Status of Tank Residual Characterization Sampling to Support Waste Tank Operational Closure at the Savannah River Site – Tank Farm Closure Project- 11206

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ABSTRACT

The Savannah River Site Tank Farm Closure Projects has successfully completed Waste Removal Activities within four of its waste storage tanks. DOE intends to remove from service and operationally close 22 waste tanks within 8 years that do not meet current containment standards. After obtaining regulatory approval, the tanks and cooling coils will be isolated and filled with grout for long term stabilization. These tanks, designated as Tank 5, 6, 18 and 19 respectively, are Type I and Type IV waste tanks located in F-Tank Farm (FTF). Operational closure of the SRS waste tanks will be performed in accordance with requirements in Section 3116 of the Ronald W. Reagan National Defense Authorization Act (NDAA) for Fiscal Year 2005, the Department of Energy's (DOE's) Radioactive Waste Management Order (DOE 435.1), and a South Carolina (SC) Industrial Waste Water Permit issued under the Pollution Control Act.

Tank 5 and Tank 6 are Type I tanks that have a capacity of 2839 cubic meters (750,000 gallons) each and Tank 18 and Tank 19 are Type IV tanks that have a capacity of 4920 cubic meters (1,300,000 gallons) each. In addition, Type I tanks have 34 vertically oriented cooling coils and two horizontally oriented cooling coil circuits along the tank floor. These cooling coils are only installed within the Type I tanks and are proven obstacles during waste removal activities and residual sample characterization efforts.

The residual material that remains in the waste tank upon removal from service must be representatively sampled and characterized. Tank residue characterization data obtained from the samples are used to prepare a tank-specific Special Analysis (SA) to confirm that the residual inventory is consistent with that assumed in the applicable Performance Assessment. Tank residue characterization will include representative sampling of the material remaining in the specific tank.

To support the waste tank system-specific closure preparations, Tank 5, Tank 6, Tank 18 and Tank 19 have all been successfully sampled with various sampling technologies. Successful characterization of the residual material is planned to minimize uncertainty in the concentration and volume values.

Residual sample collection has been filmed and photographed in Tank 5, Tank 6, Tank 18 and Tank 19 in a manner that records the location of each sample and the sampling technique, which will be utilized as part of the tank specific Closure Module detailing the remaining residual inventory.

This paper describes in detail the performance of the sampling effort and sampling technologies utilized. In addition, it will discuss the current status of the SRR Sampling and Analysis Program Plan development activities that are being incorporated to standardize the sampling program and be consistent with EPA and SCDHEC programs for future characterization activities.

INTRODUCTION

Since the early 1950s, the primary mission of SRS had been to produce nuclear materials for national defense and deep space missions. The processes used to recover these nuclear materials from production reactor fuel and target assemblies in the chemical separations areas at SRS generated significant volumes of liquid radioactive waste. This waste is currently stored in underground storage tanks in F and H Areas near the center of the site. Today, the primary focus at SRS is environmental restoration with the highest priority being removal, treatment and disposal of the liquid waste in the F Tank Farm (FTF) and H-Area Tank Farm (HTF), which are located in F-Area and H-Area respectively (Figure 1).

A legacy of the SRS mission was the generation of liquid waste from chemical separations processes in both F and H Areas. Since the beginning of SRS operations, an integrated waste management system consisting of several facilities designed for the overall processing of liquid waste has evolved. F Area is where plutonium, uranium, and other radionuclides were separated from irradiated fuel and target assemblies using chemical separations processes. The tank farms, which store and process waste from the chemical separations process, include tanks, evaporators, transfer line systems, and other ancillary equipment.

The FTF site was chosen because of its favorable terrain, proximity to the F-Canyon Separations Facility (the major waste generation source).

