NRC Staff Request for Additional Information on the Draft Basis for Section 3116 Determination and Associated Performance Assessment for the H-Area Tank Farm at the Savannah River Site

Executive Summary

In accordance with the Ronald W. Reagan National Defense Authorization Act (NDAA) for Fiscal Year 2005, Section 3116, certain waste from reprocessing of spent nuclear fuel is not high level waste if the Secretary of Energy, in consultation with the U.S. Nuclear Regulatory Commission (NRC), determines that the criteria in NDAA Section 3116(a) are met. According to the U.S. Department of Energy (DOE), the "Draft Basis for Section 3116 Determination for the Closure of H-Tank Farm at the Savannah River Site" (DOE/SRS-WD-2013-001, Rev. 0) (referred to herein as the draft Basis for Waste Determination), which was submitted to the NRC for review on February 6, 2013, demonstrates that the NDAA criteria are satisfied. The draft Basis for Waste Determination at the H-Area Tank Farm (HTF) addresses stabilized residuals in waste tanks and ancillary structures (including integral equipment) at the time of closure.

In order to fulfill its consultative responsibilities, the NRC staff is reviewing the draft Basis for Waste Determination in conjunction with its review of the "Performance Assessment for the H-Area Tank Farm at the Savannah River Site" (SRR-CWDA-2010-00128, Rev. 1) (referred to herein as the HTF Performance Assessment). The NRC review is conducted in accordance with NUREG-1854, "NRC Staff Guidance for Activities Related to U.S. Department of Energy Waste Determinations," Draft Final Report for Interim Use, August 2007.

The review of these documents and supporting reference material is being conducted by an NRC team of technical experts with expertise in earth and physical sciences as well as analytical modeling. In conducting the review, NRC staff also engaged DOE in a series of technical exchanges to clarify the approaches and rationales documented in the draft Basis for Waste Determination and Performance Assessment. These clarifications have enabled NRC staff to improve its understanding of the approaches and the supporting technical bases developed by DOE. The review of these documents informed by the clarifications from DOE during the technical exchanges has led to a number of comments on the technical bases for DOE conclusions in the draft Basis for Waste Determination.

The review focused on key differences between the F-Area Tank Farm (FTF) and HTF performance assessments and supporting information. The comments reflect those differences, because NRC staff has minimized the repetition of comments that were made during an earlier consultation for FTF. NRC staff has identified in this document those previous recommendations and comments that remain relevant for HTF, but does not expect DOE to provide additional information to address these previous recommendations and comments during the consultative process for HTF. However, DOE may elect to provide NRC additional information to address the recommendation or comment if available.

In summary, NRC staff has no comments on DOE's ability to meet NDAA Criterion 1 of Section 3116 that waste does not require permanent isolation in a deep geologic repository for spent fuel or high-level radioactive waste. NRC staff has several comments related to NDAA Criterion 2 that waste has had highly radioactive radionuclides removed to the maximum extent practical. These comments focus on DOE's approach for selection and application of cleaning technologies, as well as technology optimization and estimation of removal efficiency; the practicality of removing additional material from the Tank 16H annulus; the impact of oxalic acid cleaning; and the status of low-volume pump technology.

Finally, NRC staff has several comments related to NDAA Criterion 3 that waste will be disposed of in accordance with the performance objectives of 10 CFR Part 61, Subpart C. Comments related to Criterion 3 are focused on the conceptual models, abstractions, and supporting technical basis for the HTF Performance Assessment. In particular, these comments address general performance assessment approaches, radiological inventory estimates that are expected to remain after removal of highly radioactive radionuclides to the maximum extent practical, release of radionuclides from the residual waste and tanks into the environment, transport of radionuclides to a designated receptor, and inadvertent intrusion. The NRC staff is providing no comments related to waste classification, closure cap modeling, or site stability at this time beyond those from the FTF consultation that remain relevant for HTF.

The NRC staff is providing two comments related to general performance assessment approaches. One comment pertains to transparency of screening of features, events, and processes. The second comment focuses on the impact of biosphere modeling changes from the FTF consultation to the HTF Performance Assessment. NRC staff is providing five comments on HTF inventory estimates. Specifically, the comments address uncertainty surrounding annulus volume and concentration assumptions, inventory adjustments, and how historical process knowledge is reflected in the projected inventories.

NRC staff is providing 19 comments regarding waste release and near-field flow and transport modeling. Two of the comments are related to steel liner corrosion. The first comment questions the implicit conclusion from the modeling that carbon steel liners in contact with chloride remain essentially passive, ensuring very low corrosion rates. The second comment questions the assumed effective diffusivities for species important to steel corrosion through the cementitious materials. A third comment questions the reasonableness of pyrite as a surrogate for reducing capacity in the tank fill grout, possibly resulting in an over-estimation of reducing chemical conditions which tend to limit releases. Another two comments address the composition of the water contacting the grout and the residual waste: one pertaining to the basis for mixing of conditioned water that has migrated through the reducing grout and unconditioned groundwater and a second pertaining to the basis for the amount of dissolved oxygen in the groundwater in the geochemical modeling. Four additional comments question the selected solubility controlling phases for key radionuclides including plutonium and technetium. Four more comments pertain to modeling of preferential pathways through the tanks including through the annulus of Type I and II tanks that contain contamination outside of the primary steel liner. Another comment questions whether unsaturated zone models of the near-field are appropriate to simulate saturated zone releases from partially and fully submerged tanks. Finally, the last five comments are clarifying in nature and seek documentation on groundwater in-leakage into fully and partially submerged tanks; question the mineralogy of the hydrated grout assumed for geochemical modeling and its impact on chemical transitions; seek clarification for the basis for cement-leachate impacted sorption model

parameters, seek clarification on grouting plans for transfer lines, and question the validity of chloride diffusion boundary conditions supporting corrosion modeling.

NRC staff is also providing eight comments regarding hydrology and far-field transport modeling. The comments include four requests for additional information that are related to far-field flow and transport model calibration and time-variant recharge and flow. The comments also include four that seek clarification on vertical and transverse dispersivities as well as mixing and dilution factors estimated for the probabilistic modeling. Finally, NRC staff is providing two comments related to the inadvertent intruder analysis that seek clarification on whether the analysis considered the alternative cases involving preferential flow and transport pathways that are considered for protection of the general population.

While NRC staff certainly appreciates the complexity inherent in attempting to model the performance of the disposal facility over the 10,000 year compliance period and beyond, NRC staff thinks that additional information is needed to support DOE's draft Basis for Waste Determination. While some of NRC staff concerns are expected to be addressed during the consultative process, other concerns, such as some that are identified as previous comments during the FTF consultation, can only be realistically evaluated over a longer time period than allowed for completion of NRC staff's technical evaluation report in calendar year 2014. NRC staff expects that additional sampling and waste characterization, material property investigations, and other data collection activities will need to occur to provide adequate support for the Performance Assessment models that may include executing additional laboratory and field experiments as well as performing additional modeling and calculations. NRC staff would like to initiate discussion with DOE, as soon as possible, regarding the types of activities that could be conducted to increase confidence that waste can be disposed of in accordance with the 10 CFR Part 61 performance objectives.

NRC staff's comments are binned according to risk-significance. In general, responses to requests for additional information (denoted by RAI) are expected to impact NRC staff's conclusions with respect to Criterion 1, 2, or 3 (e.g., ability to meet performance objectives in Subpart C of Part 61 of title 10, *Code of Federal Regulations* (10 CFR Part 61), while clarifying comments (denoted by CC) are of lower risk-significance. Requests for additional information and clarifying comments are presented by technical topic with a summary of the comments and their risk-significance provided at the beginning of each topical area.

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Background

In accordance with the Ronald W. Reagan National Defense Authorization Act (NDAA) for Fiscal Year 2005, Section 3116, certain waste from reprocessing of spent nuclear fuel is not high level waste if the Secretary of Energy, in consultation with the U.S. Nuclear Regulatory Commission (NRC), determines that the criteria in NDAA Section 3116(a) are met. According to the U.S. Department of Energy (DOE), the "Draft Basis for Section 3116 Determination for the Closure of H-Tank Farm at the Savannah River Site" (DOE/SRS-WD-2013-001, Rev. 0) (referred to herein as the draft Basis for Waste Determination), which was submitted to the NRC for review on February 6, 2013, demonstrates that those criteria (as specified below) are satisfied. The draft Basis for Waste Determination for the H-Area Tank Farm (HTF) addresses stabilized residuals in waste tanks and ancillary structures (including integral equipment) at the time of closure.

The NDAA Section 3116(a) provides in pertinent part:

> *IN GENERAL – Notwithstanding the provisions of the Nuclear Waste Policy Act of 1982, the requirements of section 202 of the Energy Reorganization Act of 1974, and other laws that define classes of radioactive waste, with respect to material stored at a Department of Energy site at which activities are regulated by a covered State pursuant to approved closure plans or permits issued by the State, the term "high-level radioactive waste" does not include radioactive waste resulting from the reprocessing of spent nuclear fuel that the Secretary of Energy (in this section referred to as the "Secretary"), in consultation with the Nuclear Regulatory Commission (in this section referred to as the "Commission"), determines –*
>
> *(1) does not require permanent isolation in a deep geologic repository for spent fuel or high level radioactive waste;*
>
> *(2) has had highly radioactive radionuclides removed to the maximum extent practical; and*
>
> *(3)(A) does not exceed concentration limits for Class C low-level waste as set out in section 61.55 of title 10, Code of Federal Regulations, and will be disposed of –*
>
> *(i) in compliance with the performance objectives set out in Subpart C of part 61 of title 10, Code of Federal Regulations; and*
>
> *(ii) pursuant to a State-approved closure plan or State-issued permit, authority for the approval or issuance of which is conferred on the State outside of this section; or*
>
> *(3)(B) exceeds concentration limits for Class C low-level waste as set out in section 61.55 of title 10, Code of Federal Regulations, but will be disposed of –*
>
> *(i) in compliance with the performance objectives set out in subpart C of part 61 of title 10, Code of Federal Regulations;*
>
> *(ii) pursuant to a State-approved closure plan or State-issued permit, authority for the approval or issuance of which is conferred on the State outside of this section; and*

(iii) pursuant to plans developed by the Secretary in consultation with the Commission.

DOE concluded in its draft Basis for Waste Determination, that the stabilized residuals within the waste tanks and ancillary structures (including integral equipment) located at HTF at the time of closure are not high-level waste pursuant to the criteria set forth in NDAA Section 3116(a). DOE noted that the draft Basis for Waste Determination would be finalized after DOE completed consultation with NRC and, although not required by NDAA Section 3116, after public review and comment.

In order to fulfill its consultative responsibilities, the NRC staff is reviewing the draft Basis for Waste Determination in conjunction with its review of the "Performance Assessment for the H-Area Tank Farm at the Savannah River Site" (SRR-CWDA-2010-00128 Rev. 1) (referred to herein as the HTF Performance Assessment). The NRC staff review is conducted in accordance with NUREG-1854, "NRC Staff Guidance for Activities Related to U.S. Department of Energy Waste Determinations," Draft Final Report for Interim Use, August 2007. The review of the DOE documents and supporting reference material is being conducted by an NRC team of technical experts with expertise in earth and physical sciences as well as analytical modeling.

As part of its initial review, NRC staff conducted five technical exchanges with DOE. The purpose of these technical exchanges was to gain clarification from DOE on its approaches and better inform the RAIs. NRC staff placed summaries for the technical exchanges listed below in the NRC's Agencywide Documents Access and Management System (ADAMS)[1]. Further, Appendix A of this document contains a complete listing of all NRC staff clarification comments discussed during the technical exchanges listed below as well as summaries of DOE responses.

- April 4, 2013 – Accession No. ML13106A338
- April 17, 2013 – Accession No. ML13126A127
- May 9, 2013 – Accession No. ML13154A327
- May 16, 2013 – Accession No. ML13193A072
- July 3, 2013 – Accession No. ML13199A413

NRC staff provided DOE an early indication of its proposed RAIs during a public meeting conducted on June 5, 2013. NRC staff also placed a summary of this meeting in ADAMS at Accession Number ML13183A410.

NRC staff has completed its initial review of the draft Basis for Waste Determination and supporting Performance Assessment. The review of the DOE documents and the technical exchanges with DOE has led to a number of comments on the technical bases for the DOE

[1] NRC's Agencywide Documents Access and Management System (ADAMS) can be accessed via the internet at http://www.nrc.gov/reading-rm/adams.html.

conclusions in the draft Basis for Waste Determination. These comments include requests for additional information (denoted by RAI-) and clarifying comments (denoted by CC-). Clarifying comments generally (i) seek clarification on DOE approaches to facilitate NRC staff's review of DOE's draft Basis for Waste Determination and supporting Performance Assessment, or (ii) assist NRC staff with documenting the results of its review in a technical evaluation report. Given the lower, expected risk-significance of clarifying comments, compared to requests for additional information, DOE's response is not expected to be as detailed as it would be for a request for additional information. However, it is also expected that in some limited cases, a clarifying comment might have been more appropriately labeled a request for additional information. In these instances, insufficient information was available at the time to accurately judge the risk-significance of the comment and label it appropriately. Nonetheless, it is anticipated that DOE will respond to the clarifying comment in a manner reflective of the risk significance of the comment.

NRC staff has drafted the following requests for additional information and clarifying comments to assist with completion of its review and development of a technical evaluation report that will document NRC staff recommendations to DOE on meeting the NDAA criteria for residual waste and related tank/auxiliary components at the HTF. The requests for additional information and clarifying comments are discussed according to NDAA criteria in the following sections.

Criterion 1

Waste Does Not Require Permanent Isolation in a Deep Geologic Repository for Spent Fuel or High-level Radioactive Waste

NRC staff has no comments on Criterion 1.

Criterion 2

Waste has had Highly Radioactive Radionuclides Removed to the Maximum Extent Practical

NRC staff has completed its initial review of the draft Basis for Waste Determination and supporting documentation for Criterion 2 of the NDAA which requires that the waste has had highly radioactive radionuclides removed to the maximum extent practical. The draft Basis for Waste Determination contains information related to DOEs approach to Criterion 2 in Sections 2 and 5 as well as related information throughout the document and in supporting documentation as noted in the following comments. The NRC staff is requesting additional information having to do with DOE's general approach for selection and application of cleaning technologies, as well as technology optimization and estimation of removal efficiency. NRC staff is also requesting specific information having to do with the practicality of removing additional material from the Tank 16H annulus, as well as the impact of oxalic acid cleaning and how lessons learned from FTF tank cleaning will be incorporated into future tank cleaning efforts. To develop

the following comments, staff reviewed the draft Basis for Waste Determination for HTF and supporting documents. The staff's review criteria pertaining to Criterion 2 are contained in section 3 of NUREG-1854.

Additionally, during the consultative process for the FTF waste determination, NRC staff provided recommendations and comments to DOE regarding Criterion 2 in the FTF Technical Evaluation Report (ML112371715). Table 1 identifies those recommendations and comments that NRC staff believe are also relevant for HTF. NRC staff does not expect DOE to provide additional information to address these previous recommendations and comments during the consultative process for HTF. However, DOE may elect to provide NRC additional information to address the recommendation or comment, if the information is available for HTF.

Table 1. FTF Criterion 2 Recommendations or Comments Relevant to HTF

ID[1]	FTF Recommendation or Comment[2]	HTF Relevance
6	NRC recommends DOE more fully evaluate costs and benefits of additional HRR removal, including (i) consideration of benefits of additional HRR removal over longer performance periods (and considering uncertainty in the timing of peak HRR doses), (ii) justification for assumptions regarding alternative cleaning technology effectiveness, and (iii) comparison of costs and benefits of additional HRR removal to similar DOE activities.	The remains relevant to removal of highly radioactive radionuclides at HTF. See also RAI-MEP-7.
35	NRC recommends DOE specifically consider and evaluate HRR removal in its technology selection and effectiveness evaluations consistent with the NDAA.	DOE provided V-ESR-G-00003, Rev. 1, which provided a description of the waste removal technology selection process, the baseline technologies, and consideration of future technologies used to support DOE's demonstration that NDAA Criterion 2 would be met. See also RAI-MEP-2.
36	NRC recommends DOE continuously evaluate new technologies, participate in technology exchanges, and not default to previous evaluations for technology selection.	NRC staff continues to support continuous evaluation of new technologies and participation in technology exchanges. See also RAI-MEP-2 and RAI-MEP-6.
37	NRC recommends DOE include more specificity in its process for determining HRRs are removed to the maximum extent practical, including (i) defining the term end states versus removal goals and (ii) clarifying when conditions are sufficiently similar to warrant use of a previous technology evaluation.	DOE provided V-ESR-G-00003, Rev. 1, which provided a description of the waste removal technology selection process, the baseline technologies, and consideration of future technologies used to support DOE's demonstration that NDAA Criterion 2 would be met. However, the approach lacks details in the specific implementation of the process. See also RAI-MEP-1, RAI-MEP-3, RAI-MEP-4, RAI-MEP-5, and RAI-MEP-6.

Notes: [1] ID corresponds to ID assigned in Table A-1 of the FTF Monitoring Plan (ML12212A192)
[2] FTF Recommendation or Comment taken from Table A-1 of the FTF Monitoring Plan (ML12212A192) unless otherwise identified.

HRR: Highly Radioactive Radionuclides.

RAI-MEP- 1
Given that oxalic acid cleaning has significant downstream impacts, DOE should clarify its limitations as part of the technology baseline.

Basis
Section 5.3 of V-ESR-G-00003, Rev. 1 describes the chemical cleaning process using oxalic acid as part of the technology baseline. One of the challenges of working with oxalic acid is the formation of oxalates, which have downstream impacts. SRR-STI-2010-00015, Rev. 0 describes that for every tank that undergoes chemical cleaning about 51,000 kg of new sodium oxalates solids will be created for feed to Defense Waste Processing Facility (DWPF) as well as 1900 m^3 (500,000 gal) of salt waste. DOE describes the following oxalic acid impacts: additional wash cycles for DWPF feed, increased likelihood of feed breaks to DWPF, extension of the operating life of the entire Liquid Waste System, and evaporator foaming and scaling problems. WSRC-TR-2004-00317, Rev. 0 discusses potential limits on the use of oxalic acid due to downstream impacts on the liquid waste system. Specifically, the "sludge batch can contain about 10 % (by weight) of total solids as sodium oxalate before increasing the number of canisters produced or changing sludge processing", and "10 % (by weight) sodium oxalate in total solids amounts to disposal of 1 to 6 sludge heels depending on waste type of sludge heel cleaned and specific sludge batch."

DOE had been pursuing enhanced chemical cleaning technology which would have destroyed or oxidized the oxalates before introduction to the destination waste tank through a separate oxidation process. However, DOE stated in the technical exchange teleconference with the NRC staff on May 16, 2013 that this technology was not currently being funded, primarily due to nuclear safety concerns (ML13193A072).

In the teleconference, DOE referred NRC staff to Appendix B of the draft Basis for Waste Determination, which describes the process for documenting the removal to the maximum extent practical and includes how DOE plans to characterize the liquid waste system status as part of the technology evaluation. Appendix B states that DOE will consider storage space, compatibility of the waste, downstream impacts, status of the salt waste, impact on future waste streams, and available equipment when characterizing the liquid waste system.

Given that the use of oxalic acid has potential negative impacts in many of these areas; DOE has stated that its use will be carefully controlled. It would be useful at this point in time to assess the practicality of oxalic acid remaining as part of the technology baseline evaluating the considerations listed in Appendix B of the draft Basis for Waste Determination.

Path Forward
Please clarify how limitations surrounding oxalates might impact the cumulative number of HTF tanks that can undergo chemical cleaning with oxalic acid, and the likelihood that oxalic acid will remain part of the technology baseline for cleaning of future tanks. If oxalic acid is not likely to remain as part of the technology baseline, please clarify other technologies DOE may be pursuing as an alternative given that enhanced chemical cleaning is no longer being pursued.

RAI-MEP- 2

DOE should update the process or strategy for considering developments in waste tank cleaning technologies that occur after the waste determination process has been completed.

Basis

During the FTF consultation, NRC staff requested that DOE document its strategy for considering and selecting technologies in addition to what had been previously documented in the 2003 Systems Engineering Evaluation (G-ESR-G-00051, Rev. 0). In response to the NRC staff comments, DOE provided V-ESR-G-00003, Rev. 1, which provided a description of the waste removal technology selection process, the baseline technologies, and consideration of future technologies used to support DOE's demonstration that NDAA Criterion 2 would be met. Given recent DOE technology decisions (e.g., no longer funding enhanced chemical cleaning), DOE should update their documentation of the technology baseline. Also, although emphasis on highly radioactive radionuclide removal is discussed in V-ESR-G-00003, Rev. 1, recent technology applications and selections do not appear to target highly radioactive radionuclides. For example, during oxalic acid cleaning for Tank 5F less than 10% of the plutonium and americium isotopes were removed (SRNL-STI-2009-00492, Rev. 0). A new technology presented in the draft Basis for Waste Determination is low temperature aluminum dissolution which was used in Tank 12H after bulk mechanical removal and prior to oxalic acid cleaning. Low temperature aluminum dissolution dissolves only aluminum and results showed minimal leaching of other metals; therefore, this technology does not target removal of highly radioactive radionuclides directly (X-CLC-H-00921, Rev. 0). DOE indicated in the June 5, 2013 meeting that low temperature aluminum dissolution was never intended to target highly radioactive radionuclides directly, but instead was meant to change the rheology of the waste in order to facilitate future removal of highly radioactive radionuclides (ML13183A410).

Path Forward

Provide an updated comprehensive description of DOE's current process for selection and evaluation of waste retrieval technologies to show that NDAA Criterion 2 will be met for tanks yet to be cleaned. Include a clear description of whether or not the technology is intended to remove highly radioactive radionuclides and how it accomplishes their removal if intended to do so. DOE should also update the status of several technologies in its documentation of the technology baseline that were discussed in SRR-LWE-2013-00077 (e.g., the low-volume pump, robotic arm). Finally, DOE should indicate how more recent information is considered in the technology selection process and the potential for technologies to target highly radioactive radionuclide removal.

RAI-MEP- 3

DOE's approach to developing an implementation strategy for a cleaning technology including the steps and criteria used in decision-making should be documented.

Basis

NUREG-1854 states that NRC staff should evaluate DOE's selection and *application* of removal

technologies. DOE has a defined a generic process for *selecting* technologies in Appendix B of the draft Basis for Waste Determination. However, this process does not describe DOE's approach for designing the *application* of a specific technology. For example, prior to implementing the cleaning technology selected for sludge removal (e.g., submersible mixing pumps or Bingham slurry pumps), DOE develops a mixing strategy (i.e., the number, location, indexing of pumps, etc.). In the prior cleaning experience, DOE has adjusted its mixing strategy for specific tanks by moving a pump to a different riser, adding a pump(s), changing the indexing, or otherwise removing obstacles (e.g., cutting cooling coils).

DOE's process for determining an initial strategy or adjusting a particular strategy is not well documented and it is not clear that consistency is applied in the decision making surrounding the mixing strategy. For example, there seem to be inconsistencies in the decision process for mixing strategies for different tanks. Section 3.3.3 of SRR-CWDA-2011-00126, Rev. 0 states that DOE installed three Bingham slurry pumps in the Tank 16H risers for mechanical sludge removal campaigns 3-5 whereas only one pump had been used for the first two campaigns. It is not clear why DOE's initial strategy for Tank 16H did not include three Bingham slurry pumps.

As another example, mechanical sludge removal campaigns in Tank 6F were accomplished with two submersible mixing pumps. Mounds remained under risers 1 and 5 following the mechanical sludge removal in August, 2007 due to the limited effective cleaning radius of the submersible mixing pumps. DOE has anticipated that the effective cleaning radius was 15 m (50 ft) and, thus, planned for only two submersible mixing pumps; however, the actual effective cleaning radius was less than anticipated as demonstrated in Tanks 5F and 6F. In the third Tank 5F mechanical sludge removal campaign in February, 2008, DOE added a third submersible mixing pump to facilitate waste retrieval under riser 1. It was not clear to NRC staff why a third or fourth submersible mixing pump was not also added to Tank 6F to facilitate waste retrieval during mechanical sludge removal. SRR-CWDA-2012-00071, Rev. 0 (page 94) indicates that a third submersible mixing pump was added to Tank 6F later, during mechanical feed and bleed. NRC staff inquired about the apparent inconsistencies with Tank 5F and 6F cleaning campaigns in comments on the Tanks 5F and 6F Closure Module (ML13081A051). DOE clarified that only four total submersible mixing pumps can be connected at any one time in the area where Tanks 5F and 6F are because of electrical limitations (ML13191A132). Since two submersible mixing pumps were being used in Tank 5F and two in Tank 6F, the third submersible mixing pump during mechanical sludge removal in Tank 6F could not be used while cleaning was still being conducted in Tank 5F absent significant changes in the electrical setup. While this explanation clarifies the limitations DOE encountered during cleaning Tanks 5F and 6F, it is not clear how this lesson learned regarding actual effective cleaning radius of submersible mixing pumps will be applied for future tank cleaning. It is also not clear how potential options for the transfer pumps (e.g., location, number, etc.) are considered in the planning stages to maximize solids removal.

In cases such as this, decisions to stop waste removal activities based on programmatic or schedule constraints should be supported by an evaluation of the costs and potential benefits of continuing removal operations. A technology that DOE presented in a briefing to the state of

South Carolina in April 2013 (SRR-LWE-2013-00077) may assist DOE in predicting the effectiveness or benefits of certain mixing strategies. Specifically, DOE is cooperating with Hanford on the development of mixing models that can predict different slurry behavior. DOE stated that this is still in the beginning stages, but is a growing area with potential to enhance cleaning efforts at the Savannah River Site. In Tanks 5F and 6F, DOE considered the addition of a fourth submersible mixing pump, but decided that the costs would have outweighed the benefits, noting that the benefits were unknown for the amount of residual solids remaining in Tank 5F and 6F (SRR-CWDA-2010-00157, Rev. 0; SRR-CWDA-2011-00033, Rev. 1; SRR-CWDA-2011-00005, Rev. 1). The mixing model might have aided in predicting potential benefits of an additional pump(s).

Path Forward

Describe DOE's generic approach to developing an implementation strategy for a cleaning technology, including the steps and criteria used in decision making. Include a specific example of how this generic approach is implemented with the development of the pumping/mixing strategy for a specific tank. For example, DOE should indicate how limitations in the effective cleaning radius of submersible mixing pumps identified during Tanks 5F and 6F cleaning will be considered for HTF tanks yet to be cleaned. DOE should also clarify how lessons learned from past cleaning experience will be considered in deciding the mixing strategies (types of pumps, number of pumps, location, etc.) for future cleaning. Include the process that will be followed for deciding when and how to adjust the initial strategy to make it more effective if needed (i.e., the practicality of installing additional pumps, moving pumps, cutting cooling coils, etc. would be helpful). Finally, clarify the timeline of the use of the mixing model at HTF that is being developed for Hanford.

RAI-MEP- 4

DOE’s approach to optimization of technology through sampling and monitoring during cleaning should be documented.

Basis

Section 5.3 of the DOE/SRS-WD-2013-001, Rev. 0 states that "throughout the heel removal process, DOE continually evaluates the ongoing effectiveness of the technology being implemented and optimizes the existing technologies." DOE stated in SRR-STI-2013-00198 that there will be "Sampling and monitoring program in place to ensure operational efficiency..." during Tank 12H oxalic acid cleaning. These include visual inspections after each chemical strike and a volumetric examination of the tank wall after the third chemical strike. Visual inspections are described throughout the multiple cleaning phases of Tank 16H (SRR-CWDA-2011-00126, Rev. 0). Visual observations, transfer line radiation readings, and ratio of water additions to solids removed were used for Tank 18F and 19F (DOE/SRS-WD-2010-001, Rev. 0). During Tank 5F mechanical feed and bleed campaigns, radiological data was collected using electronic personnel dosimetry in a valve box on the transfer line between Tanks 5F and 6F transfer line readings (SRR-CWDA-2012-00071, Rev. 0). These are all examples of the types of sampling and monitoring that DOE has completed during the cleaning of specific tanks,

but the general approach is not well documented. NRC staff acknowledges that each tank will be evaluated on a case-by-case basis and generic action thresholds for metrics are not practical. However, documentation of the general process including the types of sampling and monitoring as well as examples of metrics that may be used would be useful to ensure consistency in the approach for each tank.

Path Forward
Please clarify the process for determining the sampling and monitoring that will take place during future tank cleanings. Clarify what metrics are used throughout the process to determine effectiveness.

RAI-MEP- 5
DOE should document its general approach for evaluating removal efficiency of cleaning technologies.

Basis
NUREG 1854, Section 3.3 advises NRC staff to verify that DOE's reported removal efficiencies are reasonably reliable. Specifically, if DOE bases its decision to terminate removal activities on declining removal efficiency, it is important to have confidence in the reported removal efficiencies of a specific technology.

