Second Set of Request for Additional Information Questions
For the U.S. Nuclear Regulatory Commission
Technical Review Reports Regarding the 2020 Savannah River Site
Saltstone Disposal Facility Performance Assessment

INTRODUCTION:

The U.S. Nuclear Regulatory Commission (NRC) staff identified the following Request for Additional Information (RAI) Questions while drafting Technical Review Reports (TRRs) regarding the U.S. Department of Energy (DOE) 2020 Savannah River Site (SRS) Saltstone Disposal Facility (SDF) Performance Assessment (PA) (NRC's Agencywide Documents Access and Management System [ADAMS] under Package Accession No. Main Library (ML) ML20190A055).

The staff has organized the review into 13 technical topics: (1) Performance Assessment Methods; (2) Saltstone Performance; (3) Infiltration and Erosion Control; (4) Disposal Structure Performance; (5) Far-Field Flow and Transport; (6) Inadvertent Human Intruder; (7) Biosphere; (8) Inventory; (9) Site Stability; (10) Selection of Features, Events, and Processes; (11) Conceptual Models and Future Scenario Uncertainty; (12) Near-Field Flow; and (13) Radionuclide Release. Not all technical topics will be in each set of RAI Questions.

Each NRC RAI Question will be identified by its technical topic and the number of the RAI Question in that technical topic. Each RAI Question contains the requested information, a Basis, and a Path Forward. The Path Forward represents one possible approach to a resolution of the RAI Question. The NRC staff understands that there may be more than one approach to adequately address the technical issue raised in each RAI Question. The adequacy of the DOE responses to some RAI Questions may depend on the nature of the resolution of other RAI Questions.

This second set of NRC RAI Questions for the TRRs is related to the following four technical topics: Infiltration and Erosion Control, Model Integration, Radionuclide Release, and Far-Field Flow and Transport. In addition, the NRC staff has some Clarifying Comments (CCs) about the 2020 SDF PA. The NRC staff plans to include additional questions related to the technical topic of Infiltration and Erosion Control in the future third and final set of RAI Questions.

RAI Questions for the Technical Topic of Infiltration and Erosion Control (IEC):

IEC-1

The NRC staff needs additional information on the depth (or head) of water that is anticipated to exist on the upper geomembrane liner.

Basis

Equation 4.4-3 in the DOE 2020 SDF PA is used in conjunction with Equation 4.4-4 to calculate leakage through the composite liner system. The 2020 SDF PA did not describe what the depth (or head) of water is anticipated to be present on the geomembrane. Note that the 2009 SDF PA indicated that as much as 1 meter (m) (~40 inches (in.)) of water could build up on the geomembrane. The NRC staff understands that a different approach was used in the 2020 SDF PA to calculate leakage through the composite liner, which results in much less projected leakage through the composite barrier. In that approach, infiltrated water is projected to be

retained on the geomembrane and ultimately drained to the side slopes via the lateral drainage layer. The NRC staff notes that the build up of head on the geomembrane could reduce slope stability within the closure cap. Changes from the 2009 SDF PA to the 2020 SDF PA (i.e., less projected infiltration in the 2020 SDF PA) could result in more head build up on the geomembrane than what was estimated in the 2009 SDF PA and the change in slope from 1 percent (%) to 3% would increase the potential for localized slope instability.

Path Forward
Provide the values for the maximum head build up on the geomembrane liner. The NRC staff recognizes that the detailed stability calculation for the closure cap has not been performed yet. However, the NRC staff is requesting this information to assess whether there is reasonable assurance that the proposed cover design can be constructed with adequate slope stability. When the slope stability calculation is performed, the maximum head on the geomembrane should be considered in the analysis.

IEC-2
The NRC staff needs additional information about the quantity and flow velocities of water leaving the upper lateral sand drainage layer.

Basis
Table 4.4-3 in the DOE 2020 SDF PA identified two percolation estimates for water that makes its way to the upper lateral sand drainage layer: (1) 400 millimeters/year (mm/yr) (15.75 inches/year (in./yr)) for current climate conditions and (2) 650 mm/yr (25.59 in./yr) for wetter climate conditions. The NRC staff requests additional information about how those two percolation estimates translate to flow quantities and flow velocities in the upper lateral sand drainage layer. The NRC staff notes that large quantities of water could be conveyed through the upper lateral sand drainage layer to the side slope of the closure cap that may result in a concentrated flow on the side slope of the closure cap, which may result in greater-than-anticipated erosion. In addition, significant flow through the upper lateral sand drainage layer could impact the performance of the drainage layer. If the flows through the sand drainage layer are significant enough to entrain, mobilize, and potentially remove sand particles over time, then the long-term performance of the sand drainage layer could be compromised (e.g., settlement of overlying sediment into voids in the sand drainage layer could result in a decrease in hydraulic conductivity). Therefore, the NRC staff requests information about: (1) the total volumetric flow rate at the cover side slope and (2) the velocity of water as it leaves the upper lateral sand drainage layer. The NRC staff recognizes that the side slope erosion protection is a future design consideration; however, the NRC staff is requesting this information to assess whether there is reasonable assurance a safe design can be constructed to accommodate the expected flow rates.

Path Forward
Provide the estimated total volumetric flow leaving the upper lateral sand drainage layer at the side slopes (i.e., on a per unit width basis or as a total flow). In addition, please provide additional information regarding the potential impact of the assumed flows and flow rates on the sand drainage layer.

IEC-3
The NRC staff needs additional information about the infiltration estimates entering the upper lateral sand drainage layer and how changes in the backfill thickness and lack of vegetation may impact the infiltration calculation.

Basis

The DOE 2020 SDF PA described that the DOE anticipated that the thickness of the upper backfill layer will decrease over time as the result of erosion. Table 4.4-8 and Figure 4.4-12 in the 2020 SDF PA showed that the upper backfill layer was expected to decrease in thickness from 76 centimeters (cm) (30 in.) to as little as 29.7 cm (11.7 in.), depending on the type of vegetation present. The 2020 SDF PA included a sensitivity analysis that showed that a change in thickness of the middle backfill layer had little impact on the infiltration. However, the 2020 SDF PA did not include a sensitivity analysis for the depth of the upper backfill layer. A change in thickness of the upper backfill layer could affect the evapotranspiration capabilities of the upper layers of the closure cap. Additionally, the NRC staff determined that, while the 2020 SDF PA did consider the presence of different types of vegetation on the final cover, it did not evaluate a scenario in which no vegetation was present for an extended time (e.g., the effect of a forest fire or drought on infiltration).

Path Forward

Provide an evaluation of the infiltration to the upper lateral sand drainage layer based on the minimum anticipated thickness of the upper backfill layer. Alternatively, provide additional justification or comparisons showing that the assumptions about infiltration through the middle backfill layer can also be applied to the upper backfill layer. To address the vegetation aspect, the DOE could provide an infiltration calculation assuming no vegetation is present.

IEC-4

The NRC staff needs additional information about the materials being considered to fill in the voids of the erosion barrier and about potential performance issues related to the erosion barrier depending on the selected material.

Basis

In the DOE 2020 SDF PA, the DOE did not describe what material will be used to fill the voids in the erosion barrier. Instead, in Section 3.2.6.8, the DOE listed that as an open issue related to the SDF closure cap concept, which is to be addressed as the design concept matures in the future. The erosion barrier is a risk-significant feature of the closure cap, which is intended to: (1) prevent erosion of the middle backfill and deeper layers of the cover; (2) prevent animal intrusion into the lower layers; and (3) limit the rate of water flow into the middle backfill. The risk-significance of that barrier is such that the preliminary technical bases need to support the assumed performance.

In Appendix F in the DOE document WSRC-STI-2008-00244, Rev. 0 (ADAMS Accession No. ML20206L305), the DOE described the hydraulic properties for two different types of material being considered to fill the voids between the stones: (1) sandy soil and (2) controlled low strength material (CLSM). For sandy soil, the NRC staff has issues about the impact of root growth. For example, due to the depth that tap roots of the loblolly pine are able to grow, those roots could grow through sandy or backfill-type soil if used in an erosion barrier and potentially impact the placement of the stones as these roots grow. Eventually, sufficient generations of tree roots may disrupt the erosion barrier and severely degrade performance.

Compared to an erosion barrier filled with sandy soil, an erosion barrier filled with CLSM would increase the chance of lateral flow occurring on top of the erosion barrier due to the lower hydraulic conductivity of the CLSM; thereby, potentially decreasing the stability of the closure cap. One technical issue involves the volume of lateral flow that would exit at the upper reaches of the side slope above the erosion barrier, which could result in an increase in the current modeled flow rate on the side slope. Another technical issue is the stability of the edges of the

upper backfill layer as the backfill material may be carried out by the lateral flow into the side slopes. The NRC staff notes that Section IEC-7 in SRR-CWDA-2011-00044, Rev. 0 (ADAMS Accession No. ML111180141) described that slope stability should not be an issue even with a build up of head; however, that section provided no reference or calculations to support that conclusion.