The FTF is a 22 acre site consisting of 22 liquid waste storage tanks, two evaporator systems, transfer pipelines, six diversion boxes (DBs), one catch tank, a concentrate transfer system (CTS) tank, and three pump pits (PPs). Tank 5 and Tank 6 are Type I tanks that are located within FTF along with Tanks 18 and Tank 19 which are Type IV tanks. The FTF was constructed to receive waste generated by various SRS production, processing, and laboratory facilities. The use of FTF isolated these wastes from the environment, SRS workers, and the public. With FTF and HTF, facilities are in place to pretreat the accumulated sludge and salt solutions (supernate) to enable the management of these wastes within other SRS facilities (i.e., Defense Waste Processing Facility (DWPF) and Saltstone Production Facility (SPF)). These treatment facilities convert the sludge and supernate to more stable forms suitable for permanent disposal in a federal repository or the Saltstone Disposal Facility (SDF), as appropriate.

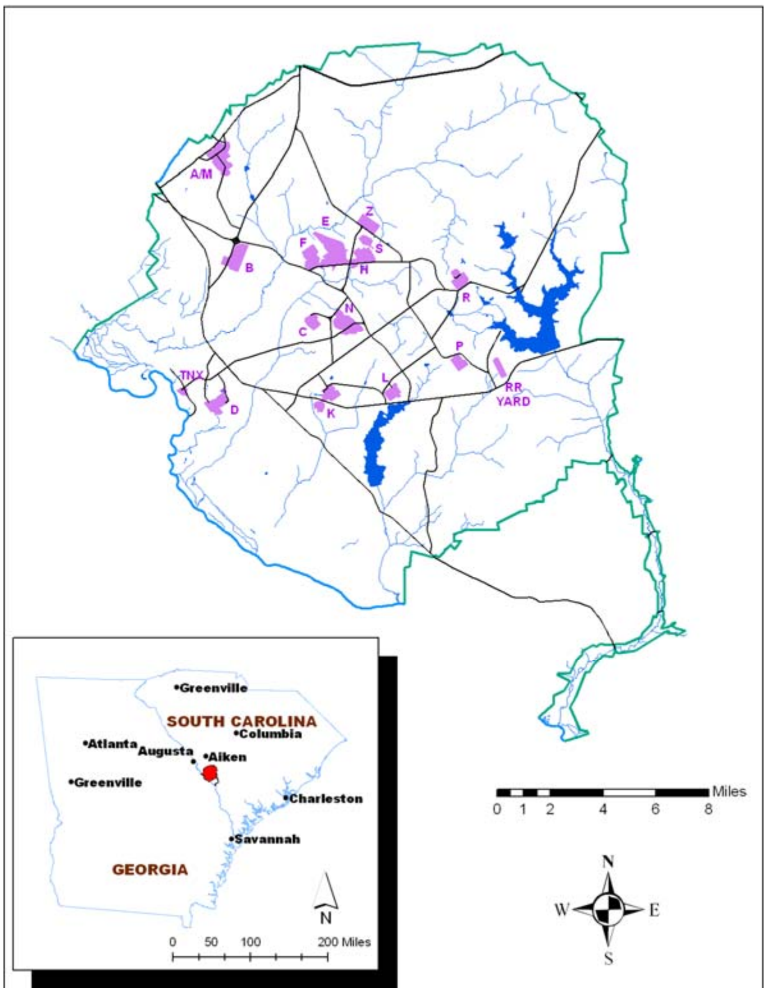

Figure 1 SRS Operational Area Location Map

DOE intends to remove from service and operationally close 22 waste tanks within 8 years that do not meet current containment standards.

Waste Tank Designs

Five waste tank designs were used during the FTF/HTF construction period. All waste tanks are constructed of carbon steel and reinforced concrete, but the design details vary due to the changing design philosophy during the construction period. The various tank designs affect accessibility for residual material sampling, with the greatest interferences caused by interior cooling coils. Type I, II, and III/IIIA tanks contain an annular area, a design feature providing secondary containment. Some Type I and II tanks have contamination in the annulus due to leakage through cracks in the primary tank liner. Contaminated annuli will be cleaned during the waste removal phase, and annulus sampling is not anticipated. The four basic tank types and construction are described below.