As a comment on the Tanks 5F and 6F Closure Module, the NRC staff suggested that DOE should consider analyzing tank waste samples prior to chemical sludge removal to enable a more thorough and accurate analysis of key radionuclide removal (ML13081A051). DOE reported removal percentages for specific radionuclides in the Closure Module (page 53) based on liquid process samples taken during each chemical sludge removal campaign which were compared to a solid sample taken from Tank 5F during mechanical sludge removal campaigns in 2006 prior to chemical cleaning (SRR-CWDA-2012-00071, Rev. 0). Note that a solid process sample had also been taken prior to chemical cleaning between the mechanical sludge removal campaigns. The solid process sample taken during the mechanical sludge removal campaigns was taken after the second mechanical sludge campaign and before mechanical sludge removal campaigns 3-7. Given that mechanical sludge removal may not have removed all species proportionally (i.e., faster settling constituents may increase as mechanical sludge removal progresses), the sample taken may not represent the composition of the sludge directly prior to chemical cleaning. Therefore, the report utilized the liquid process samples taken during chemical sludge removal as opposed to the solid sample taken during mechanical sludge removal. The report recommended that directly prior to chemical cleaning future tanks DOE collect a sludge sample and have personnel from Savannah River National Laboratory analyze it for key contaminants. SRNL-STI-2009-00492, Rev. 0 stated this would provide a baseline for comparison, which would allow for better evaluation of the efficiency of future chemical cleaning activities. At the June 5, 2013 meeting (ML13183A410), DOE informed NRC that it was able to retrieve a sample from Tank 12H prior to chemical cleaning, because there happened to be an accumulation that was accessible directly beneath the riser. The NRC staff acknowledges that

specific circumstances for each tank may not always be conducive to sampling at various stages of cleaning and that there are financial and worker dose considerations. However, it would be helpful for DOE to document general guidelines for conditions when it is appropriate to take a sample between cleaning phases. This will ensure good practices and consistency in the approach to evaluating removal efficiency for future tanks.

NRC staff also suggested in its comments on the Tanks 5F and 6F Closure Module (ML13081A051) that DOE perform a critical evaluation of the differences in oxalic acid delivery, waste agitation, waste transfer, and other factors that led to more successful cleaning of Tank 16H compared to Tank 5F and 6F. Such an evaluation could also compare the effectiveness of the upcoming Tank 12H chemical cleaning.

Path Forward
Clarify DOE's general approach to evaluating the effectiveness of previously implemented cleaning technologies. The clarification should include a specific example of how this generic approach will be implemented with the evaluation of oxalic acid effectiveness for Tank 12H. With the understanding that each tank is different, and technologies are not expected to be equally effective on all tanks, DOE should also describe how the approach compares the effectiveness for cleaning technologies between different tanks. Finally, DOE should include generic guidelines on when it is appropriate to sample the sludge prior to chemical cleaning.

RAI-MEP - 6
Lessons learned from removal from Tanks 5F and 6F with regard to limitations due to low liquid levels should be incorporated into plans for future cleaning.

Basis
Section 2.3.2.1 of DOE/SRS-WD-2013-001, Rev. 0 states that "the SMPs [submersible mixing pumps] are required to be shut down as the liquid level approaches the elevation of the discharge nozzles to prevent waste spraying." Because the submersible mixing pumps could not be operated at lower liquid levels, ineffective mixing during acid strike 2 in Tanks 5F and 6F appears to have contributed to the formation of solids during chemical cleaning. The second chemical sludge removal campaign lasted 54 days for Tank 5F, and 46 days for Tank 6F. The third chemical sludge removal campaign for Tank 6F lasted 90 days. The long residence time of the oxalic acid may have contributed to the formation of oxalates in addition to the lack of mixing (SRR-CWDA-2012-00071, Rev. 0). DOE has indicated that a low volume mixing pump, which would be able to operate at lower liquid levels, has been evaluated to support chemical cleaning in its technology April, 2013 briefing to the state of South Carolina (SRR-LWE-2013-00077), but in the May 16, 2013 teleconference (ML13193A072) with NRC staff, DOE explained stated that the technology is not available at this time.

Path Forward
DOE should clarify the timeline of the low volume mixing pump technology and whether DOE anticipates it to be available for future cleaning of HTF tanks. DOE should also clarify the reasons for the long residence time of oxalic acid during chemical sludge removal strike 2 for

Tanks 5F and 6F while there was no mixing and if the long residence time of oxalic acid was a contributing factor to the formation of oxalates. If the length of time the oxalic acid sat in the tank without mixing was a contributing factor to the buildup of oxalates, DOE should explain how similar circumstances will be managed in future cleaning efforts.

RAI-MEP- 7

The practicality of removing additional material from the Tank 16H annulus should be analyzed.

Basis

The 2008 samples from the Tank 16H annulus described in WSRC-STI-2008-00203, Rev. 0 showed a wide variation in the annulus material, and specified that the material inside the duct was more soluble than the material outside the duct. "The sample from outside the duct at IP-35 shows more water insoluble material than the sample from inside the duct. Interestingly, the sample from outside the duct at IP-118 contains much more water insoluble material than the sample from outside the duct at IP-35....the IP-118 sample also shows a small difference in composition from the top to the bottom of the sample. The bottom section of the sample appears to contain more water soluble material than the top based on the XRD [X-ray diffraction] data. This aspect of the sample again seems reasonable since the material at the bottom of the annulus would also be less accessible to the washing/waste removal conducted in the annulus. The samples from outside the dehumidification duct at two locations in the annulus show very different compositions and estimated solubility in water. This indicates the waste material in Tank 16H annulus may have a wide range of compositions at different locations." If some parts of the material in the annulus (and especially the duct) are soluble, it may be practical to remove additional amounts of it. The last cleaning effort was in 1977 and mixing was poor as exhibited by the variability in sample results. Prior DOE documentation assumed that it would be necessary to remove additional material from the annulus, but efforts to clean the annulus ceased because the mechanical technology that was being pursued was not mature enough to deploy (ML13183A410). Waste in the annulus and/or sand pads tends to be more risk significant, because it contains more soluble radionuclides and is located outside of the primary containment. NRC staff is concerned that the base case (and alternative cases) in the HTF Performance Assessment may underestimate annular contamination risk (see RAI-NF-12 and RAI-NF-13).

Path Forward

Please provide more detailed information on the practicality of removing additional waste from the Tank 16H annulus to the extent necessary to reduce the risk, taking into consideration the potential risk posed by preferential pathways and addressing the issues identified in RAI-NF-12 and RAI-NF-13. As a further consideration please describe the practicality of removing additional waste from the ventilation duct since it is more soluble than the annulus floor material.

Criterion 3

The Waste Will be Disposed in Accordance with Performance Objectives in 10 CFR 61, Subpart C

NRC staff has completed its initial review of the draft Basis for Waste Determination and supporting documentation for Criterion 3 of the NDAA which requires that the waste will be disposed in accordance with the performance objectives in 10 CFR 61, Subpart C, and pursuant to a State-approved closure plan or State-issued permit. If the waste exceeds concentration limits for Class C low-level waste as set out in 10 CFR 61.55, the waste must also be disposed pursuant to plans developed in consultation with the NRC. The draft Basis for Waste Determination contains information related to Criterion 3 in Sections 6 through 8 as well as related information in the associated Performance Assessment and supporting documents.

Waste Classification

Section 3116 of the NDAA requires DOE to determine the class of the waste it subjects to the waste incidental to reprocessing process for the sole purpose of determining whether clause (a)(3)(A) or (a)(3)(B) of Section 3116 applies. This determination is important to NRC staff's understanding of the scope of its review. For example, greater than Class C waste subject to a WIR determination must meet Section (a)(3)(B) that contains an additional requirement not found in (a)(3)(A)—namely, it requires DOE to dispose of incidental waste pursuant to plans developed by the Secretary in consultation with the Commission. From its initial review, NRC staff has no comments on waste classification.

Performance Objectives

Section 3116 of the NDAA also requires the waste to be disposed in compliance with the performance objectives set out in 10 CFR Part 61, Subpart C. Subpart C details the performance objectives for land disposal of radioactive waste. The performance objectives provide reasonable assurance that exposures to humans are within the limits established to address protection of the general population from releases of radioactivity (10 CFR 61.41), protection of individuals from inadvertent intrusion (10 CFR 61.42), protection individuals during operations (10 CFR 61.43), and stability of the disposal site after closure (10 CFR 61.44).

During the consultative process for the FTF waste determination, NRC staff provided recommendations and comments to DOE in the FTF Technical Evaluation Report regarding its demonstration that waste in FTF would be disposed in accordance with the performance objectives (ML112371715). These recommendations were incorporated into factors established in the FTF Monitoring Plan (ML12212A192) to assess whether disposal occurs in accordance with the performance objectives in 10 CFR Part 61, Subpart C. NRC staff has identified in the following sections which technical issues addressed by monitoring factors are believed to also be relevant for HTF. Monitoring factors relevant to protection of the general population from

releases of radioactivity and site stability are discussed in detail in the subsequent sections.

The NRC staff considers the technical issues addressed by the FTF monitoring activities established for protection of the general population (10 CFR 61.41) also generally applicable to protection of individuals from inadvertent intrusion (10 CFR 61.42) because the groundwater pathway is considered in both analyses. However, inadvertent intrusion may be the more limiting performance objective if natural attenuation between the 1 m (boundary at which the 10 CFR 61.42 analysis is performed) and 100 m (boundary at which the 10 CFR 61.41 analysis is performed) significantly reduces the risk of certain key radionuclides. The FTF Monitoring Plan (ML12212A192) identifies key radionuclides that are particularly important to inadvertent intrusion at FTF. NRC staff is similarly reviewing key radionuclides important for the HTF inadvertent intruder analysis. Another important consideration for the 10 CFR 61.42 analysis is the assumed exposure location. While NRC staff understands DOE's basis for assignment of exposure locations in the probabilistic modeling for HTF, and has no additional information needs at this time, NRC staff plans to complete its review in this area and document its findings in the staff's technical evaluation report.

Though not listed in the following sections, FTF Monitoring Area 7 establishes factors to monitor whether waste disposal provides reasonable assurance that 10 CFR 61.43, protection of individuals during operations, is met at FTF. NRC staff expects that the issues associated with these factors will also be relevant for HTF. NRC staff understands DOE's approach for protecting individuals during operations. NRC staff does not expect DOE to provide additional information to address monitoring factors during the consultative process for HTF.

Performance Assessment

This section contains NRC staff comments on the general issues associated with the development of the HTF Performance Assessment. Specific comments about particular model abstractions employed in the HTF Performance Assessment are discussed in subsequent sections. The comments related to general performance assessment issues focus on the transparency of DOE's screening of features, events and processes and the impact of changes to the dose modeling since the FTF consultation.

Factors potentially important to general issues with performance assessment for FTF are discussed in the FTF Monitoring Plan (ML12212A192). These factors include scenario analysis, model and parameter support and FTF Performance Assessment revisions. Table 2 lists the monitoring factors, as well as other potential performance assessment maintenance activities that were recommended in the NRC staff's FTF Technical Evaluation Report (ML112371751) and indicates those recommendations and comments that NRC staff believes remain relevant for HTF. NRC staff does not expect DOE to provide additional information to address these FTF monitoring factors or potential performance assessment maintenance items during the consultative process for HTF. However, DOE may elect to provide NRC additional information to address the items in Table 2 that are relevant for HTF if available.

Table 2. FTF Performance Assessment Monitoring Factors Relevant to HTF[1]

FTF Monitoring Factor	HTF Relevance
FTF Monitoring Area 6—Performance Assessment Maintenance[2]	
6.1: Scenario Analysis As discussed in the FTF Monitoring Plan (ML12212A192), NRC staff will review DOE methodology for identification, screening, and dispositioning of features, events, and processes and the formation of scenarios considered in revisions to the FTF Performance Assessment. In the FTF Monitoring Plan (ML12212A192), NRC staff plans to monitor DOE efforts to address the following recommendation from Table A-2: NRC recommends DOE perform a systematic scenario analysis in which DOE identifies, screens, and dispositions features, events, and procesess using transparent and traceable documentation of the features, events, and processes considered, the screening arguments, and how features, events, and processes are implemented in the models to support future waste determination efforts.	DOE documents its evaluation of features, events, and processes in SRR-CWDA-2012-00044, Rev. 1 and SRR-CWDA-2012-00011, Rev. 0. The NRC staff review identified issues with transparency and traceability of the screening methods as discussed in CC-PA-2.
6.2: Parameter and Model Support As discussed in the FTF Monitoring Plan (ML12212A192), NRC staff will examine experimental and site characterization data and information from literature that DOE relies upon to support model selection and parameter justification for revisions to the FTF Performance Assessment. In the FTF Monitoring Plan (ML12212A192), NRC staff plans to monitor DOE efforts to address the following recommendation from Table A-2: (i) DOE should better assess uncertainty in the timing of peak dose, given the inherent level of uncertainty associated with predicting doses over tens of thousands of years; key parameters, such as steel liner failure times and chemical transition times, may be overly constrained. *Continued*	(i) NRC staff continues to be concerned about the uncertainty in the timing of the peak dose given the inherent uncertainties over tens of thousands of years and DOE's basis for steel liner failure and chemical transition times. Further discussion on steel liner failure and chemical transition times are discussed in Table 10.

Table 2. FTF Performance Assessment Monitoring Factors Relevant to HTF[1]

FTF Monitoring Factor	HTF Relevance
6.2: Parameter and Model Support (Continued) (ii) NRC recommends DOE provide additional support for the likelihood of its base case or expected Case A. (iii) NRC recommends DOE improve the transparency and documentation of its benchmarking process. NRC recommends DOE perform a more methodical and systematic approach to applying the benchmarking process in future updates to its FTF Performance Assessment. (iv) NRC suggests DOE consider consistency between the plotting interval and calculation time step size. DOE should correct errors in its probabilistic assessment (e.g., porosity of 1E-20). DOE also should present results for the point of maximum exposure. *Continued*	(ii) Table 5.6-5 of the HTF Performance Assessment lists the probability applied for each waste tank case. DOE elected to use a single value for all tank types in contrast to the tank type specific case probabilities employed in FTF (See Table 5.6.2 of SRS-REG-2007-00002, Rev. 1). Section 5.6.3.2 of the HTF Performance Assessment describes the assumptions that were used as part of engineering judgment to inform the likelihood assigned to each case. DOE indicates the base case (case A) is considered most likely because preferential flow paths through cement barriers (as represented by cases B-E) are not likely to occur immediately at time of closure. NRC staff remains concerned that DOE lacks an adequate basis for the likelihood of each waste tank case. See RAI-NF-10. (iii) DOE made improvements to its benchmarking process and documentation in the HTF Performance Assessment. NRC staff has concerns with the lack of benchmarking of alternative cases and the limited suite of radionuclides and locations that are benchmarked. These concerns will be discussed in staff's technical evaluation report. However, because DOE uses the probabilistic model to inform (not to make) the HTF compliance demonstration, no additional information is needed at this time. (iv) NRC staff understands DOE's HTF approach and, therefore, is not requesting additional information at this time. NRC staff thinks that doses at the point of maximum exposure in the Upper Three Runs Aquifer (rather than the Gordon aquifer) should be compared to dose standards when demonstrating compliance with the performance objectives. However, DOE's continued use of Gordon aquifer concentrations/dose in the probabilistic analysis is acceptable to present additional risk information, as long as the probabilistic analysis results are not used to compare against dose standards. NRC staff understands DOE's approach and will document its evaluation of the HTF 100 m compliance boundary in its technical evaluation report.

Table 2. FTF Performance Assessment Monitoring Factors Relevant to HTF[1]

FTF Monitoring Factor	HTF Relevance
6.2: Parameter and Model Support (Continued) (v) NRC made a general comment that DOE could improve its parameter distribution assignments, hybrid modeling approach, benchmarking process, and evaluation and interpretation of probabilistic modeling results. With respect to parameter distributions, NRC included several items in its open items database, most of which are listed in other recommendations, with the exception of probability of basemat bypass. (vi) NRC recommends DOE evaluate plant transfer factor uncertainty in future updates to its FTF Performance Assessment. DOE should consider appropriateness of excluding common vegetable types in its assignment of plant transfer factors (DOE only considers root vegetable data) based on production data rather than household data that might be more appropriate for a resident gardener. (vii) NRC recommends DOE evaluate appropriateness of assumptions related to drinking water consumption in future updates to its FTF Performance Assessment, such as partitioning consumption rates based on use of both bottled water and community water. Biosphere parameters should be reasonably conservative and reflect behavior of the average member of the critical group.	 (v) DOE has made notable improvements to its presentation of PA results (showing doses over longer time periods and for alternative configurations). DOE has also improved transparency in its benchmarking process (see Table 11). NRC still has concerns regarding support for DOE's assignment of configuration probabilities, basemat bypass and other waste release parameter assignments (see Table 10) (vi) Plant transfer factors are reported in Section 4.6.1.1 of the HTF Performance Assessment and were taken from SRNL-STI-2010-00447, Rev. 0. NRC notes that DOE's approach to plant transfer factors remains consistent between FTF and HTF. NRC staff understands DOE's approach and supporting basis and therefore is not requesting additional information at this time. (vii) For HTF, DOE continues to use FTF drinking water consumption rates. NRC staff understands DOE's approach and supporting basis and therefore is not requesting additional information at this time.

Notes: [1] In general, NRC staff considers many of the FTF Monitoring Areas 1-6 applicable to Performance Assessment. However, this table only covers general considerations. For considerations addressing specific model abstractions, see subsequent tables.

To develop the following comments, staff reviewed the HTF Performance Assessment and supporting documents. The NRC staff's review criteria pertaining to the performance assessment are contained in Section 4 of NUREG-1854.

CC-PA- 1
DOE should clarify its screening of features, events, and processes in SRR-CWDA-2012-00011, Rev. 0 to improve transparency and traceability, in particular the use of expert judgment in lieu of data collection, the membership of the FEPs screening team, and the documentation of subject matter expert's basis for judgment.

CC-PA- 2
Several changes were made to biosphere parameters for HTF. It is not clear how these changes impact the relative risk of various highly radioactive radionuclides compared to earlier performance assessments. Provide groundwater pathway dose conversion factors for HTF to facilitate comparison with previous analyses.

Inventory

Inventory estimates are risk-significant because inventory is directly related to dose for those radionuclides that are not assumed to be solubility limited in the contaminated zone. For those radionuclides that are solubility limited in the contaminated zone, inventory can also significantly impact the projected dose and increased inventories may help ensure that mass is not depleted below solubility limits prior to chemical transitions that lead to higher release rates from the contaminated zone.

DOE's approach to inventory for HTF is a departure from the approach taken for FTF in that the volume of residual material assumed to remain in each tank is higher. DOE projects that about 15 m^3 (4000 gal) will remain in each tank for HTF. For FTF, DOE initially projected that 0.1524 cm (0.06 in), which equates to approximately 0.8 m^3 (210 gal), but increased the projected residual *inventory* by an order of magnitude, which can be thought of as uncertainty in the concentration of residual waste in the tank or the amount (i.e., volume) of waste that can be removed from the tank based on uncertainty in cleaning effectiveness.

NRC staff comments on HTF inventory are related to uncertainty surrounding annulus volume and concentration assumptions, inventory adjustments, and how historical process knowledge is reflected in the projected inventories. To develop the following comments, staff reviewed the HTF Performance Assessment and supporting documents. The staff's review criteria pertaining to radionuclide inventory in residual waste are contained in sections 3.1, 3.2, 4.2, 4.3.3, and 4.4 of NUREG-1854.

Factors potentially important to inventory for FTF are discussed in the FTF Monitoring Plan (ML12212A192). These factors include final inventory estimates for cleaned tanks, sampling of the residual waste to determine concentrations after cleaning, residual volume estimates and

associated uncertainty, ancillary equipment inventory, and waste removal as it pertains to demonstrating that releases of radioactivity are as low as reasonably achievable. Table 3 lists the FTF inventory monitoring factors and identifies those technical issues addressed by the FTF monitoring factors that are relevant for HTF. NRC staff does not expect DOE to provide additional information to address these FTF monitoring factors during the consultative process for HTF. However, DOE may elect to provide NRC additional information to address the items in Table 3 if available.

Table 3. FTF Inventory Monitoring Factors Relevant to HTF

FTF Monitoring Factor	HTF Relevance
Monitoring Activity 1—Inventory	
1.1: Final Inventory and Risk Estimates As discussed in the FTF Monitoring Plan (ML12212A192), NRC staff will review final inventories for cleaned tanks used in special analyses that provide final dose projections, including the use of inventory multipliers in the probabilistic modeling.	DOE has not developed final inventories for HTF to date. DOE indicated in Section 8.2, "Further Work" of the HTF Performance Assessment that it intends to refine and confirm existing radionuclide inventories that will be present in the HTF tanks at site closure. NRC staff does have concerns with the *projected* inventory for the HTF Performance Assessment including evaluation of uncertainty (See Inventory RAIs below).
1.2: Residual Waste Sampling As discussed in the FTF Monitoring Plan (ML12212A192), NRC staff will review sampling and analysis plans for cleaned tanks including the basis for the radionuclides evaluated and the locations and numbers of samples analyzed.	The HTF Performance Assessment inventories were based on projections. Therefore, NRC staff has not reviewed sampling and analysis plans for HTF.
1.3: Residual Waste Volume As discussed in the FTF Monitoring Plan (ML12212A192), NRC staff will review DOE efforts to improve final volume estimates and consideration of volume uncertainty at FTF.	The HTF Performance Assessment inventories were based on projections. Therefore, NRC staff has not reviewed final volume estimates for HTF. However, DOE has preliminary volume estimates for Tank 16H based on the expected final configuration for the tank. NRC staff has concerns with the treatment of uncertainty in annular volume estimates for Tank 16H (See RAI-INV-1).
1.4: Ancillary Equipment Inventory As discussed in the FTF Monitoring Plan (ML12212A192), NRC staff will review DOE activities related to sampling and analysis of transfer lines to verify inventory estimates for ancillary equipment at FTF.	DOE indicated in Section 8.2, "Further Work" of the HTF Performance Assessment that it intends to refine and confirm existing radionuclide inventories for piping and ancillary equipment at site closure for HTF.
1.5: Waste Removal (As it Pertains to ALARA) As discussed in the FTF Monitoring Plan (ML12212A192), NRC staff will review DOE analysis of removal of highly radioactive radionuclides to the maximum extent practical to the extent that the DOE's Criterion 2 analysis is used to demonstrate that ALARA criteria are met.	NRC staff is requesting additional information having to do with DOE's general approach for selection and application of cleaning technologies, as well as technology optimization and estimation of removal efficiency. NRC staff is also requesting specific information having to do with the practicality of removing additional material from the Tank 16H annulus, as well as how lessons learned from FTF tank cleaning will be incorporated into future cleaning efforts (See RAIs under Criterion 2).

Notes:
ALARA: As Low As Reasonably Achievable

RAI-INV- 1
Annular volume uncertainty could be quantified.

Basis
NUREG-1854 states that the reviewer should evaluate the methods used for estimating waste volumes, and confirm that uncertainty has been considered and propagated into the inventory estimate. On page 40 of SRR-CWDA-2011-00126, Rev. 0, DOE estimates that approximately 18 m^3 (4,700 gal) is remaining in the Tank 16 Annulus using a depth profile of the waste in the annulus. Figure 3.6-4 of SRR-CWDA-2011-00126, Rev. 0 shows nine depth values, although it is unclear if these depth values were determined visually or measured. DOE later estimated the remaining volume as about 12.5 m^3 (3,300 gal) (HTF Performance Assessment and SRR-LWE-2012-00039, Rev. 0) through the use of camera views and interior landmarks (i.e., duct diameter, annulus wall radius) as well as a depth measurement under each of the four risers. DOE separates the residual annulus material into: (1) material at the bottom of the annulus outside the ventilation duct (estimated at 8 m^3 (2,100 gal)), and (2) material inside the ventilation duct (estimated at 4.5 m^3 (1,200 gal)). There are a total of 13 inspection ports in the Tank 16H annulus, and DOE visually estimated material depths from multiple locations in the annulus outside the duct and from five locations inside the duct. These depth estimates range from 5 cm (2 in) to 40 cm (16 in). Still, there are many areas of the annulus (and inside the duct) where visual determination of the waste level was not possible, so there is some degree of uncertainty associated with the estimate. In those areas, DOE extrapolated the waste level using the data from surrounding areas. DOE clarified that the more recent estimate is the correct one, but it is unclear why this value is superior to the first one and also the reasons for the differences between the two values assuming they were both made using estimated profiles of the waste.

Also, in Section 9.0 of SRR-CWDA-2010-00023, Rev. 3, DOE describes how multipliers are applied to the tank inventories to account for uncertainty in the HTF Performance Assessment. However, similar inventory multipliers are not applied for the annuli of the tanks. The HTF Performance Assessment states that estimates for the annulus material are extremely conservative compared to the amount anticipated to remain, so uncertainty multipliers are not necessary. DOE estimates that Tanks 9H, 10H and 14H annuli contain about 3,300, 1,100, and 5,600 gal of material respectively, although 3,300 gal is assumed for all tanks with residual material in the annulus in the HTF Performance Assessment (ML13183A410).

Path Forward
Provide estimates of the uncertainty of remaining volume in Tank 16H annulus and describe how this uncertainty is related to the uncertainty of the material in the annuli or other tanks. Clarify why the 12.5 m^3 (3,300 gal) estimate is more accurate than the 18 m^3 (4,700 gal) estimate and the reason for the different values.

RAI-INV- 2
The representativeness of Tank 16H annulus samples for Tanks 9H, 10H, and 14H is not clear.

Basis
Section 2.5.1.2 of SRR-CWDA-2010-00023, Rev. 3 describes how, for those radionuclides analyzed in the four Tank 16H annulus samples, DOE applies the concentrations of the Tank 16H annulus sample results to other tanks with annulus material (Tanks 9H, 10H and 14H). DOE also states that the material in the Tank 16H annulus is expected to be chemically different than the other tanks due to the unique circumstances of the leak in Tank 16H (i.e., rapid leak) and the history of Tank 16H annulus (i.e., use of sand in determination of leak sites). The NRC staff recognizes that the data on annulus material was limited at the time of the development of the draft Basis for Waste Determination, and that the only annulus samples available currently are those taken from Tank 16H annulus. However, the impact on the expected differences between Tank 16H annulus material and that of the other tanks on the inventory estimate could be further explained.

Path Forward
Please clarify the technical basis for using Tank 16H annulus concentrations in the annuli of Tanks 9H, 10H, and 14H given the expected chemical differences between Tank 16H annulus material and that of the other tanks. Please describe the impact of the anticipated differences on the inventory estimates in terms of radionuclides that could be under- or over-estimated as a result of assuming the Tank 16H annulus concentrations.

RAI-INV- 3
There are differences in processes between HTF and FTF which are not reflected in projected inventories.

Basis
NUREG 1854 advises the reviewers to determine whether there is an adequate technical basis for the accuracy of inventory estimates based on historical or process knowledge. HTF and FTF processed different waste streams, which would lead to expected differences in the inventories. SRNL-STI-2012-00479 states that there is expected to be approximately 2000 times more U-234 at HTF than at FTF because HTF mainly processed enriched uranium while FTF processed irradiated depleted uranium targets. There is also expected to be about 100 times more U-233 and 70 times more U-236 at HTF.

The Waste Characterization System did not provide values for U-234, or U-236, so DOE estimated these inventories using other methods. SRR-CWDA-2010-00023, Rev. 3 states, "...there were other constituents for which WCS did not estimate an inventory for all HTF tanks. Therefore, these radionuclide concentrations were estimated only for waste tanks where no values were present in WCS. The isotopes requiring additional estimates were Ba-137m, Cl-36, H-3, K-40, Pd-107, Pt-193, Ra-226, Ra-228, Th-229, Th-230, Th-232, U-232, U-234, U-236, Y-90, and Zr-93." Table 2.2-1 in SRR-CWDA-2010-00023, Rev. 3 describes the methods used to estimate Ba-137m, C-14, H-3, Y-90, B, and Mo. However, SRR-CWDA-2010-00023, Rev. 3

does not provide details on how the other radionuclides not included in the Waste Characterization System were estimated. Details should be provided as to the methods for estimation and whether inventories were estimated based on the values of other radionuclides for the same tank or for other tanks.

The estimates for some radionuclides (e.g., U-234) do not appear to agree with expectations provided in SRNL-STI-2012-00479, Rev. 3. DOE estimates 24.42 GBq (0.66 Ci) of U-234 in the Type III/IIIA tanks at HTF. Assuming $15m^3$ (4,000 gal) of waste per tank and 1.2 g/cm^3 bulk (dry) density of waste, results in approximately 6 mg U-234 per kg of waste. This concentration is similar to the average U-234 in FTF waste of 7-8 mg/kg reported in WSRC-STI-2007-00192, Rev. 1. It might be coincidental that the projected U-234 concentrations for HTF happen to be similar to the FTF data. However, if some constituents that were not reported in the Waste Characterization System for HTF were estimated based on data from FTF, it is possible that certain radionuclides could have been underestimated since differences are expected in the waste streams between HTF and FTF. Examples of other potentially important radionuclides that do not follow the expectations from SRNL-STI-2012-00479, Rev. 3 are U-233, U-236. In addition to explaining the methods for estimating those radionuclides that are not listed in the Waste Characterization System, it would be helpful if DOE could explain why inventory projection ratios may not follow the expectations in SRNL-STI-2012-00479, Rev. 3.