Lastly, in Section IEC-7 of the DOE document SRR-CWDA-2011-00044, Rev. 0, the DOE also described that none of the nominal saturations listed pose a problem to plant health in terms of root drowning; however, that also had no references or supporting calculations. Therefore, the NRC staff requests additional information to determine whether higher saturation levels may adversely affect the vegetation assumed in the 2020 SDF PA.

The NRC staff recognizes that the side slope erosion protection is a future design consideration; however, the NRC staff needs to understand the anticipated flow to determine if there is reasonable assurance that a safe design can be constructed to accommodate the expected flow rates.

Path Forward
Provide information regarding what, if any, material is planned to be used to fill the voids in the erosion barrier. If the DOE intends to fill the voids with sandy soil, then provide the anticipated duration of an intact erosion barrier and the subsequent performance of a degraded erosion barrier. If the DOE intends to fill the voids with CLSM, then provide the estimated total volumetric flow leaving the upper backfill layer at the side slopes (i.e., on a per unit width basis or as a total flow). Alternatively, the DOE can provide calculations demonstrating that lateral flow on top of the erosion barrier is not a viable conceptual model. In addition, please provide additional information regarding the potential impact of the assumed flows on the erosion barrier (e.g., plant health in terms of higher moisture contents).

IEC-5
The NRC staff needs additional information about cases where the lateral sand drainage layers and the high density polyethylene (HDPE)/geosynthetic clay liner (GCL) composite barriers degrade during the period of performance to evaluate the risk-significance of those layers.

Basis
The first NRC Request for Supplemental Information (RSI) Comment (RSI-1) in the NRC Preliminary Review Letter (ADAMS Accession No. ML20254A003) requested the DOE to provide an analysis that demonstrates the effects of the combined uncertainties of the upper lateral sand drainage layers, lower lateral sand drainage layer, HDPE barriers, HDPE/GCL composite barriers, saltstone degradation, and moisture characteristic curves (MCCs) to evaluate the risk-significance of those flow barriers. One method suggested by the NRC staff was to include those features and variables in a probabilistic analysis of the SDF performance and use input range values consistent with the NRC RSI Comments about the sand drainage layers (RSI-2); HDPE, GCL, and HDPE/GCL composite barriers (RSI-3); saltstone degradation (RSI-4); and MCCs (RSI-5). The DOE provided a response to RSI-2 in the DOE document SRR-CWDA-2021-00031, Rev. 0 (ADAMS Accession No. ML21089A122) and a response to RSI-3 in the DOE document SRR-CWDA-2021-00033, Rev. 0 (ADAMS Accession No. ML21089A123).

The NRC staff expects radionuclide releases to be sensitive to flow because increased water flow accelerates saltstone degradation, which is expected to further increase flow, causing a feedback loop. That sensitivity to water flow makes it difficult to determine system performance

by considering sensitivity analyses that evaluate barriers to flow individually. Because of the significant uncertainties in the performance of both the closure cap and the engineered barriers above the disposal structures, it is important to consider the degraded performance in both layers to understand the uncertainty in the system performance. Including degraded performance of both barriers in a probabilistic analysis does not represent a “worst case” scenario because many of the same technologies are used in both the closure cap and the engineered barriers above each disposal structure (i.e., sand drainage layers, HDPE/GCL composites) and those technologies could suffer common-cause failures in each barrier. In addition, evaluating degraded performance of both barriers is a means of assessing, reducing or managing, and documenting the inherent uncertainty of the system.

The NRC staff notes that the probability distributions the DOE developed to model the lateral sand drainage layers (SRR-CWDA-2021-00031, Rev. 0) and HDPE/GCL composite barriers (SRR-CWDA-2021-00033, Rev. 0) appear unlikely to enable the NRC staff to gain significant risk insights because very few realizations reflect degraded conditions. As described in greater detail below, the DOE chose the most likely values of each distribution (i.e., the distribution modes) to be equal to the undegraded values. The NRC staff believes those distribution modes are not consistent with the discussions in the NRC staff RSI-2 and RSI-3. Furthermore, selecting the mode to reflect the undegraded conditions in a log-triangular distribution resulted in very few realizations that reflected significantly degraded performance. The NRC staff notes that when combined in a probabilistic assessment where each distribution is sampled independently, very few or no distributions will result that reflect degraded performance in multiple flow barriers, which would not provide the information that the NRC staff requested in RSI-1.

Sand Drainage Layers
The DOE document SRR-CWDA-2021-00031, Rev. 0 included recommended ranges of parameter values for initial and degraded conditions associated with the lateral sand drainage layers. The purpose of SRR-CWDA-2021-00031, Rev. 0 was to partially address RSI-2. In addition, the NRC staff expects that the DOE plans to use the distributions in a probabilistic model developed in response to RSI-1. The NRC staff notes that using the undegraded value of the saturated hydraulic conductivity (K_{sat}) of the sand drainage layers as the mode of the distribution did not reflect the technical issues described in RSI-2 or the technical issues summarized below.

The DOE described recommendations for simulating a degraded sand drainage layer with lower K_{sat} values in Section 4.3.3 in SRR-CWDA-2021-00031, Rev. 0, which included a probability distribution for the final degraded K_{sat} values for the closure cap sand drainage layers (Table 4.3-2). Section 4.3.3 indicated that it was possible that no change (i.e., no silting-in of the sand) will occur and that it was reasonable for the distribution for the final K_{sat} value to have a maximum value equal to the initial, undegraded value. In Section 4.3.1, the DOE identified specific analog sites, which served as a technical basis for the assumption that silting-in of the drainage layers will not occur. The DOE originally described results from those analog sites in the DOE document SRRA107772-000009, Rev. A (ADAMS Accession No. ML18170A244). In the “NRC Staff Preliminary Comments on DOE Document SRRA107772-000009 (Rev. A)” (ADAMS Accession No. ML19087A171), the NRC staff questioned several of the DOE conclusions, including the DOE conclusion about silting-in. The DOE has not yet resolved those NRC staff questions. Therefore, the NRC staff still believes there is considerable uncertainty in the DOE conclusions.

Section 4.3.2 in SRR-CWDA-2021-00031, Rev. 0 included updated information about fine particles accumulating in geotextiles and geonets and indicated that the pore water in cover systems had too little energy to induce migration of fines into a drainage layer. However, the NRC staff believes the projected amount of precipitation falling at the SDF site may create enough energy for the pore water in cover systems to induce migration of fines into a drainage layer. Therefore, based on the NRC staff issues in the 2018 TRR (ADAMS Accession No. ML18117A494) and the NRC staff issue that the precipitation at the SDF could create enough energy to induce migrations of fines, the NRC staff needs additional support for the DOE assumption that the undegraded K_{sat} value is a defensible mode of the distribution for the final K_{sat} value for the sand drainage layers.

In Figures 6.1-1 and 6.1-2 in SRR-CWDA-2021-0031, Rev. 0, the shape of the log-triangular distribution for the K_{sat} of the sand drainage layer with a mode equal to the initial value resulted in few realizations that reflect the degradation mechanisms that the NRC staff described in RSI-2. The NRC staff notes that a probabilistic analysis that uses that distribution will not provide the information the NRC staff needs to develop risk insights about system behavior with multiple degraded flow barriers, especially if the performance of those barriers also are modeled with probability distributions that assume the most likely outcome is no degradation during 10,000 years of performance.

HDPE/GCL Composite Barriers
The DOE document SRR-CWDA-2021-00033, Rev. 0 included recommended ranges of parameter values to represent initial, partially degraded, and fully degraded states of HDPE/GCL composite barriers. The purpose of that document was to partially address RSI-3. In addition, the NRC staff expects that the DOE will use the probability distributions developed in that document in a probabilistic model developed by the DOE in response to RSI-1. As described in more detail below, the NRC staff determined that some of the probability distributions developed in SRR-CWDA-2021-00033, Rev. 0 were weighted toward values that did not reflect the degradation mechanisms that the NRC described in RSI-3. Consequently, the NRC staff notes that very few realizations will provide the necessary information to demonstrate the effects of the combined uncertainties in the flow barriers, as described above.

Section 7.3 of SRR-CWDA-2021-00033, Rev. 0 provided recommended values for the initial K_{sat} value for the GCL based, in part, on work by Rowe (see References section below). Rowe recommended generic values for the initial GCL K_{sat} with a minimum of 7.0×10^{-10} centimeters/second (cm/s), a maximum of 2.0×10^{-6} cm/s, and a mode or “reasonable value” of 5.0×10^{-9} cm/s. SRR-CWDA-2021-00033, Rev. 0 indicated that, because the “reasonable value” from Rowe is more than five times higher than the highest K_{sat} value measured from an exhumed GCL at the Barnwell, South Carolina site with 14 years of performance, the minimum and reasonable values Rowe recommended for the initial GCL K_{sat} should be scaled down by a factor of five. SRR-CWDA-2021-00033, Rev. 0 indicated that the scaling factor would yield a minimum of 1.4×10^{-11} cm/s and a “reasonable value” of 1.0×10^{-9} cm/s. However, a scaling factor of five would result in a minimum value of 1.4×10^{-10} cm/s rather than a minimum value of 1.4×10^{-11} cm/s.