- Type I tanks were constructed in the early 1950s. Type I tanks are 75 feet in diameter and 24.5 feet high, and have a nominal operating capacity of 750,000 gallons. Type I tanks have a second outer, partial height, steel liner that acts as a limited secondary containment. Type I tanks contain 34 vertical cooling coils and two horizontal cooling coils across the tank floor.

- Type II tanks were constructed between 1955 and 1956. Type II tanks are 85 feet in diameter at the inner liner and 27 feet high, with a nominal operating capacity of 1,030,000 gallons. Type II tanks have a second outer, partial height, steel liner.

- Type III/IIIA tanks are 85 feet in diameter at the inner liner and 33 feet high, with a nominal operating capacity of 1,300,000 gallons. Type III tanks have a second outer, full height, steel liner. Type IIIA tanks have an underliner leach ate collection grid under the tank.

- Type IV tanks were constructed in the late 1950s. Type IV tanks are 85 feet in diameter and are approximately 34 1/2 feet high at the inner liner springline, with a nominal operating capacity of 1,300,000 gallons. Type IV tanks have a leach ate collection grid under the tank.

Two Type IV tanks in the FTF, Tanks 17 and 20, have been closed and filled with grout under SCDHEC and EPA-reviewed and approved Closure Plan (CP) and Closure Modules (CM). Tanks 18 and 19 which are Type IV tanks along with Tanks 5 and 6 which are Type I tanks are all undergoing closure activities.

Tank Closure Strategy

The typical closure process steps for the SRS Tank Farm Tanks are:

1.) Bulk Waste Removal
2.) Mechanical Heel Removal
3.) Chemical Cleaning Process – utilizing Oxalic Acid
4.) Sampling/Characterization and DOE/Regulatory Reviews
5.) Tank Grouting

The SRS Tank Closure Project has successfully completed Bulk Sludge Removal, Mechanical Heel Removal and Sampling within Tank 5, Tank 6, Tank 18 and Tank 19 utilizing various technologies. For Tanks 5, 6, 18 and 19, the DOE has concurred that it is appropriate to cease waste removal operations and preliminary process history data has been presented to EPA and SCDHEC to obtain agreement that there is reasonable assurance that further waste removal efforts are not technically practicable from an engineering perspective and it is appropriate to transition to the sampling and analysis phase of the waste tank system removal from service process.

Sampling Summary

SRR Closure Projects has successfully sampled residual material within Tank 5, 6, 18 and 19 with various sampling technologies. Residual sample collection has been filmed and photographed in a manner that records the location of each sample and the sampling techniques. Closure Project Engineering also utilized this information to learn and improve on sampling techniques and subsequent sampling designs. The sampling process is a learning process the closure sampling team has embraced and has shown major improvements each evolution by incorporating lessons learned throughout the sampling design and execution process.

Tank 18 and Tank 19 are Type IV tanks that were one of the first set of tanks that were sampled and characterized. Due to the final topography of the residual material, sampling tools were designed to obtain representative samples. Scrape samplers were designed with 30-40 ft poles that were very cumbersome for sample operators and exposed the operator to more radiological dose than originally planned. As described in the waste tank designs, the type VI tanks have no obstruction within the primary tank area which allows access to the residual material. However, Tank 18 and Tank 19 had abandoned equipment that occupied tank risers along with historical radiological contamination rates that posed accessibly problems. With these constraints, Closure Engineering conceptualized during sampling design the use of the VersaTrax 150 remote crawler (Figure 3). The VersaTrax is a remote crawler that was converted to a sampler that provided much flexibility to obtain the needed representative samples within Tank 18 and Tank 19. The crawler allowed the operator to receive minimal to no radiological dose and performed a 100% sample retrieval rate.