Path Forward
Please clarify how DOE estimated the inventories for radionuclides not included in the Waste Characterization System and not explained in Table 2.2-1 of SRR-CWDA-2010-00023, Rev. 3. Please also explain the differences in inventory projections from the expectations that are described in SRNL-STI-2012-00479, Rev. 3.

RAI-INV- 4
The representativeness of 2010 Tank 16H annulus samples for the concentration of the material in the Tank 16 annulus is not clear.

Basis
DOE uses the concentration of the four samples taken in 2010 (all from outside of the ventilation duct) to represent all of the Tank 16H material (SRNL-STI-2012-00178, Rev. 0). The material inside the ventilation duct which DOE estimates to be roughly one-third of the total material (HTF Performance Assessment) has higher concentrations of several highly radioactive radionuclides based on comparison of the 2006 samples (WSRC-STI-2008-00203, Rev. 0) to the 2010 samples. Note that the two samples taken from outside the ventilation duct in 2006 also have higher concentrations than the 2010 samples. DOE has not adequately explained why the 2006 samples were not used in the inventory calculation for Tank 16H annulus. DOE has also not provided adequate justification for why the concentration of the samples taken from outside the duct in 2010 adequately represents the concentrations of material inside the duct for the purposes of the HTF Performance Assessment. NRC staff acknowledges that the Tank 16H annulus will be sampled again for purposes of final characterization and that the final inventories

will be evaluated in a special analysis. However, it is not clear why results from the samples taken in 2006 were not used to help inform the projected inventory calculations in the HTF Performance Assessment, especially if the concentrations were higher for certain highly radioactive radionuclides.

Table 4. Results of Annulus Samples Collected in 2006

	HTF-16-06-104 (IP-35 Inside Duct)	HTF-16-06-105 (IP-35 Outside Duct)	HTF-16-06-106 (IP-II8 Outside Duct)
U total (IM) (mg/kg)	6.64E+02	5.49E+02	7.03E+01
Pu-238 (SA) (dpm/kg)	1.84E+10	1.15E+10	1.24E+09
Pu-239 (SA) (dpm/kg)	3.46E+09	2.08E+09	2.26E+08
Np-237 (IM) (dpm/kg)	1.39E+07	1.13E+07	1.65E+06
Sr-90 (BS) (dpm/g)*	1.21E+10		
Cs-137 (GS) (dpm/g)*	7.84E+08		

* results of the Cs-137 and Sr-90 analysis of an archived portion of sample (HTF-16-06-104) (SRNL-STI-2012-00178)
IM: Inductively Coupled Plasma-Mass Spectrometry
SA: Separation/Alpha Spectroscopy
GS: Gamma Spectroscopy
BS: Beta Spectroscopy

Table 5. Results of Annulus Samples Collected in 2010

	N	S	E	W	Average
U total (mg/kg)	5.28E+01	1.25E+02	2.59E+02	2.58E+02	1.74E+02
Pu-238 (SA) (dpm/kg)	1.18E+06	2.72E+06	4.22E+06	5.81E+06	3.48E+06
Pu-239 (SA) (dpm/kg)	1.71E+05	4.50E+05	7.31E+05	1.09E+06	6.11E+05
Np-237 (IM) (dpm/kg)	1.50E+03	2.67E+03	4.05E+03	4.15E+03	3.09E+03
Sr-90 (BS) (dpm/g)	3.65E+08	1.55E+09	1.54E+09	2.58E+09	1.51E+09
Cs-137 (GS) (dpm/g)	2.33E+09	1.63E+09	2.09E+09	3.15E+09	2.30E+09

Path Forward

DOE should clarify why the 2006 annulus samples were not used (in addition to the 2010 annulus samples) to help inform the inventory calculation for Tank 16 annulus. DOE should also provide justification for why the concentration of the samples taken from outside the ventilation duct in 2010 adequately represents the concentration of material inside the duct for the purposes of the HTF Performance Assessment.

RAI-INV- 5
Cs, Sr, and Zr inventory adjustments require further justification.

Basis
During the May 16, 2013 clarification teleconference, NRC staff asked DOE to clarify the assumptions regarding Cs-137, Sr-90, and Zr-93 inventories (ML13193A072). In response, DOE provided SRR-CWDA-2013-00086, Rev. 0 which describes that the Cs-137 and Sr-90 concentrations are calculated using total inventory and volume data from the Waste Characterization System and the Zr-93 concentrations are estimated by using a ratio of Sr-90 to Zr-93 of 58,000:1 developed from sludge batch samples. SRR-CWDA-2013-00086, Rev. 0 reports initial concentration in Table A3-5 which is adapted in Table 6.

Table 6. Initial Concentrations of Cs-137, Sr-90, and Zr-93 for Tanks 9H-15H. (Adapted from Table A3-5 of SRR-CWDA-2013-00086, Rev. 0.)

	Units*	Tank 9	Tank 10	Tank 11	Tank 12	Tank 13	Tank 14	Tank 15
Cs-137	Ci/gal	1.2E+00	1.2E-01	3.2E+00	8.4E-01	1.3E+00	3.7E-01	2.1E+00
Sr-90	Ci/gal	1.6E+01	1.7E+00	5.8E+01	1.5E+01	2.1E+01	5.4E+00	3.7E+01
Zr-93	Ci/gal	2.8E-04	3.0E-05	1.0E-03	2.5E-04	3.7E-04	9.3E-05	6.3E-04
Sr-90:Zr-93		5.7E+04	5.7E+04	5.8E+04	6.0E+04	5.7E+04	5.8E+04	5.9E+04

*To convert Ci to Bq multiply by 3.7×10^{10}

DOE calculates the total activity (in Curies) by assuming 4,000 gallons per tank and decays it to the time of closure in year 2032. The maximum value within each tank type grouping is chosen to represent that tank type. DOE then reduces the magnitude of the cesium, strontium, and zirconium inventories for all tank types by one order of magnitude based on process samples taken before and after chemical cleaning of Tank 5F. SRR-CWDA-2013-00086, Rev. 0 reports Tank 5F process sample concentrations before and after chemical cleaning in Table A3-9 which is reproduced in Table 7.

The results in Table 7 were measured from a single process sample that was taken during mechanical sludge removal campaigns and a single process sample taken after chemical cleaning, and therefore do not represent the heterogeneity of the tank. Furthermore, since the before sample was taken in the middle of the mechanical sludge removal campaigns, the values may not accurately represent the actual effectiveness of chemical cleaning. Given that Tanks 5F and 6F (which were cleaned with oxalic acid) have been fully characterized, it is useful to compare the projected inventories to the final characterization results for these tanks. Tanks 18F and 19F (Type IV) have also been fully characterized, but they were not chemically cleaned due to the zeolite resin in these tanks. Two of the Type IV tanks in HTF (Tank 23H and 24H) contain or have processed zeolites, as well as several of the Type III/IIIA HTF Tanks

Table 7. Tank 5F Concentrations for Cs-137, Sr-90, Elemental Sr and Zr Before and After Chemical Cleaning. (Adapted from Table A3-9 of SRR-CWDA-2013-00086, Rev. 0.)

		Before (WSRC-STI-2007-00192)		**After** (SRNL-STI-2009-00492, Rev.0)	
	Units*	Aqua Regia	Peroxide Fusion	Aqua Regia	Peroxide Fusion
Cs-137	mCi/kg	1.09E+03	-	4.86E+01	3.51E+01
Sr-90	mCi/kg	3.70E+04	-	5.82E+03	5.46E+03
Sr	mg/kg	1.29E+03	1.71E+03	1.08E+02	<3.97E+02
Zr	mg/kg	3.91E+03	-	1.11E+03	-

*To convert Ci to Bq multiply by $3.7x10^{10}$

(Tanks 32H, 38H, 40H, 42H, and 51H). Chemical cleaning of tanks with zeolite may not be practical, and therefore adjusting the inventory of these tanks may not be appropriate. As can be seen in Table 8, the majority of the projected inventories for these the tanks that have already been cleaned were not overestimated by an order of magnitude (i.e., 10x). All inventories were estimated within one order of magnitude and many of the projected inventories were underestimated, especially with respect to Zr-93. Also, the final ratio of Sr-90 to Zr-93 is substantially less than the 58,000:1 for Tanks 5F-6F and Tank 19F.

Table 8. Projected and Measured Inventories of Cs-137, Sr-90, and Zr-93 for Selected FTF Type I and IV Tanks and HTF Projections for Type I and IV Tanks.

	Tank 5F/6F (Type I)		**Tanks 18F/19F (Type IV)**		**HTF Projections**	
	Projected[1] (Ci)	**Measured[2] (Ci)**	**Projected[1] (Ci)**	**Measured[2] (Ci)**	**Type I[3] (Ci)**	**Type IV[3] (Ci)**
Cs-137	**5/6:** 9.2E3	**5:** 3.5E3 **6:** 6.7E3	**18:** 9.7E3 **19:** 6.5E3	**18:** 9.2E3 **19:** 4.2E3	7.9E-2	2.4E3
Sr-90	**5/6:** 1.3E5	**5:** 9.7E4 **6:** 2.0E5	**18:** 1.1E3 **19:** 5.2E0	**18:** 2.5E3 **19:** 6.9E0	1.4E4	3.1E2
Zr-93	**5/6:** 1.0E-3	**5:** 3.0E1 **6:** 2.2E1	**18:** 1.0E-3 **19:** 1.0E-3	**18:** 8.6E-2 **19:** 1.8E-2	4.0E-1	8.8E-3
Sr-90:Zr-93		**5:** 3E3 **6:** 9E3		**18:** 3E4 **19:** 4E2	3.5E4	3.5E4

Notes: [1] SRS-REG-2007-00002, Rev. 1
[2] SRR-CWDA-2012-00071, Rev. 0
[3] SRR-CWDA-2010-00128, Rev. 1
*To convert Ci to Bq multiply by $3.7x10^{10}$

Path Forward
DOE should provide additional justification for estimating the zirconium inventory based on an assumed ratio to the Sr-90 concentration given that the measured results for the tanks which have been cleaned do not reflect a 58,000:1 Sr-90 to Zr-93 ratio. DOE should also clarify the basis for reducing cesium, strontium, and zirconium by a one order of magnitude for all tank types given that the experience with cleaning the tanks thus far does not reflect an overestimation, but rather an underestimation in many cases. Finally, DOE should clarify if the tanks containing zeolite in HTF are intended to be cleaned using chemical cleaning and how this impacts the assumed cesium, strontium, and zirconium inventory for those tanks.

Infiltration and Erosion Controls

DOE evaluates the performance of engineered surface barriers in the HTF Performance Assessment, which will be designed to limit the amount of water infiltration into the waste tanks. NRC staff reviewed the HTF Performance Assessment and supporting documents. The staff's review criteria pertaining to infiltration and erosion controls are contained in Sections 4.2, 4.3.1, 4.3.2, 4.4, 4.5, and 4.6 of NUREG-1854. The NRC staff review has identified no comments on closure cap assumptions.

Factors potentially important to infiltration and erosion control for FTF are discussed in the FTF Monitoring Plan (ML12212A192) under Monitoring Activity 5, titled "Closure Cap Performance". These factors include the long-term hydraulic performance and erosion protection design of the closure cap and closure cap functions that maintain releases of radioactivity as low as reasonably achievable. Table 9 lists the monitoring factors, as well as other potential performance assessment maintenance activities that were recommended in the NRC staff's FTF Technical Evaluation Report (ML112371751) and indicates those recommendations and comments that NRC staff believes remain relevant for HTF. NRC staff does not expect DOE to provide additional information to address these FTF monitoring factors or potential performance assessment maintenance items during the consultative process for HTF. However, DOE may elect to provide NRC additional information to address the items in Table 9 relevant to HTF if available.

Table 9. FTF Infiltration and Erosion Control Monitoring Factors Relevant to HTF

FTF Monitoring Factor	HTF Relevance
5.1: Long-Term Hydraulic Performance of the Closure Cap As discussed in the FTF Monitoring Plan (ML12212A192), NRC staff will review model support for (i) long-term hydraulic conductivity of the upper foundation layer and lateral drainage layer and (ii) the long-term erosion of the topsoil layer.	NRC staff plan to review model support information related to the long-term hydraulic performance of the closure cap for HTF as it becomes available. No addition information requests in this area are needed at this time.
5.2: Long-Term Erosion Protection Design As discussed in the FTF Monitoring Plan (ML12212A192), NRC staff will review erosion protection designs (e.g., assessment of an acceptable rock source, and the ability of an integrated drainage system to accommodate design features).	NRC staff plan to review DOE's long-term erosion protection designs for HTF as they become available. No addition information requests in this area are needed at this time.
5.3: Closure Cap Functions That Maintain Doses ALARA As discussed in the FTF Monitoring Plan (ML12212A192), several closure cap functions may provide additional barriers to release. For example, the closure cap limits infiltration, may limit the transport of deleterious species into the disposal system, and may reduce the likelihood of water table rise above the bottom of the tanks. Accordingly, NRC staff will review closure cap design, construction, and maintenance consistent with ALARA criteria.	NRC staff plan to review closure cap information for HTF as it becomes available. No additional information requests in this area are needed at this time.

ALARA: As Low As Reasonably Achievable

Waste Release and Near-Field Transport

This section contains comments on the waste release modeling in the near-field environment of HTF that is documented in the HTF Performance Assessment and supporting references. DOE abstracted (i.e., simplified) the tank system at HTF using the PORFLOW® model for the base case. In addition, DOE conducted uncertainty and sensitivity analyses using the GoldSim® modeling platform to risk-inform conclusions regarding compliance with the 10 CFR Part 61 performance objectives. The comments in this section relate to tank system performance modeling and include abstractions for corrosion of the steel liners, degradation of cementitious materials, release of radionuclides from the tank system, and transport through the near-field environment.

NRC staff comments primarily focus on the adequacy of the technical basis for the base case conceptual model and supporting parameters for waste release. These comments are related to waste release conceptual models from the inventory modeled in the contaminated zone within the primary steel liner and inventory modeled in the tank annulus and underlying sand pads; steel liner failure times; selection of solubility limiting phases and estimated solubility limits; chemical transition times; and sorption parameters of radionuclides in cementitious materials and near-field soils.

Of particular interest for HTF is that Type I and II tanks are either fully or partially submerged in groundwater. Several of the Type I and II tanks have additional risk factors. Tanks 12H, 14H, 15H, and 16H are assumed to have a failed liner at closure. In addition, Tanks 9H, 10H, 14H, and 16H are assumed to contain significant waste outside of the primary steel liners. Annular

waste is potentially risk significant because the waste is generally more soluble and is located outside of primary containment. Although Tanks 12H and 15H do not have as significant of quantities of radionuclides outside of the primary liner, DOE assumes no credit for the steel liners in these tanks to limit flow into the tanks or releases of radionuclides.

The HTF Performance Assessment does not adequately assess waste release from the submerged and partially submerged tanks via a preferential pathway. Alternative cases B-E provide some risk insight into the effects of a preferential pathway, however, these cases may not adequately account for the risk posed by Tanks 9H, 10H, 12H, 14H, 15H, and 16H.

To develop the following comments, NRC staff reviewed the HTF Performance Assessment and supporting documents. The NRC staff's review criteria pertaining to near-field release of radionuclides are contained in Sections 4.2, 4.3.2, 4.3.3, 4.4, 4.5, and 4.6 of NUREG-1854.

Additionally, during the consultative process for the FTF waste determination, NRC staff provided recommendations and comments to DOE regarding radionuclide releases from the tanks and subsequent transport in near-field environment in the FTF Technical Evaluation Report (ML112371715). Table 10 identifies those recommendations and comments that NRC staff believe remain relevant for HTF. NRC staff does not expect DOE to provide additional information to address these previous recommendations and comments during the consultative process for HTF. However, DOE may elect to provide NRC additional information to address the issues associated with the FTF monitoring factors that are relevant to HTF if available.

Table 10. FTF Monitoring Factors Relevant to HTF Waste Release and Near-Field Transport

FTF Monitoring Factor	HTF Relevance
FTF Monitoring Area 2 – Waste Release	
2.1: Solubility Limiting Phases/Limits and Validation In the FTF Technical Evaluation Report (ML112371715) and Monitoring Plan (ML12212A192), the primary NRC staff recommendation and monitoring factor was for DOE to perform experiments to validate Geochemist's Workbench calculations used to determine solubility limiting phases, solubility limits, and chemical transition times. NRC staff recommended that these experiments should study (i) pH and E_h evolution of the grout pore water over time, (ii) controlling solubility limiting phases, and (iii) static and dynamic leach tests to study the mobility of highly radioactive radionuclides, including consideration of alteration of tank residuals following chemical cleaning with reagents, such as oxalic acid.	In the HTF Performance Assessment, DOE continues to lack adequate experimental support for Geochemist's Workbench calculations used to determine solubility limiting phases and solubility limits as will be discussed in the NRC staff's HTF technical evaluation report. At HTF, like at FTF, NRC staff expects the projected receptor dose to be sensitive to solubility limits for technetium, plutonium and neptunium. DOE applies very low solubility limits associated with co-precipitation with iron phases over all modeled chemical conditions for technetium which resulted in no significant releases at any time for the base case. See also RAI-NF-7. Further, in the HTF Performance Assessment, DOE significantly decreased its solubility by six orders of magnitude compared to the solubility assumed in the FTF Performance Assessment (SRS.REG-2007-00002, Rev. 1) in more neutral pH environment associated with Oxidizing Region III which resulted in no significant releases of plutonium at any time. In Appendix C of the FTF Monitoring Plan (ML12212A192), NRC staff discusses experimental observations that suggest the possible presence of plutonium carbonate species which would be expected to be more soluble. Additionally, updated solubility modeling indicates that above a critical threshold E_h plutonium solubility can be risk significant upon transition to Oxidized Region II. These concerns are discussed further in RAI-NF-6. Finally, NRC staff notes that neptunium solubilities decreased by approximately two orders of magnitude under Oxidized Regions II and III. NRC staff understands the DOE approach for neptunium and has no comment at this time; however, experimental validation of neptunium solubility is still needed.

Table 10. FTF Monitoring Factors Relevant to HTF Waste Release and Near-Field Transport

FTF Monitoring Factor	HTF Relevance
2.2: Chemical Transition Times and Validation As stated above (Monitoring Factor 2.1), DOE continues to lack adequate experimental support for Geochemist's Workbench calculations used to determine chemical transition times for HTF. NRC staff listed concerns in the FTF Monitoring Plan (ML12212A192) including uncertainty with the thermodynamic data, characteristics of infiltrating water, and solid phase assumptions in the geochemical modeling. In NRC staff's Technical Review Memorandum (ML12272A082) for FTF monitoring, NRC staff expressed concerns with the assumed mineralogy (i.e., pyrite) controlling the longevity of reducing conditions.	For the HTF Performance Assessment, staff continues to have concerns with the assumed mineralogy in geochemical modeling that controls chemical transition times, as well as the dissolved oxygen content of water contacting the contaminated zone. See also RAI-NF-3 and RAI-NF-5. RAI-NF-4 discussed NRC staff concerns related to the assumption that 10 percent of the groundwater in contact with the contaminated zone is conditioned by reducing grout.
FTF Monitoring Area 3 – Cementitious Material Performance	
3.1: Concrete Vault Performance (As It Relates to Steel Liner Corrosion) As discussed in the FTF Technical Evaluation Report (ML112371715) and Monitoring Plan (ML12212A192), NRC listed a number of concerns with the assumed steel liner failure times. For example, NRC staff was concerned with DOE assumptions regarding initial conditions and degradation of cementitious materials. NRC staff was also concerned that in the FTF Performance Assessment (SRS-REG-2007-00002, Rev. 1) base case DOE did not consider aggressive service conditions and corrosion mechanisms that had been observed at FTF (e.g., groundwater in-leakage and water table rise). NRC staff was also concerned with construction features (e.g., construction joints, cracking) that may lead to preferential pathways through the vault and DOE assumptions regarding the time to initiation of carbonation-induced corrosion (i.e., assumptions regarding the progression of the carbonation front).	In the HTF Performance Assessment, DOE assumes that HTF Tanks 12H, 14H, 15H, and 16H are initially failed (i.e., are not a significant barrier to flow and transport) due to the location and number of leak sites. For other tanks, the primary corrosion mechanisms are carbonation- and chloride-induced depassivation of the carbon steel liners, similar to FTF Performance Assessment (SRS-REG-2007-00002, Rev. 1). NRC staff continues to have concerns about corrosion mechanisms that are considered in the HTF Performance Assessment. NRC staff concerns related to the passivity of the carbon steel liner under chloride-induced corrosion due to assumptions regarding oxygen availability (e.g., transport rates and distribution). See RAI-NF-1. In RAI-NF-2, NRC staff discusses concerns with the assumption that the diffusion coefficients for carbon dioxide and oxygen that are used for steel liner lifetime estimates appropriately bound the permeability changes in concrete due to carbonation..

Table 10. FTF Monitoring Factors Relevant to HTF Waste Release and Near-Field Transport

FTF Monitoring Factor	HTF Relevance
3.2: Groundwater Conditioning As discussed in the FTF Monitoring Plan (ML12212A192), NRC staff has concerns with assumptions regarding groundwater conditioning that limits key` radionuclide solubility for long periods of time. Groundwater conditioning via interactions with infiltrating water and reducing tank grout could be compromised if flow were to primarily occur along preferential pathways.	NRC staff continues to have unresolved technical concerns regarding the potential for the existence or creation of preferential flow paths through the grouted tanks. See also RAI-NF-10. For HTF, NRC staff also has concerns about DOE's assessment of preferential flow paths through the annulus for tanks with significant annular contamination. For example, observations of preferential pathways through HTF vaults (e.g., annular waste in Tank 16 is thought to have entered the environment via construction joints in the concrete vault) have been observed. See RAI-NF-12, RAI-NF-13 and CC-NF-1.
3.3: Shrinkage and Cracking As discussed in the FTF Monitoring Plan (ML12212A192), NRC staff has concerns with mechanisms that could create preferential pathways such as shrinkage gaps and cracks in the grout monolith. Accordingly, NRC staff plans to monitor factors important to shrinkage and cracking including cracking caused by steel corrosion, thermal gradients, alkali-silica reaction, differential settlement, etc.	NRC staff continues to have concerns related to shrinkage and cracking that could lead to preferential pathways through HTF engineered barriers. However, NRC staff has no additional information needs at this time.
3.4: Grout Performance As discussed in the FTF Monitoring Plan (ML12212A192), NRC staff plans to monitor development, testing, and placement of grout in FTF tanks/vaults under appropriate conditions of temperature and humidity to ensure proper curing.	The technical concerns addressed by the monitoring factor are relevant to HTF. However, NRC staff has no additional requests for information is needed at this time for HTF.

Table 10. FTF Monitoring Factors Relevant to HTF Waste Release and Near-Field Transport

FTF Monitoring Factor	HTF Relevance
3.5: Basemat Performance As discussed in the FTF Monitoring Plan (ML12212A192), NRC staff plans to monitor the ability of the concrete basemats to attenuate release from FTF tanks, including the effects of preferential pathways (e.g., construction joints) and sorption coefficients, particularly for neptunium and plutonium.	For HTF, NRC staff continues to have concerns regarding the performance of the tank basemats to attenuate release. DOE assigns neptunium K_d values for cementitious materials that are much higher than were used for the FTF: 10,000 ml/g for middle-age reducing conditions, 10,000 ml/g for middle-age oxidizing conditions, and 5,000 ml/g for old-age oxidizing conditions (HTF Performance Assessment, Table 4.2-29). The corresponding values for FTF were 3,000, 1,600, and 250 ml/g (SRS-REG-2007-00002, Rev 1, Table 4.2-33). The cited reference for the HTF values is SRNL-STI-2009-00473; Tables 17 and 18 in that report contain the rationales. The K_d values for plutonium listed in the HTF Performance Assessment, Table 4.2-29, are supported in SRNL-STI-2009-00473, Tables 17 and 18, by experimental data yielding very high apparent K_ds. The recent experimental work reported in SRNL-STI-2009-00636, Rev. 0, however, concludes that its high apparent K_ds resulted from solubility control of neptunium and plutonium. NRC staff understands the approach and will present its review of SRNL-STI-2009-00473 in the technical evaluation report.
3.6: Use of Stabilizing Grout (As It Pertains to ALARA) As discussed in the FTF Monitoring Plan (ML12212A192), NRC staff plans to monitor DOE's efforts to use grout to stabilize tank waste including grouting of tank/vault features that could lead to preferential pathways. NRC staff will also monitor DOE's efforts to develop a grout formulation to minimize shrinkage, if consistent with ALARA.	The technical concerns addressed by the monitoring factor are relevant to HTF. However, NRC staff has no additional requests for information is needed at this time for HTF.

Table 10. FTF Monitoring Factors Relevant to HTF Waste Release and Near-Field Transport

FTF Monitoring Factor	HTF Relevance
FTF Monitoring Area 6 – Performance Assessment Maintenance	
6.2: Model and Parameter Support In the FTF Monitoring Plan (ML12212A192), NRC staff plans to monitor DOE efforts to address the following recommendations/comments from Table A-2: (i) Uncertainty in steel liner performance, including more aggressive service conditions and corrosion mechanisms than assumed in the FTF Performance Assessment (SRS-REG-2007-00002, Rev. 1) should be considered, as well as a patch model for waste release, if deemed to be risk-significant. *Continued*	(i) The technical concerns addressed by the monitoring factor are relevant to HTF. See discussion under FTF Monitoring Factor 3.1 above.

Table 10. FTF Monitoring Factors Relevant to HTF Waste Release and Near-Field Transport

FTF Monitoring Factor	HTF Relevance
6.2: Model and Parameter Support (Continued) (ii) Additional support for probabilistic parameter distributions, including solubility limiting phases, cement K_ds (based on sediment variability), chemical transition times, basemat bypass, and configuration probability. Continued	(ii) The HTF probabilistic model assumes a discrete distribution for the solubility controlling phases, as discussed in Section 5.6.3.3 of the HTF Performance Assessment. DOE assumes that the probability of iron co-precipitation for plutonium, neptunium, technetium, and uranium is 50% with the remaining 50% assigned to the base case solubility values. The co-precipitated phases typically have significantly lower solubility limits. NRC staff continues to assess the likelihood of iron co-precipitated phases for key radionuclides. See also RAI-NF-9. NRC staff has concerns with the assumed solubility limiting phases/solubility limits for plutonium and technetium (e.g., iron co-precipitation) in the HTF Performance Assessment as discussed in RAI-NF-6. NRC staff continues to have concerns with the basis for parameter distributions for cement K_ds in the HTF Performance Assessment. The HTF probabilistic model implements a triangular distribution for the chemical transition times similar to FTF, as discussed in Section 5.6.3.8 of the HTF Performance Assessment. DOE applies ±30% for the transition times from Reducing II to Oxidizing II conditions and ±50% for the transition times from Oxidizing II to III based on SRNL-STI-2012-00404. NRC staff remains concerned that the distributions do not adequately bound the uncertainty in the chemical transition times. See also RAI-NF-3, RAI-NF-5, and CC-NF-2. The HTF probabilistic model assumes a triangular distribution for the likelihood of a preferential transport pathway (i.e., zero K_d) through the basemat for all cases, as discussed in 5.6.3.6 of the HTF Performance Assessment. DOE implements a range from 0% to 10% with 0% being the most likely amount of preferential transport. NRC staff understands the approach and is not asking any further questions. However, NRC staff remains concerned that the DOE has not provided an adequate basis for the basemat bypass distribution. Configuration probability is discussed in Table 2.

Table 10. FTF Monitoring Factors Relevant to HTF Waste Release and Near-Field Transport

FTF Monitoring Factor	HTF Relevance
6.2: Model and Parameter Support (Continued) (iii) NRC recommends DOE obtain FTF specific data to support material property assignments including hydraulic conductivity, moisture characteristic curves, and K_ds. (iv) NRC will monitor DOE's efforts to study the impact of cement leachate on radionuclide mobility.	(iii) NRC staff continues to have concerns with the basis for material property assignments—primarily cement K_ds—in the HTF Performance Assessment. (iv) SRNL-STI-2009-00473 (Page 147) indicates that once the high pH front resulting from calcium hydroxide that leaches from cementitious material reaches the aquifer DOE believes that it would likely be rapidly diluted and would have negligible influence on radionuclide sorption. Therefore, DOE did not incorporate the effect of leachate on radionuclide mobility in the saturated zone modeling nor for near-field modeling of Type I and II tanks which are fully or partially submerged in the groundwater. However, DOE does simulate the effect of cement leachates on near-field transport in the vadose zone for Type III/IIIA and IV tanks that are located above the aquifer until the contaminated zone reaches Oxidized Region III chemical condition. DOE developed K_ds in SRNL-STI-2009-00473 from differences between cement-leachate impacted and non-impacted K_ds for Hanford sediments (PNNL-16663) and indicated that the approach is to provide early guidance to future and research data needs (Pg. 46). NRC staff will continue to evaluate information related to cement-leachate impacted radionuclide mobility as it becomes available. See also CC-NF-3.

RAI-NF- 1

DOE should provide additional support for the implicit conclusion that the carbon steel liner in contact with chloride solution would remain essentially passive due to an assumption of limited availability of oxygen to support chloride-induced corrosion.