Using the same scaling factor of five that the DOE recommended for the initial minimum and mode values on the initial maximum value of 2.0×10^{-6} cm/s would result in a maximum initial K_{sat} value of 4.0×10^{-7} cm/s. However, the DOE chose a different method to derive the recommended maximum value for the initial K_{sat}. Instead of using 4.0×10^{-7} cm/s, the DOE used 4.0×10^{-9} cm/s, based on the range of the manufacturers’ specified maximum K_{sat} values

(i.e., 5.0×10^{-9} cm/s or 3.0×10^{-9} cm/s) per Rowe. It is unclear to the NRC staff why: (1) the maximum value of the initial K_{sat} was derived differently than minimum and reasonable values and (2) whether there was defined technical bases for the manufacturers bases.

Recommendations for simulating a degraded HDPE/GCL composite barrier with higher K_{sat} values were described in Section 8.2.2 of SRR-CWDA-2021-00033, Rev. 0. To simulate GCL degradation, the DOE applied a multiplier to the distribution of initial K_{sat} values. The DOE represented that multiplier as a log-triangular probability distribution (Table 8.2-1). As described in Section 8.2.2, the DOE chose a minimum value of 1 for the degradation multiplier because the DOE believed it was possible that no degradation of the GCL or its K_{sat} value will occur (i.e., a degradation multiplier of 1 sets the final value equal to the initial value, representing no degradation). The NRC staff determined that the degradation multiplier values other than that of the minimum should represent some degree of degradation because: (1) long-term studies of GCL performance are lacking, as described in Section 8.2, and (2) the final degraded state of GCL and its resulting K_{sat} values are associated with significant uncertainty. However, the DOE also chose a value of 1 for the most likely value (i.e. the mode) of the degradation multiplier (i.e., representing no degradation).

The NRC staff notes that using a mode of 1 in a log-triangular distribution representing the degradation multiplier significantly diminishes the number of realizations that reflect degradation of the HDPE/GCL composite barrier. One basis that the DOE provided for using a mode of 1 was the data from the above-mentioned GCL from the Barnwell, South Carolina site, which had a K_{sat} of less than 1.0×10^{-9} cm/s after 14 years of service. Although the Barnwell site has essentially the same climate as the Z-Area, the design of the Barnwell cover system differs from the current SDF closure cap design. In addition, the 1.0×10^{-9} cm/s K_{sat} value was based on only one data set from a GCL that is only 14 years old. It is not clear to the NRC staff that: (1) the single data set is an adequate technical basis for the mode or (2) that the degradation the Barnwell GCL underwent in 14 years of service is representative of the GCL degradation that would occur at the SDF in 1,000 years or 10,000 years of service.

Another basis that the DOE provided for choosing a distribution mode of 1 for the degradation multiplier was a study showing that the end state for the GCL K_{sat} can be approximated as a function of the ionic strength of the water in the GCLs, with lower ionic strength being associated with less degradation. Section 8.2.2 in SRR-SWDA-2021-00033, Rev. 0 indicated that the DOE expected that the chemical composition infiltrating the closure cap will be similar to the chemistry of local groundwater, which, in the case of the groundwater at SRS, has very low ionic strength. Although the NRC staff also assumes that the cover infiltrating water will be similar, there is uncertainty associated with that assumption, as there is with the DOE assumption that the very low ionic strength of the SRS groundwater will remain unchanged for hundreds to thousands of years.

Table 9.3-3 and Figure 9.3-1 in SRR-CWDA-2021-00033, Rev. 0 presented estimated closure cap GCL K_{sat} values for realizations with partial failure. The DOE used an approach by Sun, et al. (see References section below) to simulate the partial failure condition. That approach assumed that the area of existing defects would double on a regular basis, so that by the end of the service life, the initial defects will already have doubled in area relative to the initial conditions. The increase in defect area was intended to address the potential impacts of any new defects that may form over time. However, as shown in Figure 9.3-1, fewer than 5% of the realizations exceeded the 4.0×10^{-7} cm/s value that the DOE scaling factor of five adjustment would have yielded for the maximum initial K_{sat} value. Furthermore, no realizations exceeded 4.0×10^{-7} cm/s until approximately 4,000 years after closure. In addition, as shown in

Table 9.3-3, the median did not increase above 7.14×10^{-9} cm/s in 10,000 years and its increase over that timeframe was less than an order of magnitude. All values plateaued shortly before 5,000 years.

The NRC staff has similar issues about Table 9.3-5 and Figure 9.3-3 in SRR-CWDA-2021-00033, Rev. 0, which presented estimated closure cap GCL K_{sat} values for realizations with complete failure. For most realizations, the GCL was assumed to remain intact with initial conditions until the end of the service life, when the GCL is assumed to instantly fail completely. If the GCL were to then have vertical K_{sat} value similar to that of backfill, then the K_{sat} value would be 4.1×10^{-5} cm/s. However, the recommended maximum modeling GCL K_{sat} from Rowe that was scaled down by a factor of five (i.e., 4.0×10^{-7} cm/s) was only obtained for fewer than 5% of the realizations, so that the risk information obtained in any intended probability analysis would be much diminished. The median value never exceeded 1.0×10^{-8} cm/s, even after 10,000 years of degradation.

In RSI-2 and RIS-3, the NRC staff requested additional information to address specific issues regarding the sand drainage layers and HDPE/GCL composite barriers. The NRC staff will review that information when it is received. However, the NRC staff notes that the probability distributions proposed in the DOE documents SRR-CWDA-2021-00031, Rev. 0 and SRR-CWDA-2021-00033, Rev. 0 will not allow the NRC staff to gain meaningful risk insights about the system performance because they yield very few realizations that reflect non-negligible barrier degradation. That result appears to be due to the selection of distribution modes that reflect no degradation in combination with the log-triangular shapes of the distributions. The NRC staff notes that when the distributions for the barriers are sampled independently, few or no realizations of the whole SDF system model will reflect degraded performance of multiple barriers, as requested in RSI-1, and the NRC staff will be unable to gain the risk insights it needs to assess the projected SDF performance.

Path Forward
Provide probability distributions for the final K_{sat} of the sand drainage layers and HDPE/GCL composite barriers that provide enough realizations that reflect degraded states that, when those distributions are sampled independently in a probabilistic analysis, some realizations will demonstrate the effects of the combined uncertainty in multiple flow barriers, as described in RSI-1. The distributions should address the specific technical issues described in RSI-2 and RSI-3, as well as the additional issues discussed in this RAI Question.

RAI Questions for the Technical Topic of Model Integration (MI):

MI-1

The NRC staff needs additional information about benchmarking GoldSim projections of radionuclide release to the aquifer for cases the DOE developed in response to the NRC RSI Comments in the NRC Preliminary Review Letter (ADAMS Accession No. ML20254A003).

Basis
In the DOE 2020 SDF PA, the DOE benchmarked GoldSim model results to the more detailed model results from the Closure Cap Model, Vadose Zone Transport Model, and Aquifer Transport Model. To benchmark the GoldSim model of radionuclide release and near-field transport, the DOE compared the projected releases of iodine-129 (I-129), chlorine-36 (Cl-36), and cesium-135 (Cs-135) from each disposal structure type to the aquifer for cases in the

Central Scenario (i.e., the Realistic, Most Probable and Defensible (MPAD), Pessimistic cases). Table MI-1 (see below) shows the projected releases from Saltstone Disposal Structure (SDS) 7. The relationship between the GoldSim and PORFLOW projections of I-129 release to the aquifer differs between the three Central Scenario cases. In contrast, the peak releases of Cl-36 projected by GoldSim and PORFLOW are in good agreement for all three model cases. The variation in the release of Cs-135 is not known because benchmarking results for Cs-135 release to the aquifer were only included for the MPAD case.

The larger variation for I-129 among the Central Scenario cases as compared to the variation for Cl-36 likely occurs because the GoldSim and PORFLOW models implement different conceptual models for I-129 release; but, the same conceptual model for Cl-36 release. Specifically, PORFLOW implements a shrinking core model for I-129 release while GoldSim uses a pore-flush exchange model. Both PORFLOW and GoldSim use a pore-flush exchange model for Cl-36 release.

Table MI-1: Ratio of I-129 Peak Release from SDS 7 to the Aquifer Projected by the GoldSim and PORFLOW Models with Key Model Properties for the Central Scenario Cases (based on data from Tables 4.4-5, 4.4-43, 5.6-6, 5.6-8, and 5.6-9 in the 2020 SDF PA).

Case	Infiltration after 2,000 Years for Central Scenario Cases (mm/yr)	Time to Complete Saltstone Degradation for SDS 7 in Central Scenario Cases (years)	Ratio of GoldSim to PORFLOW Projected Peak Release Rate		
			I-129	Cl-36	Cs-135
Realistic	0.0083	2.6×10^{8}	2.39	1.02	(a)
MPAD	0.13	1.7×10^{7}	1.33	1.01	1.07
Pessimistic	0.69	2.6×10^{6}	1.16	0.98	(a)

(a) The DOE presented results for I-129 and Cl-36 in the Realistic and Pessimistic cases

It is unclear to the NRC staff whether the decreasing trend for I-129 would converge toward agreement between the two models in cases with greater infiltration and faster saltstone degradation or whether the peak releases projected by GoldSim would underestimate the I-129 release projected by PORFLOW at higher infiltration and degradation rates. Benchmarking in cases with greater infiltration and faster saltstone degradation could be relevant to the cases that the DOE is developing in response to the NRC RSI Comments.

