November 10, 2015

MEMORANDUM TO: Doug Mandeville, Acting Chief
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Division of Decommissioning,
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SUBJECT: TECHNICAL REVIEW OF “TANK 16H SPECIAL ANALYSIS FOR THE PERFORMANCE ASSESSMENT FOR THE H-TANK FARM AT THE SAVANNAH RIVER SITE”, SRR-CWDA-2014-00106, REV. 1, FEBRUARY 2015 (DOCKET NO. PROJ0734)

The U.S. Nuclear Regulatory Commission (NRC) staff has performed a technical review of the subject document prepared by the United States Department of Energy (DOE) to support Tank 16H closure at the H-Area Tank Farm Facility (HTF) at the Savannah River Site (SRS). This technical review report supports Monitoring Factor 1.1, “Final Inventory and Risk Estimates”, as detailed in NRC staff’s plan for monitoring the SRS Tank Farm Facilities (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15238B403). Additionally, this technical review report evaluates DOE’s effort to address technical issues identified in Monitoring Factors 3.1, “Hydraulic Performance of Concrete Vault and Annulus (As It Related to Steel Liner Corrosion and Waste Release”, and 3.5 “Vault and Annulus Sorption”, through analysis of an “alternate fast zone case”. Another significant change to DOE’s HTF performance assessment made in the Tank 16H Special Analysis was an increase in the distribution coefficient for iodine, which was evaluated by NRC staff under Monitoring Factor 4.1, “Natural Attenuation of Key Radionuclides”. DOE also updated the inventory for Tank 16H in this Special Analysis. The evaluation of the Tank 16H inventory conducted under Monitoring Factors, 1.2 “Residual Waste Sampling”, and 1.3, “Residual Waste Volume” is discussed in more detail under a separate technical review report (ML15301A830). Finally, DOE made significant changes to its biosphere model. These changes are described in this technical review report but will be evaluated in a separate technical review report under Monitoring Factor 6.2 “Model and Parameter Support”.

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The Tank 16H Special Analysis provides useful information on the potential risks associated with Tank 16H. However, with regard to DOE's alternate fast zone case to address technical issues identified by NRC staff under Monitoring Factors 3.1 and 3.5, the NRC staff concludes that additional information related to the release of radionuclides from the annulus is needed to have reasonable assurance that DOE disposal actions at the HTF will meet the performance objectives in 10 CFR Part 61, Subpart C. In addition, technical concerns identified in the Tanks 18 and 19 Special Analysis (ML13100A230) and 5 and 6 Special Analysis (ML13273A299) Technical Review Reports are also relevant to the HTF performance assessment and Tank 16H Special Analysis and are not repeated in this report.

With respect to Monitoring Factor 1.1, NRC staff has technical concerns related to DOE's management of inventory uncertainty in the deterministic modeling used to demonstrate compliance with the performance objectives in 10 CFR Part 61, Subpart C, as well as consideration of inventory uncertainty through use of multipliers in its probabilistic modeling. NRC staff will continue to monitor DOE's inventory development for the purpose of performance assessment calculations under Monitoring Factor 1.1, "Final Inventory and Risk Estimates". However, because the probabilistic analysis is not strictly relied on, but rather, informs the demonstration of compliance of Tank Farm facilities with the performance objectives in 10 CFR Part 61, Subpart C, technical concerns related to development of inventory multipliers can be addressed as a longer-term activity under Monitoring Factor 6.2 "Model and Parameter Support".

With regard to DOE's change in iodine distribution coefficient, NRC staff concludes that the revised values are not adequately supported. Given the potential risk-significance of the iodine distribution coefficient to the compliance demonstration for multiple facilities at the SRS, including the Saltstone Disposal Facility, NRC staff needs DOE to provide additional information to support its selection of distribution coefficient.

The uncertainty in the performance assessment results based on assumptions made in the annular waste release model are expected to be especially risk-significant (i.e., order of magnitude or more impact on peak dose from the HTF). The technical issues with respect to the iodine distribution coefficient are expected to be less risk-significant (i.e., less than an order of magnitude impact on peak dose); however, the risk-significance of this parameter value could increase should DOE increase the value of the parameter value or make other changes to its model that influence the impact of the distribution coefficient on the results. The risk-significance of other changes to the HTF performance assessment model are discussed in more detail in separate technical review reports, as discussed above.

Enclosure:
Technical Review of the
Tank 16H Special Analysis

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Enclosure:
Technical Review of the
Tank 16H Special Analysis

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Technical Review of Special Analysis for Tank 16H

Date: October 30, 2015

Reviewers

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Primary Document

SRR-CWDA-2014-00106, Revision 1, "Tank 16 Special Analysis for the Performance Assessment for the H-Tank Farm at the Savannah River Site", Savannah River Remediation, LLC, Closure and Waste Disposal authority, Aiken, South Carolina, February 2015.

Summary of Technical Reports

SRR-CWDA-2014-00106, Revision 1, "Tank 16 Special Analysis for the Performance Assessment for the H-Tank Farm at the Savannah River Site", February 2015.

The Tank 16H Special Analysis updates the H Tank Farm (HTF) Performance Assessment (PA) model (SRR-CWDA-2010-00128, Rev. 1), including: (i) an updated inventory, (ii) separation of the annulus and sand pad inventories, (iii) updated sorption coefficients for iodine, (iv) a sensitivity analysis for annular release, (v) the use of a revised dose methodology, and (vi) a correction to the H-Tank Farm model. The results from the Tank 16H Special Analysis show the projected peak dose within 100,000 years to be approximately 0.02 mSv/yr (2 mrem/yr) from I-129 occurring at around 4,000 years after closure (see Figures 1 and 2).

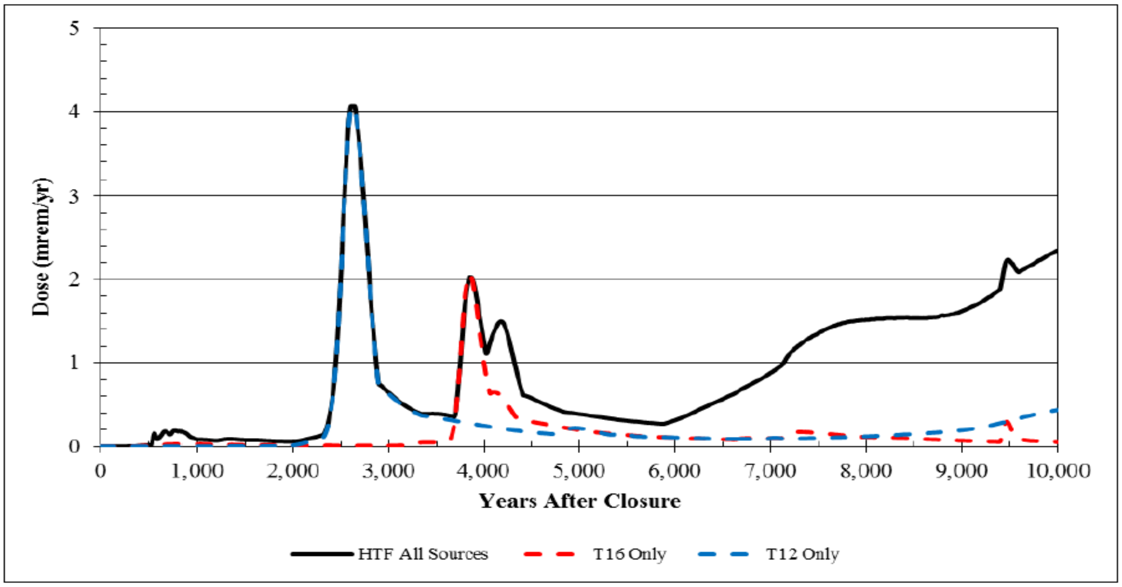

Figure 1. 100-Meter MOP Groundwater Pathway Dose within 10,000 Years (SRR-CWDA-2014-00106, Revision 1, Figure 6.4-11)