Basis

The documents on life estimation of high level waste tank steel (SRNL-STI-2010-00047; WSRC-STI-2007-00061, Rev. 2) include computations that are strongly dependent on CO_2 and O_2 diffusion coefficients. Long steel lifetimes are dependent on the concrete vault being an effective diffusive barrier (See RAI-NF- 2). The corrosion rates for carbon steel in contact with chloride solution used in the performance assessment are practically in the passive regime, due to the assumed diffusion transport resistance by the concrete.

According to Table 4.2-32 in the HTF Performance Assessment, DOE used general corrosion rates of the carbon steel activated by chloride in the range of 0.04 to 0.09 mil/yr [Figure 40 and 41, $D(O_2)=10^{-4}$ cm^2/s, SRNL-STI-2010-00047] for Type I and II tanks, and corrosion rates equal to 0.04 mil/yr for Type III and IV tanks [Tables 28 and 29, $D(O_2)=10^{-4}$ cm^2/s, WSRC-STI-2007-00061, Rev. 2]. The magnitude of those corrosion rates corresponds to passive corrosion. As a comparison, a liner 0.5-in thick would corrode in 12,500 years at a rate of 0.04/mil/yr. Because of this slow rate, DOE concludes that the liner failure time is mostly controlled by the penetration time of a carbonation front, and that results are almost independent of the magnitude of the oxygen diffusion coefficient, provided that it is less than 10^{-4} cm^2/s.

The steel liner failure times for various tank types for the performance assessment are summarized in Table 4.2-32 of the HTF Performance Assessment. As previously stated, for Type I and II tanks the assumed value of the oxygen diffusion coefficient was 10^{-4} cm^2/s, independently of the case (A, B, C, D, or E). For Type III/IIIA and IV tanks, DOE assumed a value of the oxygen diffusion equal to 10^{-6} cm^2/s, also independently of the configuration. The numerical distinction to the performance assessment results of selecting and oxygen diffusivity of 10^{-4} cm^2/s or 10^{-6} cm^2/s is negligible, as associated liner corrosion rates are computed by the DOE to be in the passive range (due to the assumption of oxygen diffusion control of the corrosion rate).

In the computation of corrosion rates controlled by oxygen diffusion (chloride-induced corrosion case) that are described in SRNL-STI-2010-00047 and WSRC-STI-2007-00061, Rev. 2, assumptions that corrosion is uniform and that the oxygen reduction reaction ($1/2\ O_2 + H_2O + 2e^- \rightarrow OH^-$) happens at the same location as the iron oxidation reaction ($Fe \rightarrow Fe^{2+} + 2e^-$) are implicit. In SRNL-STI-2010-00047, the possibilities of galvanic corrosion and macro-cell corrosion (due to different levels of water saturation and oxygen availability) associated with the separation of anodic and cathodic regions on the liner are recognized. In general, anodic areas could be much smaller than cathodic areas, potentially leading to liner regions undergoing faster corrosion than computed under the assumption of uniformly spread corrosion. Oxygen reduction could occur on other metal surfaces with accessible oxygen, such as the rebar or

transfer lines (the liner is possibly in electrical contact with concrete vault rebar and transfer lines). The availability of oxygen for corrosion reactions should be higher above the water line for partially or fully immersed tanks. Also, the chloride concentration in the concrete vault could be higher near the water line, due to evaporation; thus contributing to differentiation between cathodic and anodic areas in the liner and rebar.

The implicit conclusion in the DOE analyses that the carbon steel remains in the passive state depends strongly on considerations and assumptions of effective diffusivity through cementitious materials over long time periods (see RAI-NF- 2), uniformity of the corrosion process, and space-point balance of cathodic and anodic reactions.

Path Forward

Provide a technical basis for the implicit conclusion that the carbon steel liner in contact with chloride solution would remain passive, especially since (i) concrete could degrade as a function of time, (ii) oxygen availability varies along metal surfaces especially for tanks partially or fully immersed, and (iii) it is not strictly necessary for oxygen reduction to occur at the same location where carbon steel actively corrodes.

RAI-NF- 2

Provide a technical basis for the assumption that the diffusion coefficients for carbon dioxide and oxygen that are used for steel liner lifetime estimates appropriately bound the permeability changes in concrete due to carbonation.

Basis

To estimate steel liner lifetimes in the HTF Performance Assessment base case (i.e., Case A), DOE assumes effective diffusion coefficients for carbon dioxide [$D(CO_2)$=1E-6 cm^2/s] and oxygen [$D(O_2)$=1E-4 cm^2/s (Type I/II); $D(O_2)$=1E-6 cm^2/s (Type III/IIIA/IV)] through cementitious materials. On page 317 of the HTF Performance Assessment, DOE indicates that diffusion coefficients are typically calculated or measured to be approximately 1.0E-8 cm^2/s.

Rebar corrosion is known to crack concrete and cause spallation, due to the volume expansion of corrosion products. Literature information relates the timing of cracking, due to carbonation, and the extent of cracking to the rebar cover. The rebar cover is the thickness of the concrete on top of the rebar. It is not clear how the analysis in SRNL-STI-2010-00035, Rev. 0 relates to information in the literature linking cracking to the cover thickness.

Analyses in the literature relate cracking of reinforced concrete to the cover thickness (e.g., Parrot, 1990; Andrade et al., 1993; Molina et al., 1993; Neville, 1996). The rebar cover in the reinforced concrete vaults are expected to be a few centimeters of concrete. Parrott (1990) states that cracks are not expected when the carbonation depth is less than one-half of the cover, but significant rebar corrosion, cracking and spallation can occur when the carbonation depth is in excess or well in excess of the cover thickness.

Cracks would affect permeability of concrete and the diffusivity of CO_2 through the system.

Enhanced diffusivity of CO_2 would enhance the penetration rate of the carbonation front, which in turn would activate corrosion of deeper rebar, and potentially cause additional cracking of the concrete. Rebar could also actively corrode due to the presence of chloride in the groundwater.

Information is needed on whether a gradual rebar corrosion process and cracking of the concrete vault would affect significantly affect permeability of the concrete vaults thereby potentially reducing steel liner lifetime estimates (SRNL-STI-2010-00035, Rev. 0) used in the HTF Performance Assessment.

Path Forward
Provide a technical basis for the diffusion coefficients for carbon dioxide and oxygen assumed for steel liner lifetime projections. The basis should discuss whether the coefficients appropriately account for permeability changes of the concrete due to carbonation, especially since rebar can be located close to the vault surface and can exhibit enhanced corrosion rates due to carbonation at an earlier time.

RAI-NF- 3
The technical basis should be enhanced for the estimated longevity of reducing conditions that is important to the retention of redox-sensitive radionuclides in the waste tanks.

Basis
Reducing conditions are assumed in the HTF Performance Assessment to provide a significant chemical barrier to the release of redox-sensitive radionuclides. The longevity of reducing conditions is dependent on the ability of reduced sulfur species in the blast furnace slag to react with dissolved oxygen in the infiltrating water. The HTF Performance Assessment utilized Geochemist's Workbench to estimate the longevity of reducing conditions. The simulation used the mineral pyrite (FeS_2) to account for the reducing capacity of the grout (SRNL-STI-2012-00404, Rev. 0).

The lack of empirical data supporting the selection of pyrite to represent the grout reducing capacity means the calculated E_h transition time is uncertain. Recent research indicates that sulfide phases present in blast furnace slag might not be adequately accounted for by the use of pyrite as a proxy, as discussed in ML12272A082. PNNL-21723 reported observed reduced sulfur species in leachates from saltstone simulant experiments that also utilized blast furnace slag to impart reducing conditions. If the reduced sulfur phase(s) in blast furnace slag is more soluble than pyrite, the geochemical modeling in the HTF Performance Assessment would overestimate the longevity of reducing conditions in the grout.

Path Forward
DOE should provide additional support for the assumption that pyrite is a reasonable proxy in geochemical modeling for representing the reducing capacity. Additional support could include laboratory studies conducted to determine the reducing capacity that may be removed by leaching.

RAI-NF- 4

The technical basis for the ratio of 90% unconditioned groundwater to 10% grout conditioned water contacting the contaminated zone for conditions B, C, and D for submerged and partially submerged tanks throughout the period of performance is not well supported.

Basis

The HTF Performance Assessment assumes that the water contacting the contaminated zones in the submerged and partially submerged tanks consists of 90% unconditioned groundwater and 10% conditioned water that has migrated through the reducing grout. The assumption of 10% mixing of conditioned water provides a significant chemical barrier to radionuclide release. The basis for the 90:10 ratio approximates the modeled lateral-to-vertical groundwater flow velocities. However, the presence of engineered barriers at the HTF challenges this assumption.

The closure cap and the grouted tanks both decrease the likelihood that 10% of the water contacting the contaminated zone will be conditioned by the overlying grout. The presence of the closure cap is assumed to limit water migrating into the partially submerged tanks early in the performance period. In addition, the low hydraulic conductivity of the grout relative to the high potential hydraulic conductivity of preferential pathways also calls into question the assumption of 10% of the water that contacts the contaminated zone will be conditioned by the overlying grout. It is not clear to NRC staff that overlying grout will be able to condition water migrating through preferential pathways within the tanks.

Path Forward

Provide additional technical bases for assuming that the water contacting the residual waste will consist of at least 10% water that is conditioned by the grout under closed conditions. DOE should consider the impact of time-dependent degradation of engineered barriers on this assumption. Alternatively, DOE could assess the sensitivity of the results to this assumption (e.g., assume a bounding condition of 100% of the water contacting the contaminated zone is unconditioned by the overlying grout).

RAI-NF- 5

The concentration of dissolved oxygen in the groundwater that was assumed in the geochemical modeling for the submerged and partially submerged tanks might be underestimated.

Basis

The assumed low dissolved oxygen in groundwater prolongs the reducing conditions for the submerged and partially submerged tanks relative to the non-submerged tanks. DOE relies on well P27D, because it is currently the only well in HTF area with measured dissolved oxygen values. However, well P27D is anomalously low relative to the other SRS water table wells. DOE stated that the low dissolved oxygen is due to local geology and that the values are likely reasonable for Type I tanks, however, DOE expects the dissolved oxygen values to be higher for Type II tanks (ML13126A127). NRC staff is concerned that several factors could have

resulted in well P27D dissolved oxygen values being lower than groundwater conditions within the HTF, including screening depth and locally impacted groundwater conditions.

Path Forward
DOE should evaluate the impact of using dissolved oxygen values that are consistent with measurements of unimpacted groundwater dissolved oxygen values across SRS (i.e., how many pore volumes would be required to transition the grout from reducing to oxidizing conditions). Alternatively, DOE could collect additional dissolved oxygen measurements within the HTF at locations and elevations that are in closer proximity to the tanks.

RAI-NF- 6
The assumed solubility values for plutonium in the deterministic and probabilistic analyses are not well supported.

Basis
The assumed solubility of plutonium under reducing and oxidizing conditions in the HTF Performance Assessment provide a significant chemical barrier to waste release. The HTF Performance Assessment relies on a study in SRNL-STI-2012-00404, Rev. 0 that assumes $PuO_{2(am, hyd)}$ will control the solubility at 3E-11 mol/L under the three assumed chemical conditions. This assumption appears to be based on the thermodynamic calculations reported in SRNL-STI-2012-00087, Rev. 0. In this report, DOE argues that plutonium particles will be present as $PuO_{2(am, hyd)}$ based on thermodynamic stability. NRC staff are concerned that this assumption is not well supported and is inconsistent with Savannah River Site observations.

Residual waste samples from Tank 18F were indicative of a plutonium carbonate phase that had a significantly higher solubility than the phase assumed in the HTF Performance Assessment (ML12272A082). As discussed by NRC staff in the technical review, there may be a thermodynamic potential for plutonium carbonate phase(s) to transform into $PuO_{2(am, hyd)}$; however, several factors may inhibit or preclude transformation. If higher solubility plutonium phases are present in risk-significant quantities after the final cleaning of the tanks, additional information will be needed to demonstrate that the 10 CFR Part 61 performance objectives will be met. This information includes verification that any higher-solubility plutonium phases will convert to lower solubility phases under reducing grouted conditions. In addition, the HTF Performance Assessment has insufficient support for: (i) the as-modeled E_h threshold at which the solubility of plutonium significantly increases and (ii) the assumption that the E_h of infiltrating water will remain less than this threshold value during oxidizing conditions.

Path Forward
During the final characterization of residual tank waste, DOE should: (i) demonstrate that the quantity of high-solubility plutonium phase(s) remaining in the tanks is not risk-significant or (ii) if the quantity is risk significant, the high-solubility phase(s) will convert to lower-solubility phases under reducing grouted conditions. DOE should also provide additional support for the assumption that the E_h of infiltrating water will remain below the E_h threshold upon which

plutonium transitions to a higher solubility phase than assumed in the HTF Performance Assessment.

RAI-NF- 7

DOE does not provide a sufficient basis for assuming that 100% of the technetium-99 is co-precipitated with iron.

Basis

The assumption that 100% of the Tc-99 is co-precipitated with iron significantly limits its release under all chemical conditions. Based on SRNL-STI-2012-00404, Rev. 0, DOE assumes that tank washing will effectively remove all of the more soluble Tc-99. The authors also cite several studies from Hanford that provide evidence of Tc-99 being co-precipitated with iron. However, DOE has not demonstrated that tank washing will remove all of the more soluble technetium-99 and that the remaining Tc-99 will be co-precipitated with iron.

Path Forward

If the inventory of Tc-99 is not reduced to an insignificant risk level, DOE should provide experimental evidence to support the assumption that technetium solubility is controlled by iron co-precipitation under all chemical conditions.

RAI-NF- 8

The assumption that solubility limits apply to radionuclides that migrate upward from annular waste into the contaminated zone is not well supported.

Basis

Although no solubility control is assumed for radionuclides associated with waste initially located in tank annuli, solubility controls are realized for radionuclides that are able to diffuse into the contaminated zone from the annulus. For example, DOE estimates that technetium-99 in Tank 16H is present in higher quantities in the annulus (primary sand pad) compared to the contaminated zone with no effective transport barrier between the two (Tank 16 is assumed to have a failed liner initially; the tank liner would constitute a transport barrier to upward diffusion if it were effective). The Tc-99 inventory located within the primary liner is constrained to low aqueous concentrations owing to solubility controls associated with iron co-precipitated phases that are placed on this constituent in the contaminated zone. The assumption that solubility limiting phases would control the solubility of radionuclides that diffuse upward from the annulus is not well supported, particularly for radionuclides (i.e., technetium) that DOE models as co-precipitated with iron phases. Given the large concentration gradient and small diffusion length between the primary sand pad, where the bulk of Tank 16H annulus contamination is placed in the PORFLOW® model, and the contaminated zone, a significant portion of Tc-99 diffuses into the contaminated zone where it is retained for most of the simulation timeframe due to very low solubility limits associated with iron co-precipitation. Although Tc-99 in Tank 16H may not be risk-significant, risk-significant quantities of key radionuclides may be present in Tank 16H or other tanks and experience the same phenomena.

Path Forward
Assess the sensitivity of solubility control on that portion of annular inventory that diffuses into the contaminated zone on tank releases (or resultant doses). DOE should also provide a basis for solubility limits in the contaminated zone for radionuclides that are transported upward from the annulus and sand pads in Type I and II tanks. In particular, the basis should address the appropriateness of iron co-precipitated phases to limit solubility of radionuclides that have migrated into the contaminated zone within the primary tank liner.

RAI-NF- 9
Solubility values used in the probabilistic modeling do not adequately account for uncertainty.

Basis
In Section 5.6.3.3 of the HTF Performance Assessment, DOE states that the uncertainty in solubility values is accounted for by conservatively selecting the solubility controlling phases. DOE also discusses that the uncertainty in thermodynamic data is addressed by modifying the chemical transition times in GoldSim®.

The probabilistic model in the HTF Performance Assessment assumes a discrete distribution for the solubility controlling phases, as discussed in Section 5.6.3.3 of the HTF Performance Assessment. DOE assumes that the probability of iron co-precipitation for plutonium, technetium, neptunium, and uranium is 50% with the remaining 50% assigned to approximate the solubility values listed in Table 4.2-11 of the HTF Performance Assessment. The values listed in Table 4.2-11 of the HTF Performance Assessment are approximately consistent with the base case values for the deterministic modeling for plutonium, neptunium, and uranium. For technetium, DOE assumes that it is co-precipitated with iron in the deterministic base case rather than using its solubility value listed in Table 4.2-11 of the HTF Performance Assessment. However, DOE has only provided indirect evidence of iron co-precipitation of highly radioactive radionuclides. Furthermore, DOE does not account for the possibility of higher solubility phases due to the presence of carbonate ions even though analyses of residual waste from Tank 18F identified a uranyl carbonate phase and were also indicative of a plutonium carbonate phase (ML12272A082). In addition, the base case solubility values do not represent a reasonable upper solubility limit.

To help account for the uncertainty in relying on thermodynamic data for solubility values, DOE utilized the uncertainty information provided by the Nuclear Energy Agency (NEA) with the NEA database (SRNL-STI-2012-00404, Rev. 0). The range of solubility values, as calculated in SRNL-STI-2012-00404, Rev. 0, exceed the base case solubility values assumed in the probabilistic model for plutonium, neptunium, and uranium.

It is not clear how the uncertainty in thermodynamic data was accounted for with the modifications in the chemical transition times. For example, the solubility of plutonium does not appreciably vary between three assumed chemical conditions. However, SRNL-STI-2012-00404, Rev. 0 indicates that the uncertainty in thermodynamic data can result in two orders of magnitude variation in solubility. Accordingly, varying the chemical transition times would not

account for the uncertainty in thermodynamic data related to the solubility of plutonium.

In Section 5.6.7.3 of the HTF Performance Assessment, DOE provides a one-off deterministic sensitivity analysis of plutonium, neptunium, technetium, and uranium solubility values. The pessimistic solubility values that DOE assumed in study 1 provide only limited risk insight. Unless implausible, these pessimistic values should be considered to develop the solubility value distributions in the full probabilistic analysis.

NRC staff disagree with DOE's assertions that: (i) solubility controlling phases for plutonium, neptunium, technetium, and uranium were conservatively selected and (ii) varying the chemical transition times adequately accounts for the uncertainty in thermodynamic data. Based on the lack of direct evidence supporting the assumed solubility controlling phases and the thermodynamic modeling reported in SRNL-STI-2012-00404, Rev. 0 which suggests higher solubility values are possible, NRC staff is concerned that the assumed probability distributions in the HTF Performance Assessment for plutonium, neptunium, technetium, and uranium are optimistic.

Path Forward
DOE should revise the assumed probability distributions with more defensible values and provide revised results from the probabilistic analysis.

RAI-NF- 10
The assumption that there is not a preferential pathway through the tank vaults and grout in the base case is not well supported. Consideration of a preferential pathway is especially important for Type I and II tanks that are submerged or partially submerged, with several containing significant quantities of radionuclides outside of the primary liner.

Basis
DOE assigns a probability of 75% to the base case (Table 5.6-5 of the HTF Performance Assessment), assuming that preferential pathways are not likely to occur throughout the entire period of performance. Based on historical evidence of waste release from Tank 16H into the environment (DP-1358) and operational observations of groundwater in-leakage over a relatively short timeframe, NRC staff are concerned that the probability of water migrating into the tanks through preferential pathways in the concrete vaults and contacting the waste is greater than assumed in the HTF Performance Assessment. 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. In addition, the grouting of the tanks will reduce the hydraulic head associated with the submerged and partially submerged tanks; however, the hydraulic gradient of the Upper Three Runs aquifer will still provide a small hydraulic driving force.

Path Forward
DOE should provide additional technical basis for assuming that preferential pathways are a low probability scenario in light of observations suggesting preferential pathways already exist

through concrete vaults. Alternatively, DOE could include the presence of preferential pathways in their base case analysis or treat the various cases as independent conceptual models and report the conditional results (i.e., unweighted by their likelihood).

RAI-NF- 11

The assumption that the flow of water through the preferential pathway is limited to water that has infiltrated through the closure cap, may underestimate the release of short-lived radionuclides for submerged and partially submerged tanks.

Basis

Alternative cases B-E in the HTF Performance Assessment are designed to account for mechanisms that could result in the occurrence of a preferential pathway. The HTF Performance Assessment assumes that flow through the preferential pathway is only from water that has infiltrated through the closure cap. The closure cap is designed to limit infiltration early in the performance period, providing time for shorter-lived radionuclides (e.g., Sr-90 and Cs-137) to decay to less significant levels. However, operational experience suggests that groundwater in-leakage through a preferential pathway could occur earlier in the performance period. The assumption of limiting flow through the preferential pathway to water that has infiltrated through the closure cap could significantly underestimate the release of short-lived radionuclides due to groundwater in-leakage.

Path Forward

DOE should evaluate the potential release of radionuclides due to groundwater in-leakage via a preferential pathway through the submerged and partially submerged tanks.

RAI-NF- 12

In Tanks 9H and 10H (Type I), the loading of the annular source term in the reducing grout and the location of the preferential pathway appear to be unrealistic.

Basis

In DOE's PORFLOW® model (see Figure 1), the annular waste in Tanks 9H and 10H is loaded within the bottom of the annular reducing grout. Loading of the annular waste into the bottom of the reducing grout in DOE's PORFLOW® model assigns K_d values associated with reducing grout. For redox-sensitive radionuclides, this appears to significantly limit mobility even though this waste is assumed to be highly mobile. In addition, the preferential pathway represented in cases B-E does not intersect the annular waste in Tanks 9H and 10H. Based on operational experience, NRC staff is concerned that groundwater in-leakage into the annular region could occur and that the associated risk with this scenario is not adequately addressed within the Performance Assessment.

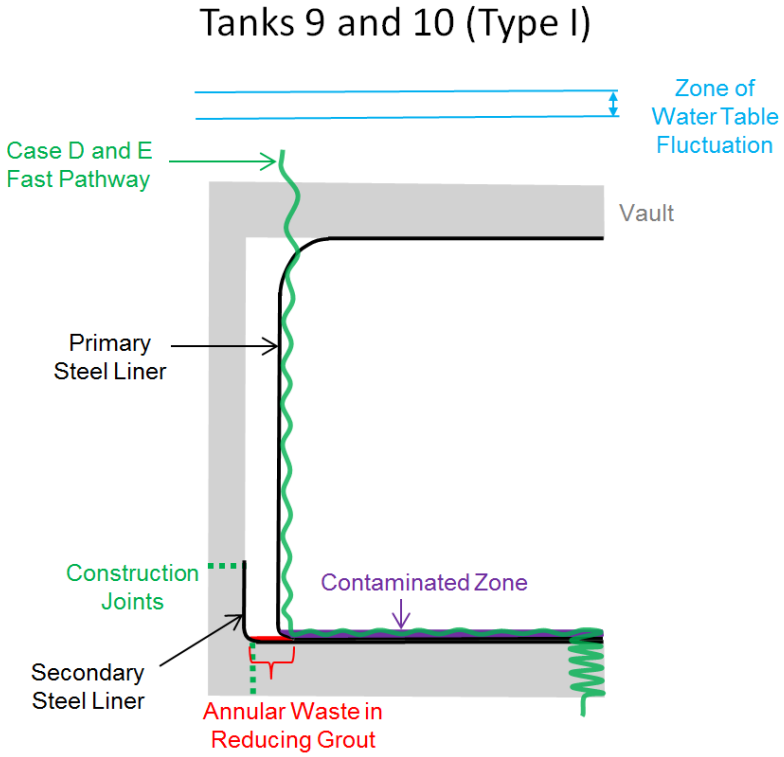

Figure 1. Illustration of the as-modeled annular waste and fast pathway in Tanks 9H and 10H

Path Forward

DOE should evaluate a waste release scenario due to groundwater in-leakage into and out of the annular region and contacting the high-solubility waste in the annuli of Tanks 9H and 10H.

RAI-NF- 13

In Tanks 14H and 16H (Type II), it is not clear to what extent the preferential pathway interacts with the waste located in the primary and secondary sand pads.

Basis

The potential release of radionuclides from the sand pads in Tanks 14H and 16H could be limited by the amount of water flowing through the preferential pathway and/or diffusion of the radionuclides out of the sand pads (See RAI-NF-8). The sand pads in Tanks 14H (primary sand pad only) and 16H (primary and secondary sand pads) contain a significant amount of activity. In the HTF Performance Assessment, DOE assumes that the steel liners in between the sand pads in these tanks are not barriers to flow. However, the preferential pathway is modeled as occurring above the sand pads in the contaminated zone (see Figure 2). The extent to which the sand pad inventories are contacted by flow in the preferential pathway is not clear. In

addition, the HTF Performance Assessment does not discuss the extent of diffusion out of the sand pads and into the adjacent cementitious materials.

It appears that a potentially significant fraction of the highly radioactive radionuclide inventory is diffusing into the basemat and/or contaminated zone prior to release. Diffusion of radionuclides out of the primary and secondary sand pads is facilitated in the model by a high diffusion coefficient, large concentration gradient, small diffusion length, assumption of no steel liners, and a delay in the flow through the fast pathway due to closure cap. Although the steel liners are not assumed to not be intact for Tanks 14H and 16H due to the large number of leak sites, the steel liner could still act as a partial barrier to diffusion. Also, the delay in flow through the preferential pathway, due to the assumption of flow being limited to infiltration through the closure cap, may overestimate the amount of time radionuclides can diffuse out of the sand pads if groundwater in-leakage were to occur.

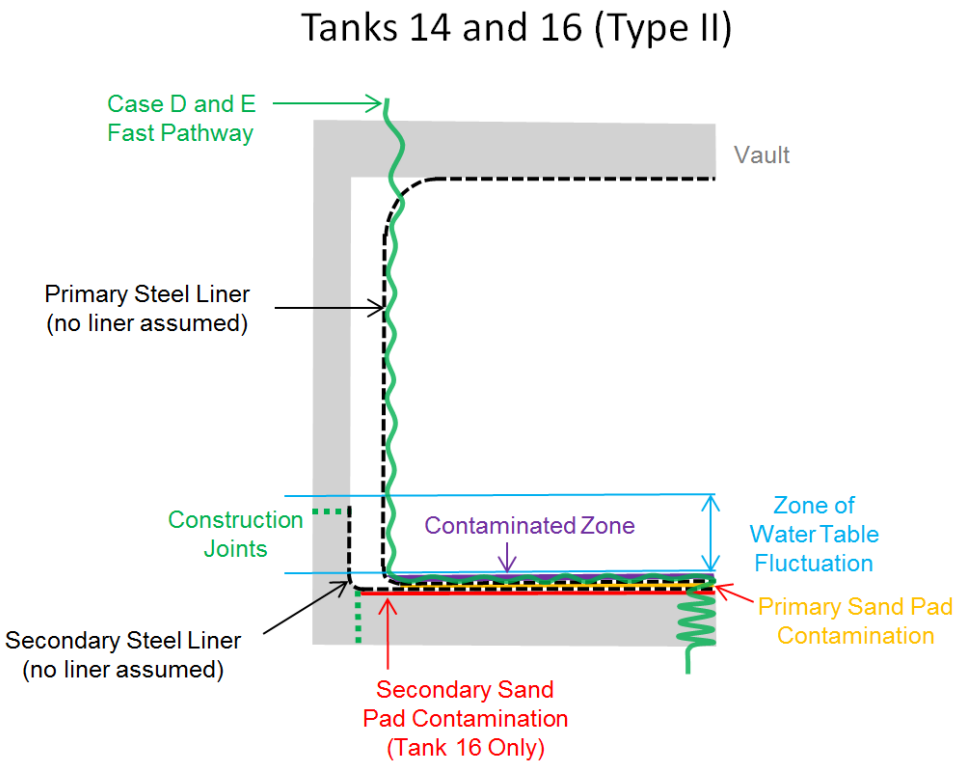

Figure 2. Illustration of the as-modeled sand pad waste and fast pathway in Tanks 14H and 16H

Path Forward

DOE should discuss the extent to which the preferential flow path affects the waste located in the sand pads and its risk significance. This should include the fraction of the inventory of the

short-lived radionuclides (e.g., cesium-137 and strontium-90) that decay prior to significant flow occurring in the fast flow path. DOE should also provide discussion regarding the fraction of the highly radioactive radionuclides (e.g., technetium, plutonium, and neptunium) that diffuse out of the sand pads and into the grout or basemat.

RAI-NF- 14

Although several HTF sources are expected to be located below the water table, tank releases are modeled under unsaturated conditions in the Performance Assessment. DOE should provide additional support for modeling HTF source releases under unsaturated conditions.

Basis

DOE simulates releases from HTF sources that are expected to be located below the water table through use of unsaturated, near-field flow and contaminant transport models. Radionuclide fluxes extracted from the unsaturated zone models are then used to load radioactivity into the HTF/PORFLOW® model that is used to simulate saturated zone transport at HTF.

For submerged and partially submerged tanks (i.e., Type I and II tanks), no vadose zone is expected to be present but inclusion of a vadose zone in the near-field model domain may increase travel times to a potential receptor if the contaminant flux is calculated based on flux out of the near-field model domain (versus flux out of the tank/vault system). Predicted doses may also be sensitive to the manner in which contaminant flux is loaded in the saturated zone model (e.g., number of source cells or source location). Finally, release rates from HTF sources may be higher in the saturated zone compared to the vadose zone in certain cases. Therefore, DOE should provide additional clarification or support for model simplifications to provide assurance that doses are not significantly underestimated in the HTF Performance Assessment.