Because of the risk-significance of I-129 in the 2020 SDF PA, the NRC staff needs information about benchmarking releases of I-129 during the Performance Period in cases with larger infiltration and degradation rates to interpret the GoldSim model results. In addition, the NRC staff needs benchmarking information for Cl-36 and Cs-135 for cases with increased infiltration and degradation rates to interpret GoldSim model results for other radionuclides with low and moderate sorption in the wasteform, respectively.

For the additional cases, the NRC staff needs time history information, such as the information in Figure 5.6-19 in the 2020 SDF PA because comparing only the projected peak release rates can underestimate the difference between the release rates projected by GoldSim and PROFLOW PORFLOW during the Performance Period. For example, Table 5.6-6 in the 2020 SDF PA showed a 33% greater peak projected by the GoldSim model than the PORFLOW model for the MPAD case (i.e., within 40,000 years of site closure); however, Figure 5.6-19 showed the difference at the end of the Performance Period was approximately a factor of two.

Path Forward
Provide benchmarking information for I-129, Cl-36, and Cs-135 releases to the aquifer projected by the GoldSim model for the cases being developed in response to the NRC RSI Comments. The DOE results should include comparisons at the time of peak release and within the Performance Period.

RAI Questions for the Technical Topic of Radionuclide Release (RR):

RR-1
The NRC staff needs additional information about the transition from Reducing Region III conditions to Oxidizing Region III conditions in the shrinking core model for I-129 release.

Basis
Table 5.8-14 in the DOE 2020 SDF PA stated that "… under Compliance Case conditions, all available I-129 is released from the saltstone before this chemical transition [from Reducing Region III to Oxidizing Region III conditions] occurs." The DOE limited that description to Compliance Case conditions. However, because increased water flow through a node in the shrinking core model for I-129 release would be expected to increase both the rate of oxidation and I-129 release, it appears that the description could be generalizable to any simulation with the same or lower modeled saltstone reducing capacity. The NRC staff may be able to use that information to assess the K_d value of 4 milliliters/gram (mL/g) that the DOE used to represent I-129 sorption in Oxidized Region III saltstone because of the NRC staff issues about the technical basis for that value (see RAI RR-2 below). In particular, the NRC staff needs to know whether that description applies to the cases developed for the DOE responses to the NRC RSI Comments.

Path Forward
Provide information about the conditions under which the description in Table 5.8-14 of the 2020 DOE SDF PA that the I-129 inventory in a node was depleted before the transition from Reducing Region III to Oxidizing Region III conditions occurs can be generalized to other cases that have greater projected flow through saltstone. The information should also indicate whether the description can be generalized to the cases being developed in response to the NRC RSI Comments.

RR-2
The NRC staff needs additional information about the technical basis for the K_d value the DOE used to represent iodine sorption in saltstone under Oxidizing Region III conditions.

Basis
Unlike the sorption coefficients for iodine in saltstone under chemically reducing conditions, which were based on experiments with simulated saltstone cores, the K_d value the DOE used to represent iodine sorption under oxidizing conditions was based on the results of several different experiments with ordinary concrete that the DOE referenced in the DOE document SRNL-STI-2009-00473, Rev. 1 (ADAMS Accession No. ML17047A417). In that document, the DOE indicated that iodine sorption to concrete tends to increase as the ratio of calcium (Ca) to silicon (Si) increases. That indicates that the sorption of iodine on saltstone could be less than its sorption on concrete because saltstone contains less ordinary Portland cement than concrete, giving it a lower initial Ca/Si ratio. Other variables, such as the absence of aggregates from saltstone, also could affect iodine sorption. Although some of the measured values the DOE cited in its basis for iodine sorption coefficients under oxidizing conditions were greater

than the 4 mL/g value the DOE used to represent iodine sorption in Oxidizing Region III saltstone, recommendations in two other DOE documents (ADAMS Accession Nos. ML20206L156 and ML21126A195) were lower (i.e., 0 mL/g or 1 mL/g for conservative estimates and 2 mL/g for best estimates).

Although the DOE does not expect the saltstone monolith to transition to oxidizing conditions during the Performance Period, the outer nodes of the shrinking core model the DOE used to represent I-129 release do transition to Oxidizing Region III conditions during the Performance Period. Therefore, the NRC staff needs additional information about the technical basis for the I-129 K_d under those chemical conditions to evaluate the projected releases of I-129 during the Performance Period.

Path Forward
Provide a technical basis for the applicability of the experiments cited in the DOE document SRNL-STI-2009-00473, Rev. 1 (ADAMS Accession No. ML17047A417) to the sorption of iodine in saltstone under Oxidizing Region III conditions.

RR-3
The NRC staff needs additional information to support the K_d values for strontium (Sr) and radium (Ra) in saltstone and reducing cementitious materials.

Basis
The DOE represented Sr sorption in reducing cementitious materials, reducing saltstone, and oxidizing saltstone with K_d values of 1,000 mL/g in “Region I” and “Region II” (i.e., young and middle age) material and 100 mL/g in “Region III” (i.e., old) material. The NRC staff previously reviewed the DOE document SRNL-STI-2010-00667, Rev. 0 (ADAMS Accession No. ML113320395) that described the experimental basis for the K_d values for Sr. In the 2013 NRC SRS SDF Monitoring Plan (ADAMS Accession No. ML13100A113), the technical note for Monitoring Factor 5.04 stated:

> *It is not clear to NRC staff that sufficient data have been obtained to support using those new derived Sr values in PAs. For example, the investigators who performed that research [in the DOE document SRNL-STI-2010-00667, Rev. 0] speculated that the dissolved Sr measurements may, in fact, be controlled by $SrSO_4$ solubility rather than sorption. There is a suggestion in the document that $SrSO_3$ could also be a controlling solid, perhaps under more reducing conditions. If the amount of desorption observed in a leaching experiment is controlled by solubility, then the experimental artifact will result in the calculated K_d value being artificially high. Thus, [the] DOE needs to provide more information on Sr leaching from saltstone to support the revised Sr K_d values.*

The DOE document SRNL-STI-2016-00106, Rev, 0 (ADAMS Accession No. ML16173A174) reported K_d values for Sr of 40 mL/g in an oxidized saltstone core and approximately 50 mL/g in a core under an inert atmosphere. In the DOE document SRNL-STI-2009-00473, Rev. 1 (ADAMS Accession No. ML17047A417), the DOE indicated that it did not know the reasons for the difference between the results from the two reports (i.e., SRNL-STI-2010-00667, Rev. 0 and SRNL-STI-2016-00106, Rev. 0). However, it appeared that the reason might be that the higher values reported in SRNL-STI-2010-00667, Rev. 0 represent precipitation rather than sorption. The DOE document SRNL-STI-2009-00473, Rev. 1 indicated that the higher values were used because the results were based on site-specific materials; however, the lower K_d values reported in SRNL-STI-2016-00106 also were based on experiments with cores from field-emplaced saltstone.

The DOE document SRNL-STI-2009-00473, Rev. 1 based the K_d values for Ra in saltstone and other cementitious materials on measured values for barium (Ba) and Sr. Therefore, the uncertainty in the K_d values for Sr affect the basis for the values for Ra. In addition, the DOE hypothesized that the high measured values for Ba reflected solubility rather than sorption. Because solubility reflects a limit on the concentration in the aqueous phase rather than a proportion between the concentrations in the aqueous and solid phases, an apparent K_d based on solubility is sensitive to the concentration in the solid phase. Therefore, it is unclear to the NRC staff whether the high values measured for Ba (i.e., greater than 7,400 mL/g under inert gas conditions) are applicable to Ra at the concentrations that the DOE expects Ra to have in saltstone and during transport through disposal structure concrete.

<u>Path Forward</u>
Provide a technical basis to support the K_d values assigned to Sr and Ra in cementitious materials, including saltstone. The bases for Sr should address the lower distribution coefficients reported in SRNL-STI-2016-00106, Rev. 0 and the potential that the results reported for Sr in SRNL-STI-2010-00667, Rev. 0 were affected by precipitation. The results for Ra should address: (1) the uncertainties for the values for Sr and (2) the applicability of K_d values based on solubility-limited Ba to Ra at the concentrations the DOE expects Ra to have in saltstone and during transport through disposal structure concrete.

<u>RR-4</u>
The NRC staff needs additional information regarding the DOE assumption that mechanical dispersivity can be set to zero in the Vadose Zone Transport Model.