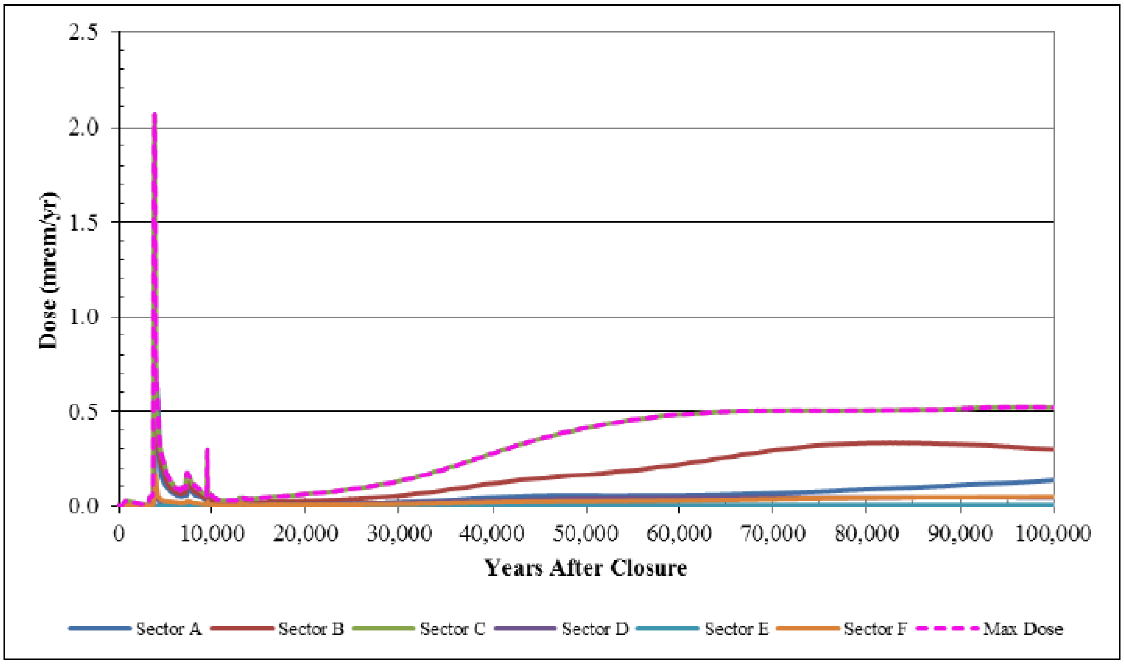

Figure 2. 100-Meter MOP Groundwater Pathway Dose within 100,000 Years for Each Sector - Tank 16H Contribution Only (SRR-CWDA-2014-00106, Revision 1, Figure ES-2)

Inventory

The H-Area Tank Farm Waste Tank Closure Inventory report (SRR-CWDA-2010-00023, Revision 4) provides the radiological characterization at the presumed date of closure for use in the Performance Assessment model. Revision 4 of this report updates the inventories for Tanks 16H and 12H to reflect the final inventory determination for Tank 16H and new inventory information for Tank 12H. In addition, the annulus and sand pad inventories for Type I and II tanks have been updated with final Tank 16H sampling and analysis results and volume estimates. This document also provides information regarding inventory multipliers to account for uncertainty in projected inventories. The inventory adjustments made in this report are incorporated into the HTF modeling in the Tank 16H Special Analysis.

Of the 54 initial radionuclides remaining following initial screenings, 15 additional radionuclides were eliminated from future consideration for Tank 16H based on characterization data. These radionuclides are Ac-227, Al- 26, Eu-152, Eu-154, H-3, Pd-107, Pt-193, Ra-228, Se-79, Sm-151, Sn-126, Th-229, Th-232, U-232, and U-236. These radionuclides were screened out because the activity anticipated to remain after operational closure is not expected to contribute to radiological impacts.

As discussed in more detail in the Tank 16H Inventory technical review report (ML15301A830), the volume of Tank 16H was updated to reflect the final volume determination of (1.2m^3) 330 gal for the tank floor and (7.2 m^3) 1,910 gallons in the annulus. Also, the residual material volume from the equipment in the Tank 16H primary tank, (0.1 m^3) 26.3 gallons, was added to the Tank 16H floor volume to give a final residual material volume of the Tank 16H floor of approximately 1.3 m^3 (356 gal). The volume of the primary sand pad is still assumed to be 5 m^3 (1,300 gal) and the secondary sand pad is still assumed to be 0.1 m^3 (26 gal). Final residual volume estimates for the primary tank and annulus used in Tank 16H Special Analysis (SRR-CWDA-2014-00071) versus the HTF PA estimates are shown below in Table 1. Details regarding the statistical analysis for the final concentrations assumed for the Tank 16H primary floor and annulus are contained in SRNL-STI-2014-00321. The concentrations in the Tank 16H primary and secondary sand pads are assumed to be the same as those in the Tank 16H annulus. Tables 5.01, 5.03, 5.05, and 5.06 in the Tank 16H Special Analysis provide the final residual inventories at final facility closure for the waste tank, annulus, primary, and secondary sand pads, respectively. Table 2 provides a summary of the potentially risk-significant increases in radionuclide inventories compared to the inventory assumed in the HTF performance assessment.