Path Forward

DOE should clarify if the near-field model fluxes are calculated at the bottom of the HTF tank basemats or at the bottom of the near-field model domain.

DOE should clarify the location of source loading (elevation of source release relative to the water table) and the number of source cells used to represent the source. DOE should provide an estimate of the range in potential dose based on dilution or concentration of the contaminant flux given source loading selections.

DOE should evaluate the impact of simulation of HTF source releases in an unsaturated zone model for submerged and partially submerged tanks. DOE should consider all relevant flow/transport regimes in evaluating whether radionuclide release rates could be potentially underestimated. For example, DOE should consider cases where flow rates through the engineered system may be low and releases limited by diffusion. For example, relatively high flow around the tank/vaults in the saturated zone at early times could lead to higher release rates, if flow rates in the saturated zone maintain a higher concentration gradient. DOE should also consider cases where flow occurs predominately through preferential pathways through the

tank/vaults in alternative configurations (i.e., could releases be underestimated at early times in the near-field model if flow were to occur primarily through preferential pathways in the saturated zone prior to significant cementitious material degradation). Finally, DOE should consider the period of time when flow through the grout monolith increases significantly and releases are dominated by advection through the cementitious materials. Details regarding hydraulic head gradients and the magnitude of flow through the engineered system in a saturated system should be provided. Note that additional detail from Portage modeling (PORTAGE-08-022) may be helpful in responding to a portion of this request for additional information.

CC-NF- 1

Provide documentation of groundwater in-leakage into the submerged and partially submerged tanks.

CC-NF- 2

DOE should provide additional support for the assumption that the chemical transition from Oxidized Region II to Oxidized Region III is not risk significant. The assumed solubilities for the highly radioactive radionuclides in the HTF do not appear to be sensitive to the pH transition. However, future revisions to the HTF Performance Assessment and updated geochemical modeling may indicate that certain radionuclide solubilities are sensitivity to pH.

The normative mineralogy of the hydrated grout assumed for the Geochemist's Workbench modeling of grout degradation is based on a mass balance calculation using the chemical composition of unhydrated cement. DOE used select phases that were taken from published cement simulations (i.e., Höglund, 2001; Lothenbach and Winnefeld, 2006; Kulik, 2011) to represent the normative mineralogy in the grout degradation modeling. However, the minerals that DOE selected to represent the hydrated grout are inconsistent with the minerals from Höglund (2001) and Lothenbach and Winnefeld (2006). Because the mineralogy used in modeling grout degradation determines the pH evolution of grout pore water, which in turn affects the calculated solubility, using an incorrect mineralogy in the model could lead to non-conservative solubilities and releases of radionuclides from the contaminated zone.

CC-NF- 3

DOE should provide a basis that the use of Hanford sediments to develop the cement-leachate impacted K_ds (Table 4.2-25 of the HTF Performance Assessment) for HTF vadose zone soil is appropriate. Further, DOE should clarify why the Hanford derived cement leachate factor for plutonium (a factor of two) was not applied to derive the cement-leachate impacted from the non-impacted K_d in the HTF Performance Assessment. In its clarification, DOE should also more clearly describe how the factor of two was derived from PNNL-16663, which resulted in a factor of 0.25.

CC-NF- 4
DOE should clarify whether the piping that enters the tanks will be grouted.

CC-NF- 5
The analytic solution to the diffusion equation to compute the chloride concentration on page 32 in SRNL-STI-2010-00047 appears to be incorrect to use at long times. It appears to only be valid to use at short times, when the depth of the chloride penetration is small compared to the vault thickness. The analytical solution assumes a fixed concentration at x=0, zero concentration at x=∞, and zero initial concentration. Instead, a correct solution for long times should consider zero flux at the concrete/liner interface, to keep all of the chloride within the vault thickness. Because of the incorrect use of the analytic equation, chloride concentrations at the concrete/steel interface in Figures 18 and 19 may be underestimated. Such figures are only provided to derive a notion of times for chloride to diffuse. These results do not appear relevant to time estimates in the stochastic methodology. Confirm that these results are not relevant to estimates of liner failure.

Hydrology and Far-Field Transport

In the HTF Performance Assessment, DOE uses a far-field model to simulate the flow and transport of radiological constituents released from HTF tanks through the saturated zone to various points where a receptor might be exposed. PORFLOW® is used to deterministically simulate flow and transport in the far-field environment for the base case and alternative configurations. Far-field *transport* is also simulated in a probabilistic analysis using GoldSim® for the base case and alternative configurations. NRC staff focused its review of the HTF Performance Assessment on factors affecting far-field model dilution including infiltration rates, flow directions, Darcy velocities, and dispersion.

Factors potentially important to far-field performance for FTF are discussed in the FTF Monitoring Plan (MLA12212A192). These factors include natural attenuation of plutonium and calcareous zone dissolution impacts on contaminant flow and transport. NRC staff also listed review of environmental monitoring data as a monitoring factor for FTF. Table 11 lists the FTF monitoring factors, as well as other potential performance assessment maintenance activities that were recommended in NRC staff's FTF TER (ML112371751), and indicates those recommendations and comments that NRC staff believes remain relevant for HTF. NRC staff does not expect DOE to provide additional information to address monitoring factor technical issues or potential performance assessment maintenance items during the consultative process for HTF. However, DOE may elect to provide NRC additional information to address the Table 11 items relevant to HTF, if available.

During its review of the HTF Performance Assessment, NRC staff developed new comments specific to HTF related to model calibration and time-variant recharge and flow. To develop the HTF far-field comments, staff reviewed the HTF Performance Assessment and supporting

documents. The staff's review criteria pertaining to far-field radionuclide transport are contained in Sections 4.2, 4.3.4, 4.4, 4.5 and 4.6 of NUREG-1854.

Table 11. FTF Hydrology and Far-Field Transport Monitoring Factors Relevant to HTF

FTF Monitoring Factor	HTF Relevance
FTF Monitoring Area 4 – Natural System Performance	
4.1: Natural Attenuation of Plutonium As discussed in the FTF Monitoring Plan (ML12212A192), NRC staff noted technical concerns with the K_d averaging approach employed in the FTF Performance Assessment (SRS-REG-2007-00002, Rev. 1) for plutonium that tends to delay the timing of peak dose for more mobile forms of plutonium that may exist in Savannah River Site environments based on site-specific data and modeling.	Plutonium sorption in the natural environment is modeled in the HTF Performance Assessment using the results of a statistical analysis conducted in SRNL-STI-2011-00672, Rev. 0 of 64 K_d values from many areas and materials around the Savannah River Site. The report considered only a limited set of chemical conditions (i.e., pH) and did not consider redox states for plutonium. Further, the long-term lysimeter experiments (as referenced in Kaplan et al., 2006) indicate that although most plutonium is in the (IV) oxidation state, there is a small component that at times is much more mobile. Additional detail is provided in Appendix E of the FTF Monitoring Plan (ML12212A192). Recognizing that plutonium chemistry is especially complex and disproportionation presents a difficult problem; NRC staff continues to evaluate the appropriateness of averaging K_d values for use in the HTF Performance Assessment.
4.2: Calcareous Zone Dissolution As stated in the FTF Monitoring Plan (ML12212A192), NRC staff is seeking additional information to support DOE's treatment of the variably grouted calcareous zones located primarily in the lower zone of the Upper Three Runs Aquifer at FTF. In its Technical Evaluation Report (ML112371715), NRC staff recommended DOE conduct tracer studies and field mapping of seepage locations along Upper Three Runs Creek to evaluate the impact of these zones on contaminant flow and transport. DOE could also perform downhole imaging of groundwater velocities to address this monitoring factor.	SRNL-TR-2012-00160, Rev. 0 reviewed calcareous zone investigations at the Savannah River Site and suggests that calcareous zones are less a factor in H-Area than in areas to the southeast and that hydraulic properties for any zones within HTF are encompassed by the range of physical properties included in the General Separations Area hydrogeological model and other dependent models (Page 7). NRC staff continues to be concerned with the potential for preferential flow and reduced attenuation of key radionuclides due to calcareous zone dissolution. Because PORFLOW model documentation suggests that HTF plumes are likely to be transported in the lower Upper Three Runs Aquifer prior to reaching the 100 m compliance boundary, this issue is of relevance to HTF. NRC staff will continue to assess the significance of calcareous zones dissolution on far-field flow and transport at HTF as new information becomes available.
4.3 Environmental Monitoring As part of routine monitoring activities, NRC staff plan to review environmental monitoring data generated for FTF to inform the degree of natural attenuation of key radionuclides at FTF. Environmental monitoring data can also be used to help evaluate the predictive capability of the far-field models.	NRC staff plan to review environmental monitoring data for HTF as it becomes available. No addition information requests in this area are needed at this time.

Table 11. FTF Hydrology and Far-Field Transport Monitoring Factors Relevant to HTF

FTF Monitoring Factor	HTF Relevance
FTF Monitoring Area 6 – Performance Assessment Maintenance	
6.2: Model and Parameter Support The FTF Monitoring Plan (ML12212A192), Table A-2, lists the following performance assessment maintenance activities related to far-field model performance. (i) NRC recommends DOE investigate the significant amount of dispersion in its near-field and far-field models that may be attributable to large changes in the adjacent element size and large difference in element size between the vadose zone and far-field models. DOE should also evaluate the adequacy of the time discretization for swiftly moving constituents, such as Tc-99. (ii) NRC recommends DOE evaluate the appropriateness of the assumed level of physical dispersion in the FTF model (longitudinal and transverse vertical). (iii) NRC recommends DOE provide greater transparency and traceability of far-field calibration, including consideration of more extensive calibration focused on the area of interest. (iv) NRC recommends DOE evaluate compliance with the POs in 10 CFR Part 61, Subpart C, at the point of maximum exposure in the UTRA.	(i) SRNL-STI-2012-00465, Rev. 0 indicates that in an attempt to avoid excessive numerical dispersion at the 100-meter scale, DOE implemented a grid resolution in HTF/PORFLOW model finer than the 200 feet x 200 feet grid used in the GSA/PORFLOW model. The model was developed from the GSA scale model using a 33 foot x 33-foot (6x6) with variable vertical grid refinement, with the primary focus being on the 1-meter and 100-meter concentrations. SRNL-STI-2012-00465, Rev. 0 indicates that the longitudinal numerical dispersion associated with this mesh size is approximately 5.1 m which is slightly larger than ideal, but DOE considers reasonable for average HTF plume travel distances that are well beyond 100 m. NRC staff thinks that improvements have been made to the HTF/PORFLOW model in the area of grid discretization and has no further information requests at this time. NRC staff will continue to evaluate the discretization of the near-field model to ensure that numerical dispersion is not excessive. NRC staff will also evaluate the coupling of the near-field and far-field models. However, no additional information is needed at this time. (ii) In HTF aquifer transport modeling, hydrodynamic dispersion is represented by a stratified dispersion model (WSRC-TR-99-00282) defined by longitudinal horizontal, longitudinal vertical, transverse horizontal and transverse vertical dispersivities of 3.16 meter, 0.316 meter, 0.316 meter, and 0.0316 meter, respectively, which are 3.28 %, 0.328 %, 0.328 %, and 0.0328 % of a nominal 100-meter plume travel distance. NRC staff thinks that improved capability to simulate dispersion in the updated version of PORFLOW used to develop the HTF/PORFLOW model and changes in the assumed level of dispersion in the HTF/PORFLOW model have increased the technical defensibility of the assumed level of far-field dispersion in the HTF/PORFLOW model and has no additional questions in this area at this time. (iii) PORFLOW documentation indicates relatively high residuals and difficulty in calibrating the model local to HTF. Therefore, model calibration is of greater focus in the HTF review compared to FTF. NRC staff has developed specific comments on HTF/PORFLOW calibration. See RAI-FF-1, RAI-FF-2, and RAI-FF-3. (iv) NRC staff thinks that doses at the point of maximum exposure in the Upper Three Runs Aquifer (rather than the Gordon aquifer) should be compared to dose standards when demonstrating compliance with the performance objectives in 10 CFR Part 61, Subpart C. However, DOE's continued use of Gordon aquifer concentrations/dose in the probabilistic analysis is acceptable as long as the results are not used for comparison against dose-based standards.

RAI-FF- 1

The HTF/PORFLOW® model may not be well calibrated. DOE should provide more detail regarding model calibration at HTF.

Basis

GSA/PORFLOW® (and GSA/FACT[2]) documentation suggests that the GSA model is not well calibrated local to HTF. For example, WSRC-TR-96-00399, Rev. 1, Volume 2 indicates that:

- there are unexpected high residuals east of HTF (Page 23);
- relatively larger residuals are found in and east of HTF (Page 24);
- additional work is needed to better define the artificial recharge and hydraulic conductivity field at HTF, and that artificial recharge may be excessive suggesting the hydraulic conductivity field may require additional adjustment (Page 25); and
- additional work is needed to better define uncertainty in model predictions (Page 25).

Further, WSRC-TR-2004-00106, Rev. 0 indicates on page 23 that GSA/PORFLOW head residuals are generally relatively large compared to GSA/FACT and that the artificial recharge zone in the GSA/FACT model was more effective at reducing head residuals at HTF but was considered less realistic. Page 24 of WSRC-TR-2004-00106, Rev. 0 goes on to state that more extensive model calibration would improve the GSA/PORFLOW® model.

The HTF/PORFLOW® model uses the flow field output from the GSA/PORFLOW® model to simulate contaminant fate and transport for the purpose of making dose predictions in the HTF Performance Assessment. If the HTF/PORFLOW® model is not well-calibrated, the dose predictions may be over- or under-estimated depending on such factors as source location and radionuclide.

Path Forward

DOE should provide additional information regarding the goodness of fit of the model to calibration targets (e.g., water levels) local to the area of interest at HTF. This information should include residuals and calibration statistics for calibration targets available at the time of GSA/PORFLOW® modeling. More recent information could also be used to evaluate model agreement to measured values, if calibration targets used at the time of modeling are not thought to be representative of post-closure conditions (see RAI-FF- 2). Environmental monitoring data could also be used to help validate the HTF/PORFLOW® model and demonstrate the sufficiency of the model in predicting contaminant fate and transport at HTF. For example, DOE could perform backwards particle tracking to identify the source of observed

[2] The GSA/FACT model is the predecessor to the GSA/PORFLOW® model. Similar data sets were used to construct both models. A similar conceptual model of the GSA is implemented in the models.

Gordon aquifer contamination. If corroborating source release information is available, validation exercises may provide additional support for the predictive capability of the HTF/PORFLOW® model.

RAI-FF- 2

HTF calibration targets developed during GSA model development may not represent post-closure conditions. DOE should evaluate the representativeness of HTF calibration targets to long-term conditions.

Basis

The GSA/FACT and GSA/PORFLOW® models, upon which the HTF/PORFLOW® model is based, were calibrated to what was considered long-term average water levels at the time of modeling. However, operational sources and sinks at HTF may have influenced water level measurements used to develop calibration targets. Calibration targets may also be biased high or low in comparison to long-term values given the relatively short time interval over which water level measurements were averaged. If the HTF/PORFLOW® model is not well calibrated to calibration targets representative of post-closure conditions, it is unclear if the HTF/PORFLOW® model is adequate for the purposes of simulating post-closure contaminant flow and transport at HTF.

Path Forward

GSA/FACT model documentation lists a number of potential sources local to HTF. For example, WSRC-TR-96-00399, Rev. 1, Volume 2 (page 21) lists a number of water leaks or potential sources to the model and indicates that undoubtedly unknown leaks exist at HTF. DOE should evaluate the potential for GSA/PORFLOW® calibration targets to have been influenced by potential sources and sinks, including the sources listed in the GSA/FACT model documentation.

Since the GSA/FACT and GSA/PORFLOW® models were developed, additional information has been collected at HTF that could also be used to evaluate the representativeness of the calibration targets. DOE could perform the following types of activities related to consideration of new information:

- Develop new calibration targets based on a longer or more representative period of record.
- Develop uncertainty ranges for calibration targets.
- Evaluate the goodness of fit of the HTF/PORFLOW® model to new calibration targets.
- If necessary, recalibrate the GSA/PORFLOW® model[3].

Finally, DOE could provide arguments as to why the HTF/PORLOW® model is adequate for the purposes of making long-term dose predictions for the HTF Performance Assessment (e.g.,

[3] Model recalibration is a long-term effort that is not expected to be accomplished during the RAI resolution period.

sufficient accuracy or biased towards higher dose predictions).

RAI-FF- 3

A strong physical basis for adjustments to the Upper Three Runs Aquifer hydraulic conductivity at HTF during GSA/PORFLOW® model calibration was not provided. DOE should provide additional support for hydraulic conductivity assignments at HTF.

Basis

Adjustments to hydraulic conductivity during the GSA/PORFLOW® model calibration process may not be adequately supported and could lead to significant impacts to the flow field at HTF. Changes in hydraulic conductivity could lead to increased or decreased dilution factors and travel times. Dose predictions could be under- or over-estimated depending on such factors as source location and radionuclide.

GSA/PORFLOW® model documentation (WSRC-TR-2004-00106, Rev. 0) indicates that during model recalibration, hydraulic conductivity was lowered and artificial recharge sources[4] omitted at HTF. The documentation indicates that a low permeability confining zone or generally lower hydraulic conductivity was thought to exist at HTF but supporting details were lacking. More recently, DOE indicated that there may be evidence of low permeability zones and perched water at HTF but upon further investigation stated that there appears to be a lack of corroborating evidence for perched zones at HTF (ML13126A127; ML13154A327).

Path Forward

DOE should perform the following activities to clarify and provide additional support for the hydraulic conductivity assignments at HTF:

- Clarify the horizontal and vertical extent of hydraulic conductivity adjustments at HTF.
- Provide additional support for the hydraulic conductivities assumed for HTF.
- Evaluate the impact of hydraulic conductivity adjustments on key radionuclide concentrations and dose at the compliance boundaries.

RAI-FF- 4

Time variant recharge rates and flow are not considered in the HTF/PORFLOW® model but may be risk-significant. DOE should evaluate the impact of time-variant recharge rates and flow on HTF Performance Assessment predictions.

Basis

HTF flow fields may be variable over time due to climatic variability or engineered barrier degradation; however, DOE uses a long-term, steady state (saturated zone) model to predict contaminant fate and transport at the HTF. Changes in flow rates and directions at HTF over

[4] Artificial recharge sources at HTF were added during predecessor model, GSA/FACT, calibration.

time may have a significant impact on dose predictions.

While the GSA/PORFLOW® model uses a recharge rate of 19 in/yr over most areas of the model domain (WSRC-TR-2004-00106, Rev. 0), the long-term infiltration rate is assumed to be approximately 12 in/yr after degradation of the engineered closure cap. Additionally, the engineered closure cap at HTF is assumed to be effective at reducing recharge to relatively low rates for hundreds to thousands of years following HTF closure. Yet, the impact of the closure cap on recharge rates following facility closure is not considered in the far-field model.

While the closure cap is generally expected to reduce infiltration, the area between the west and east closure caps may represent an area of increased infiltration due to runoff from the caps. The impact of increased runoff from the caps was evaluated in Portage (PORTAGE-08-022, Rev. 0), but infiltration was limited in the drainage area between the west and east caps and a more detailed evaluation of the effect of the cap on HTF performance would be beneficial.

While the FTF Performance Assessment (SRS-REG-2007-00002, Rev. 1) did not consider time-variant recharge rates, in most cases releases from the tanks were not assumed to occur until after the closure cap and cementitious materials were degraded and recharge rates were near long-term, steady-state values. However, time-variant recharge rates may be more risk-significant for HTF sources due to the fact that some tank liners are assumed to be initially failed and releases could occur much earlier in time prior to closure cap and cementitious material degradation (for submerged and partially submerged tank sources).

Path Forward
DOE could perform the following activities to evaluate the impact of time-variant recharge and flow at HTF. Note that some of the activities have been partially evaluated in PORTAGE-08-022, Rev. 0. This report can be used as a starting point in addressing this request for additional information but additional detail would be helpful.

- Compare modeled or hand-contoured potentiometric surfaces at various points in time to evaluate the potential for climatic variability to effect flow rates and directions at HTF. Note that observed flow field variability may be influenced by operations as discussed in RAI-FF- 2 and would not be necessarily indicative of long-term natural variability relevant to the HTF Performance Assessment.

- If found or thought to be significant, evaluate the potential impact of climatic variability on the HTF flow field. This would include evaluation of the impact of variability on dilution, dispersion, and cumulative impacts due to changes in flow rates and directions.

- Evaluate the impact of lower recharge rates due to the presence of an engineered closure cap on HTF water levels and the HTF flow field.

- Evaluate the impact of increased recharge in drainage areas, particularly the area between the west and east engineered closure caps, on HTF water levels and the HTF flow field.

- Evaluate the impact of engineered barrier degradation (e.g., closure cap and tank cement/grout) on HTF releases and the HTF flow field over time.

CC-FF- 1
Page 59 of SRR-CWDA-2010-00093, Rev. 2 indicates that some HTF plumes are spread over both aquifers and that higher vertical dispersivities are generally needed for the eastern plumes. Clarify what tank sources are spread over both aquifers and the differences between vertical dispersion for western versus eastern sources in GoldSim® probabilistic modeling.

CC-FF- 2
Page 60 of SRR-CWDA-2010-00093, Rev. 2 indicates that differences in flow directions were more significant for western sources, leading to the need for higher transverse dispersivities for western sources. Clarify the degree of transverse spreading for various sources at HTF and how changes in transverse dispersivity in GoldSim® probabilistic modeling are used to simulate the effect of changing flow directions.

CC-FF- 3
DOE indicated during the June 6, 2013 (ML13183A410) site visit that additional mixing is performed at the end of the flow path in GoldSim® probabilistic modeling to account for increased velocities. Clarify effective dilution factors applied at the end of the flow path near the compliance boundary in GoldSim® modeling.

CC-FF- 4
Provide approximate (effective) dilution factors for various HTF sources in GoldSim® probabilistic model considering vertical and horizontal dispersion, as well as additional mixing due to increased dilution at the end of the flow path. Evaluate dilution for various source release profiles such as pulse or continuous releases with respect to peak dose for various source locations and radionuclides.

Inadvertent Intrusion

To develop the following comments, staff reviewed the HTF Performance Assessment and supporting documents. DOE performed an inadvertent intruder assessment to demonstrate compliance with performance objectives related to direct intrusion into the disposal facility after institutional controls are assumed to fail at 100 years. The staff's review criteria pertaining to the approach to the inadvertent intruder assessment are contained in Section 5 of NUREG-1854. The following comments address issues associated with transparency of intruder calculations.

CC-INT-1
Clarify whether intruder doses presented in Section 6 of the HTF Performance Assessment (SRR-CWDA-2010-00128, Rev. 1) consider alternative cases.

CC-INT-2
Provide detailed results for alternative case E.

Site Stability

NRC staff reviewed the draft Basis for Waste Determination, the HTF Performance Assessment and supporting documents. The NRC staff's review criteria pertaining to the approach to site stability are contained in Section 7 of NUREG-1854. The FTF Monitoring Plan (ML12212A192) identifies one factor potentially important to site stability for FTF— differential settlement. Table 12 lists the FTF monitoring factor, as well as another recommendation that was identified in the FTF Technical Evaluation Report (ML112371715), and the relevance for HTF. NRC staff does not expect DOE to provide additional information to address the monitoring factor or recommendation during the consultative process for HTF. However, DOE may elect to provide NRC additional information to address the Table 12 items relevant to HTF, if available.

Table 12. FTF Site Stability Recommendations or Comments Relevant to HTF

FTF Monitoring Factor	HTF Relevance
8.1: Settlement As discussed in the FTF Monitoring Plan (ML12212A192), NRC staff will review information related to closure cap settlement and stability, including consideration of (i) increased overburden from the tank grout and closure cap on settlement and (ii) potential for subsidence associated with ongoing dissolution of calcareous sediment in the Santee Formation.	(i) NRC staff plan to review information related to settlement due to increased overburden for HTF as it becomes available. No addition information requests in this area are needed at this time. (ii) DOE indicates in SRR-CWDA-2010-00128, Rev. 1 (Pg. 79) that soft zones have been encountered in the Santee Formation beneath most of Savannah River Site, but are less common in the northwest (updip) and more common in the southeastern (downdip near K Area) regions. During the May 9, 2013 technical exchange (ML13154A327), DOE indicated that SRNL-TR-2012-00160, Rev. 0 suggests that soft zones are less a factor in H-Area than in areas to the southeast (e.g., Vogtle Nuclear Power Plant). DOE also referred to research conducted by Georgia Institute of Technology that is not yet published that suggests soft zones are 40,000 years old and were not significantly impacted by the major Charleston earthquake. Further, SRNL-TR-2012-00160, Rev. 0 (Pg. 7) noted that DOE will continue to investigate the extent to which calcareous zones may be significant for the Utley Formation which overlies the Santee Formation and has exhibited cavernous voids near Waynesboro, GA. NRC staff will continue to assess the significance of soft zones on demonstrating site stability at HTF as additional information becomes available.
NRC Recommendation 34[1] NRC concluded that assumed long-term compressive strength of the grout monolith is not adequately supported and may be optimistic based on observations of vault cracks, discussed in TER Section 4.2.9.1 (ML112371715). While cracking of the vault concrete and tank grout is not expected to result in significant structural tank collapse, the integrity of the vault concrete and tank grout is important to steel liner performance and waste release.	DOE indicated in SRR-CWDA-2010-00128, Rev. 1 (page 311) indicated the use of a compressive strength of 1,800 psi for long-term degraded cement property is an appropriate lower bound based on T-CLC-F-00421, Rev. 0. NRC staff will continue to assess the adequacy of the support for DOE's long-term compressive strength in light of HTF observations and the potential impact on steel liner performance and waste release.

Notes: [1] See Table A-1 of the FTF Monitoring Plan (ML12212A192)

References

Andrade et al., 1993. Andrade, C., C. Alonso, and F. J. Molina. “Cover cracking as a function of bar corrosion: Part I-Experimental test.” *Materials and Structures*. October 1993, Volume 26, Issue 8, pp 453-464.

CBU-PIT-2005-00099, Rev. 0. Hamm, B.A. “Tank Farm Zeolite Historical Review and Current Inventory Assessment.” Revision 0. Aiken, South Carolina: Westinghouse Savannah River Company. June 10, 2005.

DOE/SRS-WD-2010-001, Rev. 1. “Draft Basis for Section 3116 Determination for Closure of F-Tank Farm at the Savannah River Site.” Revision 1. Aiken, South Carolina: U.S. Department of Energy, Savannah River Site. September 30, 2010

DOE/SRS-WD-2013-001, Rev. 0. “Draft Basis for Section 3116 Determination for Closure of H-Tank Farm at the Savannah River Site.” Revision 0. Aiken, South Carolina: U.S. Department of Energy, Savannah River Site. February 6, 2013.

DP-1358. Poe, W.L. “Leakage from Waste Tank 16, Amount, Fate, and Impact.” Aiken, South Carolina: E.I. du Pont de Nemours and Co., Savannah River Laboratory. November, 1974.

G-ESR-G-00051, Rev 0. Zupon, D.A. “Waste Removal, Balance of Program, Systems Engineering Evaluation Report.” Revision 0. Aiken, South Carolina: Westinghouse Savannah River Company LLC. September 17, 2003.

Höglund, 2001. Höglund, L.O. “Project SAFE: Modeling of Long-term Concrete Degradation Processes in the Swedish SFR Repository.” SKB Report R-01-08. Stockholm, Sweden: Swedish Nuclear Fuel and Waste Management Co. 2001.

Kaplan et al., 2006. Kaplan, D. I., D. I. Demirkanli, L. Gumapas, B. A. Powell, R. A. Fjeld, F. J. Molz, and S. M. Serkiz. “11-Year Field Study of Pu Migration from Pu III, IV, and VI Sources.” *Environmental Science and Technology.* Vol. 40, pp. 443-448. 2006.

Kulik, 2011. Kulik, D.A. “Improving the Structural Consistency of C-S-H Solid Solution Thermodynamic Models.” *Cement and Concrete Research*. Vol. 41. pp. 477–495. 2011.

Lothenbach and Winnefeld, 2006. Lothenbach, B. and F. Winnefeld. ”Thermodynamic Modeling of the Hydration of Portland Cement.” *Cement and Concrete Research*. Vol. 36. pp. 209–226. 2006.

LWO-LWE-2006-00128. Ludwig, W.C. “Engineering Path Forward—Tank5 Riser Obstructions.” Aiken, South Carolina: Savannah River Site. May 5, 2007.

LWO-LWE-2007-00204. Nguyen, Q.L. and D.J. Clark. "Tank 16 Annulus Cleaning—Engineering Technology Development." Presentation. Aiken, South Carolina: Savannah River Site. October, 2007.

ML112371715. "Technical Report for F-Area Tank Farm Facility, Savannah River Site, South Carolina—Final Report." ADAMS Accession No. ML112371715. Washington, DC: U.S. Nuclear Regulatory Commission. October 27, 2011.