<u>Basis</u>
Section 4.4.5.2.3 in the DOE 2020 SDF PA indicated that longitudinal and transverse mechanical dispersivity was assumed to be zero in the Vadose Zone Transport Model, including in saltstone, disposal structure concrete, and unsaturated soil. In the 2020 SDF PA and the supporting document for the Vadose Zone Transport Model (SRNL-STI-2009-00115, Rev. 0, ADAMS Accession No. ML21124A241), the DOE indicated that mechanical dispersion could be neglected because the different properties of the cementitious materials were modeled explicitly and the mechanical dispersion in the unsaturated soil is expected to be “low.” However, the Central Scenario cases in the 2020 SDF PA model saltstone as an intact monolith. Therefore, it is not clear to the NRC staff that mechanical dispersion between intact and degraded portions of saltstone and disposal structure concrete (e.g., along surfaces and fractures) was adequately represented by modeling the longitudinal and transverse dispersivity as zero.

Section 5.8.3.7 in the 2020 SDF PA provided the results of a sensitivity analysis where the DOE increased the longitudinal dispersivity to 1 m (3 feet (ft)) and the transverse dispersivity to 0.1 m (0.3 ft). Figure 5.8-32 showed that increasing mechanical dispersivity increased projected releases in the MPAD by approximately 30% and caused them to occur earlier. However, the DOE did not provide a basis for assuming the longitudinal and transverse mechanical dispersivity values could not be greater than the modeled values. Therefore, it is unclear to the NRC staff whether the results shown in Figure 5.8-32 bound the potential effects of neglecting mechanical dispersion on radionuclide release to the aquifer.

<u>Path Forward</u>
Provide an analysis that accounts for mechanical dispersion in the Vadose Zone Transport Model. Alternatively, provide additional technical bases to demonstrate that setting the dispersion coefficient to zero adequately represents the mechanical dispersion in the Vadose

Zone Transport model (e.g., the DOE could consider whether numerical dispersion adequately accounts for mechanical dispersion). In addition, provide a technical basis for assuming the values assigned in the sensitivity analysis in Section 5.8.3.7 in the 2020 SDF PA were representative or bounding. The DOE response should account for the flow conditions of any cases developed in response to the NRC RSI Comments.

RAI Questions for the Technical Topic of Far-Field Flow and Transport (FF):

FF-1

The NRC staff needs additional information from a local SDF flow and transport model.

Basis

There are potentially risk-significant issues associated with using the local PA model known as the Aquifer Transport Model (ATM). The ATM was generated with a mass-conserving linear interpolation scheme directly from the regional General Separations Area (GSA) velocity model; however, it cannot be considered a separate flow model with its own boundary conditions and material property assignments. The NRC staff expects a local SDF flow and transport model (e.g., a revised ATM based on a local SDF/GSA flow model) can address the NRC staff issues below that the local PA model extracted from the GSA model could not.

A. Elevation data from the latest cone penetration testing (CPT) characterization work in the Z-Area representing upper and lower boundaries of the tan clay confining zone (TCCZ) do not appear to be consistent with values assigned in the ATM. Although CPT allowed new hydrostratigraphic surfaces to be generated in the 2016 GSA model (ADAMS Accession No. ML18081A304) and used in the 2018 GSA model (ADAMS Accession No. ML19053A383), elevation discrepancies still exist for the upper surface of the TCCZ between Figure 4-22 in the DOE document SRR-CWDA-2018-00036, Rev. 0 (ADAMS Accession No. ML20206L238) and Figure 19 in the DOE document SRNS-RP-2015-00902, Rev. 0 (ADAMS Accession No. ML16057A135), which depicted the results of 2015 CPT characterization work in the Z-Area.

   The CPT field study results were also visually represented in the DOE document SRR-CWDA-2018-00036, Rev. 0 (see Figure 4-14). Comparing the top of the TCCZ contours in the southern half of the Z-Area between Figure 4-14 and Figure 4-22 in SRR-CWDA-2018-00036, Rev. 0 showed differences between the two contour maps. For example, between the southern edge of SDS 4 and the eastern boundary of the Z-Area in Figure 4-22 showed a high point over 70.7 m (232 feet (ft)) high. However, Figure 4-14 did not show such a peak and instead showed a relatively flat 69.5 m (228 ft) high. Such differences in elevations may cause calibration difficulties (e.g., difference between simulated and measured Upper Three Runs Aquifer-Upper Aquifer Zone (UTRA-UAZ) water table elevations) as shown in Figure 1 in SRNL-L3200-2017-00107, Rev. 0 (ADAMS Accession No. ML20206L132). While the measured water table contours were relatively smooth and evenly spaced apart, the simulated elevation contour lines in the eastern corner of the Z-Area near SDS 4 frequently were not evenly spaced apart and less smooth.

   TCCZ elevation differences may have consequences for the velocity and direction of the groundwater flowpaths. However, based on measured water elevations, the top of the TCCZ is such that sufficient water is available for contaminants to travel in the UTRA-UAZ. In contrast, for the area around SDS 4, TCCZ elevations in the 2018 GSA

model, and therefore the ATM, did not allow sufficient water for contaminant transport above the TCCZ and caused the particles to move into the UTRA-Lower Aquifer Zone (LAZ). Potential contaminants would follow different paths from the source to the McQueens Branch and the travel times may consequently differ. The NRC staff needs to know the effect differences in upper and lower TCCZ boundary elevations have on the SDF dose results.

B. In the 2012 NRC SDF Technical Evaluation Report (ADAMS Accession No. ML121170309), the NRC staff noted the limited calibration data in the area of interest (i.e., Z-Area) and that calibration statistics for all of the GSA did not provide helpful information on the goodness-of-fit of the model to long-term conditions that are local to SDF. In SRNL-L3200-2017-00107, Rev. 0 (ADAMS Accession No. ML20206L132), the DOE described that the uncertainty could be reduced through model refinement based on local-scale, site-specific data to define the hydraulic gradients and properties in shallow hydrostratigraphic units. New wells have been drilled in and around the Z-Area since the development of the 2016 GSA model and it is unclear to the NRC staff how data from those wells would impact flow model calibration.

As described above, comparisons of simulated and measured water table levels in the UTRA-UAZ showed that additional calibration may be needed in the southeastern corner of the Z-Area (see Figure 1 in SRNL-L3200-2017-00107, Rev. 0). In addition, comparisons of measured and simulated water heads in the UTRA-LAZ showed that additional calibration was needed in the entire model domain (see Figure 2 in SRNL-L3200-2017-00107, Rev. 0). Figure 2 of SRNL-L3200-2017-00107, Rev. 0 showed a roughly 3 m (10 ft) discrepancy in elevation between the simulated and measured UTRA-LAZ contour lines. For the Z-Area, that could make a difference on where and how quickly potential contaminants would move through the TCCZ and therefore could affect the timing and location of contaminants reaching hypothetical receptors. The same simulated UTRA-LAZ heads also do not match the more recent measured UTRA-LAZ water heads in Figure 3 and Figure 5 in the 2020 Z-Area Groundwater Report (SRNS-TR-2020-00414, Rev. 0, ADAMS Accession No. ML21019A303). The NRC staff needs to know the effect mismatches between simulated and measured water elevations in the UTRA-UAZ and UTRA-LAZ have on the SDF dose results.

C. Measurements of contaminant concentrations from the SDS 4 plume are inconsistent with model results. The DOE document SRNL-L3200-2017-00107, Rev. 0 (ADAMS Accession No. ML20206L132) provided the steps taken to validate the 2016 GSA flow model using UTRA-UAZ and UTRA-LAZ water head data and concentration measurements associated with contaminants from SDS 4. The NRC staff has encouraged the DOE to use the information of the plume's characteristics to help increase confidence in the SDF PA results. However, plume data are inconsistent with model results. For example, the DOE document SRR-CWDA-2018-00036, Rev. 0 (ADAMS Accession No. ML20206L238) described that there was approximately 3.0 m (10 ft) of water at well ZBG-2 above the TCCZ and samples were obtained from well ZBG-002D, which was screened in the UTRA-UAZ. In contrast, Figure 7 in SRNL-L3200-2017-00107, Rev. 0 showed that the 2016 GSA flow model was calibrated such that little if any water existed above the TCCZ. That model calibration resulted in the projection of a relatively quick downward flow through the TCCZ followed by lateral flow and transport in the UTRA-LAZ. However, that projection contradicted the plume data in the annual DOE Z-Area SDF groundwater reports (e.g., SRNS-TR-2020-00414, Rev. 0,

ADAMS Accession No. ML21019A303), which showed that the UTRA-UAZ contained contaminants years before the UTRA-LAZ did and had significantly higher contaminant concentrations. In the 2018 NRC TRR (ADAMS Accession No. ML18117A494), the NRC staff stated that, "Even if the plume travels the less than 20 ft. [6 m] vertical thickness of the TCCZ into the UTRA-LAZ and the concentration values increase in the next few years, the majority of the contaminants appear to have traveled much further in a lateral direction."