Table 1. Tank 16H Residual Volume Estimates (gal)*

Tank 16H	HTF PA	Tank 16H SA
Primary Tank	300	330
Annulus	3,300	1,900
* To convert gal to m^3, multiply by 3.8×10^{-3}		

Table 2. Potentially risk-significant increases in radionuclide inventories

Tank 16H Primary Liner Radionuclide Inventory (Ci)*

Element	HTF PA	Tank 16H SA	Factor Increase
I-129	5.3E-5	1.3E-3	25
Sr-90	2.2E3	9.4E3	4
* To convert Ci to Bq, multiply by 3.7×10^{10}			

Tank 16H Annulus Radionuclide Inventory (Ci)

Element	HTF PA	Tank 16H SA	Factor Increase
I-129	1.7E-4	7.9E3	46

Tank 16H Primary Sand Pad Inventory (Ci)

Element	HTF PA	Tank 16H SA	Factor Increase
I-129	6.9E-5	5.4E-3	78
Pu-239	1.4E0	3.2E0	2
Sr-90	3.1E3	6.9E3	2

Tank 16H Secondary Sand Pad Inventory (Ci)

Element	HTF PA	Tank 16H SA	Factor Increase
I-129	1.4E-6	1.1E-4	79
Pu-239	2.9E-2	6.4E-2	2
Sr-90	6.3E1	1.4E2	2

Using the latest sample results from the Bulk Oxalic Acid Cleaning and the preliminary volume estimates, DOE adjusted the assigned inventory for Tank 12H. Although final statistical analysis of the Tank 12H residual samples had not been completed at the time of this report, the updated inventory incorporated knowledge from process samples taken during cleaning. The changes are summarized in an Appendix to this TRR. The final inventory for Tank 12H will be evaluated by the NRC staff in a separate technical review report.

To account for uncertainty in the inventory, multipliers between 0.01 and 10 were applied to the assigned inventories for each radionuclide in the HTF PA. The radionuclide inventory multipliers were modeled with a log uniform distribution to account for a range of values. The maximum of the distribution is either 1 (if the radionuclide was not detected and the inventory was based on the detection limit) or 10 (if the radionuclide was detected). DOE compares the Tank 16H final inventory values to the assigned HTF PA inventory values. For all constituents the maximum underestimates are close to a factor of 10. DOE does not apply uncertainty factors to the primary or secondary sand pad inventory or ancillary equipment inventory. DOE states that the peak dose is driven by the inventory in the primary tank and annulus as opposed to the sand pads and there is a lack of data to define the uncertainty in these components.

Waste Release

In addition to the updated inventories, revisions to the HTF PA model in the Tank 16H Special Analysis include: (i) segmentation of the annulus inventories in the PORFLOW transport model, (ii) updated K_d values for iodine, (iii) a revised dose calculation methodology, and (iv) new sensitivity analyses related to radionuclide release from the annulus and sand pads.

For the Type I and II tanks, which includes Tank 16H, the bottom half-inch of the "ANNULUS_GROUT" was defined as a new distinct material zone "ANN_WASTE". The "ANN_WASTE" zone was assigned the same physical properties as the "CONTAM_ZONE", which is located inside the primary liner, and with Reduced Region II cement K_d values and no solubility control. As with the "CONTAM_ZONE" and overlying reducing tank grout, the "ANN_WASTE" zone Eh and pH transitions are linked to the overlying "ANNULUS_GROUT".

DOE conducted a sensitivity analysis to address NRC staff concerns (see NRC Staff Evaluation section of this report) related to the risk associated with preferential pathways and contamination located outside of the primary containment in several tank annuli in HTF, including Tank 16H. This analysis is referred to as the alternate fast zone (AFZ) submodel, which is carried out using the updated HTF GoldSim SRS HTF v1.010 Rad model. The AFZ for Type I and II tanks includes several updates, as described in Section 6.4.6.3 in the Tank 16H Special Analysis and is summarized below:

- Groundwater flow into and out of the tank system is through the upgradient and downgradient construction seams, respectively.
- For the Type I tanks, groundwater flows circumferentially around the annulus (see Figure 6.4-15 in the Tank 16H Special Analysis).
- For the Type II tanks, groundwater traverses the annulus grout and the primary sand layer (see Figure 6.4-16 in the Tank 16H Special Analysis).
- Flow through the pathway is controlled, in part, by a 1% hydraulic gradient between the most upgradient and downgradient portions of the tank system.

- Hydraulic conductivities through the pathway are based on the time-dependent hydraulic conductivities used for the annulus grout in the HTF PORFLOW base case.
- The construction joint does not act to limit flow through the preferential pathway.
- Flow through the preferential pathway is limited by the annulus grout.
- All cementitious materials, which are subject to sorption, are assumed to be oxidized and use the K_d values for Oxidized Region III.
- The sand pad contamination zones are not assumed to be subject to sorption.

DOE evaluated the release of Sr-90 and Cs-137 for an HTF Inadvertent Human Intruder (IHI), because of the short half-life of these radionuclides relative to the travel time to the 100-m boundary. DOE's AFZ analysis indicated that the release of Sr-90 and Cs-137 from the annulus has a negligible impact on doses when compared to the HTF PA Base Case. The AFZ analysis also demonstrated that the assumption of a low hydraulic conductivity of the annulus fill grout, which is assumed to be 2.1E-9 cm/s from 0 to 5,100 years, allows for the decay of Sr-90 and Cs-137 prior to release. DOE also stated that even if a continuous zone of high conductivity could occur, the source exposure area would have to be unrealistically large to produce significant radionuclide releases. Accordingly, DOE concluded that the HTF PA Base Case model provides reasonable assurance of meeting the performance objectives.

Far-Field Transport

In the Tank 16H Special Analysis, K_d values for iodine in the natural environment were updated based on recent observations and research (SRNL-STI-2012-00518). Previously, DOE assumed that all of the iodine in the natural environment exists as iodide. However, Otosaka et al. (2011) observed that iodine existed in F-Area Seepage Basin wells as iodide (15%), iodate (42%), and organo-iodide (43%), including "background" wells that were considered representative of the far-field at F-Area. Based on these observations and subsequent research, which included laboratory experiments to study the sorption of iodide and iodate, K_d values for iodine were increased from 0.3 mL/g to 1 mL/g for sandy soils and from 0.9 mL/g to 3 mL/g for clayey soil[1].

Revised Dose Methodology

DOE has revised its dose methodology for all liquid waste performance assessments at SRS and documented the approach and parameter values in SRR-CWDA-2013-00058. DOE's approach remains generally consistent with past approaches. The NRC staff plans to develop a TRR in the future that documents its review of the revised methodology. The NRC staff's review will follow-up on concerns identified during previous reviews, such as DOE's basis for drinking water consumption rates, selection of plant types and associated transfer factors treatment of uncertainty in plant transfer factors, and any significant changes in the revised dose methodology from previous PAs, including DOE's use of per-capita consumption rates and age- and gender-weighting of dose conversion factors.

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[1] It is important to note that only the Gordon Confining Unit and backfill are assigned the material property of clayey soil in the far-field and near-field models, respectively, and the clayey soil distribution coefficient is expected to have minimal impact on transport from H-Area Tank Farm sources to the compliance boundary based on previous NRC reviews.

NRC Staff Evaluation

Inventory

The updated inventories used in the Tank 16H Special Analysis are an improvement to the projected inventories used previously. Nonetheless, post-waste retrieval inventories should still be considered estimates, because radionuclide concentrations and waste volumes remaining in the tanks after waste retrieval operations are completed are uncertain. Given the final inventories of cleaned tanks are uncertain, it is not clear to the NRC staff that inventory uncertainty is properly managed for cleaned tanks in deterministic analyses (e.g., the reference case volume is expected to have a significant amount of uncertainty associated with it, yet “best estimates” of volume that may be biased low are used to determine the residual waste inventory). Potential issues with sample representativeness discussed in the Tank 16H Inventory technical review report (ML15301A830) may lead to an under-estimate (or over-estimate) of residual waste concentrations for key radionuclides in the Tank 16H annulus. DOE should consider whether it has appropriately managed volume and sampling and analysis uncertainty in the deterministic reference case relied on to demonstrate compliance with the performance objectives.

Table 5.0-1 in the Tank 16H Special Analysis indicates that key radionuclides such as I-129 and Sr-90 in the primary liner of Tank 16H were significantly underestimated by factors of 25 and 4, respectively. The annular inventory for I-129 is also significantly underestimated by almost a factor of 50[2]. During the July 28-29 Onsite Observation Visit (ML15239A628), NRC staff inquired about the cause of this underestimation and the potential for the inventory in other tanks to be similarly underestimated. DOE responded that I-129 in the tanks had been assumed to be soluble, but appears to be in a less mobile form. DOE indicated that it is unclear if the iodine has been present in a less mobile complex, if the cleaning process resulted in a less mobile form (e.g., iodate), or if the iodine was taken up by silver or mercury. As discussed further in the far-field evaluation section, it is unclear to NRC staff in what chemical form the iodine exists in the tank and annulus of Tank 16H and how that chemical form may change under grouted conditions. Additionally, it is unclear to NRC staff what chemical form iodine may exist in the far-field of H-Tank Farm Facility following release from the engineered system. DOE was unable to offer a clear explanation for the underestimation of the inventory of Sr-90 in both the primary liner and sand pads of Tank 16H in the July 28-29 Onsite Observation Visit.

During the July 28-29 Onsite Observation Visit (ML15239A628), NRC also inquired about the basis for the revision of the residual waste volume in the Tank 16H annulus from 3,300 gal to 1,900 gal. DOE discussed that the revised inventory was determined, in part, by marking the shaft of an auger tool when the top and bottom of the waste was reached, to estimate the waste thickness. As the previous thickness was based primarily on visual observation, DOE indicated that it has more confidence in the volume estimates based on measured values. NRC staff discusses technical concerns related to DOE’s waste sampling and analysis, and volume estimation methods used to develop the final inventory for Tank 16H in a separate technical review report (ML15301A830), focused primarily on the more risk-significant annular inventory.

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[2] It is important to note that the inventory of I-129 was underestimated by a factor of approximately 80 in the sand pads, which suggests that the I-129 concentration in the annulus of Tank 16H was even more grossly underestimated than the final inventory, but due to the decrease in the estimated annular waste volume, the increase in the I-129 inventory in the annulus was only a factor of about 50.

Although the estimate for the residual waste volume in the annulus has been reduced by more than 40%, a potentially risk-significant radionuclide inventory nonetheless remains.

DOE incorporates uncertainty into inventory projections for tanks that have not been cleaned through the use of inventory multipliers that range from 0.01 to 10 times the estimated inventory. The NRC staff has expressed concern in prior reviews with the use of a minimum inventory multiplier of 0.01, while the maximum inventory multiplier is 1 (for undetected radionuclides whose inventory is based on the detection limit) or 10 (for detected radionuclides) (ML13273A299). NRC staff notes that there were less cases in which radionuclide inventories were underestimated by more than a factor of 10 for Tank 16H than for Tanks 5F and 6F, but the example of the potentially risk-significant I-129 being underestimated for Tank 16H is an indication that the maximum multiplier of 10 may not be high enough to bound uncertainty. DOE should continue to compare the assigned PA inventory values and the final determined inventory values of operationally closed tanks to gauge the appropriateness of the multipliers. When radionuclides are significantly underestimated, DOE should make an effort to understand the reason for the underestimation by reviewing past sampling data and historical knowledge in order to better inform projected inventories for tanks that have not yet been cleaned. For example, DOE should address whether I-129 is potentially underestimated in other tanks that are yet to be cleaned.

Regarding the sand pad inventory for Type II Tanks, NRC staff notes that a lack of data on the uncertainty for the sand pads is not a good basis for lack of consideration of inventory uncertainty. There is uncertainty surrounding the concentration of the material in the annulus. Any waste material that may have migrated from the annulus to the primary and secondary sand pads in Tank 16H following the 1960 leakage event was not directly contacted in subsequent annulus waste retrieval campaigns, and therefore, may have higher concentrations of more soluble materials. Furthermore, the material in the sand pad does not have any silica additions from sandblasting. The silica increased the volume of waste in the annulus which may have lowered the concentrations of waste materials in the annulus. On the other hand, formation of less soluble, sodium aluminum silicate compounds may have increased concentrations of certain key radionuclides. Considering all of the tank inspection and cleaning activities conducted in the annulus of Tank 16H, it is unclear if the concentrations of individual key radionuclides in the annulus relative to the concentrations in the sand pad are higher or lower. For example, as described in WSRC-STI-2008-00203, the concentrations in the interior of the dehumidification duct (which does not have any silica content) contains more water soluble material than the other two samples from outside the duct as might be expected because this material would be less accessible to the washing/waste removal done in the annulus in the past.

The secondary sand pad inventory is assumed to be 0.1 m^3 (26 gal) as an estimate of what was potentially released into the environment. The NRC staff believes that uncertainty in the secondary sand pad inventory should be considered. According to DP-1358, a maximum of 2.6 m^3 (700 gal) of waste rose above the top of the secondary containment pan of Tank 16H for about six hours on September 8, 1960. From this information, the uncertainty should be bounded by the maximum amount that rose above the secondary containment pan instead of relying on the deterministic value of 0.1 m^3 (26 gal), which represents 10 gallons more than the estimated void volume of the vault construction joint that was implicated as the release pathway from the Tank 16H annulus to the environment.

Still, the deterministic inventories assumed for the primary sand pads in Tanks 14H and 16H are likely biased high by the assumption that the entire sand pad pore volume is assumed to be saturated with residual material. For Tanks 13H and 15H, DOE assumes that a smaller volume (0.378 m^3 (100 gal)) is in the primary sand pad layer because DOE believes the amount of material that leaked from the primary tank is limited, and therefore, not much material reached the sand pad. The cleaning of Tanks 13H and 15H will not provide additional information on the amount of material that leaked from the primary tank into the annulus and then the sand pads, because the sand pads are not directly accessible. DOE should address whether the deterministic estimates for the sand pads in these tanks reasonably bound the uncertainty given that no multipliers are assumed for the sand pads and the volumes are unlikely to change.

NRC staff will continue to monitor DOE's parameterization of final radionuclide inventories in special analyses under Monitoring Factor 1.1, "Final Inventory and Risk Estimates" listed in NRC staff's plan for monitoring at the Tank Farm Facilities (ML15238B403). NRC will also continue to monitor DOE's basis for concluding that all potentially risk-significant radionuclides have been identified and are targeted for analysis under Monitoring Factor 1.2, "Residual Waste Sampling."

In summary, NRC staff has technical concerns related to DOE's management of inventory uncertainty in the deterministic modeling used to demonstrate compliance with the performance objectives in 10 CFR Part 61, Subpart C, as well as consideration of inventory uncertainty through use of multipliers in its probabilistic modeling. NRC staff will continue to monitor DOE's inventory development for the purpose of performance assessment calculations under Monitoring Factor 1.1, "Final Inventory and Risk Estimates". However, because the probabilistic analysis is not strictly relied on, but rather, informs the demonstration of compliance of Tank Farm facilities with the performance objectives in 10 CFR Part 61, Subpart C, technical concerns related to development of inventory multipliers can be addressed as a longer-term activity under Monitoring Factor 6.2 "Model and Parameter Support" in the NRC staff's plan for monitoring SRS Tank Farm Facilities (ML15238B403).

Waste Release

In the Tank 16H Special Analysis, DOE redefines the bottom half inch of the previous "ANNULUS_GROUT" zone as the "ANN_WASTE" zone; however, DOE indicates the same material properties assumed for the "CONTAM_ZONE" are applied to the "ANN_WASTE" ZONE, or Reduced Region II[3] sorption (but no solubility control). In the base case analysis, chemical transitions in the "ANN_WASTE" zone are dictated by the overlying annulus grout. This assumption implies that the annulus waste and overlying grout are well-mixed, which is not supported, particularly for waste located in the annulus duct. Additional support is needed for the base case assumption that annular grout will represent a significant barrier to key radionuclide release from the annulus.

DOE simulated an alternate fast zone conceptual model as reported in the Tank 16H Special Analysis to address NRC staff's TER recommendations related to the risk associated with the Tank 16H annulus and sand pads. However, the AFZ sensitivity analysis that was conducted in the Tank 16H Special Analysis does not adequately address the concerns raised in NRC staff's Technical Evaluation Report (TER) for the HTF (ML14094A496). Namely, in Sections 4.2.9.3 and 4.2.9.4 of the HTF TER, NRC staff states the following:

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[3] In the alternate fast zone analysis, DOE assumes oxidized region III conditions for the cementitious materials.

- "The NRC staff is concerned that risk from the radionuclide inventories outside of the primary liners is not adequately accounted for in DOE's analyses. The NRC staff recommends that DOE conduct a more comprehensive analysis of the *potential release of radionuclides from the annuli and sand pads in the Type I and Type II tanks*. Implementation of this recommendation is necessary for the NRC staff to have reasonable assurance that the performance objectives in 10 CFR Part 61, Subpart C can be met. Dose projections from the potential release of the radionuclides in the annuli and sand pads are likely to be very sensitive to several key assumptions, which should be well supported. These assumptions include, but are not limited to (1) the assumed release scenario; (2) the chemical composition of the infiltrating water; (3) the volumetric flow rate through grouted tanks, including *shrinkage gaps and cracks*; and (4) the solubility of the annulus and sand pad waste. If the possibility of *rise and fall of the water table* in the vicinity of the Type I and II tanks cannot be excluded, DOE should *evaluate a scenario where water drains from any gaps in the annulus and sand pad* regions."

- "Grouting of the tanks and annuli will help limit the presence of preferential pathways; however, *grout shrinkage and degradation are likely to result in preferential pathways*."

- "Grouting of the tanks and annuli will help limit the presence of preferential pathways and the hydraulic head associated with the fully and partially submerged tanks; however, grouting will not necessarily eliminate flow. Because of the activity of key short lived (e.g., Cs-137, Sr-90) and *long-lived radionuclides (e.g., Pu-239)* in the annulus and sand pads and the high solubility of this waste (Section 3.4.2.2; SRR-CWDA-2010-00128, Rev. 1) even minimal flow through the grouted annuli and sand pads could result in a significant dose."

The AFZ analysis implemented by DOE does not address all of NRC staff's TER recommendations made during consultation. Namely, DOE (i) did not evaluate the impact of shrinkage gaps and cracks in the grouted annulus, but instead assumed that the annular grout constituted a barrier to flow, thereby effectively eliminating the impact of preferential flow through the annulus, (ii) did not evaluate the impact of rise and fall of the water table, which NRC staff thinks could result in the greatest risk associated with waste in the annulus and sand pads, and (iii) did not evaluate long-lived radionuclides (e.g., Np-237, Pu-239).

The assumption that the annulus grout is a significant flow barrier is problematic in this sensitivity case. NRC staff intended for DOE to run a case with a preferential pathway through the entire tank system, and not simulate a low conductivity grout that restricts flow in the preferential pathway through the annulus. Unless it can be demonstrated that shrinkage or cracking will not occur in the grout annulus, NRC staff continues to recommend that DOE evaluate radionuclide release from the annulus and sand pads with a continuous preferential pathway. Secondly, DOE assumes that the fast pathway is saturated with a 1% hydraulic gradient between the most upgradient and downgradient portions of the tank system (see Figure 3, Scenario 1). In the July 28-29, 2015, Onsite Observation Visit (ML15239A628), NRC staff reiterated their concern of the risk associated with the potential rise and fall of the water table. NRC staff thinks that the rise and fall of the water table is likely to be more risk significant for radionuclide release from the annulus than under a saturated flow condition. A rise and fall of the water table could be simulated with a unit hydraulic gradient (versus 0.01) and likely corresponds to a greater volume of water contacting the residual waste in the annulus (see

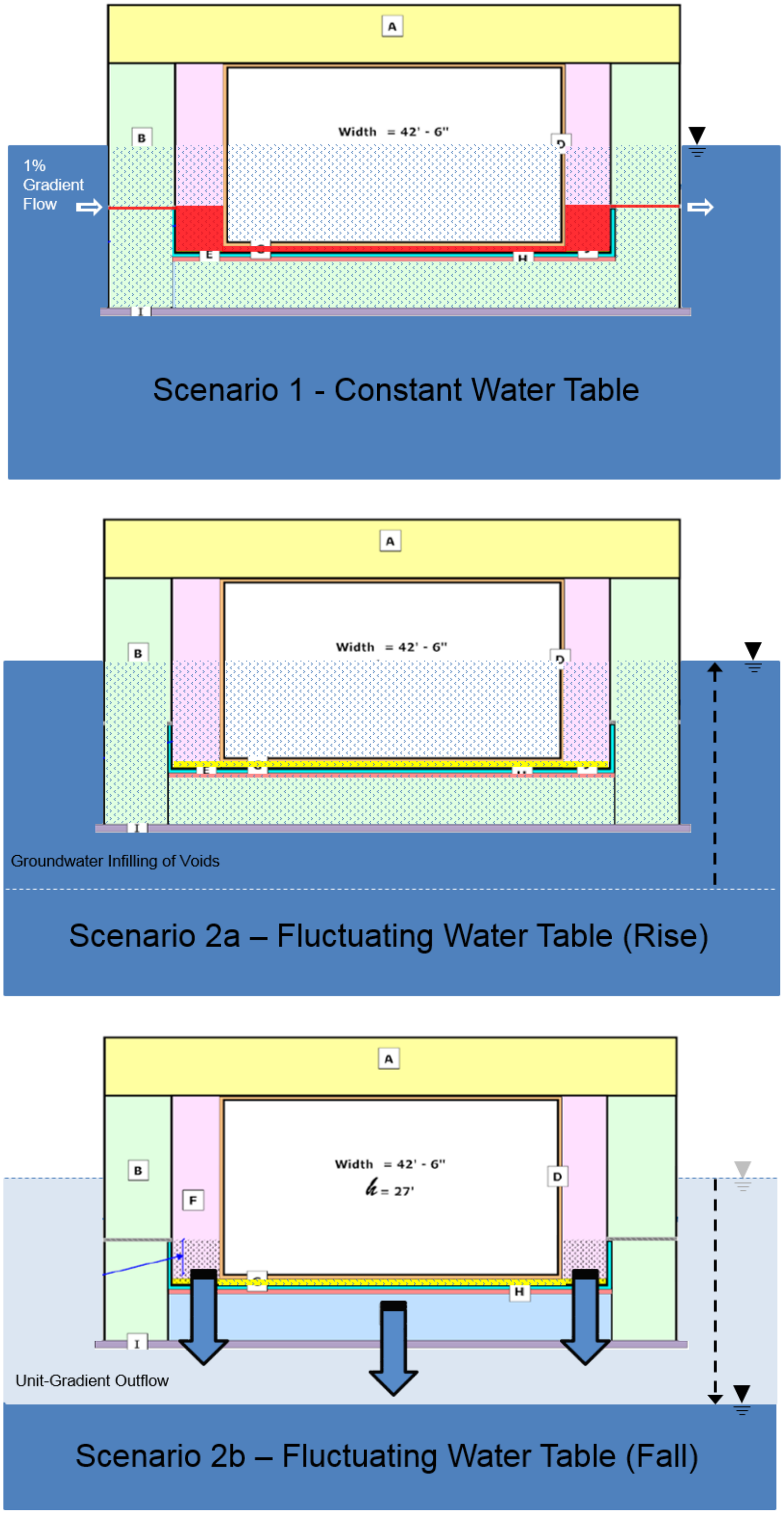
Figure 3, Scenarios 2a and 2b). If the possibility of this scenario cannot be excluded, it should be evaluated by DOE. In addition, the basis for the 1% hydraulic gradient to represent the potential across the resistive engineered barrier is not clear. If DOE relies on the AFZ analysis with the 1% hydraulic gradient, additional information should be provided to support this value. Lastly, the inventories of long-lived radionuclides (e.g., Pu-239, Np-237) are potentially risk significant and should be included in the AFZ analysis. Based on these limitations of the AFZ analysis, NRC staff concludes that DOE's Tank 16H Special Analysis does not adequately evaluate the potential risk associated with the Tank 16H annulus and sand pads. To address this technical issue, DOE could run additional simulations that consider the essential elements listed in the bullets above (e.g., consideration of shrinkage gaps, rise and fall of the water table, and long-lived radionuclides).

NRC staff concerns related to DOE's 10 CFR 61.41 compliance demonstration for the H-Tank Farm are also relevant to 10 CFR 61.42 compliance demonstration, because of the groundwater pathway (see Sections 4.2.16 and 4.2.17 of the NRC staff's HTF TER, ML14094A514). Further, NRC staff continues to have concerns with the disproportionate risk that short-lived radionuclides (e.g., Sr-90, Cs-137) may pose for inadvertent intruders at the 1-m boundary.

Related to the AFZ analysis, DOE discussed that even if a continuous zone of high conductivity could occur, an unrealistically large source area would have to be exposed for significant radionuclide release. NRC staff agrees that source contact area could be limited in the vadose zone. However, it is unclear to NRC staff that the residual annulus waste in Tank 16H would not be significantly contacted during saturated or partially saturated conditions.

DOE added the capability to import diffusion data in the updated GoldSim model; however, DOE does not appear to use PORFLOW inputs or otherwise consider diffusion in the alternate fast zone model implemented in GoldSim (e.g., SRR-CWDA-2014-00060 indicates that no diffusion data were imported from PORFLOW and no results from PORFLOW were used in the alternate fast zone calculations). Comparisons against PORFLOW simulations showed that the alternate fast zone model oftentimes under-predicted the release due to the lack of consideration of diffusion through the wall. If diffusion could be an important transport mechanism controlling the release of radioactivity from the engineered system, DOE should consider diffusive transport through the engineered materials.

During the July 28-29, 2015, Onsite Observation Visit (ML15239A628), NRC inquired as to the adequacy of the GoldSim model in accurately simulating the impact of preferential pathways through the engineered system without additional PORFLOW analysis and abstraction. DOE responded that PORFLOW simulations helped inform the GoldSim model, although PORFLOW information was not directly used in the GoldSim calculations. The GoldSim model relied on spreadsheet calculations for flow fields. DOE should consider whether a more complex model is needed to evaluate the impact of alternative conceptual models for annular waste release.


Scenario 1 - Constant Water Table

Scenario 2a – Fluctuating Water Table (Rise)

Scenario 2b – Fluctuating Water Table (Fall)

Figure 3. Water movement through grouted tank system under constant and fluctuating water table scenarios (adapted from SRR-CWDA-2014-00106)

Far-Field Transport

The revised sediment K_d values[4] for iodine are based on field observations and recent experimental data. The observations from the F-Area Seepage Basins show that iodine exists in the subsurface as iodate and organo-iodine, in addition to iodide. The NRC staff agrees that the potential exists for I-129 released from the tank farms to be converted from iodide to iodate and organo-iodide. However, NRC staff have several concerns related to the level of support for the revised K_d values related to: (i) the stability of iodate, (ii) the use of a composite K_d value to represent multiple iodine species, (iii) an apparent disconnect between pH, speciation, and sorption, (iv) the spatial and temporal variability of field conditions, (v) representativeness of F-Area Seepage Basin aquifer sediments to the SRS Tank Farm far-field environments, and (vi) chemical form of iodine expected to be released from the tanks.

- Figure 8 in SRNL-STI-2012-00518 shows the measured K_d values for iodide and iodate at weeks 8 and 12. Although the iodide appears to be stable, the K_d values for iodate decrease significantly between weeks 8 and 12, which is consistent with iodate gradually converting to iodide. Additional information is needed to evaluate the conditions under which more strongly sorbing iodate and organo-iodine species are stable in the far-field at the SRS Tank Farm Facilities.

- In SRNL-STI-2012-00518, the authors calculate a composite K_d value to represent different species of iodine as a model simplification because the PA modeling currently considers only a single iodine K_d value. If the mechanisms of iodine sorption are not well understood or well represented in the performance assessment model, there is a potential to significantly under-estimate the dose associated with iodine through use of a composite K_d. NRC staff previously identified issues associated with plutonium K_d averaging (see Appendix E of the SRS Tank Farm Facilities Monitoring Plan-ML15238B403). While the impact of K_d averaging may be minimal for the relatively low values of distribution coefficient selected for use in the Tank 16H Special Analysis for iodine, the impact of K_d averaging should be evaluated to support the approach used in the Tank 16H SA.

- In SRNL-STI-2012-00518, the authors discuss that iodate is favored under more neutral and basic environments (e.g., pH>6) versus more acidic environments (e.g., pH<4) and that elevated iodate concentrations are consistent with increased sorption. However, the sorption of both iodide and iodate decreases significantly starting at pH 4 and tends towards zero as the pH approaches 6.75. Accordingly, the pH condition that support the stability of iodate might only narrowly intersect with the pH environment where the sorption of iodine species is non-negligible. For example, the background pH in non-impacted SRS groundwater is approximately 5-6, and iodine release from the grouted tank system is expected to occur in a pH that ranges from 9 to 11.

- Table 2 from Otosaka et al. (2011) and summarized again in Table 8 of SRNL-STI-2012-00518, shows that the speciation of iodine between the three "background" wells for the F-Area Seepage Basins is highly variable. It is unclear to NRC staff how spatial and temporal variability in chemical conditions in the engineered and natural system at the F- and H-Area Tank Farms, may influence the speciation, and therefore sorption, of iodine. The speciation of iodine appears to very sensitive to a complex series of interdependent

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[4] The revised iodine K_d values result in approximately a factor of two decrease in the projected dose due to I-129.

variables: pH, Eh, presence of organic matter and microbial activity. Additional support should be provided for the spatial and temporal stability of iodate under field conditions, including the influence of cementitious materials on aquifer pH.

- As indicated in SRNL-STI-2012-00518, the clay content of SRS soils is important to iodate sorption because it has organic matter and the mechanism for sorption is the binding to the organic matter. It is unclear if the "background" wells at the F-Area Seepage Basin are similar in composition to the soils in the far-field environments of F- and H-Area with respect to clay content.

- SRNL-STI-2012-00518 indicates that once iodide was added to the SRS subsurface sediment ("North Borrow" sediments), negligible amounts of iodate were formed. Additionally, due to the very low sediment organic matter concentrations, little organo-iodine was observed in the aqueous phase. The experiments in SRNL-STI-2012-00518 do not appear to be consistent with the observations at the "background" wells at F-Area Seepage Basin reported in Otosaka et al. (2011). Additional information is needed to better understand the conditions where more strongly sorbing forms of iodine are stable in the environs of the Tank Farm Facilities. Additionally, the chemical form of iodine in the tank waste may be an important factor with respect to the speciation of iodine in the natural system once released from the engineered system. Additional information is needed on the chemical forms of iodine expected in the residual tank waste at the time of closure and how this chemical form may change over time.

Kaplan et al. (2011) discusses that only under extremely oxidizing conditions should iodine exist as iodate in the terrestrial environment. While the field data reported in Otosaka et al. (2011) show significant fractions of iodate present at less than extremely oxidizing conditions, oxidation of iodide to iodate raises a potential concern. If the environmental conditions are sufficiently oxidizing to result in the formation of iodate, NRC staff are concerned that other redox-sensitive radionuclides (e.g., Pu) could be transported more quickly in the environment than assumed in the FTF and HTF PAs. DOE discussed during the Onsite Observation Visit (ML15239A628) that they are working on an update to a site-wide K_d report, which will also include data from the lysimeter study. NRC staff review of the updated K_d report will be conducted under Monitoring Factor 4.1, "Natural Attenuation of Key Radionuclides."

During the July 28-29, 2015, Onsite Observation Visit (ML15239A628), NRC staff commented that the conceptual model for the different configurations is not clear in the probabilistic model (i.e., it was not clear if the conceptual models defined in deterministic modeling were preserved in the probabilistic modeling). For example, the probabilistic models vary (i) Case, (ii) cement degradation times, and (iii) steel liner failure times. In the deterministic modeling, DOE assumes that in certain Cases (e.g., Cases C and E that include a preferential pathway and the cement degradation times are relatively prolonged, similar to the base or reference case), flow occurs primarily through the preferential pathway and not the overlying reducing tank grout, leading to faster chemical transitions (e.g., faster transition from reducing to oxidizing conditions that can lead to higher solubility of key radionuclides). Because both the (i) Case and (ii) the cement degradation times vary in the probabilistic model, the underlying conceptual models defined in the deterministic modeling are ambiguous. NRC staff asked DOE to clarify what material controlled the chemistry of the contaminated zone in the probabilistic model. DOE took NRC's question as a follow-up action from the July 28-29 Onsite Observation Visit. Following the onsite observation, DOE provided a written response in SRR-CWDA-2015-00117. DOE responded that the flow rates through the materials, pore volume of the materials, and number of pore volumes to transition from reducing to oxidizing conditions and lower pH (based on geochemical modeling), determine the chemical state for the various materials (or segments), including the contaminated zone. NRC staff understood this response to mean that the overlying tank grout did not control the chemistry of the contaminated zone. This response is inconsistent with NRC staff's understanding of what was done for the deterministic modeling in the H-Tank Farm PA and the probabilistic modeling in the F-Tank Farm PA. For example, an assumption was made in the F-Tank Farm PA that the chemistry of the contaminated zone was controlled by the overlying grout for all cases except for Case G, which was run in response to an NRC request for additional information. Additionally, in the HTF performance assessment (deterministic model), the selection of Case (e.g., Case A-E) determines whether the chemical transition is controlled by the overlying tank grout (Cases A, B, and D) or whether the chemical transitions are rapid due to flow that occurs primarily through the preferential pathway (Cases C and E where limited groundwater conditioning via interaction with the reducing tank grout occurs). NRC staff plan to discuss this technical issue further with DOE in a subsequent teleconference or a future onsite observation visit.

Furthermore, because there is limited basis or support for the assigned probabilistic parameter distributions, the full range of plausible parameter space may not have been evaluated in the probabilistic analysis. Solubility, for example, is constrained to non-risk-significant values for most key radionuclides, although potentially risk-significant values for plutonium were observed in Tank 18 residual waste (ML12272A082). DOE has not demonstrated that the relatively high solubility plutonium phase(s) will be converted to a low solubility phase(s) under grouted conditions. DOE did evaluate in a deterministic sensitivity analysis (e.g., risk-significant Pu solubility was evaluated in the Tanks 18 and 19 Special Analysis for what was described as a "conservative Eh"), but this risk-significant solubility was not evaluated in the probabilistic assessment. Accordingly, it is difficult to draw conclusions from the probabilistic assessment.

Figures 5.3-1 through 5.3-4 in SRR-CWDA-2014-00060 provide results for the "all cases" and base case probabilistic models for either 1000 or 10,000 years. The results of the analyses reveal that Sr-90 is one of the key radionuclides contributing the largest doses in the analyses particularly over shorter evaluation periods. Although the mean doses are less than 1 mrem/yr, the results seem to indicate that for some realizations, Sr-90 dose can be risk-significant, and that short-lived radionuclides can drive the dose results. NRC staff plans to investigate these realizations in more detail and will discuss with DOE in a future teleconference or onsite observation.

Revised Dose Methodology

NRC staff will evaluate DOE's revised dose methodology in a future technical review report.

Follow-up Actions

NRC staff will continue to monitor DOE's parameterization of final radionuclide inventories in special analyses under Monitoring Factor 1.1, "Final Inventory and Risk Estimates" listed in NRC staff's plan for monitoring at the Tank Farm Facilities (ML15238B403).

Under Monitoring Factor 3.1, "Hydraulic Performance of Concrete Vault and Annulus (As It Relates to Steel Liner Corrosion and Waste Release" and Monitoring Factor 3.5, "Vault and Annulus Sorption", NRC staff will continue to monitor DOE's analysis of the potential release of radionuclides from the annulus and sand pads, including: (i) a continuous preferential pathway, (ii) a fluctuating water table, and (iii) long-lived radionuclides. NRC staff will also evaluate DOE's implicit assumption that the annulus waste and overlying grout is well-mixed.

Although not specifically listed under Monitoring Factor 4.1, "Natural Attenuation of Key Radionuclides," NRC staff will monitor DOE's development of information to support the sorption of iodine in the natural environment based on its risk significance.

Open Issues
There are no Open Issues.

Conclusions
As a result of the review of several DOE documents that support the Tank 16H Special Analysis and discussions with DOE during the July 28-29 Onsite Observation Visit, the NRC staff concludes that the Tank 16H Special Analysis provides useful information on the potential risks associated with Tank 16H. However, the NRC staff also concludes that additional information related to the release of radionuclides from the annulus is needed to have reasonable assurance that DOE disposal actions at the HTF will meet the performance objectives in 10 CFR Part 61, Subpart C. To reach these conclusions, the NRC staff focused on a number of areas listed in the SRS Tank Farms Monitoring Plan (ML15238B403) related to Monitoring Factor 1.1, "Final Inventory and Risk Estimates", Monitoring Factor 3.1, "Hydraulic Performance of Concrete Vault and Annulus (As It Related to Steel Liner Corrosion and Waste Release)", Monitoring Factor 3.5, "Vault and Annulus Sorption", and Monitoring Factor 4.1, "Natural Attenuation of Key Radionuclides" as detailed in NRC staff's plan for monitoring the SRS Tank Farm Facilities.

With respect to Monitoring Factor 1.1, NRC staff has technical concerns related to DOE's management of inventory uncertainty in the deterministic modeling used to demonstrate compliance with the performance objectives in 10 CFR Part 61, Subpart C, as well as consideration of inventory uncertainty through use of multipliers in its probabilistic modeling. NRC staff will continue to monitor DOE's inventory development for the purpose of performance assessment calculations under Monitoring Factor 1.1, "Final Inventory and Risk Estimates". However, because the probabilistic analysis is not strictly relied on, but rather, informs the demonstration of compliance of Tank Farm facilities with the performance objectives in 10 CFR Part 61, Subpart C, technical concerns related to development of inventory multipliers can be addressed as a longer-term activity under Monitoring Factor 6.2 "Model and Parameter Support".

With regard to DOE's change in iodine distribution coefficient, NRC staff concludes that the revised values are not adequately supported. Given the potential risk-significance of the iodine distribution coefficient to the compliance demonstration for multiple facilities at the SRS, including the Saltstone Disposal Facility, NRC staff needss DOE to provide additional information to support its selection of distribution coefficient.

The uncertainty in the performance assessment results based on assumptions made in the annular waste release model are expected to be especially risk-significant (i.e., order of magnitude or more impact on peak dose from the HTF). The technical issues with respect to the iodine distribution coefficient are expected to be less risk-significant (i.e., less than an order of magnitude impact on peak dose); however, the risk-significance of this parameter value could increase should DOE increase the value of the parameter value or make other changes to its model that influence the impact of the distribution coefficient on the results. The risk-significance of other changes to the HTF performance assessment model are discussed in more detail in separate technical review reports, as discussed above.

Finally, technical concerns identified in the Tanks 18 and 19 Special Analysis (ML13100A230) and 5 and 6 Special Analysis (ML13273A299) Technical Review Reports are also relevant to the HTF performance assessment and Tank 16H Special Analysis and have not been repeated in this report.

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Appendix: Summary of Changes to Tank 12H Inventory in the Tank 16H SA

The H-Area Tank Farm Waste Tank Closure Inventory report (SRR-CWDA-2010-00023, Revision 4) provides the radiological characterization at the presumed date of closure for use in the Performance Assessment model. In addition to including final inventories for Tank 16H, Revision 4 of this report updates the inventories for Tank 12H based on new inventory information for Tank 12H. Although final statistical analysis of the Tank 12H residual samples had not been completed at the time of this report, the updated inventory incorporated knowledge from process samples taken during cleaning.

The Tank 12H inventory adjustments are based on Tank 12H heel material that will not be seen in the Type I and II tanks. Therefore, the inventory in Tank 12H is treated independently and is not part of the Type I and II tank grouping.

Of the original 54 radionuclides, the following 19 radionuclides have been screened out of future consideration for Tank 12H because the curies anticipated to remain after operational closure are not expected to contribute to radiological impacts: Ac-227, Al-26, Cf-249, Cf-251, Cl-36, Cm-247, Cm-248, Co-60, Eu-152, Eu-154, H-3, K-40, Pd-107, Pt-193, Pu-242, Pu-244, Se-79, Sm-151, and U-236.

The residual volume of the Tank 12H tank floor is adjusted to be 5.7 m^3 (1,500 gal). Also an estimated 1.5 m^3 (400 gal) of additional material is encrusted on the vertical cooling coils. The annulus is assigned a volume of 0.1 m^3 (25 gal) of dried salt material.

Radionuclides of interest which were increased include the following:

- Cs-137 was increased from 790 Ci to 2,500 curies to account for the material expected to remain after BOAC.
- I-129 was increased from 2.8E-04 Ci to 2.6E-02 Ci. DOE expects this to account for any additional I-129 in the Cooling Coil External Scale Material Inventory.
- Np-237 was increased from 0.21 Ci to 0.72 Ci.
- Pu-238 was increased from 6,500 Ci to 9,820 Ci.
- Pu-239 was increased from 80 Ci to 394 Ci.
- Pu-240 was increased from 50 Ci to 394 Ci.
- Pu-241 was increased from 760 Ci to 2,460 Ci
- Sr-90 was increased from 14,000 Ci to 130,000 Ci to account for material expected to remain after BOAC.
- Tc-99 was increased from 8.1 Ci to 12 curies to account for potential Tc-99 in the Cooling Coil External Scale Material Inventory.
- Th-232 was increased from 0.029 Ci to 0.055 Ci.
- U-232 was increased from the 2.10E-03 Ci to 2.10E-02 Ci.
- U-233 was increased from 0.59 Ci to 3.3 Ci.
- U-234 was increased from 0.096 Ci to 1.68 Ci.
- U-238 was increased from 0.029 Ci to 0.184 Ci.