ML111920367. Shaffner, J., "Summary of Teleconference Between U.S. Nuclear Regulatory Commission Staff and U.S. Department of Energy Representatives Concerning Responses to RAIs Related to Closure of F-Tank farm, Savannah River Site," Memorandum to File PROJ0734. Washington, DC: U.S. Nuclear Regulatory Commission. July 12, 2011.

ML12212A192. "U.S. Nuclear Regulatory Commission Plan for Monitoring Disposal Actions Taken by the U.S. Department of Energy at the Savannah River Site F-Area Tank Farm Facility in Accordance With the National Defense Authorization Act for Fiscal Year 2005," ADAMS Accession No. ML12212A192. Washington, DC: U.S. Nuclear Regulatory Commission, January, 2013.

ML12272A082. Alexander, G. "Technical Review: Waste Release and Solubility Related Documents Prepared by United States Department of Energy to Support Final Basis for Section 3116 Determination for the F-Area Tank Farm Facility at Savannah River Site. Project No. PROJ0734." Memorandum to J. Jesse. ADAMS Accession No. ML12272A082. Washington, DC: U.S. Nuclear Regulatory Commission. May, 2013.

ML13081A051. "NRC Staff Comments on: 'Industrial Wastewater Closure Module for the Liquid Waste Tanks 5F and 6F F-Area Tank Farm', SRR-CWDA-2012-00071, Revision 0, January, 2013." ADAMS Accession No. ML13081A051. Washington, DC: U.S. Nuclear Regulatory Commission. March, 2013.

ML13191A132. DHEC Response to NRC Staff Comments on: "Industrial Wastewater Closure Module For The Liquid Waste Tanks 5F and 6F F-Area Tank Farm, Savannah River Site," SRR-CWDA-2012-00071, Revision 0, January 2013.

ML13126A127. Shaffner, J. "Summary of Clarification Discussion between the U.S. Nuclear Regulatory Commission Staff and the U.S. Department of Energy and Savannah River Remediation Staff Concerning Flow and Transport of Water and Contaminants related to H-Area Tank Farm at the Savannah River Site." Memorandum to File PROJ0734. ADAMS Accession No. ML13126A127. Washington, DC: U.S. Nuclear Regulatory Commission. May 10, 2013.

ML13154A327. Shaffner, J. "Summary of Clarification Discussion between the U.S. Nuclear Regulatory Commission Staff and the U.S. Department of Energy and Savannah River Remediation Staff Concerning Flow Modeling and Calibration related to H-Area Tank Farm at the Savannah River Site." Memorandum to File PROJ0734. ADAMS Accession No. ML13126A127. Washington, DC: U.S. Nuclear Regulatory Commission. July 5, 2013.

ML13183A410. Shaffner, J. "Summary of a Public Meeting Between NRC and DOE Concerning RAIs Related to Proposed Waste Determination for Closure of H Area Tank Farm at SRS; and a Consultation Site Visit by NRC Staff to H Tank Farm." Memorandum to File PROJ0734. ADAMS Accession No. ML13183A410. Washington, DC: U.S. Nuclear Regulatory Commission. July 23, 2013.

ML13193A072. Shaffner, J. "Summary of Clarification Discussion between the U.S. Nuclear Regulatory Commission Staff and the U.S. Department of Energy and Savannah River Remediation Staff Concerning Flow Modeling and Calibration related to H-Area Tank Farm at the Savannah River Site." Memorandum to File PROJ0734. ADAMS Accession No. ML13193A072. Washington, DC: U.S. Nuclear Regulatory Commission. July 16, 2013

ML13199A413. Shaffner, J. "Summary of Clarification Discussion between the U.S. Nuclear Regulatory Commission Staff and the U.S. Department of Energy and Savannah River Remediation Staff Concerning Uncertainty Analyses related to H-Area Tank Farm at the Savannah River Site." Memorandum to File PROJ0734. ADAMS Accession No. ML13199A413. Washington, DC: U.S. Nuclear Regulatory Commission. July 29, 2013.

Molina et al., 1993. Molina, F. J., C. Alonso, and C. Andrade. "Cover cracking as a function of rebar corrosion: Part 2—Numerical model." *Materials and Structures*. November 1993, Volume 26, Issue 9, pp 532-548.

Neville, 1996. Neville, A.M. "Properties of Concrete." (Chapter 10, *Durability of Concrete*) London, United Kingdom: John Wiley & Sons, Inc. 1996.

NUREG-1854. "NRC Staff Guidance for Activities Related to U.S. Department of Energy Waste Determinations." Draft Final Report for Interim Use. ADAMS Accession No. ML072360184. Washington, DC: U.S. Nuclear Regulatory Commission. August, 2007.

Parrot, 1990. Parrott, L. J. "Damage Caused by Carbonation of Reinforced Concrete," *Materials and Structures*, 23, 230-4. 1990.

PNNL-21723. Cantrell K.J., and B.D. Williams. "Equilibrium Solubility Model for Technetium Release from Saltstone Based on Anoxic Single-pass Flow through Experiments." Richland, Washington: Pacific Northwest National Laboratory. 2012.

PNNL-16663. Cantrell, K.J., J. M. Zachara, P. E. Dresel, K. M. Krupka, and R. J. Serne. "Geochemical Processes Data Package for the Vadose Zone in the Single-Shell Tank Waste Management Areas at the Hanford Site." Richland, Washington: Pacific Northwest National Laboratory. September, 2007.

PORTAGE-08-022, Rev. 0. "H-Area Tank Farm Model Development for Tanks in the Water Table—PORFLOW Version 6.20.0." Revision 0. Idaho Falls, Idaho: PORTAGE, Inc. November, 2008.

SRNL-STI-2009-00473. Kaplan, D.I. "Geochemical Data Package for the Performance Assessment Calculations Related to the Savannah River Site." Aiken, South Carolina: Savannah River National Laboratory. March 15, 2010.

SRNL-STI-2009-00492, Rev. 0. Poirier, M.R. and S.D. Fink. "Analysis of Samples from Tank 5F Chemical Cleaning." Revision 0. Aiken, South Carolina: Savannah River National Laboratory. December 9, 2009.

SRNL-STI-2009-00636, Rev. 0. Lilley, M. S., B. A. Powell, and D. I .Kaplan. "Iodine, Neptunium, Plutonium, and Technetium Sorption to Saltstone Under Oxidizing Conditions." Revision 0. Aiken, South Carolina: Savannah River National Laboratory. December 16, 2009.

SRNL-STI-2009-00634, Rev. 0. Miller, T.J., B.A. Powell, and D.I. Kaplan. "Neptunium IV and V Sorption to End-Member Subsurface Sediments of the Savannah River Site." Revision 0. Aiken, South Carolina: Savannah River National Laboratory. December 2, 2009.

SRNL-STI-2010-00035, Rev. 0. Langton, C.A. Chemical Degradation Assessment for the H-Area Tank Farm Concrete Tanks and Fill Grouts. Revision 0. Aiken, South Carolina: Savannah River National Laboratory. January, 2010.

SRNL-STI-2010-00047. García-Díaz, B.L. "Life Estimation of High Level Waste Tank Steel for H-Tank Farm Closure Performance Assessment." Aiken, South Carolina: Savannah River National Laboratory. March, 2010.

SRNL-STI-2010-00148, Rev. 0. Jones, W.E., M.R. Millings, and B.H. Rambo. "Hydrogeologic Data Summary in Support of the H-Area Tank Farm Performance Assessment." Revision 0. Aiken, South Carolina: Savannah River National Laboratory. February, 2010.

SRNL-STI-2010-00493, Rev. 0. Seaman, J.C. and D.I. Kaplan. "Chloride, Chromate, Silver, Thallium, and Uranium Sorption to SRS Soils, Sediments, and Cementitious Materials." Revision 0. Aiken, South Carolina: Savannah River National Laboratory. September 29, 2010.

SRNL-STI-2011-00551, Rev. 0. Stefanko, D.B. and C.A. Langton. "Tanks 18 and 19-F Structural Flowable Grout Fill Material Evaluation and Recommendations." Revision 0. Aiken, South Carolina: Savannah River National Laboratory. September, 2011.

SRNL-STI-2011-00672, Rev. 0. Almond, P.M., D.I. Kaplan, and E.P. Shine. "Variability of Kd Values in Cementitious Materials and Sediments." Revision 0. Aiken, South Carolina: Savannah River National Laboratory. January, 2012.

SRNL-STI-2012-00087, Rev. 0. Denham, M. "Evolution of Chemical Conditions and Estimated Plutonium Solubility in the Residual Waste Layer During Post-Closure Aging of Tank 18." Revision 0. Aiken, South Carolina: Savannah River National Laboratory. February, 2012.

SRNL-STI-2012-00178, Rev. 0. Hay, M.S. and S.H. Reboul, "Characterization of Samples from Tank 16H Annulus." Revision 0. Aiken, South Carolina: Savannah River National Laboratory. April, 2012.

SRNL-STI-2012-00404, Rev. 0. Denham, M. and M. Millings. "Evolution of Chemical Conditions and Estimated Solubility Controls on Radionuclides in the Residual Waste Layer During Post-Closure Aging of High-Level Waste Tank." Revision 0. Aiken, South Carolina: Savannah River National Laboratory. August, 2012.

SRNL-STI-2012-00465, Rev. 0. Jordan, J.M., G.P. Flach, and M.L. Westbrook. "PORFLOW Modeling Supporting the H-Tank Farm Performance Assessment." Revision 0. Aiken, South Carolina: Savannah River National Laboratory. August, 2012.

SRNL-STI-2012-00479, Rev. 3. Reboul, S.H. "Chemical Differences Between Sludge Solids at the F and H Area Tank Farms." Revision 3. Aiken, South Carolina: Savannah River National Laboratory. August 2012.

SRNL-TR-2012-00160, Rev. 0. Bagwell, L. "A Review of Subsurface Soft Zones at Savannah River Site with Emphasis on H Area Tank Farm (U)." Revision 0. Aiken, South Carolina: Savannah River National Laboratory. July, 2012.

SRR-CWDA-2009-00054, Rev. 0. "Comment Response Matrix for Nuclear Regulatory Commission (NRC) Comments on the F-Tank Farm Performance Assessment." Revision 0. Aiken, South Carolina: Savannah River Remediation, LLC. March 31, 2010.

SRR-CWDA-2010-00023, Rev. 3. Dean, B. "H-Tank Farm Waste Tank Closure Inventory for Use in Performance Assessment Modeling." Revision 3. Aiken, South Carolina: Savannah River Remediation LLC. May, 2012.

SRR-CWDA-2010-00093, Rev. 2. Lester, B. "H-Area Tank Farm Stochastic Fate and Transport Model." Revision 2. Aiken, South Carolina: Savannah River Remediation LLC. August, 2012.

SRR-CWDA-2010-00128, Rev. 1. "Performance Assessment for the H-Area Tank Farm at the Savannah River Site." Revision 1. Aiken, South Carolina: Savannah River Remediation LLC. November, 2012.

SRR-CWDA-2010-00157, Rev. 0. Dickert, G. "Proposal to Cease Waste Removal Activities in Tanks 5 and 6 and Enter Sampling and Analysis Phase." Presentation. Revision 0. Aiken, South Carolina: Savannah River Remediation LLC. November 3, 2010.

SRR-CWDA-2011-00005, Rev. 1. Stephens, B.A. and K.D. Gilbreath. "Tank 6 History of Waste Removal 1964 Through 2010." Revision 1. Aiken, South Carolina: Savannah River Remediation LLC. June, 2011.

SRR-CWDA-2011-00033, Rev. 1. Gilbreath, K.D., et al., "Tank 5 History of Waste Removal 1959 Through 2010." Revision 1. Aiken, South Carolina: Savannah River Remediation LLC. June, 2011.

SRR-CWDA-2011-00126, Rev. 0. Marusich, C.M. "Tank 16 History of Waste Removal 1959 Through 2010." Revision 0. Aiken, South Carolina: Savannah River Remediation LLC. September, 2011.

SRR-CWDA-2012-00011, Rev. 0. Hommel, S. "Features, Events, and Processes for Liquid Waste Performance Assessments." Revision 0. Aiken, South Carolina: Savannah River Remediation LLC. February 14, 2012.

SRR-CWDA-2012-00044, Rev. 1. Hommel, S. "Evaluation of Features, Events, and Processes in the H-Area Tank Farm Performance Assessment." Revision 1. Aiken, South Carolina: Savannah River Remediation LLC. October 30, 2012.

SRR-CWDA-2012-00071, Rev. 0. "Industrial Wastewater Closure Module for the Liquid Waste Tanks 5F and 6F F-Area Tank Farm, Savannah River Site." Revision 0. Aiken, South Carolina: Savannah River Remediation LLC. January 2013.

SRR-CWDA-2013-00055, Rev. 1. Pavletich, J. "Tank 16 Residuals Sampling—Sampling and Analysis Approach for the Tank 16 Primary and Annulus Residual Materials." Presentation to the South Carolina Department of Health and Environmental Control. Revision 1. Aiken, South Carolina: Savannah River Remediation LLC. April 17, 2013.

SRR-CWDA-2013-00086, Rev. 0. Thomas, S.A. "Follow-up in Support of US NRC HTF Consultation Clarifying Phone Calls." Letter to S. Ross. Revision 0. Aiken, South Carolina: Savannah River Remediation LLC. June 12, 2013.

SRR-LWE-2012-00039, Rev. 0. Clark, D.J. and J.L. Clark, "Estimation of Waste Material in the Tank 16 Annulus Following Sampling in November 2011." Memorandum to G.C. Arthur. Revision 0. Aiken, South Carolina: Savannah River Remediation LLC. February 28, 2012.

SRR-LWE-2012-00082. Tisler, A. "CY2011 Annual SCDHEC Technology Briefing." Presentation to the South Carolina Department of Health and Environmental Control. Aiken, South Carolina: Savannah River Remediation LLC. April 30, 2012.

SRR-LWE-2013-00077. Tisler, A. “Annual SCDHEC Technology Briefing.” Presentation to the South Carolina Department of Health and Environmental Control. Aiken, South Carolina: Savannah River Remediation LLC. April 17, 2013.

SRR-LWP-2009-00001, Rev. 17. Chew, D.P. and B.A. Hamm. “Liquid Waste System Plan.” Aiken, South Carolina: Savannah River Remediation LLC. Revision 17. February 29, 2012.

SRR-STI-2010-00015, Rev. 0. Ketusky, E., T. Huff, C. Sudduth, S. Jones, J. Remark, and M. Sillanpää. “Enhanced Chemical Cleaning: Effectiveness of the UV Lamp to Decompose Oxalates – 10502.” Revision 0. Aiken, South Carolina: Savannah River Site. February, 2010.

SRR-STI-2013-00198. Subramanian, K. and J. Vitali. “Tank 12 Bulk Oxalic Acid Cleaning Flowsheet Strategy.” Presentation to SCDHEC. Aiken, South Carolina: Savannah River Remediation, LLC. April, 2013.

SRS/REG-2007-00002, Rev. 1. “Performance Assessment for the F-Tank Farm at the Savannah River Site.” Revision 1. Aiken, South Carolina: Savannah River Remediation, LLC. March 31, 2010.

T-CLC-F-00421, Rev. 0. Carey, S.A. “Structural Assessment of F-Area Tank Farm After Final Closure.” Calculation. Revision 0. Aiken, South Carolina. December 18, 2007.

V-ESR-G-00003, Rev. 1. Caldwell, T. “Waste Removal Technology Baseline: Technology Development Description.” Revision 1. Aiken, South Carolina: Savannah River Remediation, LLC. June 15, 2011.

WSRC-STI-2007-00061, Rev. 2. Subramanian, K. H. “Life Estimation of High Level Waste Tank Steel for F-Tank Farm Closure Performance Assessment, Rev. 2.” Revision 2. Aiken, South Carolina: Savannah River National Laboratory. June, 2008.

WSRC-STI-2007-00192, Rev. 1. Hay, M.S., K.P. Crapse, S.D. Fink, and J.M. Pareizs. “Characterization and Actual Waste Tests with Tank 5F Samples.” Revision 1. Aiken, South Carolina: Savannah River National Laboratory. August 30, 2007.

WSRC-STI-2008-00203, Rev. 0. Hay, M.S., “Characterization of Samples from Tank 16H Annulus.” Revision 0. Aiken, South Carolina: Savannah River National Laboratory. May, 2008.

WSRC-TR-96-00399, Rev. 1. Flach, G.P. and M.K. Harris. “Integrated Hydrogeological Modeling of the GSA, Vol. 2: Groundwater Flow Model.” Revision 1. Aiken, South Carolina: Westinghouse Savannah River Company. April 1999.

WSRC-TR-2004-00106, Rev. 0. Flach, G. “Groundwater Flow Model of the General Separations Area Using PORFLOW.” Revision 0. Aiken, South Carolina: Westinghouse Savannah River Company LLC. July 15, 2004.

WSRC-TR-2004-00317, Rev. 0. Pike, J., N.P. Badheka, and E.T. Ketusky. "Flowsheet for SRS Waste Tank Heel Removal Using Oxalic Acid." Revision 0. Aiken, South Carolina: Westinghouse Savannah River Company. November 10, 2004.

WSRC-STI-2007-00192, Rev. 1. Hay, M.S., K.P. Crapse, S.D. Fink, and J.M. Pareizs. "Characterization and Actual Waste Tests with Tank 5F Samples." Revision 1. Aiken, South Carolina: Savannah River National Laboratory. August 30, 2007.

WSRC-STI-2008-00203, Rev. 0. Hay, M.S., "Characterization of Samples from Tank 16H Annulus." Revision 0. Aiken, South Carolina: Savannah River National Laboratory, Westinghouse Savannah River Company. May, 2008.

X-CLC-H-00921, Rev. 0. Sudduth, C.B. "Effects of Low Temperature Aluminum Dissolution (LTAD) on Tank 12 Sludge Heel." Calculation. Revision 0. Aiken, South Carolina. June 6, 2012.

Appendix A

NRC Clarification Questions and Summaries of DOE Responses for
Technical Exchanges Conducted as part of the
Consultation on the Draft Basis for Section 3116 Determination for
Closure of H-Tank Farm at the Savannah River Site

ID	TITLE	NRC QUESTION	SUMMARY OF DOE RESPONSE
		Meeting Date: April 4, 2013	
1	Pyrite as Reductant in Blast Furnace Slag	Clarify the basis for assuming pyrite as the reductant within blast furnace slag.	Acknowledged the uncertainties in trying to account for actual geochemical processes that may be present in grout. DOE evaluated the uncertainty in the E_h transition in sensitivity and probabilistic analyses. Suggested that pyrite is a reasonable surrogate for the total reduction capacity because reduction capacity is also available from CSH phases not just BFS and more iron than just from BFS. Suggested that the reduction capacity might be in an amorphous glassy phase and that CaS and pyrite may represent the upper and lower bounding solubilities, respectively. Conducting a project to understand capacity of glass phase reductant.
2	Ratio of Groundwater to Infiltration in Geochemical Modeling	Clarify the basis for 90:10 ratio of groundwater to grout-conditioned infiltration, including potential for bypass flow.	DOE stated that the groundwater-to-conditioned infiltration was based on the ratio of 90:10 representing: (i) the two most varied chemistries and (ii) the lateral-to-vertical groundwater flow velocities as modeled by Portage.
3	Dissolved Oxygen Concentration in Groundwater	Clarify the basis for dissolved oxygen concentration for submerged tanks including whether additional data from well P27D or other H-Area wells exist.	Suggested that there may be geologic reasons as P27D appears to be screened across or in an unnamed clay layer that lies above the TCCZ. Indicated that Type I tanks are also situated in what is thought to be the same clay. Indicated the well was resampled in 2002 and DO, pH, and E_h were similar to earlier sampling events. Stated that it may also be possible P27 could be affected by H-Area coal pile run-off basin.
4	Solubility of Plutonium in Oxidized Regions II and III	Clarify the basis for plutonium in Oxidized Regions II and III in light of several E_h values above 0.45V.	Assumed E_h in Oxidized Regions II and III are below dissolved oxygen saturation. Linearly interpolated between E_h value at pH 11.1 (Oxidized Region II) and pH 9.2 (Oxidized Region III).

ID	TITLE	NRC QUESTION	SUMMARY OF DOE RESPONSE
5	Iron Co-precipitation of Technetium	Clarify the basis for 100% iron co-precipitation of technetium under all chemical conditions in the deterministic model.	Believe most soluble Tc is removed during cleaning, leaving behind presumably insoluble Tc. Pointed to research from Hanford and explained that there is no basis for selection of a fraction of co-precipitation with iron that is below 100%. Examined faster Tc release in a sensitivity analysis that suggested the percentage of co-precipitation is not the key factor regarding Tc release.
6	Reduced Region II Solubility Controlling Phase for Iron Selenide	Clarify the basis for $FeSe_2$ (cr) for Reduced Region II.	Noted $FeSe_2$ (cr) is a low-temperature phase with a known natural mineral.
7	Solubility Modeling Database	Clarify how was the HTF Geochemist's Workbench database was developed from the NEA and JAEA databases.	Built own database from online NEA database. Stated NEA database did not contain oxalate complexes. JAEA contained oxalate complexes. Insufficient time to consider oxalate complexes that are in NEA database so the information was not considered.
8	Annular Source Term	Clarify how the source term was modeled in PORFLOW® for tanks with leak sites (i.e., Tanks 9-16).	For all Type I tanks (9-12) and most Type II tanks (13-15), modeled two inventories: (a) the contaminated zone within the primary liner with solubility controls and (b) an annular source (Type I: 0.5-inch; Type II: 1-inch primary sandpad) with no solublity controls. For Tank 16, modeled three inventories: (a) the contaminated zone within the primary liner with solubility controls, (b) an annular source represented in the 1-inch primary sandpad with no solubility controls, and (c) a source located in the 1-inch secondary sandpad with no solubility controls.
9	Moisture Characteristic Curve for Sand Pads	Clarify the basis for and discuss the risk significance of the assumed MCC for the sand pad material modeled in PORFLOW®.	Indicated that the sand pad is always saturated in the modeling, therefore, not expected to be risk significant.

ID	TITLE	NRC QUESTION	SUMMARY OF DOE RESPONSE
		Meeting Date: April 17, 2013	
1	Follow-up on Dissolved Oxygen Concentration in Groundwater	Clarify the basis for dissolved oxygen concentration for submerged tanks including whether additional data from well P27D or other H-Area wells exist.	Indicated that lower DO data appears to be valid. Also stated that no information is available for continuity of unnamed clay layer across HTF. Stated that lower DO is likely reasonable Type I tank analyses. However, DO would be expected to be higher in water adjacent to higher elevation tanks (i.e., Type II).
2	Follow-up on Annular Source Term - Tank 16 Secondary Sand Pad Inventory	Clarify the basis for Tank 16 secondary sand pad source term of 26-gallons	Stated basis is from estimated 16 gallons from DP-1358 that entered the environment and was considered conservative since assumed 26 gallons is greater than 16 gallons.
3	Tank 16 Annulus Ventilation Duct Inventory	Clarify how the volume of waste in the Tank 16 ventilation duct was estimated as 1,200 gallons.	Indicated that the appropriate SME were not participating in the teleconference and DOE would follow-up on how estimate was made.
4	Chemical Conditioning for Cases B/D	Clarify the basis for the assumption in Cases B and D that infiltrating water that enters the grouted tank will flow through the grout matrix prior to contacting the CZ in a manner that allows the full volume of the tank grout to influence the chemistry of the water.	Stated that Cases B and D represent one end of the spectrum where the full capacity of the grout is available for chemical conditioning while cases C and E represent minimal conditioning to inform sensitivity analyses.
5	Hydraulic Degradation of Cementitious Materials	Clarify the approach used to model degraded cementitious materials	Stated that the approach for changing hydraulic conductivity of the cementitious materials differs from FTF PA and is discussed in SRNL-STI-2012-00465, Section 2.6. FTF employed a linear hydraulic conductivity transition with time after initiation began. HTF employs a log-linear hydraulic conductivity transition.
6	Reducing Grout Samples	Clarify apparent inconsistency between the values for reducing grout samples LP#8-016A reported in Table 3-6 of SRNL-STI-2011-00551 and MACTEC lab report for the same samples	Because the grout fractures quickly in the model, the initial (intact) hydraulic properties have a small impact on contaminant release.

ID	TITLE	NRC QUESTION	SUMMARY OF DOE RESPONSE
7	GSA/PORFLOW® and HTF/PORFLOW® Pathlines	Clarify why pathlines modeled in GSA/PORFLOW® and HTF/PORFLOW® appear to be different	Suggested that differences might be due to differences in elevations for starting points and DOE would investigate further.
8	Uncalibrated Hydraulic Conductivity Assignments in GSA/FACT	Clarify whether known core lithologies (e.g., mud fraction) from discrete intervals were correlated with known field- or laboratory-measured hydraulic conductivities from the same intervals	Discussed during May 9, 2013 teleconference.
9	Calibration Statistics and Residuals Local to HTF	Clarify why estimated residuals and baseflow estimates that exceeded project-stated targets are considered acceptable (i.e., large UTR hydraulic head residuals in H-area were noted during FTF consultation; baseflow estimates were noted during Saltstone review.)	Clarified potential problem with calibration target that led to maximum residual. Clarified that maximum residual was not located at HTF.
10	Potentiometric Surfaces	Clarify the impacts of differences between modeled and hand-drawn potentiometric surfaces at HTF (e.g., 2012 environmental monitoring report)	Not discussed due to time.
11	Changing Flow Directions	Clarify the impact of changing flow directions between UTR-UZ and UTR-LZ as well as between UTR and GA.	DOE clarified that the UTR-UZ and UTR-LZ had different flow directions. DOE evaluated the impact of cumulative sources in GoldSim® sensitivity studies.
12	Vertical Gradient	Clarify the impact of the apparent strong vertical gradient at HTF.	Stated a hard pan layer (i.e., low permeability zones) on the outskirts of H-Area causes higher observed heads.
13	Impact of Potential Recharge Sources on Flow Model Calibration	Clarify whether any potential sources of water may have affected calibration targets (e.g., water addition system, artificial recharge sources). Clarify how recharge and hydraulic conductivity were changed during calibration.	Discussed water addition system. No other specific sources were discussed. Indicated that initially there was no basis for sources of recharge, however, recently there is a possibility that low permeability zones may be causing higher water table.
14	Flow Model Calibration via Inverse Modeling	Clarify the rationale for not implementing automated calibration of initial parameter set via inverse modeling.	Not discussed due to time.

ID	TITLE	NRC QUESTION	SUMMARY OF DOE RESPONSE
15	Tanks with Leak Sites and Flow Model Validation	Clarify how previous leaks were considered during model validation (e.g., flow directions and plume extent discerned from Tank 16 release data)	Indicated that while there are a data points for number of nonvolatile β, there are no discernable plumes in HTF. Noted construction of a water injection system under Type II tanks to mitigate anticipated drought conditions. Instead the system was used in reverse to extract water from beneath the tank pads.
16	Environmental Monitoring of HAA 9AR	Clarify when environmental data from well HAA 9AR undergoes post-laboratory validation. Clarify the status of this well (i.e., no data was provided in 2012 environmental monitoring report).	Indicated HAA 9AR is not part of environmental monitoring program.
17	H-Area Hydrogeologic Units	Clarify apparent conflicts in hydrogeologic unit information for H-Area: - Average actual thicknesses of the UTRA-LZ is reported at 60 ft. [SRNL-STI-2010-00148, Pg. 11]; Average model thickness is 65 ft [SRNL-STI-2010-00148, Fig. 53] - GA ranges in thickness from 55 to 70 ft [SRNL-STI-2010-00148, Pg. 12]; Average model thickness is 85 ft. [SRNL-STI-2010-00148, Fig. 54]	Stated that the cited text was meant to be a general description showing a range of thicknesses. Indicated that the modeled thickness is consistent with data specific to H-Area.
18	HTF Vadose Zone Properties	What is the technical basis for suggesting that the HTF vadose zone properties "most likely represent the [E-Area] upper vadose zone properties as identified in WSRC-STI-2006-00198"?	Indicated that the LZ from E-Area is saturated at HTF. Stated that backfill properties were modeled for the vadose zone (e.g., Sandy K_d).
19	Water Table Fluctuations	Clarify what site factors caused the rapid decline and recovery of the water table during the 1985-1987 period. SRNL-STI-2010-00148 (Pg. 18) indicated that the water table may fluctuate as much as ± 10 ft in response to seasonal variations and longer climatic cycles, but the historical data do not appear to support this envelope. The same reference showed graphical records that the water table elevation at HTF has fluctuated as much as ± 15 ft or more during 1985-1987.	Indicated that the modeling performed by Portage was helpful for understanding the impact of the engineered cap. Stated that variations in precipitation do not appear to account for variability in water table during the 1985-1987 time period. Suggested it may be the result of diminution of perched water during drought conditions. Also, suggested that could have been from possible draw-down for construction activities (e.g.,pump pits 7-10).
20	Compliance Boundaries	Clarify the basis for the variable lateral distance of the 100-m and 1-m boundaries from the tanks, distributed transfer line polygons, and ancillary equipment.	Indicated that the boundary determination was predicated on including as many as possible of the waste tanks, ancillary equipment, and transfer lines as inventory sources.