That difference between observed and modeled water flows in the UTRA-UAZ could result in two different receptor scenarios, depending on the conceptual model being used. The plume data indicates that initial contaminants could remain longer and more concentrated in the UTRA-UAZ than in the UTRA-LAZ and that the DOE needs to consider the possibility that a hypothetical receptor could obtain water from the more accessible UTRA-UAZ. The DOE 2020 SDF PA included a receptor obtaining water from the UTRA-LAZ; however, without a refined model of water flow above the TCCZ, that projected dose could be underestimated. SRNL-L3200-2017-00107, Rev. 0 stated that, "Refinements to the TCCZ elevation and thickness may produce better agreement with field observations, which suggest greater plume presence above the TCCZ." Therefore, the NRC staff needs additional information about flow in the UTRA-UAZ that is consistent with observations from the contaminant plume from SDS 4.

D. The ATM may not adequately account for the influence of the closure cap on the dose (i.e., the assumed uniform recharge as applied to the entire GSA model domain remains in place for the ATM and the Compliance Case did not include reduced infiltration or groundwater recharge due to the presence of the closure cap).

   The DOE 2020 SDF PA documented two sensitivity cases that addressed recharge, including a case that applied a recharge rate of 0.13 mm/yr (0.0051 in./yr) to the area beneath the SDF closure caps to simulate the reduction in recharge that the closure cap could cause. However, those sensitivity cases did not revise the models to account for potential changes to the elevation in the water table or to the flow velocity as a response to the lower recharge rates. Sensitivity results using Compliance Case conditions showed that the reduced recharge rates resulted in a general increase to the projected doses, although it is not clear if these increases would persist if more realistic conditions were modeled. Due to the complicated hydrogeology of the Z-Area and the interconnectivity between many of the features and processes (e.g., the reduced recharge would need to travel through a thicker unsaturated zone), it is possible that dose results may differ from the sensitivity case results. Therefore, the NRC staff needs additional information about the effects of realistic recharge rates below the closure cap on the SDF dose results.

<u>Path Forward</u>
Provide additional information from a new local SDF flow and transport model (e.g., a model that the DOE has developed in response to the NRC RSI). That information should show the risk-significance to SDF dose projections of using: (1) different upper and lower TCCZ boundary elevations; (2) either water elevations closely matching measured UTRA-UAZ and UTRA-LAZ water elevations or the 2020 SDF PA simulated water elevations; (3) either calibrated water elevations using SDF 4 plume information or the 2020 SDF PA simulated water elevations; and (4) different groundwater recharge rates below the closure cap as well as considering possible changes to interconnected features and processes that such a reduction in rate may cause.

FF-2

The NRC staff needs additional information about how uncertainty associated with stream baseflow measurements, as used in both the 2016 GSA model (ADAMS Accession No. ML18081A304) and the 2018 GSA model (ADAMS Accession No. ML19053A383), may affect the 2020 SDF PA dose results.

Basis

Information about baseflow is important to understand whether the model is well calibrated, particularly in the complex groundwater flow system of the GSA, which includes both deeper and shallower aquifers. The NRC 2019 TRR, "General Separations Area 2016 and 2018 PORFLOW Models and Associated Documentation Supporting the F-Area and H-Area Tank Farm Facility Performance Assessments at the Savannah River Site" (ADAMS Accession No. ML19277H550) described that matching baseflow data with specific hydrogeologic layer model outflow was important to obtaining a unique or realistic calibrated solution. However, the stream baseflow data used for the 2016 GSA flow model validation analyses and 2018 GSA flow model validation analyses were not from the recent Base Period used to develop head calibration targets; but, rather used the data to validate the earlier 1999 GSA model. Section 3.3 and Section 3.4 of the DOE document SRNL-STI-2016-00261, Rev. 0 (ADAMS Accession No. ML18107A108) included a plan to assemble and evaluate the completeness, representativeness, and accuracy of baseflow data used to validate both the previous GSA groundwater models and the more recent baseflow data collected. In addition, the plan included optimizing weighting factors for stream baseflow so that it could be used to calibrate, or at least to validate, the updated GSA flow model. However, that planned work to integrate more recent stream baseflow data into the calibration/validation process has not been performed and the DOE did not appear to quantitatively evaluate uncertainty in baseflow measurements for the 2020 PA. For example, although both the 2016 GSA flow model and the 2018 GSA flow model significantly underpredict baseflow to the Upper Three Runs (UTR) river, the DOE did not provide updates to the uncertainty in baseflow. In addition, it is not clear to the NRC staff whether the 50:50 assumption (i.e., that 50% of the baseflow is from the north of the UTR and 50% is from the south of the UTR) might bias baseflow estimates high or low.

Path Forward

Provide additional information about how uncertainty associated with stream baseflow measurements, as used in both the 2016 GSA model and the 2018 GSA model, may affect the 2020 SDF PA dose results.

FF-3

The NRC staff needs additional information about how uncertainty associated with uniform and constant groundwater recharge, as used in both the 2016 GSA model (ADAMS Accession No. ML18081A304) and the 2018 GSA model (ADAMS Accession No. ML19053A383), may affect the 2020 SDF PA dose results.

Basis

As indicated in the DOE document SRNL-STI-2017-00008, Rev. 1 (ADAMS Accession No. ML18081A304), the range of uncertainty in recharge in the 2016 GSA flow model produced a similar level of uncertainty in groundwater flowrates in the shallower aquifers of the model domain, although improved knowledge of the GSA recharge distribution and associated stream baseflows, such as the UTR and Crouch Branch could reduce that uncertainty. Uniform recharge was assumed over the entire GSA model domain (39 kilometers^2 (km^2)

(15 miles^2 (mi^2)), to allow calibration of the groundwater levels. However, local recharge rates that actually vary depending on elevation, topography, and vegetation cover cannot be excluded and the uniform recharge value needs to be viewed as an uncertain with a likely cause of conceptual model uncertainty. The DOE justified the uniform recharge assumption by indicating that recharge and hydraulic conductivity cannot both be independently estimated unless stream baseflow measurements were included in the set of calibration targets along with well water level elevations; however, the variability shown within the final calibrated set of four 2016 GSA groundwater models pointed to a degree of conceptual model uncertainty inherent in the 2016 GSA model.

The ATM was developed using the fully three-dimensional GSA model (i.e., the SDF flow velocity field used in the ATM was generated directly from the GSA model and its uniform recharge rate). The DOE 2020 SDF PA included both sensitivity cases involving infiltration rates and groundwater fast flowpath sensitivity cases that modified the GSA inputs to the abstractions of the ATM. No sensitivity analyses involved lower and higher GSA uniform recharge with the resulting change in the risk-significant flow velocity field in the ATM. Uncertainty and sensitivity analyses related to the impact of a homogeneous and constant GSA recharge rate on the 2020 SDF PA results could quantify that conceptual model uncertainty.

Path Forward
Provide additional information about how uncertainty associated with uniform and constant groundwater recharge in the GSA model may affect the 2020 SDF PA dose results. For example, by providing the results of sensitivity cases which vary the flow velocity field into the local SDF model domain.

FF-4
The NRC staff needs additional information about the DOE groundwater monitoring program for the SRS Z-Area, including the technical basis for the current number and location of observation wells.

Basis
The NRC staff uses Z-Area groundwater monitoring data to verify and validate the far-field transport model that the DOE used to support the 2020 SDF PA. The NRC staff also uses Z-Area groundwater monitoring data to perform its monitoring role under Section 3116 of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 (NDAA). In that NDAA monitoring role, the NRC staff assessed the DOE groundwater monitoring program for the Z-Area in the 2018 TRR (ADAMS Accession No. ML18117A494). The NRC staff issues identified in that TRR, coupled with some new issues, are identified below:

A. Figure 4 and Figure 5 in the DOE document SRNL-L3200-2017-00107, Rev. 0 (ADAMS Accession No. ML20206L132) showed the outline of the SDS 4 plume from an aerial and a cross-sectional perspective, respectively. Figure 5-4 in the DOE document SRR-CWDA-2018-00036, Rev. 0 (ADAMS Accession No. ML20206L238) also showed a cross-sectional outline of the SDS 4 plume. Each of those outlines indicated that the boundary of the plume terminates not far downgradient of the well ZBG-020D, although the DOE document SRNS-RP-2015-00902, Rev. 0 (ADAMS Accession No. ML16057A135) presented figures showing the plume had traveled considerably further. Therefore, the NRC staff needs a technical basis for locating the plume outlines immediately downgradient of well ZBG-020D, as shown in the other figures in the other two DOE documents.

B. In the 2018 NRC TRR (ADAMS Accession No. ML18117A494), the NRC staff concluded that the locations and the number of groundwater monitoring wells to adequately follow the development of the plume within the Z-Area was not sufficient, specifically that TRR stated:

… the NRC staff determined that the number of groundwater monitoring wells do not allow adequate monitoring of the current plume caused by the unintentional release of contaminants from SDS 4. The number and location of groundwater monitoring wells are not sufficient to (1) delineate the lateral and vertical boundaries of the current plume; (2) to identify the current location of the peak of the plume; and (3) to predict the future development of the plume. In addition, the NRC staff is interested in information identifying the source of the current groundwater plume and where the peak of the plume is currently and in what direction it is heading. Information on the latter would provide insights on how groundwater flows and radionuclides behave in the [Z-Area] and also allow a better evaluation of the potential safety concerns emanating from the plume.

Differences between the two DOE documents (Figure 4-1 in SRR-CWDA-2018-00036, Rev. 0 and Figure 8 in SRNL-L3200-2017-00107, Rev. 0) indicated that the direction and source of the plume are still uncertain. The DOE conclusion in SRR-CWDA-2018-00036, Rev. 0 included that, "… groundwater flow below the southernmost six cells of SDS 4 (including Cell K) would likely pass to the south of replacement well ZBG-002D and ZBG-020D and might not be detected." However, if the figure on Slide 22 in the DOE document SRR-CWDA-2014-00054, Rev. 1 (ADAMS Accession No. ML14155A014) and Figure 8 in SRNL-L3200-2027-00107, Rev. 0 are both correct, then the current groundwater monitoring system would not be able to sample contaminants from the multiple SDS 4 Cell G releases. Therefore, the NRC staff needs the technical rationale for how the groundwater monitoring system in the Z-Area is able to determine the location, direction, and velocity of the SDS 4 plume.

C. In the NRC 2018 TRR, the NRC staff determined that the number of groundwater monitoring wells in the UTRA-UAZ was not adequate. Although contaminants from saltstone would first appear in the UTRA-UAZ, groundwater monitoring wells located near SDS 2 A/2B through SDS 6 are exclusively located in the UTRA-LAZ. Despite the partial or full-time unsaturated condition of the UTRA-UAZ near SDS 4, the contaminants from the previous unintentional release contaminated the UTRA-UAZ and appeared downgradient in well ZBG-2 samples years before they appeared in samples from the UTRA-LAZ almost directly below SDS 4. In addition, the DOE document SRR-CWDA-2018-00036, Rev. 0 stated that, "… but as shown at [SDS 4] in Figure 4-6, the placement of screened zones below the TCCZ for compliance monitoring may not be sufficient." That conceptual model of flow may also be true for other parts of Z-Area, which means that a pulse of infiltrating water may bring contaminants down through the UTRA-UAZ, flow on top of the TCCZ, and remain undetected for years if no wells are present in the UTRA-UAZ. The data that DOE has collected indicated that the UTRA-UAZ is saturated for most of the time at many locations. SRR-CWDA-2018-00036, Rev. 0 also described the water table as being consistently above the TCCZ near SDS 3 A/3B and SDS 5 A/5B and there was intermittent water above the TCCZ in the vicinity of SDS 2 A/2B. Due to the findings in the DOE document SRNS-RP-2015-00902, Rev. 0 and given the hydrogeological influence of the TCCZ, the NRC staff determined that groundwater monitoring wells near disposal structures should be located in both the UTRA-UAZ and the UTRA-LAZ. However, the DOE has installed new monitoring wells exclusively in the UTRA-LAZ, such as the most recently installed

wells ZBG-017D, ZBG-018D, and ZBG-019D. Therefore, the NRC staff needs a technical basis for how the DOE monitoring system detects contaminants in the UTRA-UAZ.

Path Forward
Provide the technical basis for the location of the SDS 4 plume outlines, including the extent of the plume immediately downgradient of well ZBG-020D. Provide the technical basis for how the groundwater monitoring system in the Z-Area determines the location, direction, and velocity of the SDS 4 plume. Provide the technical basis for how the Z-Area groundwater monitoring system would adequately detect contaminants in the UTRA-UAZ due to possible future leaks in the disposal structures; alternatively, provide the technical basis for why detection of contaminants in the UTR-UAZ and monitoring of the location, direction, and velocity of the SDS 4 plume is unnecessary.

FF-5
The NRC staff needs additional information supporting the K_d values for iodine in site soil or a sensitivity analysis that shows the effect of reducing the modeled K_d values on the projected dose to a member of the public.

Basis
The K_d values used for iodine in site soils in the DOE 2020 SDF PA models are shown below in Table FF-1. The NRC staff previously reviewed those values because the DOE used the same values in the radionuclide transport models in the DOE Fiscal Year (FY) 2014 SDF Special Analysis Document (SRR-CWDA-2014-00006, Rev. 2, ADAMS Accession No. ML15097A366).

Table FF-1: K_d Values for Iodine used in Radionuclide Transport Models Supporting both the DOE 2020 SDF PA and the DOE FY 2014 Special Analysis Document

	Not Leachate Impacted (mL/g)	Leachate Impacted (mL/g)
Sandy Soils (Vadose and Saturated Zones)	1	0.1
Clayey Soils (Unsaturated Backfills)	3	0.3

The DOE main reasons for increasing the iodine K_d values from values below 1 mL/g to the values in Table FF-1 were: (1) the DOE expected more strongly sorbing iodine species (i.e., iodate and organo-iodine) to be present in subsurface soils and (2) the DOE observed slower desorption than sorption for iodine species on SRS sediment samples in laboratory tests. In both the 2015 NRC TRR, "Tank 16H Special Analysis for the Performance Assessment for the H-Tank Farm at the Savannah River Site" (ADAMS Accession No. ML15301A710) and the 2017 NRC TRR, "Sorption of Iodine at the Saltstone Disposal Facility at the Savannah River Site" (ADAMS Accession No. ML16342C575), the NRC staff described technical issues about the DOE increase in iodine K_d values.

The 2017 NRC TRR on iodine sorption coefficients included applicable NRC staff issues from the 2015 NRC TRR in addition to NRC staff issues specific to the SDF. The NRC staff concluded in the 2017 NRC TRR that the subsurface K_d values for iodine shown in Table FF-1 were not adequately supported. A revised version of the technical document that the DOE cited to support the K_d values in Table FF-1 in the DOE document SRNL-STI-2009-00473, Rev. 1 (ADAMS Accession No. ML17047A417) did not provide additional information to address those NRC staff issues. The NRC staff issues are the following:

A. The study that the DOE cited to demonstrate significant contributions of iodate and organo-iodine species in subsurface soils at SRS (DOE document SRNL-STI-2012-000518, Rev. 0, ADAMS Accession No. ML16106A229) was based on soils near the F-Area seepage basin. The NRC staff needs additional information to support the DOE conclusion that the same chemical speciation of iodine would occur in subsurface soils near the SDF. In addition, the NRC staff needs additional information to show that the clay content of the soils near the F-Area seepage basin, which the DOE showed was important to sorption, is similar to the clay content of the soils near the SDF.

B. As described in the 2015 NRC TRR, SRNL-STI-2012-00518, Rev. 0 showed the K_d values for iodate decreased significantly during the experiment, which may have occurred as iodate gradually changed to iodide. The NRC staff needs additional information to determine whether iodate and organo-iodine species would be chemically stable in subsurface soils in the SDF.

C. The NRC staff needs additional information to determine how the chemical form of iodine released from saltstone and the disposal structures will affect its speciation in site soil. For example, in SRNL-STI-2012-00518, Rev. 0 the DOE described that once iodide was added to the organic-poor "North Borrow" subsurface sediment at SRS, negligible amounts of iodate were formed.

D. The NRC staff needs additional information to determine whether a composite K_d value will either realistically or conservatively represent iodine transport in subsurface soils. In the 2015 NRC SRS Tank Farms Monitoring Plan (ADAMS Accession No. ML15238A761), the NRC staff described the NRC staff issues associated with the DOE averaging K_d values in the context of plutonium transport in subsurface soils.

E. In SRNL-STI-2012-00518, Rev.0, the DOE described that the observation of slower desorption than sorption in laboratory tests could be attributable to an experimental artifact. In that experiment, iodine was added to sediment samples in the form of iodide or iodate and allowed to adsorb before the solid and liquid phases were separated and the iodine was desorbed in a fresh solution. The DOE measured a small amount of iodate and organo-iodide in the liquid phase in the tests in which iodine was added as iodide. The NRC staff notes that the iodine that adsorbed and was then desorbed disproportionally represented more strongly sorbing species. The NRC staff needs additional information to support the DOE conclusion that the desorption K_d values represent the speciation of iodine that would occur in SDF subsurface soils.

<u>Path Forward</u>
Provide the technical bases to address the NRC staff issues or provide a sensitivity analysis to demonstrate the effect of assuming lower K_d values for iodine in the subsurface on the projected dose to a member of the public.

<u>FF-6</u>
The NRC staff needs additional information about the basis for the leachate impact factors the DOE used in the DOE 2020 SDF radionuclide transport models. In addition, the NRC staff needs information about the effect of uncertainty in the sediment leachate impact factors for iodine and Tc on the projected dose to a member of the public.

Basis

The DOE document SRR-CWDA-2016-00004, Rev. 1 (ADAMS Accession No. ML16105A043) indicated that the leachate impact factors that the DOE used in the FY 2014 Special Analysis model, which are the same as the leachate impact factors that the DOE used in the 2020 SDF PA, were developed based on measured differences between cementitious leachate impacted and non-impacted K_d values for the Hanford PAs (ADAMS Accession No. ML16106A149). The NRC staff needs additional information to evaluate whether the sediments from the Hanford Site can be used as an analog for the SRS sediments, considering the differences in their origin, composition, particle size, and chemical environment.

The DOE document SRNL-STI-2009-00473, Rev. 1 (ADAMS Accession No. ML17047A417) provided two measurements made with sediment from Hanford as the basis for the leachate impact factor for iodine. Those two measurements showed a decrease of slightly more than a factor of 20, which would equate to a leachate impact factor of 0.05 in the iodine K_d, as the pH increased from 8.1 to 9.9. In contrast, the DOE used a leachate impact factor of 0.1 for the 2020 SDF PA models, which would lead to greater projected sorption and slower projected transport than a leachate impact factor of 0.05. For Tc, SRNL-STI-2009-00473, Rev. 1 included qualitative reasons that the DOE expected sorption to decrease significantly in a high-pH, high-ionic strength environment. However, that did not provide a basis for the factor of 0.1 that the DOE used in the 2020 SDF PA. Therefore, the NRC staff needs the basis for using 0.1 to bound the effects of the leachate impact factor for iodine and Tc.

The DOE document SRNL-STI-2009-00473, Rev. 1 included several complexities of real-world systems that were not captured by the leachate factor approach, including: (1) the presence of multiple types of cementitious materials; (2) changes in leachate chemistry with time; and (3) variability in leachate impact factors based on soil texture. That document also indicated that the DOE expected to improve upon the leachate impact approach as additional measurements were made.

Because of the limited data available to support leachate impact factors and conceptual model uncertainties in the factors that the DOE described in SRNL-STI-2009-00473, Rev. 1, the NRC staff needs additional information about the potential effect of uncertainty in the leachate impact factors on the projected dose to a member of the public.

Path Forward

Provide the technical bases for the leachate impact factors for iodine and Tc that address the NRC staff issues. Provide sensitivity or uncertainty analyses that demonstrate the effect of the uncertainty in the iodine and Tc leachate impact factors on the dose to a member of the public. The sensitivity or uncertainty analyses should include a technical basis for the range of values tested for each impact factor.

Clarifying Comments (CC) about the 2020 SDF PA from the NRC Staff:

CC-1

The NRC staff needs clarification of the legend of Figure 7.1-8 in the DOE 2020 SDF PA, which appears to indicate that releases from the Compliance Case are greater than releases from the Pessimistic Case. Please clarify whether the projections are labeled as intended.

CC-2
The NRC staff needs clarification of the intended application of the irrigation rate of 2.5 cm/week (1 in./week) as used in the DOE 2020 SDF PA. It is unclear to the NRC staff whether the DOE intended the rate to represent an annual average or a value applied during the growing season. The 2020 SDF PA supporting reference WSRC-STO-2007-0004, Rev. 0 (ADAMS Accession No. ML20206L301) did not address the difference and cited the DOE document WSRC-RP-93-1174, Rev. 0 (ADAMS Accession No. ML21007A321), which included only that the irrigation rate was chosen to be "… approximately 1 inch per week [(2.54 cm/week])" without a description of the basis of the value or how it should be applied. Please clarify the intended application of the irrigation rate (i.e., annual average or average during the growing season).

CC-3
The upper right-hand corner and the lower left-hand corner of Figure 4.4-112 in the DOE 2020 SDF PA showed cross-sectional figures traversing the Z-Area. Please clarify whether all of the red dots showing input fluxes from the Vadose Zone Transport Model were represented in the two cross-sectional figures or the figure shows only those red dots intersected by the cross section.

CC-4
In the right side of the lower left-hand corner of Figure 4.4-112 in the DOE 2020 SDF PA, a cross-sectional figure showed those saturated model cells near the McQueens Branch. Please clarify whether the saturated cells lying over the unsaturated cells showed: (1) the saturated cells of the TCCZ only or (2) saturated cells in both the TCCZ and the UTRA-UAZ.

CC-5
Figure 4.4-113 in the DOE 2020 SDF PA showed the streamlines for SDS 7 and SDS 9 abruptly change course outside the 100 m (328 ft) perimeter and move into the Gordon Aquifer Unit. In addition, Figure 4.4-115 and Figure 4.4-113 showed less prominent kinks in the streamlines for SDS 2 A, SDS 2B, SDS 5 A, SDS 5B, SDS 7, SDS 8, SDS 10, SDS 11, and SDS 12. Please clarify: (1) whether the kinks represent movement from the UTRA-UAZ into the UTRA-LAZ; (2) whether the streamlines for SDS 9 and SDS 7 diverge near SDS 9 because the streamline for SDS 9 represents movement in the UTRA-UAZ, while the streamline for SDS 7 is representing movement in the UTRA-LAZ; and (3) what the orange diamonds and green squares in Figure 4.4-113 represented.

CC-6
Please clarify the reasons for the variations in the hypothetical tracer results in Figures 4.4-124 through 4.4-130 in the DOE 2020 SDF PA. For example, SDS 8 and SDS 9 are well-represented by relatively low concentrations (less than 1×10^{-7} mol/L) while SDS 7 and SDS 10 generally show higher concentrations. In addition, please clarify why Figures 4.4-18 through 4.4-130 showed Section C at the 100 m (328 ft) boundary appears to have the highest tracer concentrations, although Section D provides the largest dose for most of the Performance Period of the Compliance Case as seen in Figure 5.5-4. If the difference was due to the timing of the high concentrations at the Sector C boundary occurring after the Performance Period, then please indicate when the steady-state results shown in Figures 4.4-120 through 4.4-122 and 4.4-127 were projected to occur.

CC-7
Please clarify the large range of tracer and streamline velocities (from 14.6 m/yr to 41.51 m/yr (47.8 ft/yr to 136.2 ft/yr)) for tracers and from 10.1 m to 40.87 m (33.1 ft/yr to 134.1 ft/yr) for the streamlines found within Table 4.4-85 in the DOE 2020 SDF PA. Specifically, please clarify

whether the differences were due to which hydrogeological unit the particles were traveling in (i.e., differences in rates due to percentage of time traveled in the UTRA-UAZ versus the UTRA-LAZ) or if there was another cause for the differences in range of rates and the average groundwater velocities in the ATM for the UTRA-UAZ and for the UTRA-LAZ.

CC-8

Figure 5.5-15 and Figure 5.5-16 in the DOE 2020 SDF PA showed relatively high I-129 and Tc-99 concentrations within the SDS 10 footprint, while its plume was relatively short. Please clarify why the plumes emanating from SDS 10 were less concentrated and shorter than the I-129 and Tc-99 plumes from SDS 9 at 5,000 years and at 10,000 years. In addition, please provide the basis for modeling the three contiguous empty southern cells for SDS 1 as if they contained inventory.

CC-9

Please clarify the meaning of the two different shades of blue used in Figure 3-1 and Figure 3-2 in the DOE document SRNL-STI-2015-00351, Rev. 0 (ADAMS Accession No. ML18107A071), including any differences in how those figures were used in the calculations of the cumulative departure from the long-term average monthly precipitation. Section 2.1 in the DOE document SRNL-STI-2017-00008, Rev. 1 (ADAMS Accession No. ML18081A304) stated, "However, stream baseflows may be biased high relative to the head calibration targets, because rainfall and water levels were higher on average during the 1973-1995 period compared to 2004-2014 (Figure 3-1 or Figure 3-2 in SRNL-STI-2015-00351)." Please provide a close-up figure or a table clearly showing the higher rainfall average during the 1973 – 1995 period.

CC-10

Section 4.3.1.1 in the DOE 2020 SDF PA stated "… the Upper Vadose Zone (over [264 ft. (80.5 m) above Mean Sea Level (MSL)] consists of finer-grained sediments" and that "… the Lower Vadose Zone (below [264 ft (80.5 m)] above MSL) has a higher sand content." Table 4.3-2 of that section displayed the hydraulic properties of the upper and lower vadose soils. Please clarify whether portions of the Upper Vadose Zone that has not been used for backfill will be present between the fifteen disposal structures after completion of the closure cap. For example, Figures 3.2-30 through 3.2-32 showed the walls of SDS 3A, SDS 3B, SDS 5A, SDS 5B, SDS 7, SDS 10, and SDS 11 not to be totally surrounded by the lower backfill. Please clarify whether the Upper Vadose Zone was represented in any of the 2020 SDF PA models. If it was, then please clarify where it was represented and provide the assigned distribution coefficients.

CC-11

Figure 5.8-106 in the DOE SDF PA displayed saturation at 2,000 years to 2,300 years for the Compliance Case. Please clarify why the Upper Vadose Zone was less saturated than the lower backfill away from the disposal structure and why the mudmat was less saturated than the roof near the center of the disposal structure.

CC-12

The Aquifer Transport Model Run.dat files included a vadose zone flux scaling factor. It is not clear to NRC staff how the scaling factor was calculated. Provide a sample calculation of the scaling factor for one radionuclide for one of the disposal structures.

CC-13

Provide the Vadose Zone Flow Model files for the 375-ft diameter disposal structures for the initial time interval, at 1,000 years, at 10,000 years, and at 100,000 years.

CC-14
Please provide the GoldSim optimization models described in the DOE documents SRR-CWDA-2018-0045, Rev. 0 (ADAMS Accession No. ML20206L242) and SRR-CWDA-2018-0046, Rev. 0 (ADAMS Accession No. ML20206L243).

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