To complete sample characterization within Tank 5 and Tank 6, lesson learned from Tank 18 and Tank 19 were incorporated into the next VersaTrax crawler design. As described within the waste tank designs, the type I tanks have cooling coil obstructions within the primary tank that caused more accessibility issues than type IV tanks. The VersaTrax crawler's tracs system was redesigned to have the capability to negotiate between cooling coils, floor piping and other failed equipment obstacles.

PROCESS TO CHARACTERIZE WASTE TANK RESIDUE

The overall quality objective of the residual tank material sampling and characterization is to obtain data that are of sufficient quality for input to the tank characterization effort. The sample data collected are intended to represent the mean (average) concentration of each radionuclide and hazardous constituent present in the residual material. The SRR Closure Project Team waste sampling and characterization process which supports this objective is:

- Sample Planning
- Sample Collection
- Sample Analysis/Characterization

Sample Planning

Waste tank residue characterization includes representative sampling of the material remaining in the specific waste tank. In some cases, process knowledge and historical sampling was used to support sample planning and characterization of residuals. Tank specific sampling plans for Tank 5, Tank 6, Tank 18 and Tank 19 were utilized for sample planning and documentation. These sampling plans included the number of samples to be collected, the chosen sample locations, the volume of samples collected and the sampling techniques. Sampling methods were planned to provide the capability to collect and analyze samples from residual solid material. Sampling methods in Tanks 18 and 19 were successfully filmed and photographed to record the location of each sample and the sampling technique. Figure 2 shows a typical sampling location map utilized during sample characterization. Due to the tank access limitations and interior obstructions, in some cases it is not possible to sample some areas within the waste tank that has residual material. In this case alternate locations were identified and documented in all tank sample plans undergoing sample characterization.

During regulatory reviews with SCDHEC and EPA for tank closure of Tank 18 and Tank 19 sample planning, comments were received stating that the conceptual requirements of the sample plans were adequately provided; however, many of the specific details required to adequately document all of the technical and quality control requirements needed to ensure the data was sufficient for decision making were not provided.

Examples were as follows;

- The data quality objectives (DQOs) for the project, including the Measurement Performance Criteria for precision, accuracy/bias, representativeness, comparability, and completeness (PARCC) of data;
- References to standard operating procedures (SOPs) for the sampling protocols and analytical/radiochemical methods;
- Listing of all sampling and analysis organizations, including the analytical/radiochemical laboratory;
- The sensitivity/detection limits of the proposed scans and surveys; and analyte lists and detection limits for radioassay and analytical methods performed by laboratories;
- References to data validation guidelines and/or SOPs for data validation reviews; and
- Requirements for data assessment for reconciling sample results and quality assurance measurements to the DQOs

As a result to these comments and to support the enhancement of the waste tank residue sampling and characterization planning, the SRS Liquid Waste Tank Residuals Sampling and Analysis Program Plan (LWTRSAPP) is currently being generated to provide a defensible program basis for sampling and characterizing the residual material remaining in the tank farm system at the time of removal from service for all future tank closure activities. This program establishes the data quality objectives (DQOs) for the sampling and characterization process. The seven step EPA Data Quality Objectives (DQOs) systematic planning process *(Guidance on Systematic Planning Using the Data Quality Objectives Process (EPAQA/G-4))* has been used to identify the DQOs for this Sampling and Analysis Program Plan.

In addition, these lessons learned has caused the subsequent sample plans for Tank 5 and Tank 6 to be incorporated with the sampling logistical, technical and quality requirements for the design, implementation and assessment phases of sample data collection such that the SRR Closure Project Team is ensured the data generated satisfies the defined performance criteria.

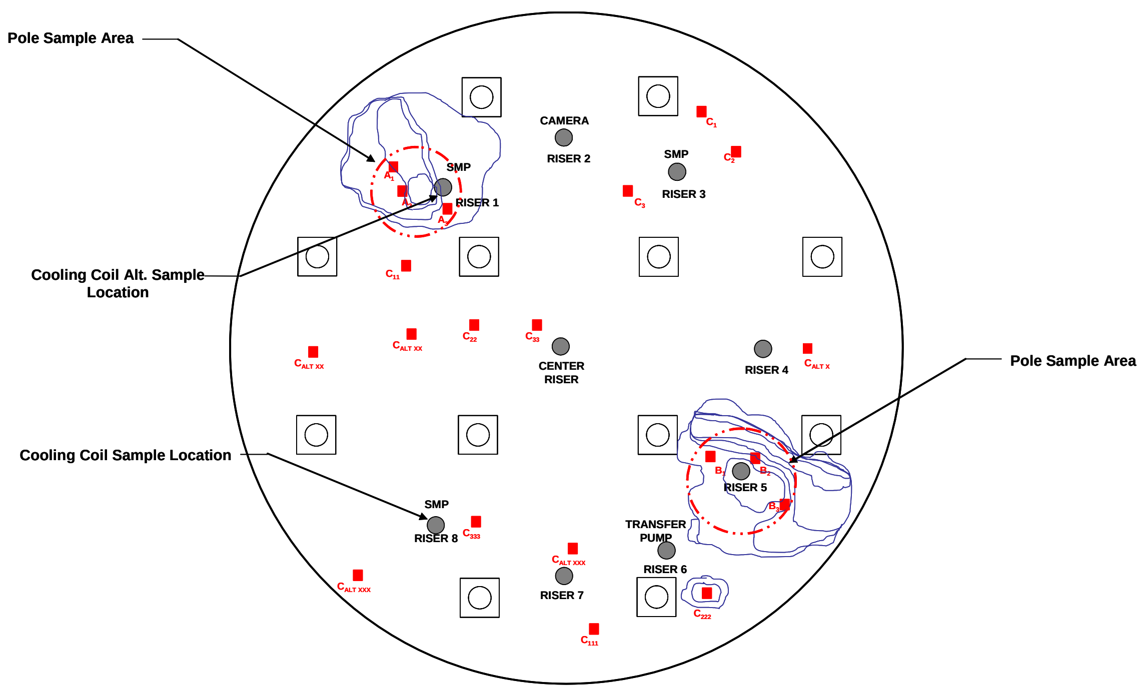

Figure 2 Tank Sampling Location Map

Sample Collection

Sampling of the residual materials within Tanks 5, 6, 18 and 19 required specialized sampling equipment. Sampler design and operation took into account several considerations, including safety and minimizing personnel exposure. Ease of operation is an important criterion, which must integrate with efficient sample handling after retrieval from the waste tank. In addition, other factors that were considered were the sample mass required for laboratory analysis, the transport container size and configuration, and the need for camera support to document the sampling activity. Ongoing sampling equipment research and design will continue throughout the operational closure effort for all tanks. To support the waste tank system-specific closure preparations for Tank 5, Tank 6, Tank 18 and Tank 19, successful sampling has been completed with various sampling technologies. Inside Tank 5 and Tank 6, internal obstructions, such as cooling coils, and riser access limitations eliminated certain sampling devices from consideration. To collect material directly under waste tank openings or tank risers, the most practical method utilized was scrape sampling which allowed the capability to retrieve 20 – 30 grams of residual material per sample location from the tank floor. However, the waste tank opening or riser accessibility for scrape sampling was limited, and other methods, such as a remote crawler had to be utilized.

After numerous sampling activities within the first tanks sampled which were Tanks 18 and Tank 19, the SRR Closure Project Team realized the remote crawler offers numerous advantages over other sampling devices. For example, due to the sampling technician operating the device remotely, radiological exposure is reduced. The crawler sample container has the ability to collect wet or dry material by scraping the tank floor with single and multiple passes to fill the container. The crawler is able to negotiate the difficult terrain of the tank bottom. However, it does have limited capability to negotiate between cooling coils, floor piping, and other obstacles. Because of its versatility and remote operation capabilities, the crawler is the preferred sampling method and was successfully utilized within Tank 18 and Tank 19. The VersaTrax 150 Crawler scrape sampling device (Figure 3) is one of two remote crawlers currently used for tank characterization. It is a modular design with precise control and ease of operation. It can be lowered through riser openings greater than six inches in diameter.

Figure 3 Remote Crawler Sampler

In some cases during sample location selection, the topography of the remaining solids or residuals are in the form of a mound which brings the concern of material variability (i.e. spatial variability due to stratification) that has to be captured during characterization. To accomplish this, the remote crawler is limited and the core sampler is more suitable for sample retrieval. A typical core sampler is shown in Figure 4. The use of a core sampler has been utilized within Tanks 5 during tank sampling activities.

Figure 4 Typical Core Sampler

Lessons learned during sampling activities within Tank 5, encountered physical characteristic changes of the tank material accumulations targeted for sampling. During sample planning and design, the tank material accumulations were recorded via video and digital photography which was utilized as a basis for sample locations and sample tool design. Initial characteristics of the material had a consistency of mud which changed to a fine powdery material by the time sampling implementation had occurred. This caused the project team to retrieve less sample material at certain sample locations. This occurrence caused the sample team to redesign the sampling plan and resample in certain locations to ensure the sampling data met specified quality expectations for decision making purposes.

Sample Analysis/Characterization

Tank residual samples from Tank 18 and Tank 19 were analyzed for both radiochemical and traditional chemical constituents of concern (CoC) with Tank 5 and Tank 6 samples currently being in the planning stages for analysis. The Savannah River National Laboratory (SRNL) is the current lab being utilized for the analytical activities. The Savannah River National Laboratory (SRNL) has matured analysis for most waste constituents identified in existing DQOs. All required analyses are specified during the planning phase and is documented within the tank specific SAP prior to sample receipt at the laboratory.
The sample locations within Tanks 5,6,18 and 19 were chosen to ensure that the different regions of the tank floor were represented and took into account the configuration and topography of the residual material. To assess the location of different populations, the sample locations were chosen to distinguish between possible different tank halves and to distinguish between differences between all regions of the tank.

The Tank 18 and Tank 19 sample results showed the residual material to be similar enough to be characterized as one population. As a result, this analysis provided high confidence that more than enough samples were taken to represent the residual material and characterize the inventory.

The constituents listed in Table 1 were analyzed for from the Tank 18 and Tank 19 samples. A majority of the analytes were digested in triplicate and each resulting solution analyzed for the requested constituents. For a few constituents, it was recognized that reaching the target detection limits was going to be challenging and thus, new or modified analytical methods and/or additional sample material were required to achieve these detection limit values. Special emphasis was placed on achieving these target detection limits for at least one sample location.

A statistical study of the sampling results was performed and demonstrated the ability to characterize the tank as one population. The study showed that a comparison of the range of relative standard deviations to the mean fell within a three sigma limit. Tank 5 and Tank 6 radiological analytes for sample analysis and detection limits are currently being planned. Closure Engineering, Closure & Waste Disposal group and SRNL are currently planning to perform triplicate analysis for the target radiological analytes specified in Table 2 for the chemical and elemental analytes.

Table I - Tank 18 and Tank 19 Constituents of Concern

Ac-227	Cm-243	Eu-154	Pa-231	Ra-226	Th-230	Ag	Mn
Al-26	Cm-244	H-3	Pd-107	Sb-126	U-232	As	Ni
Am-241	Cm-245	I-129	Pt-193	Sb-126m	U-233	Ba	NO_2
Am-242m	Cm-247	K-40	Pu-238	Se-79	U-234	Cd	NO_3
Am-243	Cm-248	Nb-93m	Pu-239	Sm-151	U-235	Cr	Pb
Ba-137m	Co-60	Nb-94	Pu-240	Sn-126	U-236	Cu	Sb
C-14	Cs-135	Ni-59	Pu-241	Sr-90	U-238	F	Se
Cf-249	Cs-137	Ni-63	Pu-242	Tc-99	Y-90	Fe	U
Cl-36	Eu-152	Np-237	Pu-244	Th-229	Zr-93	Hg	Zn

Table II - Tank 5 and Tank 6 Constituents of Concern and Detection Limits

Analytes	**Target Detection Limit**	**Unit**		**Analytes**	**Target Detection Limit**	**Unit**
H-3	1.0E-01	µCi/g		Ac-227**	1.3E-04	µCi/g
C-14	1.0E-01	µCi/g		Th-229**	1.0E-03	µCi/g
Al-26*	1.0E-03	µCi/g		Th-230**	1.0E-03	µCi/g
Cl-36*	1.0E-03	µCi/g		Pa-231**	1.0E-03	µCi/g
K-40*	1.0E-03	µCi/g		U-232	1.0E-03	µCi/g
Ni-59	9.0E-02	µCi/g		U-233	1.0E-03	µCi/g
Ni-63	1.0E-01	µCi/g		U-234	1.0E-03	µCi/g
Co-60	1.0E-03	µCi/g		U-235	1.0E-04	µCi/g
Se-79	1.0E-03	µCi/g		U-236	1.0E-03	µCi/g
Sr-90	1.0E-03	µCi/g		U-238	1.0E-03	µCi/g
Y-90	1.0E-03	µCi/g		Np-237	1.0E-03	µCi/g
Zr-93	1.0E-03	µCi/g		Pu-238	1.0E-03	µCi/g
Nb-94	3.0E-03	µCi/g		Pu-239	1.0E-03	µCi/g
Tc-99	1.0E-03	µCi/g		Pu-240	1.0E-03	µCi/g
Pd-107*	1.0E-03	µCi/g		Pu-241	1.0E-03	µCi/g
Sn-126	1.0E-03	µCi/g		Pu-242	1.0E-03	µCi/g
Sb-126	1.0E-03	µCi/g		Pu-244	1.3E-04	µCi/g
Sb-126m	1.0E-03	µCi/g		Am-241	1.0E-03	µCi/g
I-129	1.0E-04	µCi/g		Am-242m	1.0E-03	µCi/g
Cs-135	5.0E-02	µCi/g		Am-243	1.0E-03	µCi/g
Cs-137	1.0E-03	µCi/g		Cm-243	2.0E-02	µCi/g
Ba-137m	1.0E-03	µCi/g		Cm-244	1.0E-03	µCi/g
Sm-151	3.0E+00	µCi/g		Cm-245	2.0E-02	µCi/g
Eu-152	7.0E-03	µCi/g		Cm-247	1.3E-04	µCi/g
Eu-154	1.0E-03	µCi/g		Cm-248	1.3E-04	µCi/g
Pt-193*	1.0E-03	µCi/g		Cf-249	5.0E-03	µCi/g
Ra-226**	5.0E-03	µCi/g				

Conclusions

DOE intends to remove from service and operationally close 22 waste tanks within 8 years that do not meet current containment standards. The FTF Closure Projects has successfully completed sampling within Tanks 5, 6, 18 and 19 and are continuing to learn and improve during the planning and execution phase of the sampling process. In addition, to support and enhance the sampling program, the SRS Liquid Waste Tank Residuals Sampling and Analysis Program Plan (LWTRSAPP) is currently being generated to provide a defensible program basis for sampling and characterizing the residual material remaining in the tank farm system at the time of removal from service. This program is evolving along with the sampling team, sampling tool designs and sampling techniques which implement the sampling and characterization process for tank closure.

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