ID	TITLE	NRC QUESTION	SUMMARY OF DOE RESPONSE
21	Neptunium K_d in Cementitious Materials under Oxidizing Conditions	Clarify the basis for Np K_d under oxidizing conditions in cementitious materials. SRNL-STI-2009-00634, which is cited in Table 17 of SRNL-STI-2009-00473, deals only with sedimentary rocks.	Stated in some cases K_ds derived from off site (e.g., Hanford) information. Will acquire site and radionuclide specific data for a range of soil and material conditions as part of PA maintenance.
22	Neptunium K_d for Middle-Aged Reducing Conditions	Clarify the rationale from Table 18 of SRNL-STI-2009-00473 to revise Np K_d for middle-aged reducing conditions from the FTF performance assessment.	Stated in some cases K_ds derived from off site (e.g., Hanford) information. Will acquire site and radionuclide specific data for a range of soil and material conditions as part of PA maintenance.
23	Additional Analyses for Plutonium and Neptunium K_ds	Have additional analyses been conducted that attempt to elucidate Pu and Np K_d values for cementitious and sedimentary materials?	Stated in some cases K_ds derived from off site (e.g., Hanford) information. Will acquire site and radionuclide specific data for a range of soil and material conditions as part of PA maintenance.
24	Impact of Cement Leachate on Soil K_ds	Clarify how cement leachate impacts K_d values for soils in the performance assessment.	Stated in some cases K_ds derived from off site (e.g., Hanford) information. Will acquire site and radionuclide specific data for a range of soil and material conditions as part of PA maintenance.
25	Radium K_d in Soil	What is the basis for Ra K_d in soil? SRNL-STI-2010-00493 does not address radium.	Stated in some cases K_ds derived from off site (e.g., Hanford) information. Will acquire site and radionuclide specific data for a range of soil and material conditions as part of PA maintenance.

ID	TITLE	NRC QUESTION	SUMMARY OF DOE RESPONSE
		Meeting Date: May 9, 2013	
1	Follow-up on GSA/PORFLOW® and HTF/PORFLOW® Pathlines	DOE indicated that although the source locations appeared to be similar, differences in starting point elevations might explain the differences in particle tracks. DOE indicated it would confirm elevations of model starting points. Also, discuss the sensitivity of results to source loading locations.	Indicated that Fig. 4.4-13 is correct (Pg. 397). Fig. 5.2-6 (Pg. 524) generated using an incorrect plotter setting. Indicated the starting points for the pathlines are the center of each tank in plan view, either the basemat or bottom of the tank for submerged tanks in elevation view, and the water table (i.e., 275 ft) for unsubmerged tanks. Stated analyses were conducted to understand sensitivity to starting locations. Observed very little sensitivity over a starting elevation range of ±10 ft.
2	Follow-up on Calibration Statistics and Residuals Local to HTF	Clarify why estimated residuals and baseflow estimates that exceeded project-stated targets are considered acceptable (i.e., large UTR hydraulic head residuals in H-area were noted during FTF consultation; baseflow estimates were noted during Saltstone review.)	Will revisit calibration targets in greater detail to respond to RAI. Insufficient time to do so for these clarification teleconferences.
3	Potential Artificial Recharge Sources Discussed in GSA/FACT	Clarify whether any actions have been taken to reduce the following potential recharge sources that were listed in GSA/FACT documentation: a. Suspected leak in process/well water system near Tanks 21 to 24 cluster; b. Leaky storm sewer system near Tanks 9-12 (currently being fitted with sleeve to stop leaks); c. Steam condensate flow continuously to leak storm sewer in general; d. Undergound pipes associated with a tank cooling system near Tanks 9-16 has a measureable and noticeable leak.	Provided no specific information on the recharge sources. Stated that GSA/FACT modeled hydraulic heads in H-Area were too low. Discussed ways to increase WT in model (i.e., reduce hydraulic conductivity, increase recharge). Recharge was increased for GSA/FACT. When GSA/FACT was migrated to GSA/PORFLOW®, only hydraulic conductivity was decreased. Indicated that there is more uncertainty in H-Area compared to rest of GSA. GSA database is thought to have overestimated hydraulic heads in part of H-Area (specifically near Tanks 48, 49, 50, and 51). Environmental Restoration Data Management System (ERDMS) well data suggests that water levels are lower in this part of H-Area and the vadose zone is thicker. Suggested that this circumstance should have a positive impact on the compliance case. Acknowledged that conservatism is radionuclide-specific.

ID	TITLE	NRC QUESTION	SUMMARY OF DOE RESPONSE
4	Calibration Hydraulic Conductivity Adjustments at H-Area	Clarify the location(s) of hydraulic conductivity adjustment(s) at H-Area during model calibration.	Agreed to provide a map view graphic to clarify the location of this elliptical zone and provide several specific examples of hydraulic conductivity for discrete modeled hydrogeologic units. Indicated that overall around H-Area, K_h for the UTR-LZ limited to ≤ 5 ft/day, K_h for the UTR-UZ limited to ≤ 4 ft/day and K_h for TCCZ limited to 10^{-4} to 10^{-3} ft/day in addition to adjustments from GSA/FACT to GSA/PORFLOW®.
5	New H-Area Calibration Targets	Indicate whether new calibration targets are available in H-Area.	Some discussion regarding the differences in recent water level data versus calibration targets (some wells are markedly lower in recent history than the calibration targets).
6	Impact of Perched Water Zones on Calibration Adjustments	Discuss potential impact of perched water zones, mentioned at 04/17/2013 teleconference, on adjustments to model parameters during calibration.	Indicated mentioning perched water zones at 04/17/2013 teleconference may have been premature as subsequent inquiries have not yielded corroborating information. Will investigate as part of other calibration issues.
7	Follow-up on Uncalibrated Hydraulic Conductivity Assignments in GSA/FACT	Confirm whether the uncalibrated hydraulic conductivity assignments to GSA/FACT grid cells were based on a correlation between hydraulic conductivity and total mud fraction.	Confirmed that uncalibrated hydraulic conductivity assignments in GSA/FACT grid cells were based on a correlation between conductivity values measured via lab and field tests and total mud fraction observed in core from the same intervals.
8	Magnitude of Vertical to Horizontal Flow Velocity	Clarify why numerical simulations in SRNL-STI-2012-00465 assume a vertical velocity of 15 in/yr (i.e., the infiltration rate).	Indicated difficulty in extracting information from modeling conducted by Portage to support HTF PA. Will provide information at a later date. Clarified that consideration of cross-flow in estimating radionuclide flux out of the CZ was not needed given its vertical extent. However, in computing chemical transition times, flows out of the two-dimensional near-field model needed to be adjusted to account for cross-flow through thicker tank/vault components, in part to save resources associated with three-dimensional modeling.

ID	TITLE	NRC QUESTION	SUMMARY OF DOE RESPONSE
9	Impact of Cap on H-Area Flow Field	Comment on the impact of capped conditions on the flow field at H-Area (e.g., effects on particle directions).	Posited that the cap could cause preferential flow of contaminants downward instead of laterally because of the way runoff water infiltrates at the edge of the cap and moves toward the center of the HTF footprint. Stated the cap will also locally flatten the groundwater divide, thus reducing the gradient.
10	Hydraulic Properties of Grout Fill	Clarify whether grout fill was modeled using circa 2007 "Reducing Grout" curves as indicated in SRR-CWDA-2010-00128, Rev. 1 or "High Quality Concrete" as indicated in SRNL-STI-2012-00465, Rev. 0).	Used High Quality Concrete curves for intact grout. Suspect PA Rev. 1 may have had carryover from previous version. Suggested it is not very consequential since the degradation timing is more important.
11	Follow-up on H-Area Hydrogeologic Units	DOE agreed to provide data on H-area aquifer thicknesses to clarify discrepancies in reported values during 04/17/2013 teleconference.	Referred to related information in WSRC-TR-96-0399, Rev. 1
12	Follow-up on HTF Vadose Zone Properties	DOE agreed to confirm properties of H-Area vadose zone that were discussed during 04/17/2013 teleconference.	Confirmed that E-Area UTR-LZ lies beneath the water table at H-Area
13	Saturated Horizontal Hydraulic Conductivities for UTRA-UZ and -LZ	Clarify the basis for saturated horizontal conductivities for the Upper Three Runs Aquifer - Upper Zone and - Lower Zone. WSRC-TR-96-0399, Vol. 2 reported GSA/FACT UTRA-UZ and -LZ average values were 7.5 ft/day and 7.1 ft/day. WSRC-TR-2004-00106 indicated GSA/FACT values were increased 25% and 35% to arrive at unreported GSA/PORFLOW® values. SRR-CWDA-2010-00128, Rev. 1 (Pg. 281) reports average horizontal conductivities in the saturated UTRA-UZ and -LZ are 10 and 13 ft/day.	Explained that adjustments were made between the final calibrated values in GSA/FACT and the 25% and 35% increases made during GSA/PORFLOW® model calibration (i.e., lower leakances for the Gordon confining unit and higher hydraulic conductivities for the UTR-UZ and -LZ.

ID	TITLE	NRC QUESTION	SUMMARY OF DOE RESPONSE
14	Follow-up on Water Table Fluctuations	Follow-up on potential impacts from construction activities	Indicated correlation between the water table fluctuations and rainfall was fairly consistent except during the mid 1980's. No documentation related to intentional water table depression in the mid-1980s (e.g., construction activities). Stated that D-Area also appeared to have large decrease, suggesting it may not be a local effect. Will continue looking at other wells to see (though not committing to a follow-up).
15	Flow Vectors	Describe flow vectors in SRNL-STI-2012-00465 (e.g., Figure 4 relative velocities, directions in aquifer and confining units)	Covered in Magnitude of Vertical to Horizontal Flow Velocity. Need more time to respond.
16	Research Activities on Soft Zones	Discuss results from reported research on soft zones that may have hydrogeological ramifications for H-Area	Report by Laura Bagwell suggests that soft zones are less a factor in H-Area than at the nearby Vogtle NPP. Report by GT researchers not yet published. GT research suggests soft zones are 40k yrs old and were not significantly impacted by the major Charleston earthquake.
17	Flow Fields for Cases B-D	Clarify if flow fields in GoldSim® dll folder were used for Cases B-D (Cases B-D appeared to be the same as Case A).	DOE committed to provide flow field data as follow-up to phone call.
18	Cross-Flow Adjustments on Chemical Transition Times	Clarify cross-flow adjustments to chemical transition times.	Clarified that 90/10 ratio of horizontal to vertical flow was used to calculate the amount of dissolved oxygen in water to calculate the chemical transition times in geochemical modeling. Chemical transition times are reported in displaced pore volumes or DPV. The DPV counts were tracked using PORFLOW® flows for tanks above the water table. For submerged tanks, DPV counts are calculated in GoldSim®.
19	Follow-up on Compliance Boundaries	Follow-up on risk signficance of 100-m boundary selection.	Indicated that additional 1m observation points were created near source areas in HTF/PORFLOW®. Additionally, 1 m boundary data are available. GoldSim® modeling results also provide information to assess the risk-significance of a change in the compliance boundary. Inquired whether this information would be sufficient.

ID	TITLE	NRC QUESTION	SUMMARY OF DOE RESPONSE
20	Follow-up on Tank 16 Annulus Ventilation Duct Inventory	Follow-up on estimation of Tank 16 annulus ventilation duct inventory.	Follow-up moved to 05/16/2013 teleconference

ID	TITLE	NRC QUESTION	SUMMARY OF DOE RESPONSE
		Meeting Date: May 16, 2013	
1	Inventory Screening Methodology from 159 Radionuclides to 54 Radionuclides	The screening methodology describes the process to reduce the inventory list from 849 radionuclides to159 radionuclides and then to 54 radionuclides. Appendix B of SRR-CWDA-2010-00023, Rev. 3 only lists a rationale for 90 radionuclides that were eliminated from the list of 159. Please clarify the screening from 159 radionuclides to 54.	Indicated this was a documentation error that will be revised in the next version, possibly after Tank 16 data collected and analyzed (~late 2014). Agreed to provide list of 13 radionuclides (Bk-249, Ce-144, Cf-252, Cm-242, Cs-134, Eu-155, Na-22, Pm-147, Pr-144, Rh-106, Ru-106, Sb-125, Te-125m) and explain screening, which is related to half-lives.
2	Screening of Ba-137m, Y-90, Ra-226 and Th-229 in Inventory	The DOE/SRS-WD-2013-001, Rev. 0, page 5-3, states that Ba-137m, Y-90, Ra-226 and Th-229 were eliminated in the screening. However, these are all part of the 54 radionuclides for HTF. Please clarify.	Radionuclides cited were not meant to be examples of *radionuclides that were eliminated because* they were decay products of parents. They were simply examples of decay products from parents.
3	Initial Inventory Multiplier	SRR-CWDA-2010-00128, Rev. 1, page 217, states that initial inventories were increased by one order of magnitude for Type I, II and IV. However, SRR-CWDA-2010-00023, Rev. 3 does not mention increasing the WCS inventories by one order of magnitude. Please clarify.	Compared FTF approach (Ci = 10 x WCS inventories) to HTF approach (Ci = normalized estimated concentration from WCS to 4,000 gallons, the assumed residual volume).
4	Impact of Tank Cleaning on Cs, Sr, Zr Inventories	In SRR-CWDA-2010-00023, Section 3.2.1.2, DOE reduces the inventory of all tank types of cesium, strontium, and zirconium by one order of magnitude based on Tank 5 cleaning experience. Clarify the basis for reducing all three radionuclides by a one order of magnitude for all Tank Types, especially comparing the projected vs. measured for Tank 18 and 19.	Stated the basis derived from changes in concentration observed before (process sample) and after chemical cleaning (final characterization). Observed reductions in Cs, Sr, and Zr. Accumulated grab samples from Tank 5 from under riser prior to cleaning (WSRC-STI-2007-00192). Agreed to provide clarification in writing for Cs, Sr, and Zr
5	Inventory Ratios	DOE states that it based the Zr-93 values on ratios of Zr-93 to Sr-90 measured in Tank 5. The measured ratio for Tank 5 was 3000, but the projected ratio for HTF 30,000. Please clarify the basis for assuming different ratios.	Zr-93 based on ratio with Sr-90. Agreed to provide clarification in writing for Cs, Sr, and Zr

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6	Zeolite Fractions	DOE assumed that zeolite weight and volume fractions are the same in residual material after cleaning as prior to cleaning. Please clarify how it will estimate the amount of zeolite weight and volume fractions that are applied.	Cited CBU-PIT-2005-00099 for weight and volume fractions. Indicated no preferential removal assumed; the same zeolite ratio in this reference is applied to the 4000 gallons in final projections.
7	Determination of Annular Inventory in Non-Visible Regions	SRR-CWDA-2010-00128, Rev. 1 and SRR-LWE-2012-00039 estimate the remaining volume in the Tank 16 annulus as 3,300 gallons through the use of camera views and interior landmarks (i.e., duct diameter, annulus wall radius). There is residual material in the bottom of the annulus (estimated at 2,100 gallons) as well as inside the duct (estimated at 1,200 gallons). However, there are many areas of the annulus (and duct) where visual determination of the waste level was not possible. In those areas, DOE extrapolated the waste level using the data from surrounding areas. Please clarify the basis for the extrapolation and the uncertainty of this volume estimate given that the material visible from the access points may have been at a lower level (i.e., the material directly under the access points may have dissolved in prior cleaning attempts, leaving lower levels of material in the ducts under access points and higher levels of material further away from the visible areas).	Indicated video mapping to obtain estimated volumes and extrapolated for areas beyond visible portions. Indicated that there is almost 100% coverage in Tank 16 annulus (outside the duct) as a result of 13 additional inspection ports that were added (Other Type I and II tanks have 4 ports), except for pipe obstruction in one spot from two directions. Stated that the ducts were drilled into to obtain samples for solubility estimates but that the material depth was not measured where these samples were taken because the sample was not a core but was broken pieces retrieved with a vacuum. Indicated that the final volume determination for Tank 16 primary and annulus will be done along with final sampling and characterization.
8	Tank 16 Annulus Residual Waste Volume	Page 40 of SRR-CWDA-2011-00126 states that 4,700 gallons is estimated to be in the Tank 16 Annulus. However, the PA and SRR-LWE-2012-00039 estimate the remaining volume as 3,300. Confirm that 3,300 is the current estimate.	Confirmed 3,300 gallons.

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9	Tanks 9, 10, and 14 Annular Volumes	DOE applies the Tank 16 estimate of 3,300 gallons to Tanks 9, 10 and 14, which also have significant volume in the annulus. DOE expects the material in those other Type I and Type II tanks to be highly soluble since it was originally the supernate that leaked into the annulus and later dried. For Tank 16, the material is not expected to be soluble because sand was introduced into the annulus to investigate the leak sites of the primary tank. SRR-LWE-2012-00039 describes the waste depths in Tank 16 annulus that were observed below each of the risers to be 2-4 inches from the bottom of the annulus. The HTF Inventory (SRR-CWDA-2010-00023) states that the material depth in Tank 9 is 8-10 inches and the material depth in Tank 14 is 12-13 inches. Please clarify how it is conservative to apply the inventory for Tank 16 to Tanks 9 and 14 if the material depth is much less for Tank 16. Does DOE have plans to remove additional material from the annulus of Tanks 9 and 14? Also, in [LWO-LWE-2007-00204], DOE states that "Recent annulus samples taken both inside and outside the duct from Risers IP-118 and IP 35 contained significant amount of soluble waste (~50 vol%)." Please clarify their assumptions regarding the solubility of the material in the Tank 16 annulus in light of these sample results.	Indicated that depth of material cited in Tanks 9 and 14 is at various leak sites, but is not uniform around entire annulus as it is expected to be in Tank 16. Stated that after annulus cleaning the volume in Tanks 9 and 14 is expected to be much less than the 3,300 gallons estimated for Tank 16. Stated that material in mounds can be seen tapering off. Plans (as part of the baseline) to remove additional annular inventory in Tanks 9, 10 and 14. Stated that the material in Tanks 9 and 14 annuli is expected to be similar to the material inside the Tank 16 annulus duct but dissimilar to the material in the Tank 16 annulus but outside the duct due to the unique nature of the Tank 16 leak. Indicated ducts in Tank 16 annulus were drilled to obtain samples for solubility analyses. Cited 2007 and 2011 SRNL reports. Laboratory data indicates 35-50% soluble in duct. Expect waste in duct to contain less silica (from sand added for sandblasting in Tank 16). However, DOE is not surprised that there are "pockets" of material in the Tank 16 annulus that would be more soluble.
10	Representitiveness of Tank 16 annulus samples for Tanks 9, 10, and 14	For those radionuclides analyzed in the four Tank 16 annulus samples, DOE uses the concentrations of the Tank 16 annulus sample results for tanks with annulus material (Tanks 9, 10 and 14). Clarify the basis for using Tank 16 concentrations if Tank 16 annulus material is expected to be chemically different than the other Tanks with residual material (9, 10 and 14).	Expect material leaking into Tank 16 annulus to be radiologically similar to fresh waste from H Canyon. Most radionuclides precipitate quickly upon alkalining. However, some (e.g., Sr) precipitate more slowly. In Tank 16, fresh waste leaked immediately so some differences may occur such as with Sr. DOE explained that the Tank 16 concentrations were conservative because they believed the Tank 16 to contain more Sr-90 than the other tanks. Since the leak was so rapid, the Sr-90 had not precipitated out of the supernate and into the sludge within the primary tank, so there is more Sr-90 in Tank 16 annulus than would be expected in Tanks 9,10, and 14 annuli.

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11	Differences Between Annular and Primary Residual Inventory for Ni-59	The estimated Ni-59 inventory in the Type I tank annuli was estimated by setting the annulus residual inventory equal to the primary tank residual inventory (i.e., 8.6 Ci). The actual annulus inventory for Ni-59 in the Type I tanks is expected to be considerably lower than the inventory used in the HTF PA modeling. Clarify why the actual inventory in the annulus is expected to me much less than that projected in the primary if the expected volumes assumed are relatively the same, as well as the concentrations. The volume in the annulus is assumed to be 3300 gallons and the volume in the primary is assumed to be 4000 gallons.	Expect Ni to precipitate immediately upon pH adjustment; therefore, should primarily reside in the sludge within the primary tank versus within supernate that leaked from primary liner.
12	Potential Limits on Oxalic Acid Cleaning	Section 2.3.3 of DOE/SRS-WD-2013-001, Rev. 0 discusses chemical cleaning technologies. WSRC-TR-2004-00317 discusses potential limits on the use of oxalic acid due to downstream impacts on the Liquid Waste System. Specifically, the "sludge batch can contain about 10 wt% of total solids as sodium oxalate before increasing the number of canisters produced or changing sludge processing", and "10 wt% sodium oxalate in total solids amounts to disposal of 1 to 6 sludge heels depending on waste type of sludge heel cleaned and specific sludge batch." Please clarify how these limits might impact the cumulative number of HTF tanks that can undergo chemical cleaning with OA, and also the schedule of cleaning with OA.	Indicated this question would take longer to address. Continuing to evaluate chemical cleaning technologies and impacts of oxalates on downstream processes. Agreed to clarify statement about 1-6 sludge heels.

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13	Environmental Conditions Impacting Oxalic Acid Effectiveness	The DOE/SRS-WD-2013-001, Rev. 0 states that Oxalic Acid might not be as effective on some of the tanks depending on the environmental conditions to which tank has been exposed. "Environmental conditions to which the waste has been exposed also affect its dissolution characteristics; therefore, in future chemical cleaning planning, each waste tank (or groups of tanks with similar waste and similar historical conditioning) will be considered individually." Please clarify under what conditions oxalic acid is not expected to be as effective and which tanks DOE expects Oxalic Acid's effectiveness to be limited. Also, please clarify what DOE intends to use as an alternative to OA for these tanks.	Indicated this will be evaluated on a tank-by-tank basis.
14	Enhanced Chemical Cleaning Plans	The Waste Removal Technology Baseline discusses Enhanced Chemical Cleaning (ECC) [V-ESR-G-00003], which uses lower acid strength. It states that Tank 8 will be the prototype for ECC. However, Tank 8 is not planned for closure until 2020 as stated in the Liquid Waste System Plan [SRR-LWP-2009-00001 R17]. Please elaborate on the ECC technology and clarify whether any HTF tanks will be used as a prototype. Is the Chemical Cleaning that is planned for Tank 12 considered "enhanced" since DOE is planning to dilute the acid strength after the first strike, or is ECC an entirely different technology?	Clarified that ECC is intended to destroy oxalates. Currently a lack of funding and there were nuclear safety concerns.

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15	Lessons Learned for Tank 12 Oxalic Acid Cleaning Campaign	In the Tank 12 Bulk OA presentation [SRR-STI-2013-00198], the following lessons learned were described. Please elaborate on these specific adjustments for the Tank 12 cleaning campaign. i. Maximize contact of residuals with oxalic acid a. Sludge depth and chemical consituents b. Insoluble particulate mobilization ii. Provide adequate mixing iii. Control pH to prevent oxalate production iv. Pre-wash treatment tank to target sodium oxalate solubility	(i) Indicated use of 4 SLP's at maximum speed to maximize the OA-sludge surface area contact. The pumps will spread out the mounds to achieve good contact between the sludge and the acid where the sludge is deeper. This will also mobilize the insoluble particles. (ii) For Tank 12 they can operate the pumps during the entire campaign instead of just at the beginning during cleaning Tanks 5 and 6. (iii) Experience indicates increased pH (>2) reduces the solubility of metals, therefore precipitating oxalates (iv) Pre-wash to a target based on solubility of sodium oxalate, i.e. [Na+] = 0.5 M; goal is to reduce the sodium concentration to minimize sodium oxalate precipitation
16	Monitoring During Tank 12 Chemical Cleaning	DOE also stated in SRR-STI-2013-00198 that there will be "Sampling and monitoring program in place to ensure operational efficiency and safety envelope maintained" during Tank 12 OA cleaning. Please clarify what sampling and monitoring will take place during the Tank 12 chemical cleaning.	Indicated there is an operating procedure that might clarify and DOE would investigate providing the operating procedure.
17	Additional Testing of Oxalic Acid Effectiveness for HTF Wastes	Clarify whether DOE plans to perform additional testing of oxalic acid effectiveness in treating the specific type of waste expected to be present in HTF tanks targeted for chemical sludge removal with oxalic acid.	Not planning additional OA testing at this time.
18	Plans for Evaluation of Tank 12 Chemical Cleaning	As a comment on the Tanks 5 and 6 Closure Module, the NRC staff suggested that DOE perform a critical evaluation of the differences in oxalic acid delivery, waste agitation, waste transfer, and other factors that led to more successful use of oxalic acid in Tank 16 compared to Tank 5 and 6 would be informative. Such an evaluation could also compare the results of the upcoming Tank 12 chemical cleaning. Clarify whether DOE plans to perform such an evaluation for Tank 12.	Plans to evaluate the efficiency and effectiveness of Tank 12 OA cleaning. DOE does not plan to formally document the evaluation of Tank 12 OA cleaning other than in the Closure Module document for Tank 12.

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19	Tank 5 Lessons Learned on Mound Dispersal for HTF	During the cleaning of Tank 5, the cooling coils served as an obstacle to breaking up a mound under Riser 1. Please clarify how DOE intends to apply this particular lesson learned from Tank 5 experience having to do with cooling coils to HTF tanks.	Believed final state is not indicative of ability to move sludge. Stated that mounds under mixing pumps were mobilized even though the pump was not able to be lowered to the design level above the tank floor. Indicated that DOE systematically develops a mixing strategy prior to each cleaning campaign and continue to evaluate the number and location of pumps to build a strategy for heel removal campaigns in the tanks.
20	Feasibility fo Tank Amendments to Lower SMP for Cleaning	SRR-CWDA-2012-00071, Rev. 0 (page 37) indicates that the SMP installed in Riser 1 of Tank 5 could not be lowered to the tank floor due to interference with existing cooling coils that were covered by a sludge mound at the time of SMP installation. The cooling coil cutter was not implemented and the pump was left suspended directly above the sludge level. The SMP was later lowered to the horizontal cooling coil level (around 13 inches) to slurry the sludge after the mound under Riser 1 was mobilized to an area near Risers 3 and 5 (page 40). Although installation of the SMP under Riser 1 was credited with lowering the large mound under Riser 1 during mechanical sludge removal, the height of the SMP above the tank floor may have affected final solids accumulation following mechanical feed and bleed. LWO-LWE-2006-00128 indicates that the SMP design calls for placement 8 inches above or on the tank bottom. SRR-CWDA-2012-00071, Rev. 0 (page 59) indicates that the 16 inches between the SMP pump and the bottom of the tank during mechanical feed and bleed may be responsible for the solids accumulation under Riser 1. Please clarify whether DOE has plans to evaluate or has evaluated the feasibility of cutting the cooling coils under Riser 1 to allow the pump to be lowered to the tank floor during final stages of cleaning.	Believed final state is not indicative of ability to move sludge. Stated that mounds under mixing pumps were mobilized even though the pump was not able to be lowered to the design level above the tank floor.

ID	TITLE	NRC QUESTION	SUMMARY OF DOE RESPONSE
21	Status of Small Scale Robotics and Sampling Technology for HTF	Section 5.2.3 of DOE/SRS-WD-2013-001, Rev. 0 discusses optimization of existing technologies. It states that DOE is pursuing small scale robotics and sampling applications in tanks with internal obstructions. Please clarify the timeline and status of this type of technology for use in HTF.	Indicated that Tank 16 will be sampled the week of May 26 using a small vacuum technology, which is different from the technology used to retrieve the scrape samples from Tank 18 and 19.
22	Status of Robotic Arm Technology for HTF	Section 5.3, page 5-21 of the DOE/SRS-2013-001, Rev. 0 discusses how DOE is currently evaluating a robotic arm technology and other alternate technologies to determine the practicality of additional waste removal from the Tank 16 annulus. This technology is also mentioned in SRR-LWE-2012-00082. Please elaborate on the evaluations that were performed in 2007 and in 2010 conducted for potentially using this technology for annulus cleaning. Please clarify the status and timeline of this technology for HTF.	Clarified that two different robotic arm technologies were being pursued. One is for the primary Type IV tanks. A different type of robotic arm crawler technology was pursued for Tank 16 annulus. In 2007 a vendor demonstrated a technology that was portrayed to be fairly mature. However in 2010 the vendor indicated that it is not deployable. Indicated that a slucing technology was also evaluated but was not pusued due to nuclear safety issues and installation problems (inspection ports were not large enough). Will be discussed in Tank 16 MEP document.
23	Metrics for Determining Effectiveness of Heel Removal	Section 5.3 of the DOE/SRS-2013-001, Rev. 0 states that "throughout the heel removal process, DOE continually evaluates the ongoing effectiveness of the technology being implemented and optimizes the existing technologies." Please clarify how DOE continually evaluates the ongoing effectiveness of the technologies during the MSR or the CSR campaigns, especially given that photographs or samples are not usually taken until the end of the campaign. Clarify what metrics are used throughout the process to determine effectiveness (e.g., radiation transfer line readings).	Metrics are determined on a case-by-case basis in development of the specific operating strategy for each tank. Can't do this generically.

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24	Status of Mixing Model Development for HTF	DOE reviewed their efforts in investigating new technologies in a briefing to the State of South Carolina in April 2013 [SRR-LWE-2013-00077]. DOE is cooperating with Hanford on the development of mixing models that can predict different slurry behavior. DOE stated that this is still in the beginning stages, but is a growing area with potential to enhance cleaning efforts at SRS. Please clarify the timeline of their use of the mixing model in HTF that is being developed for Hanford.	Nothing additional to add.
25	Comparative Effectiveness of SMPs and Slurry Pumps	Clarify the relative effectiveness of SMPs to other types of slurry pumps for bulk sludge removal versus residual heel removal.	SMPs are more powerful with a theoretical effective cleaning radius of approximately 50 ft. SLPs only have approximately 30 ft theoretical effective cleaning radius. SMPs have limitations - nuclear safety, aerosolization, electrical loading. SMPs are being considered for Heel removal in most tanks, whereas SLPs or SMPs are being considered for Bulk Removal.
26	Status of Low Volume Mixing Pump Technology for HTF	Section 2.3.2.1 of DOE/SRS-2013-001, Rev. 0 states that "the SMPs are required to be shut down as the liquid level approaches the elevation of the discharge nozzles to prevent waste spraying". Because the SMPs could not be operated at lower liquid levels, ineffective mixing during acid strike 2 in Tanks 5 and 6 appears to have contributed to the formation of solids during chemical cleaning. DOE has indicated that a low volume mixing pump has been evaluated to support chemical cleaning but that it is not available at this time. Please clarify the timeline of the low volume mixing pump technology and whether they anticipate it to be available for future cleaning of HTF tanks.	Pulse-jet mixers found to be ineffective. Not pursuing low-volume pump.
27	Tank 16 Sampling Data	Please indicate when sampling data for Tank 16 will be available to NRC.	Indicated data should be available in late 2014 - first the primary, then the annulus.

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28	Determination of Number of SLPs	Section 3.3.3 of SRR-CWDA-2011-00126 states that three SLPs were installed in Tank 16 Risers for MSR Campaigns 3-5, whereas one pump had been used for the first two campaigns. Please describe how DOE determined that three SLPs as opposed to four were sufficient in Tank 16. Additional details regarding the practicality (financial and schedule costs and uncertain benefit) of installation of a fourth pump would be helpful. Please also describe how this type of decision will be made for future tanks.	DOE referred NRC to Appendix B of the draft Basis for Waste Determination.
29	Basis for Compositing Tank 16 Samples	The Tank 16 presentation on sampling and analysis plan (SRR-CWDA-2013-00055) states that there are three populations within the annulus (north, south, and inside the duct). Slide 29 shows a figure with the samples and composites. Please clarify the basis for compositing from the various populations. How does the decision to combine samples from different populations impact the UCL?	Indicated UCL is not adversely impacted by the compositing approach.
30	Conceptual Model of Construction Joint in Annulus	In SRR-CWDA-2010-00128, Rev. 1, Section 5.6.2.2.2, DOE describes the mass release from Type II tanks with an Intact Liner. Please clarify if this conceptual model also considers the possibility that the residual material could travel through the construction joint at the top of the annulus pan, which is what is thought to have happened with Tank 16.	PA does not explicitly model the tank vault construction joints. However, DOE has evaluated the scenario qualitatively, and does not envision this leak pathway to be a risk-significant pathway. DOE indicated that the downward flux through the tank causes the significant peaks.

ID	TITLE	NRC QUESTION	SUMMARY OF DOE RESPONSE
		Meeting Date: July 3, 2013	
1	Inadvertent Intrusion Wells in GoldSim® Model	Clarify what wells are considered for intruders in GoldSim® modeling. Is the maximum of concentrations/dose for the seven intruder wells, plus 1 m locations considered, or just the maximum of the seven intruder wells considered?	DOE indicated that it considered seven intruder wells, but didn't evaluate at the 1-m boundary in GoldSim®. DOE also indicated that it didn't perform a study to evaluate locations of wells. Rather, placement was done by professional judgment.

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2	Saturated Zone Dilution in GoldSim® Model	Clarify the components/parameters of the GoldSim® modeling that effect saturated zone dilution including the following potential mechanisms: a. Mixing vertically over aquifer thickness b. Dilution due to flow of clean water into cell/pipe elements c. Dispersion along the flow path d. Additional mixing at the end of the pipe element Provide a ball-park estimate of dilution factors for a conservative tracer from different waste tanks.	DOE indicated that vertical mixing is controlled by vertical dispersivity. The GoldSim® pipe element calculates 1-D transport including dispersion over the aquifer thickness. DOE uses the GoldSim® plume function to recalculate concentrations based on the assumed source dimensions and dispersivities. DOE used a source thickness of 3-m, which is comparable to the thickness of a numerical cell in the PORFLOW® modeling. In PORFLOW®, DOE indicated that the radionuclide flux from the near-field modeling was loaded into the saturated zone in the cell with the highest elevation that is fully saturated and has a centroid within the tank footprint. For tanks that are submerged, DOE indicated that the source cell was located at the saturated elevation closest to the basemat. DOE indicated that it believes that the sensitivity of concentrations to loading cell dimensions is insignificant. DOE provided estimates based on GoldSim® pipe element for saturated zone dilution factors: 24 from the GoldSim® pipe element if assuming full aquifer thickness of 130-m and 1.8 when using plume function and source zone thickness of 3-m with no dispersion. DOE also estimated saturated zone dilution factors from the plume function accounting for source zone thickness of 5 (500ft pipe element length), 9 (1000 ft. pipe element length), 13 (1500ft pipe element length), and 16 (2000ft pipe element length) - estimated from plume function. Only transverse dispersion was considered in calculating these dilution factors. DOE indicated that it estimated a saturated zone dilution/mixing factor at the end of the pipe element for GoldSim® modeling calculated as the ratio of the Darcy velocity near the compliance point to the Darcy velocity along the flow path to the compliance point. This factor was needed to account for increased velocity nearer the compliance point and was found to be more significant for FTF. DOE indicated that it would need to go back and check and see how significant this factor was for HTF.

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3	Representation of Saturated Zone Flow and Transport Path in GoldSim® Model	Clarify transport along the flow path in the saturated zone. Do the distances reflect both horizontal and vertical transport lengths? What portion of the flow path is represented by the pipe elements versus the cell elements upgradient of the pipe elements?	DOE clarified that the length of the pipe element pathway in GoldSim® is determined solely by horizontal distance to the boundary and covers the distance from the tank footprint to the 100-m boundary.
4	Transport of Plumes in Aquifers in GoldSim® Model	Clarify the sources whose plumes are expected to be spread over both Upper Three Runs and Gordon aquifers.	DOE indicated that it believed that most sources probably spread over both the UTRA and GA. DOE will confirm if needed.
5	Basis for Vertical Dispersion in Saturated Zone Aquifers in GoldSim® Model	Clarify why vertical dispersion is needed (particularly for the eastern plumes) when the plumes are spread across the aquifer thickness.	See response to 2 above. Vertical dispersion is simulated by the plume function. The plume function corrects the concentrations calculated by the pipe element that assumes the total thickness of the aquifer.
6	Treatment of Dispersivity in Saturated Zone Aquifers in GoldSim® Model	When flow is primarily in the vertical direction, longitudinal dispersivity is applied in the vertical direction. If plumes are assumed to be spread across the aquifer, then is it appropriate to disperse the plumes through use of the longitudinal dispersivity? Or does the dispersivity only get used for that portion of flow that is longitudinal?	See response to 2 above that partially addresses this question. Vertical dispersion is simulated by the plume function. The plume function corrects the concentrations calculated by the pipe element that assumes the plume is spread over the total thickness of the aquifer. NRC noted the difficulty in assigning longitudinal and transverse dispersivities in the abstracted model due to issues with changing vertical and horizontal flow directions in the 3-D model that are simplified to 1-D horizontal flows in GoldSim®.

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7	Transverse Horizontal Dispersivity Adjustment in GoldSim® Model	Clarify the increase in transverse horizontal dispersivity to represent the spreading of plume laterally due to changing flow direction.	DOE indicated that Figures 7.1-1 to 7.1-7 in the H-Area Tank Farm Stochastic Fate and Transport Model Report (SRR-CWDA-2010-00093, Rev. 2) depict the plumes formed by conservative tracers for Tanks 9 (Type I), 12 (Type I), 15 (Type II), 24 (Type IV), 29 (Type III), 40 (Type IIIA), and 49 (Type IIIA) .
8	Relationship of Darcy Velocity and Dilution at the 100-m Boundary in GoldSim® Model	Is the transport time a function of the Darcy velocity from stream traces only? Is the degree of dilution a function of the Darcy velocity at the 100 m boundary for the 100 m well concentrations? What are the Darcy velocities at the 100 m boundary or what level of dilution is seen at the 100 m boundary?	DOE indicated that the Darcy velocity is based on breakthrough curves and where peak comes in. See response 2 above that indicates that the mixing at the end of the pipe occurs and is a function of the ratio of the Darcy velocities over the pipe length and the end of the pipe (velocities increase nearer the 100 m boundary). DOE did not provide specific details on dilution factors (or Darcy velocity ratios) at the end of the pipe.
9	Abstraction of PORFLOW® Flows in GoldSim®	Clarify if/when deterministic flows abstracted from PORFLOW® modeling are used in the GoldSim® simulation.	DOE indicated that the GoldSim® modeling selects only from the 72 flows profiles. Case B-D flows were placeholders and were not used. Deterministic runs in GoldSim® use a Base Case flow and basecase flows were used for benchmarking.

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10	Consistency of Flow Fields with GoldSim® Probabilistic Realizations	Clarify how the flow fields generated for Cases A, C, and E comport with the actual conceptual models being simulated. Specifically comment on the apparent lack of direct correlation between parameters varied to reproduce alternative flow cases and the presence of active fast flow pathways that are central to several alternative scenarios. For example, Case E is inherently a by-passing scenario. However, assumptions regarding degradation of cementitious materials considered in alternative flow cases implemented in GoldSim® probabilistic modeling will impact the amount of flow through the fast flow pathway with the potential for many of the cases to effectively inactivate or limit the impact of the fast flow pathway. Provide information on the range of flows simulated in the fast, by-passing pathway in Case E (and alternative cases), including a comparison of flow through the fast pathway for alternative flow cases E1 through E22 and the deterministic Case E flow case. Consider whether a subset of flows should be considered for each Case consistent with the conceptual model, or alternative flow parameters altered to more accurately reflect the conceptual model.	DOE indicated that they attempted to represent flow field variability with each of the cases to produce a more robust probabilistic analysis. However, no consideration was given to how much flow was through the preferential pathway in Case E.
11	Basis for Basemat By-Pass Fraction in GoldSim®	Clarify the basis for the basemat by-pass fraction used in GoldSim® modeling. Confirm the correlation between bypass flow and bypass fraction in individual realizations.	DOE indicated that there was no correlation between by-pass flow and by-pass fraction. DOE indicated that the probabilistic model evaluated the range of potential dose as insufficient information is available to predict exactly how and to what degree preferential flow will occur. Review of maximum realizations is helpful in this regard.

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12	Simulation of Ancillary Equipment in GoldSim® Modeling	Clarify if you are able to turnoff ancillary equipment when running individual sources in GoldSim® modeling.	DOE indicated that individual sources can be simulated in the GoldSim® modeling without including the ancillary equipment. DOE clarified that if GoldSim® will not zero-out the ancillary time-series elements in the TransportModel_Results container, however.
13	TSProc.dll Source Code	Provide documentation for the TSProc.dll used in the GoldSim® modeling including source code.	DOE will provide the TSProc.dll
14	Intermediate Outputs from GoldSim® Transport Model	Clarify what intermediate outputs are or can be saved in the HTF Transport Model.	DOE clarified that intermediate outputs can be saved for the HTF Transport model. DOE indicated that in order to do so, the user would have to select that results be saved in the GoldSim® modeling HTFTransport Submodel container properties. DOE cautioned that GoldSim® has a limit to the amount of data that can be saved and the intermediate results from this submodel may overwhelm that limit.
15	Other Dynamically-Linked Library Source Codes	Provide source code for other *.dlls used with the HTF GoldSim® model.	DOE will provide source codes for all DLLs used in GoldSim®.

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16	Benchmarking of GoldSim® and PORFLOW® Models	SRR-CWDA-2010-00093, Rev. 2 indicates that benchmarking comparisons are only carried out for the Base Case. Potentially higher risk alternative cases are not benchmarked. For example, Case E represents a by-pass scenario where releases could occur significantly earlier in time at significantly higher magnitude. Benchmarking of GoldSim® modeling to PORFLOW® modeling results would be instructive to ensure all significant transport processes are adequately simulated for these higher-risk alternative cases, if these results are available or could easily be generated (FN1: It is not clear that Case E transport is simulated in PORFLOW® modeling) Additionally, benchmarking is only performed for a limited number of radionuclides (e.g., Ra-226, Tc-99, I-129, and Cs-135) all of which are relatively long-lived radionuclides. Because risk-significant quantities of short-lived radionuclides may remain in Type I and II tank annuli, benchmarking of results to simulations performed in PORFLOW® modeling for relatively short-lived radionuclides that are more sensitive to travel times would be beneficial. Finally, only certain exposure point locations are benchmarked. For example, only doses calculated at a well next to Tank 12 were evaluated for the inadvertent intruder. It is not clear that alternative configurations were simulated for the inadvertent intruder. However, alternative configurations should also be benchmarked against PORFLOW® modeling if these results are available or could be easily generated.	DOE indicated that it chose not to benchmark PORFLOW® and GoldSim® model results for the alternative cases. Benchmarking was only performed for the Base Case. DOE indicated that the HTF PA (SRR-CWDA-2010-00128, Rev. 1), Section 5.6.7.1.1 (pg. 688) discusses the alternative cases that were evaluated in PORFLOW® modeling for the 100-m compliance boundary. DOE will check to see where PORFLOW® files are stored in the set of PORFLOW® modeling files previously sent to NRC.

ID	TITLE	NRC QUESTION	SUMMARY OF DOE RESPONSE
17	Wall Flux Benchmark Factor	Clarify the use of the benchmarking factor of 0.08 to adjust the wall flux.	DOE indicated that it believed the radionuclide flux in the wall would be convective with upward and downward components. The GoldSim® modeling originally resulted in more radionuclide flux coming out of the wall than from the PORFLOW® modeling results. DOE indicated that it approximated the factor to match the PORFLOW® results. DOE stated that it believes the factor enhances diffusion of radionuclides relative to advection.

ID	TITLE	NRC QUESTION	SUMMARY OF DOE RESPONSE
18	Annular Flow Abstraction From PORFLOW® to GoldSim® Model	The PA (SRR-CWDA-2010-00128, Rev. 1), Section 5.6.2.2.1 states: *As Figure 5.6-2 illustrates, after liner failure, the GoldSim Tc-99 release overlies the PORFLOW release, indicating that the solubility control associated with the CZ* [Contaminated Zone] *is being accurately approximated in the HTF GoldSim Model. Prior to liner failure, the Tc- 99 release is dominated by the release of an inventory initialized at the bottom of the annulus. The differences between the two curves prior to liner failure are caused by differences in the manner that the annulus chemistry transition times are evaluated in the two models. In the PORFLOW model, the transition times are based on the pore volume of the entire annulus and the volumetric flow through that pore volume. In the GoldSim model, the transition times are based on the pore volume of the annulus located below the secondary liner and the volumetric flow through that abbreviated pore volume.* Clarify how the flow tracked in the annulus in PORFLOW® modeling differentiates the entire annulus versus the abbreviated annulus beneath the secondary pan. It appears that only two flows for the inner and outer annulus are tracked in PORFLOW® modeling. How are the PORFLOW® model flows then aggregated to compute the volumetric flow through just the abbreviated portion of the annulus to calculate chemical transition times in GoldSim® modeling? Although the peak dose for Tc-99 is similar between the PORFLOW® and GoldSim® model results, the chemical transition time is significantly different. Clarify if the difference in chemical transition time could be risk-significant for other radionuclides that are more sensitive to timing of release.	DOE stated that it modeled an abbreviated portion of annulus to calculate chemical transitions in GoldSim® modeling. Therefore, the GoldSim® modeling uses a smaller volume because it only includes everything below the secondary liner. DOE indicated that the difference in volumes used to represent the annulus between the GoldSim® and PORFLOW® models is the cause for the difference in chemical transition times. DOE also indicated that its modeling approaches assumed annulus inventory was not a dose driver because it was not expected to contain significant quantities of radionuclides compared to the contaminated zones within the primary tank liners. DOE discussed Tc-99 solubility studies and explained that the peak dose was approximately 40 mrem/yr after 10,000 years.

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19	Inventory Multipliers in GoldSim® Model	Section 5.6.3.1 of the PA (SRR-CWDA-2010-00128, Rev. 1), "Radiological Inventory," describes how a minimum of 0.01 and a maximum of 10 were applied as multipliers for the inventory estimates for most radionuclides based on the samples from Tanks 5, 18 and 19. a. Given that the sample results for several of the HRRs (e.g., Tc-99, Cs-137, Pu-240) were more than one order of magnitude greater than the projected values, please clarify how you are confident that a one order of magnitude multiplier is adequate for these radionuclides. b. The multipliers used in the model are based on SRR-CWDA-2010-00023, Rev. 1 instead of Rev 3. For the most part the differences in multipliers is conservative (for Pu-241 (in Tanks 9 and 10), Th-232 (in Tanks 9 and 10), U-236 (in the Type III and IIIA tanks), and U-238 (in Tanks 21, 22, and 23), the current estimate (10) is higher than the previous value (1). However, for a few radionuclides the use of the previous value is non-conservative. The PA states that this is not significant. Please clarify why the maximum multiplier was revised to be 10 in Rev 3 instead of 1 in Rev 1 for some radionuclides and why DOE is confident that the difference is not significant.	DOE indicated that although certain specific radionuclides were greater than one order of magnitude over the projected values, the general trends from sample results did not suggest that a multiplier more than an order-of-magnitude (i.e., 10x) would be necessary. Importantly, DOE stated that it wanted to avoid 'double-counting' conservatism with inventory multipliers since it also increased estimated volumes in comparison to FTF volume assumptions and increased concentrations used in response to the Tanks 5 and 6 final sample analyses. DOE expects the estimated volume of 4,000 gallons to be conservative. DOE plans to focus on updating inventory projections rather than adjusting multipliers in special analyses as tanks are cleaned. DOE indicated that it revised inventories from SRR-CWDA-2010-00023 Rev 1 to Rev 3, but that the models for the PA were not updated because of schedule conflicts. DOE evaluated whether updating the model to Rev. 3 values was risk-significant on a rad-by-rad basis by inspection. The PA (SRR-CWDA-2010-00128, Rev. 1), on page 609, discusses the risk significance for specific radionuclides including Pu-241, Th-232, U-236, U-238. DOE indicated that these radionuclides were not Highly Radioactive Radionuclides (HRRs) and that the non-conservatism was limited to small number of tanks. Therefore, DOE concluded that updating the inventory multipliers in the model was not necessary.

ID	TITLE	NRC QUESTION	SUMMARY OF DOE RESPONSE
20	Solubility Limits in Contaminated Zone for Diffused Radionuclides	Although no solubility control is assumed for contaminants located in tank annuli, solubility controls are realized for contaminants that are able to diffuse into the contaminated zone (CZ) from the annuli prior to significant release. For example, Tc-99 in Tank 16 is present in higher quantities in the annulus (primary sand pad) compared to the CZ with no effective transport barrier between the two (Tank 16 is assumed to have a failed liner at time=0 years; the tank liner would constitute a transport barrier if it were effective). The Tc-99 inventory located in the primary liner is constrained to low aqueous concentrations owing to solubility controls placed on this constituent in the CZ. Given the large concentration gradient and small diffusion length between the primary sand pad, where the bulk of Tank 16 annulus contamination is placed in the PORFLOW® model, and the CZ, a significant portion of Tc-99 diffuses into the CZ where it is retained for most of the simulation timeframe. Although Tc-99 in Tank 16 may not be risk-significant, risk-significant quantities of key radionuclides may be present in Tank 16 or other tanks and experience the same phenomena. Clarify the impact on release (or dose) of solubility control on that portion of annular inventory that diffuses into the CZ or clarify the basis for the assumption of solubility control for annular waste that diffuses into the CZ.	DOE confirmed the NRC staff observation that radionuclides diffuse from the annulus into the contaminated zone and become solubility limited. DOE reiterated its belief that sources associated with the annular contamination (rather than the contamination within the primary liner) are not significant to overall dose.

ID	TITLE	NRC QUESTION	SUMMARY OF DOE RESPONSE
21	Type I Annular Contamination Abstraction	DOE assumes that waste located in the annulus of Type I tanks is located in the bottom inch of reducing grout. Therefore, the reducing grout can constitute a barrier to waste release for key radionuclides. It is plausible that the barrier effectively retains key radionuclides until chemical transition takes place at which time flow through the system may be higher leading to higher releases. However, it is also plausible that hold-up of waste in the reducing grout can lead to an under-prediction of dose. Clarify if there are any non-conservative impacts associated with loading the annular source in the reducing grout in Type I tanks or provide a defensible basis for assuming that the waste is effectively mixed in the annular reducing grout.	DOE reiterated its belief that sources associated with the annular contamination (rather than the contamination within the primary liner) are not significant to overall dose. NRC indicated that peak realization GoldSim® results show that Sr-90 can be a dose driver (e.g., Tank 15 Sr-90 doses were in the rem range with comparable inventories for Case E).
22	Liner Integrity for Leaking Tanks	The PA (SRR-CWDA-2010-00128, Rev. 1), Section 5.6.2.1.1, "Representative Contaminant Sources," states that Tank 9 was modeled with an intact liner. However, Tank 9 (as well as Tank 10 and 14) is assumed to have significant quantities in the annulus. Clarify the basis that the primary liner is assumed to be an effective barrier given releases of material.	DOE indicated that its modeling does not allow consideration of partial liner capabilities. DOE stated that Leak sites are higher than CZ. Tank inspection reports report both the coverage of the annulus and the tank wall.

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23	Cementitious Material Transport Path from Annulus	The PA (SRR-CWDA-2010-00128, Rev. 1), Section 5.6.2.2.2 states: *For Tank 13, a Type II tank with an intact liner, the initial exit route is from the sand pad to the annulus and upward through the annulus. The mass must first migrate above the 5-foot secondary liner vertical extension, before it can leave the system by migrating through the vault wall, into the concrete basemat, and finally into the saturated zone.* This states that the waste goes through the basemat, but Figure 4.4-2 in the PA (SRR-CWDA-2010-00128, Rev. 1) shows that the basemat does not extend out to the sides from beneath the annulus. Clarify the material property assignments at the base of the wall (adjacent to the basemat) in PORFLOW® modeling and in GoldSim® modeling and if they differ from the actual materials in the real system. If the material zones differ from reality or each other, clarify how the representation of this zone in PORFLOW® modeling and/or GoldSim® modeling is adequate for the purpose of PA modeling. Clarify whether PORFLOW® models diffusion through the vault wall to the near-field environment, thereby bypassing the concrete basemat.	DOE noted that flow modeling suggests that flow beneath the tank generally proceeds towards the interior of the tank. DOE stated that in PORFLOW® modeling flow proceeds from the wall to the basemat on the underside of the tank. DOE also indicated that its GoldSim® modeling simulates diffusion from the concrete vault wall to the concrete basemat and not directly from the vault wall to the surrounding soil.

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24	Annular Fast Flow Paths	HTF tanks contain construction features that may represent potential preferential or by-passing pathways through the annulus, although these features are not explicitly represented in the models. For example, direct releases of radioactivity into the environment occurred from leakage of primary waste from Tank 16 into secondary containment. From secondary containment, it is believed that waste overtopped the secondary annulus pan and was released directly into the environment through construction features (e.g., joints) in the tank vault (DP-1358). Although Case E represents a scenario where a fast-flow pathway exists through the tank system, the fast-flow pathway only comes into contact with a portion of annular contamination located in the primary (and secondary) sand pads near the fast flow pathway in Type II tanks. Annular contamination in Type I tanks is loaded into reducing grout that will be used to stabilize the annuli during the closure process. Thus, Type I annular contamination is not in direct contact with fast flow pathways in Configuration E. Although contamination could be transported from the outer sand pads towards the inner sand pad where the fast flow pathway exists in Type II tanks, it is not clear that this mechanism adequately evaluates the potential risk of the release of contamination from tank annuli through construction joints that have already shown to transmit significant quantities of waste as well as allow in-leakage of groundwater back into the tanks due to water table rise (DP-1358) and meteoric groundwater infiltration following precipitation events. Clarify whether fast flow paths through the annular contamination in Type I tanks are modeled.	DOE confirmed that NRC's understanding of its modeling of fast flow paths through the annuli is correct. DOE stated that it doesn't think lateral flow through submerged tanks from groundwater would increase peak doses, but that it hasn't modeled lateral fast flow. DOE indicated that it believed that in order to increase peak doses, downward flows would need to be maximized and that lateral flows would likely increase travel times and decrease peak doses. NRC noted that for submerged tanks, that travel times would not be increased with lateral flows.

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25	Location of Transfer Lines in Modeling	Clarify basis for location of transfer lines in modeling. Transfer lines are located within the immediate footprint of HTF (see figure below). However, in reality transfer lines could be located closer to the 100 m boundary.	DOE indicated that it doesn't believe that simulating transfer lines closer to compliance boundary would be significant. The doses at 1 m were insignificant. DOE indicated that the doses were maximized by putting the entire transfer line inventory within the 1 m boundary.
26	Waste Classification Calculations in GoldSim® Model	Provide GoldSim® files for the waste classification calculations.	DOE indicated that it performed separate simulations for waste classification, but didn't believe that the simulations were distinct from intruder dose calculations. DOE stated that it will send waste classification calculations simulation files to NRC staff.
27	Alternative Configuration Results from PORFLOW® Model	Provide results of alternative configurations using PORFLOW®.	DOE agreed to provide PORFLOW® transport modeling files of alternative configurations, if not already provided to NRC.
28	Biosphere Pathway Dose Conversion Factors	Provide PDCFs for HTF. Clarify what changes were made to the biosphere modeling since FTF.	DOE summarized changes to the biosphere modeling: (i) new pathways for chicken and egg ingestion; (ii) leachate factor based on water introduction from precipitation and irrigation; (iii) garden crop yield increased from 0.7 to 2.2; (iv) stochastic sampling of transfer factor for beef ingestion; (v) transfer coefficients aligned with IAEA report; (vi) updated 15 cm exposure depth external DCF for Ra 2-3 orders of magnitude; (vii) ignore holdup times; (viii) annual time spent swimming increased 75%; and (ix) time boating increased 5%.

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29	Portage PORFLOW® Modeling Files	Provide PORFLOW® modeling files constructed by Portage.	DOE agreed to provide modeling files performed by Portage.
30	Portage PORFLOW® Modeling Flow Vectors	Provide information on flow vectors (magnitude) for submerged tanks initially, for fully degraded conditions, and capped conditions based on the Portage modeling results.	DOE indicated that they were not able to use Tecplot tools to to extract data from irregular grid in Portage modeling and that it had to rely instead on PORFLOW®'s graphical user interface. NRC staff will use the PORFLOW® graphical user interface to gain the information when it gains the Portage modeling.
31	Comparison of Near-Field Fluxes from PORFLOW® and Portage Modeling	Compare flux through the near-field model domain versus flux that would occur through the Portage model for submerged tanks under various conditions (initial, degraded, capped). Note that DOE provides a rationale for why horizontal flow doesn't need to be considered, but a direct comparison of the magnitude of flow rates through the tank for submerged tanks in the Portage modeling was not provided.	NRC staff indicated that it will look at this more when we get the files.

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NOTES: BFS: Blast Furnace Slag
CSH: Calcium-Silica-Hydroxide
CSR: Chemical Sludge Removal
CZ: Contaminated Zone
DLL: Dynamically-Linked Library
DO: Dissolved Oxygen
DOE: U.S. Department of Energy
DPV: Displaced Pore Volume
ECC: Enhanced Chemical Cleaning
E_h: Reduction-Oxidation Potential
FTF: F-Area Tank Farm
GA: Gordon Aquifer
GSA: General Separations Area
GT: Georgia Institute of Technology
HRR: Highly Radioactive Radionuclide
HTF: H-Area Tank Farm
JAEA: Japanese Atomic Energy Agency
K_d: Sorption Coefficient
K_h: Saturated Hydraulic Conductivity
MCC: Moisture Characteristic Curve
MEP: Maximum Extent Practical
MSR: Mechanical Sludge Removal
NEA: Nuclear Energy Agency
NPP: Nuclear Power Plant
NRC: U.S. Nuclear Regulatory Commission
OA: Oxalic Acid
PA: Performance Assessment
PDCF: Pathway Dose Conversion Factor
RAI: Request for Additional Information
SLP: Bingham Slurry Pumps
SMP: Submersible Mixing Pumps
SME: Subject Matter Expert
TCCZ: Tan Clay Confining Zone
UCL: Upper Confidence Limit
UTR(A): Upper Three Runs Aquifer (-LZ: Lower Zone; -UZ: Upper Zone)