrations less than the maximum contaminant level ([MCL], 5 µg/L).
- Based on the successful SVE treatability study in 1997 and 1999, the active SVE network was expanded (WSRC 2001) and operated through 2005. In 2007, the active SVE system was transitioned to a passive system (MicroBlowers™). The passive SVE system consists of five MicroBlowers™ rotated between the SVE well network.
- LUCs were established for 0.5 hectares (1.24 acres) were incorporated into the TAOU LUC area.

System Operations/Operation and Maintenance

The system operation requirements include the following activities:

- SVE operations in the high concentration areas of the vadose zone extracted approximately 17.7 kg (39 lbs) of VOCs from 2002 through 2021. In 2006, the system was shut down temporarily during the placement of the engineered cover system over the former TNX Area. The SVE system remained in operation during the edible oil treatability study.
- Operation of the pump and treat system ceased operations in 2007 and the T-1 Air Stripper system was dismantled and removed in 2013.
- There are no operation and maintenance activities associated with the edible oil remedial action.

The following activities are ongoing:

- Operation of five MicroBlowers™,
- Groundwater monitoring at 43 monitoring wells
- Edible oil injections were conducted in 2008, 2010, and 2015 and groundwater monitoring is being conducted to verify if additional edible oil treatment is needed based on criteria established in the second ESD to the ROD; and
- Institutional controls (i.e., LUCs) are being enforced to preclude access through the SRS Site Use/ Site Clearance program and SRS site security.

Maintenance and inspection activities associated with the engineered cover system over the OTSB/Discharge Gully and TBG and the cover system for the NTSB are integrated into the TAOU. Therefore, review of the operation and maintenance (O&M) activities associated with the cover system are addressed in the five-year remedy review for the TAOU.

Table M-4 compares the actual O&M costs for the five-year remedy review period to the estimated direct O&M costs from the ROD (WSRC 2004b). The estimated cost for Fiscal Year (FY) 2018 to FY2022 is $788,860 for the O&M costs of the SVE systems, ~~institutional controls (i.e., LUCs)~~, and five-year remedy reviews. The actual O&M cost for FY2018 to FY2022 is $1,234,149. The actual O&M costs from FY2018 to FY2022 are as expected.

V. Progress Since Last Review

The previous protectiveness statement concluded that the remedy is protective of human health and the environment. Exposure pathways that could result in unacceptable risks are being controlled by removing TCE from the most concentrated portion of the contaminated plume and through ~~institutional controls (i.e., LUCs)~~.

VI. Five-Year Review Process

The following tasks were performed as part of the review:

- Reviewed the documents listed in Section XII, Documents Reviewed;
- Confirmed the implementation of the remedial action;

VII. Technical Assessment

Is the Remedy Functioning as Intended by the Decision Document?

The remedy is functioning as intended as demonstrated below:

- The removal of PTSM soils associated with the OTSB and the sumps has achieved the remedial objectives to remove or treat contamination exceeding PTSM criteria in subsurface soils.
- The removal and consolidation under a TAOU geosynthetic cover system is effective in protecting future industrial and ecological receptors from exposure to contaminants (SRNS 2017a). Additionally, the TAOU cover system has the effect of decreasing contaminant loading by reducing surface water loading and transport through the contaminated vadose zone directly under the cover to the groundwater; thus, positively impacting groundwater treatment.
- The combined groundwater treatment approaches of pump-and-treat (ceased), edible oil (ongoing), and passive SVE (ongoing) are effective in decreasing the volume of contaminants in the groundwater and vadose zone. The 500 µg/L TCE contour has been eliminated, TCE concentrations within the edible oil treatment area are mostly less than the MCL, and a detached TCE plume continues to be present downgradient of the treatment area. There are currently no TCE concentrations in the detached plume that trigger the criterion to deploy additional edible oil. The application of the edible oil has reduced the mass of TCE in the system by 96% from 2007 through 2021.

The Land Use Control Implementation Plan for TNX Area OU governs LUC implementation, maintenance, monitoring, reporting, and enforcement (WSRC 2004a). The LUCs that are in place include physical access controls to prevent unauthorized entry to SRS (fences, guards, security patrols, etc.), use restrictions to prevent unauthorized contact, removal or excavation of contaminated soils, restrictions to prevent unauthorized access to or use of groundwater until cleanup levels are met, and restrictions to prevent disturbance of the engineered cover system. Warning signs are in good condition, and no activities were observed that would have violated the LUCs. All LUC objectives are being met.

Are Exposure Assumptions, Toxicity Data, Cleanup Levels, and Remedial Action Objectives still valid?

The exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection are still valid. There have been no changes in the physical conditions at the TNX OU that would affect the protectiveness of the remedy.

The USEPA standards and toxicity values have been updated since the last five-year remedy review as shown in Appendix B. The changes to the values for COCs at the TNX OU were not significant, and the RAOs continue to be met by the remedial action. No new standards or to-be-considered guidance have been identified that call into question the protectiveness of the remedy.

Fact sheets provided on the USEPA webpage (https://www.epa.gov/fedfac/emerging-contaminants-and-federal-facility-contaminants-concern) regarding emerging contaminants were reviewed for applicability to this site. This webpage provides a link to specific fact sheets for each of the following contaminants: 1,2,3-trichloropropane (TCP), 1,4-dioxane, 2,4,6-trinitrotoluene (TNT), 2,4-dinitrotoluene (DNT), hexahydro-1,3,5-tri-nitro-1,3,5-triazine (RDX), nanomaterials, N-nitroso-dimethylamine (NDMA), perchlorate, perflurorooctane sulfonic acid (PFOS) and other per- and polyfluoroalkyl substances (PFAS), polybrominated biphenyls, polybrominated diphenyl ethers (PBDEs) and tungsten. The only listed emerging contaminant identified as applicable to this OU is 1,4-dioxane.

Has any Other Information Come to Light that Could Call into Question the Protectiveness of the Remedy?

No new information has come to light that could call into question the protectiveness of the remedy.

VIII. Issues

No issues have been identified for the TNX Area OU.

IX. Recommendations and Follow-up Actions

SRS recommends performing an evaluation of the SVE system at TNX Area OU. The

total annual pounds of solvent removed from the MicroBlowers™ have decreased with time with approximately one pound of solvent removed per year during the last five years. With diminishing mass removal rates, a proposal to evaluate the SVE system was presented to the Core Team on May 26, 2022. It was determined at that meeting that a summary of the proposed evaluation be included as Appendix F in the *2021 Annual Comprehensive TNX Area Groundwater Monitoring and Remedial Action Effectiveness Interim Report* (SRNS 2022) which was submitted in August 2022. The SVE evaluation will be utilized to determine the following:

- VOC concentrations and mass removal rates at each SVE well;
- Evaluate the location of residual VOC mass in the vadose zone;
- Optimize SVE wells to maximize future mass removal; and
- Establish criteria for SVE system shutdown.

The SVE evaluation is currently planned to be conducted in fiscal year 2024 or 2025.

Sampling of the three new surface water locations along the X-008 ditch was conducted in the second quarter 2022. An additional sampling event is planned for the fourth quarter of 2022. Based on the fourth quarter results, a recommendation for future sampling at these sampling locations will be included in the 2022 annual report.

X. Protectiveness Statements

The remedy at the TNX Area OU is protective of human health and the environment.

Exposure pathways that could result in unacceptable risks are being controlled by removing TCE from the most concentrated portion of the contaminated plume and through ~~institutional controls (i.e., LUCs)~~. LUCs include physical access controls to prevent unauthorized entry to SRS (fences, guards, security patrols, etc.), administrative controls that maintain this site for industrial use only (SRS is a secured government facility with land use restrictions), and warning signs and use restrictions via the SRS Site Use/Site Clearance Program.

XI. Next Review

As shown in Appendix A, Table A-1, the next five-year review for SRS OUs with Operating Equipment is scheduled for January 2029.

XII. Documents Reviewed

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

SRNS, 2010b. *Enhanced Attenuation Technologies: Passive Soil Vapor Extraction*, SRNL-STI-2009-00571, Revision 1, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC

SRNS, 2012a. *Treatability Study for Edible Oil Deployment for Enhanced cVOC Attenuation for T-Area*, SRNL-STI-2012-00290, Revision 0, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC

SRNS, 2012b. *Second Explanation of Significant Differences (ESD) for the Revision 1 TNX Area Operable Unit Record of Decision (U),* SRNS-RP-2012-00205, Revision 1, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC

SRNS, 2013a. *Savannah River Site Environmental Report for 2014*, SRNS-RP-2014-00006, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC

SRNS, 2014a. *Savannah River Site Environmental Report for 2014*, SRNS-RP-2015-00008, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC

SRNS, 2015a. *Second Corrective Measures Implementation/Remedial Action Implementation Plan (CMI/RAIP) for the TNX Operable Unit (U)*, SRNS-RP-2015-00266, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC

SRNS, 2017a. *Fifth Five-Year Remedy Review Report for Savannah River Site Operable Units with Geosynthetic or Stabilization/Solidification Cover Systems (U)*, SRNS-RP-2016-00610, Revision 1, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC