

August 23, 2013

Ms. Jean Ridley, Director  
Waste Disposition Programs Division  
U.S. Department of Energy  
Savannah River Operations Office  
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SUBJECT: U.S. NUCLEAR REGULATORY COMMISSION JUNE 26-27, 2013, ONSITE  
OBSERVATION VISIT REPORT FOR THE SAVANNAH RIVER SITE SALTSTONE  
DISPOSAL FACILITY (DOCKET NO. PROJ0734)

Dear Ms. Ridley:

The enclosed report describes the U.S. Nuclear Regulatory Commission (NRC) onsite observation visit on June 26-27, 2013, at the Savannah River Site (SRS) Saltstone Disposal Facility (SDF). The visit was conducted in accordance with Section 3116(b) of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 (NDAA), which requires NRC to monitor certain disposal actions taken by the U.S. Department of Energy (DOE) for the purpose of assessing compliance with the performance objectives set out in 10 CFR Part 61, Subpart C. The activities conducted during the visit were consistent with those described in the NRC monitoring plan for salt waste disposal at SRS (dated May 3, 2007) and the NRC staff guidance for activities related to waste determinations (NUREG-1854, dated August 2007).

On every onsite observation visit to SRS, NRC is focused on assessing compliance with four performance objectives in 10 CFR Part 61, Subpart C: (1) protection of the general population from releases of radioactivity (§61.41), (2) protection of individuals from inadvertent intrusion (§61.42), (3) protection of individuals during operations (§61.43), and (4) stability of the disposal site after closure (§61.44).

On April 30, 2012, NRC issued both a Technical Evaluation Report (TER) [available via the NRC's Agencywide Documents Access and Management System (ADAMS) at Accession Number ML121020140] and a Type IV Letter of Concern [ML120650576] pertaining to waste disposal at the SRS. The TER concluded that NRC did not have reasonable assurance that salt waste disposal at the SDF met the performance objective §61.41. The Type IV Letter of Concern formally communicated NRC's concerns to both DOE and the South Carolina Department of Health and Environmental Control. DOE provided responses to the Type IV Letter to NRC in two submittals. These submittals included an updated technetium-99 (Tc-99) inventory projection for the newly constructed SRS saltstone disposal structures<sup>1</sup>; and information about DOE Case K and K1 uncertainty and sensitivity analyses. In August 2012, NRC issued a letter of acknowledgement [ML12213A447] stating that a letter to the U.S. Congress (Type II) is not needed at this time. Based on the NRC's TER analyses and DOE's revised Tc-99 inventory, the staff determined that, if DOE's new projected Tc-99 inventory for

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<sup>1</sup> Inventory projections described in DOE's response to NRC's Type IV Letter are listed in reference to Disposal Structures (Cells) 2A, 2B, 3A, 3B, 5A, and 5B. Throughout this report, these structures will be referred to as the "newly constructed" saltstone disposal structures.

the newly constructed disposal structures is correct, then it is unlikely that the salt waste disposal would cause an off-site peak dose exceeding the requirements of §61.41 (i.e., 0.25 mSv/yr (25 mrem/yr)).

The June 2013 onsite observation visit focused on technical concerns described in the NRC 2012 TER. There are no new open issues resulting from this visit. Open issues that had been identified earlier have been rolled into the concerns identified by NRC in the 2012 TER. All NRC concerns will be rolled into the monitoring factors in the revised monitoring plan that is being prepared by NRC.

The observation addressed a subset of the concerns raised in the 2012 TER. During the observation, staff was encouraged by DOE's progress in research on technetium solubility in saltstone and saltstone core testing methodologies. Results from these research activities will provide useful information about risk-significant aspects related to SDF performance. The DOE and NRC continue to work in the monitoring process to resolve all outstanding issues that led to issuance of the Type IV Letter of Concern. In accordance with the requirements of NDAA, NRC will continue to monitor DOE disposal actions at SRS.

If you have any questions or need additional information regarding this report, please contact Mr. Nishka Devaser of my staff at (301) 415-5196.

Sincerely,

**/RA/**

Aby Mohseni, Deputy Director  
Environmental Protection and  
Performance Assessment Directorate  
Division of Waste Management  
and Environmental Protection  
Office of Federal and State Materials  
and Environmental Management Programs

Enclosure:  
NRC Onsite Observation Visit Report

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## U.S. NUCLEAR REGULATORY COMMISSION JUNE 26-27, 2013, ONSITE OBSERVATION VISIT REPORT FOR THE SAVANNAH RIVER SITE SALTSTONE DISPOSAL FACILITY

### EXECUTIVE SUMMARY:

The U.S. Nuclear Regulatory Commission (NRC) staff conducted its 14<sup>th</sup> onsite observation visit, Observation 2013-01, to the Saltstone Disposal Facility (SDF) at the Savannah River Site (SRS) on June 26-27, 2013. On every onsite observation visit to SRS, NRC focuses on assessing compliance with four performance objectives in 10 CFR Part 61, Subpart C: (1) protection of the general population from releases of radioactivity (§61.41), (2) protection of individuals from inadvertent intrusion (§61.42), (3) protection of individuals during operations (§61.43), and (4) stability of the disposal site after closure (§61.44).

During Observation 2013-01, NRC focused on information regarding the April 30, 2012, NRC Technical Evaluation Report (TER) and associated Type IV Letter of Concern, where NRC concluded that it did not have reasonable assurance that salt waste disposal at the SDF met the performance objectives in 10 CFR Part 61, specifically §61.41. NRC performs monitoring activities in coordination with the State, so staff from the South Carolina Department of Health and Environmental Control (SC DHEC) also participated in this visit.

During Observation 2013-01, NRC staff and U.S. Department of Energy (DOE) staff (including DOE contractors, Savannah River Remediation (SRR) throughout this report), discussed salt waste processing and the details of recent research conducted by DOE, related to issues identified in NRC's 2012 TER. In addition, DOE provided NRC staff a tour of the saltstone processing facility (SPF), including views of the controls room. This report provides a description of the NRC activities during Observation 2013-01, including observations that NRC staff made during the visit.

There are no new Open Issues<sup>2</sup> resulting from Observation 2013-01. NRC staff received documents and a DOE presentation that pertained to the activities to be observed prior to the observation. The presentation that DOE provided to NRC staff and the documents provided by DOE for discussion at the observation are accessible via the NRC's document repository, the Agencywide Documents Access and Management System (ADAMS), via accession numbers listed below:

SRR-CWDA-2013-00093, Onsite Observation Documents - DOE Presentation during June 26-27 Observation, Rev. 1	ML13189A050
SRNL-STI-2012-00769, Solubility of Technetium Dioxides in Reducing Cementitious Material Leachates, Rev. 1	ML13070A135
SRNL-STI-2013-00118, Degradation of Cementitious Materials Associated with Saltstone Disposal Units	ML13189A205

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<sup>2</sup> The previous Open Issues are now rolled into the concerns identified by NRC in the 2012 TER. Those NRC concerns will be rolled into the monitoring factors in the revised monitoring plan that is being drafted by NRC.

Observation 2013-01 addressed a subset of the concerns raised in the 2012 TER. During the observation, staff was encouraged by DOE's progress in conducting research that provides useful information. The DOE and NRC continue to work in the monitoring process to resolve all outstanding issues that led to issuance of the NRC's Type IV Letter of Concern.

A summary of NRC staff observations and conclusions in those areas is provided below:

#### Saltstone Production Facility Operations and Discussion of Processing Cycle

- DOE provided NRC staff with details of saltstone disposal into the new disposal structures. In addition, DOE provided NRC staff a tour of the SPF, including views inside the control room. DOE described new process monitoring capabilities, which included video monitoring in the grout hopper, a humidity sensor in the vapor space of SDS 2A, and a new wet grout sample line installed in the process room.
- DOE and NRC technical staff discussed physical and chemical characteristics of blast furnace slag as it is received and when it is used in saltstone. NRC and DOE staff discussed quality assurance procedures for components of the saltstone dry feed (i.e., slag, fly ash, and cement).

#### Technical Discussion - Update on DOE's Special Analysis for Saltstone and the DOE Performance Assessment Maintenance Plan (SRR-CWDA-2013-00049)

- DOE described its new approach of coordinating and prioritizing research projects across the three liquid waste facilities performance assessment (PA) maintenance programs. DOE provided an overview of the PA maintenance plan elements related to saltstone divided into critical property testing (e.g., initial hydraulic conductivity and sorption coefficients), degradation studies, and emplaced saltstone testing. Specific aspects of the special analysis (SA) were also discussed and are summarized in the report (e.g., humidity effects on saltstone curing, saltstone oxidation front).
- DOE described potential sources of uncertainty in flow that were evaluated in sensitivity analyses. These factors included infiltration rates through the closure cap (as calculated by the HELP model), timing of complete physical degradation, initial hydraulic conductivity, and flow through construction joints. NRC staff commented that documentation and visual presentation of the deterministic sensitivity analyses are likely to be important for aspects of the analysis that are evaluated primarily with deterministic analyses. Sensitivity analysis results can reveal interrelationships of processes and provide significant insights and understanding. DOE described the status and expected schedule for the SA. DOE indicated that the SA would be reviewed by the low-level waste disposal facility federal review group (or LFRG) from July-September 2013.

#### Technical Discussion – Recent Research Activities

- NRC and DOE staff discussed NRC questions about recently published research on the solubility of technetium dioxides in reducing cementitious material leachates (SRNL-STI-2012-00769). NRC questions focused primarily on how the values recommended in SRNL-STI-2012-00769 will be used in future PAs, and included questions related to the text and figures in the document and how they were developed from its supporting references. DOE staff described the approach that was going to be used in the SA for modeling the release of Tc.

- NRC and DOE staff discussed the results of recently published research on the degradation of cementitious materials associated with saltstone (SRNL-STI-2013-00118). NRC questioned why mechanical degradation mechanisms (e.g., shrinkage, thermal loading, differential settlement) were not considered in the report. The NRC staff also asked for additional technical bases for the values identified as Best Estimates, Nominal Values, and Conservative Estimates. DOE replied that the values were based on engineering judgment. DOE showed NRC staff selected intermediate model results from the DOE draft Fiscal Year (FY) 2013 SA related to saltstone and disposal structure degradation.

## 1.0 **BACKGROUND:**

Section 3116 of the National Defense Authorization Act for Fiscal Year 2005 (NDAA) authorizes DOE, in consultation with NRC, to determine that certain radioactive waste related to the reprocessing of spent nuclear fuel is not high-level waste, provided certain criteria are met. The NDAA also requires NRC to monitor DOE disposal actions related to those determinations to assess compliance with the performance objectives in 10 CFR Part 61, Subpart C.

To carry out its monitoring responsibility under the NDAA, NRC, in coordination with the State site regulator – SC DHEC, performs three types of activities: (1) technical reviews, (2) onsite observation visits, and (3) data reviews. Those activities focus on key assumptions identified in the NRC monitoring plan. Technical reviews generally focus on reviewing additional model support for assumptions that DOE made in its PA that are considered important to the DOE compliance demonstration. Onsite observation visits generally are performed to: (1) observe the collection of data (e.g., observation of waste sampling used to generate radionuclide inventory data) and review the data to assess consistency with assumptions made in the waste determination; and (2) observe key disposal or closure activities related to technical review areas (e.g., slag/other material storage, grout formulation, preparation, or placements). Data reviews supplement technical reviews by focusing on monitoring data that may indicate future system performance or by reviewing records or reports that can be used to directly assess compliance with the performance objectives.

On March 31, 2005, DOE submitted to NRC the *Draft Section 3116 Determination for Salt Waste Disposal Savannah River Site* (DOE-WD-2005-001, Rev. 0) to demonstrate compliance with the NDAA criteria, including demonstration of compliance with the performance objectives in 10 CFR Part 61, Subpart C. In its consultation role, NRC staff reviewed the draft waste determination. In the TER issued in December 2005 (NRC, 2005), NRC documented the results of its review and concluded that there was reasonable assurance that the applicable criteria of NDAA could be met, provided certain assumptions made in the DOE analyses were verified via monitoring. Taking into consideration the assumptions, conclusions, and recommendations in the NRC 2005 TER, DOE issued the final waste determination in January 2006 (DOE-WD-2005-001, Rev. 1).

DOE submitted a revised PA to NRC in 2009 (SRR-CWDA-2009-00017). NRC reviewed SRR-CWDA-2009-00017, including holding public meetings, sending requests for additional information, and reviewing the DOE responses. On April 30, 2012, NRC issued both the TER (NRC, 2012a) and the Type IV Letter of Concern (NRC, 2012b). In the 2012 TER, NRC concluded that it did not have reasonable assurance that salt waste disposal at the SDF met the performance objectives in 10 CFR Part 61, specifically §61.41. The Type IV Letter of Concern formally communicated the NRC concerns to both DOE and the SC DHEC.

In July 2012, DOE responded to the Type IV Letter to NRC (DOE, 2012a; DOE, 2012b). DOE's response included information about an updated technetium-99 (Tc-99) inventory projection for the newly constructed disposal structures and information about the DOE Case K and K1 uncertainty and sensitivity analyses. In response to DOE's submittal, NRC issued a letter of acknowledgement, dated August 31, 2012, stating that a (Type II) Letter to the U.S. Congress is not needed at this time. Based on the NRC's TER analyses and DOE's revised Tc-99 inventory, the NRC staff determined that, if DOE's new projected Tc-99 inventory for the newly constructed disposal structures is correct, then it is unlikely to cause an off-site peak dose exceeding the requirements of §61.41 (i.e., 0.25 mSv/yr (25 mrem/yr)).

## **2.0 NRC ONSITE OBSERVATION VISIT ACTIVITIES:**

Observation 2013-01 began with a short briefing on the agenda and site safety procedures presented by DOE and attended by representatives from DOE, NRC, and SC DHEC. Discussions that followed included details of the recent saltstone production and disposal into Saltstone Disposal Structure (SDS) 2B, a tour of the saltstone production facility, research results from experiments conducted in accordance with DOE's PA maintenance program (as they relate to issues identified in NRC's 2012 TER), and an update on DOE's upcoming SA, which includes a revised conceptual model. This report summarizes those discussions.

Prior to Observation 2013-01, DOE provided NRC staff with two documents (listed below) on research related to issues identified in NRC's TER (NRC, 2012a).

SRNL-STI-2012-00769, Solubility of Technetium Dioxides in Reducing Cementitious Material Leachates, Rev. 1 ML13070A135

SRNL-STI-2013-00118, Degradation of Cementitious Materials Associated with Saltstone Disposal Units ML13189A205

### **2.1 Saltstone Production Facility Operations and Discussion of Processing Cycle:**

#### **2.1.1 Observation Scope:**

The staff's interest in discussing operations at the SPF is to ensure that the production of saltstone grout at the SDF is consistent with the assumptions made in the 2009 PA.

NRC staff monitors salt waste processing which is critical to grout quality. Section 3.2.2, “Waste Sampling”, Section 3.2.3, “Vault Construction”, Section 3.2.4, “Grout Formulation and Placement”, and Section 5, “Monitoring to Assess Compliance with §61.43 – Protection During Operations” of the May 2007 monitoring plan (NRC, 2007a) provide details of the basis for NRC staff review areas on the topic.

### 2.1.2 Observation Results:

DOE provided an update of salt waste processing, including details of recent saltstone processing in Cell 2B. The following bullets provide a highlight of the discussion:

- DOE described new monitoring capabilities.
  - Video monitoring in the grout hopper will allow DOE to monitor grout physical characteristics during production and may allow DOE to optimize production parameters. For example video monitoring will allow DOE to assess the need for anti-foaming agents. This improved monitoring capability may provide a way to simplify the saltstone mixture and resolve an NRC question about the effects of admixtures on radionuclide leaching from saltstone. **Action Item: DOE to provide to NRC information on all current admixtures in use.**
  - Humidity sensor in the vapor space of SDS 2A will reduce uncertainty in curing conditions.
  - A new wet grout sample line was installed in the process room.
- DOE noted there are currently no plans to fill the remaining space in Vault 4 with saltstone because the drain system would need to be upgraded before the space could be used.
- NRC and DOE technical staff discussed the blast furnace slag used in saltstone.
  - DOE and NRC technical staff discussed physical and chemical characteristics of the slag as it is received and when it is used in Saltstone. DOE technical staff described that, although the slag has a small mesh size (e.g., similar to powder), it is microscopically crystalline. DOE indicated that the slag becomes more porous and its surface area per unit mass increases significantly (e.g., by approximately a factor of 10) when it is mixed with the high-pH simulated salt solution. **Action Item: DOE to evaluate information available regarding blast furnace slag properties and provide to NRC (crystalline versus glass, proportion of slag oxide types, age of slag from time of grinding, temperature during storage).**
  - NRC and DOE staff discussed quality assurance procedures for components of the saltstone dry feed (i.e., slag, fly ash, and cement). **Action Item: DOE to evaluate previously provided information regarding Quality Assurance (QA) for dry feeds and will provide updated information, if any, to NRC.** DOE to supply NRC with the written QA procedures. DOE confirmed that the QA program is based on vendor analysis showing the product meets the DOE product specification (i.e., DOE does not perform third party analysis).



- The residence time of the dry feed materials in the hoppers is typically about 2 days while SPF is operating, but material does sit in the hoppers for longer periods (i.e., tens of days to months) during SPF outages.

### 2.1.3 Conclusions and Follow-up Actions:

The NRC staff will continue to monitor SPF activities, including any changes in the SPF production schedule, as the SPF continues its current processing cycle and as DOE transfers saltstone grout to the newly constructed disposal structures. There were three follow-up actions resulting from these discussions.

- 2013-01-1. DOE to provide to NRC information on all current admixtures in use.
- 2013-01-2. DOE to evaluate information available regarding blast furnace slag properties and provide to NRC.
  - Crystalline versus glass
  - Proportion of slag oxide types
  - Age of slag from time of grinding
  - Temperature during storage
- 2013-01-3. DOE to evaluate previously provided information regarding QA for dry feeds. Provide updated information, if any, to NRC.

## 2.2 Technical Discussion - Update on DOE's Special Analysis for Saltstone and the DOE PA Maintenance Plan (SRR-CWDA-2013-00049):

### 2.2.1 Observation Scope:

The objective of this monitoring activity is for DOE to provide NRC staff with an update on recent activities related to the Saltstone SA and the implementation plan for DOE's PA maintenance plan.

Based on technical information available from PA maintenance activities, DOE is in the final stages of developing a new SA that incorporates recently available technical data and modeling lessons learned from other activities to resolve uncertainties and address TER (NRC, 2012a) issues. DOE uses its PA maintenance program to both satisfy DOE internal requirements and address technical topics in the NRC monitoring plan.

DOE Manual 435.1-1 (DOE, 2001a) requires DOE to implement a PA maintenance program to evaluate changes that could affect the performance, design, and operating bases for the SDF. DOE Order 435.1 (DOE, 2001b) states that the PA maintenance program must include the conduct of research, field studies, and monitoring needed to address uncertainties or gaps in existing data. In addition to fulfilling those internal DOE requirements, DOE uses PA maintenance activities to address technical topics in the NRC monitoring plan. The SA is a part of those PA maintenance activities.

As part of monitoring under the NDAA, NRC is responsible for reviewing updates to the DOE PA and associated analyses (such as an SA). Section 3.1.2 “Oxidation of Saltstone,” Section 3.1.3, “Hydraulic Isolation of Saltstone,” and Section 3.1.4, “Model Support” of the May 2007 monitoring plan (NRC, 2007a) provide details of the basis for the NRC staff review areas.

### 2.2.2 Observation Results:

DOE presented details of both the PA maintenance plan (SRR-CWDA-2013-00049) and an update on the details of its SA. The bulleted list below provides the major points of the discussion. The reader is advised to refer to DOE’s presentation (SRR-CWDA-2013-00093) for more specific details on the bullets below.

#### *PA Maintenance Plan - General topics*

- DOE described its new approach of coordinating and prioritizing research projects across the PA maintenance program for the three liquid waste facilities (i.e., F-Tank Farm, H-Tank Farm and the SDF)
- DOE provided an overview of the PA maintenance plan elements related to saltstone divided into critical property testing (e.g., initial hydraulic conductivity and sorption coefficients), degradation studies, and emplaced saltstone testing. NRC staff asked if all of the experiments planned for this year related to the representativeness of saltstone samples focused on initial conditions, and DOE replied that they did.
- DOE explained that it would ensure that lab samples reflected the curing conditions of emplaced saltstone, and specifically indicated they would refer to the temperature profile from SDS 2B at an elevation of 3.2 m (10.5 ft.) as well as humidity data from the headspace in SDS 2A.

#### *PA Maintenance Plan - Specific topics*

- Humidity Effects on Saltstone Curing. NRC and DOE staff discussed diurnal variations in the observed humidity in the headspace of SDS 2A 30 days after emplacement. DOE noted that it expected the humidity to remain more constant during saltstone runs (i.e., when grout was being poured on a daily basis).
- Osmotic Pressure Effects on Contaminant Transport. This task consists of a literature search to better understand the potential effects of osmotic pressure on contaminant transport.
- Saltstone Leachate Impacts. DOE will perform experiments to assess the effects of leachate from cementitious materials on the  $K_d$  of various actinides and fission products in site-specific soil. DOE mentioned separate consideration of selenate, selenite, niobium, and radium in Z-area soil. The effect would be quantified as a “leachate impact factor”. DOE indicated it would assess the effects of four different solutes: (1) leachate saturated with  $\text{Ca}(\text{OH})_2$  to represent young material (pH 12), (2) leachate representative of more weathered saltstone (pH 11-12), (3) leachate at equilibrium with  $\text{CaCO}_3$  (pH 8) representing aged saltstone, and (4) artificial SRS ground water.

- Saltstone Oxidation Front. DOE indicated it would evaluate the time-dependent depth profile of saltstone oxidation (i.e., the movement of an oxidation front into saltstone) over a 5-42 month curing period. The position of the oxidation front would be determined through 2 methods: (1) thin-section leaching and subsequent ICP-MS analyses and (2) XANES analysis of Cr and S speciation of sample cross-sections. These studies will use Cr as a redox surrogate at concentrations of 500, 250, 100, and 20 mg Cr per kilogram saltstone. Studies would look at both Cr and S speciation.
- Degradation Studies. In response to an NRC question, DOE indicated that all of the work planned for this year in this area is method development.
- Non-Saturated Hydraulic Conductivity Measurements. DOE indicated it would develop and assess various techniques to measure unsaturated hydraulic conductivity of fractured and non-fractured saltstone. Specifically, DOE indicated it would assess the applicability of an unsaturated flow apparatus (UFA) for measuring hydraulic conductivity in intact unsaturated samples using ASTM D6527. If DOE finds the UFA method can be applied to unsaturated saltstone, it will apply the UFA method and a multistep overflow extraction method to samples with known fracture pathways. If DOE finds it can apply these methods to samples with known fracture pathways, it will establish methods for inducing saltstone fracturing and will assess whether the UFA and multistep overflow extraction methods can be applied to fractured saltstone.
- Saturated Hydraulic Conductivity: Alternate Measurement Techniques. DOE indicated it would compare two methods for measuring saltstone saturated hydraulic conductivity. Specifically, DOE indicated it would compare the use of a flexible wall permeameter (ASTM method D5084) with a centrifuge technique (ASTM D6527). The purpose of the evaluation is to determine if the centrifuge method can be used for measuring hydraulic conductivity in saltstone because it is a faster technique. DOE indicated it would analyze eight replicate samples by each technique, and a third party laboratory using the flexible wall permeameter technique would conduct additional confirmatory analyses.
- Saltstone Field-to-Laboratory Property Comparison: DOE described a new approach for evaluating how well laboratory-produced samples represent field-emplaced samples. Specifically, DOE described its approach of breaking the comparison into the following three groups to isolate the source of any discrepancies: (1) saltstone made with simulated salt waste mixed and cured in the laboratory, (2) saltstone made with salt waste directly from tank 50 and mixed with the full scale SPF mixer (i.e., samples pulled from the SPF process room downstream of the grout hopper) but cured in a mold in the laboratory, and (3) samples cored from field-emplaced saltstone in locations (i.e., lift heights) that correspond to the fresh grout samples that were cured in molds in items (1) and (2). DOE noted it would take and archive a salt waste sample from tank 50 at the same time as pulling the process room samples, item (2), so they can refer to a sample of the salt waste involved if necessary. NRC staff stated the logical approach to demonstrating the representativeness of laboratory samples for field-emplaced saltstone appeared to be well planned and seemed as if it would provide very useful results.

### *Update on Special Analysis*

- DOE described the status and expected schedule for the SA. DOE indicated that the SA would be reviewed by the low-level waste disposal facility federal review group, or LFRG<sup>3</sup> from July-September 2013.
- DOE described potential sources of uncertainty in flow that were evaluated in sensitivity analyses included in the SA. These factors included infiltration rates through the closure cap (as calculated by the HELP model), timing of complete physical degradation, initial hydraulic conductivity, and flow through construction joints.
- To assess the potential effects of fracturing, DOE will model oxygen generation in randomly selected blocks in the model. NRC staff commented that it would assess the conservatism of the fraction of saltstone represented by those blocks.
- NRC staff commented that documentation and visual presentation of the deterministic sensitivity analyses are likely to be important for aspects of the analysis that are evaluated primarily with deterministic analyses. Sensitivity analysis results can reveal interrelationships of processes and provide significant insights and understanding.

#### 2.2.3 Conclusions and Follow-up Actions:

The NRC will continue to monitor DOE's PA maintenance program as it applies to NRC's monitoring responsibilities under the NDAA. In addition, NRC looks forward to reviewing the DOE's revised SA when it is completed. No open issues or follow-up actions resulted from this discussion.

### 2.3 Technical Discussion – Recent Research Activities

#### 2.3.1 Observation Scope:

This section of the observation focused primarily on two technical reports (shown below) on research related to issues identified in NRC's TER (NRC, 2012a).

SRNL-STI-2012-00769, Solubility of Technetium Dioxides in Reducing Cementitious Material Leachates, Rev. 1 ML13070A135

SRNL-STI-2013-00118, Degradation of Cementitious Materials Associated with Saltstone Disposal Units ML13189A205

As noted in Section 3.1.2, "Factor 1 – Oxidation of Saltstone" of the May 2007 monitoring plan (NRC, 2007a), saltstone oxidation is considered to be important to compliance with the performance objectives primarily because oxidation can lead to increased releases of technetium from the wasteform. The release of Tc-99 from the wasteform is an important factor in the compliance with the performance objective identified in §61.41, "Protection of the General

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<sup>3</sup> The LFRG assists DOE-Environmental Management senior managers in the review of documentation that supports the approval of PAs and associated analyses (such as an SA).

Population from Releases of Radioactivity” and §61.42 “Protection of Individuals from Inadvertent Intrusion.”

As noted in Section 3.1.3, “Factor 2 – Hydraulic Isolation of Saltstone” of the May 2007 monitoring plan (NRC, 2007a), performance of the wasteform and concrete vault barriers is important to meet the performance objective in §61.41, “Protection of the General Population from Releases of Radioactivity” and §61.42 “Protection of Individuals from Inadvertent Intrusion.” The methods used to analyze the long-term performance of the SDF must account for potential mechanisms of contaminant release from the facility and the potential mechanisms for loss of integrity of the SDF engineered barriers.

### 2.3.2 Observation Results:

DOE provided presentations on each topic with authors of each technical report present at the observation. Slides from the presentations are in SRR-CWDA-2013-00093. The bulleted list below provides the details of the technical discussion on each topic. The discussion of SRNL-STI-2012-00769 below was guided by a list of questions (NRC, 2013a) provided to DOE following a technical exchange phone call on April 30, 2013 (NRC, 2013b) and in preparation for this observation. The staff’s full conclusions about SRNL-STI-2012-00769 will be documented in a technical review memo.

#### *SRNL-STI-2012-00769, Solubility of Technetium Dioxides and Primary References*

- DOE staff explained that the proposed solubility value for moderately aged cement ( $1 \times 10^{-8}$  M) (Table 11, SRNL-STI-2012-00769) was based on a combination of an experimental value of  $4.5 \times 10^{-10}$  M (pH 10.9 and  $E_h$  -0.40 V) (SRNL-STI-2012-00596) and expert judgment. DOE explained that expert judgment was used to adjust the experimental value, based on considerations of ionic strength in a closed experiment as compared to a flow-through system, as well as consideration of the relative values applicable under different conditions represented in Table 11 (i.e., oxidizing and reducing conditions of young, middle age, and old cementitious materials). In response to NRC questions, DOE explained that, although the experiments were conducted with young cement, the experimental conditions mimicked “moderately aged” conditions because the permeate pH was controlled at approximately 10.5.
- NRC and DOE staff discussed the uncertainty in the geochemical modeling due to the high ionic strengths present in early pore volumes that could lead to a higher solubility of Tc. DOE staff stated that the model uses the Debye-Hückel equation, which is valid up to an ionic strength of 1 M. DOE staff estimated that the number of pore volumes before the ionic strength decreases to less than 1 M, which NRC and DOE staff referred to as the “very early” time period, is on the order of ones. DOE staff also stated that the experimental values represented in the model were derived from experiments that included the very early time period in which the pore solution had an ionic strength greater than 1 M.
- DOE noted the results of synchrotron data (PIT-MISC-0017) on the speciation of Tc in reduced grout. DOE stated that over time the amount of Tc that was oxidized decreased to around 4% after 30 months of curing.

*SRNL-STI-2012-00769, Solubility of Technetium Dioxides, Use of Results in PA*

- DOE staff described the approach that was going to be used in the SA for modeling the release of Tc. They stated that the saltstone was initially modeled as being reduced and moderately-aged (2<sup>nd</sup> stage) and having a Tc solubility limit of  $1 \times 10^{-8}$  mol/L. At later times, the Tc was modeled as having a  $K_d$  value of 0.5 mL/g, which represents oxidized aged cement (3<sup>rd</sup> stage). Oxidized moderately-aged saltstone was not explicitly included in the model because the  $K_d$  value for this (0.8 mL/g) is similar to the  $K_d$  value for oxidized aged cement and the use of the lower  $K_d$  value for oxidized aged saltstone is conservative. NRC staff stated that it is only appropriate to exclude the young cement (1<sup>st</sup> stage) from the model if the properties of the young and moderately-aged saltstone are similar and if this simplification does not lead to an underestimation of the dose.
- NRC staff asked if the model used in the SA accounted for the possibility that the reduced sulfur is present in a more soluble form and is leached out. DOE staff stated that in the model, the reductant is only consumed by oxygen and the model does not include any leaching of the sulfur reductant.
- In response to an NRC question, DOE staff stated that the Tc solubility limit would not be modeled probabilistically in the new SA, but sensitivity cases were run in which the solubility limit was increased and decreased by an order of magnitude.

*SRNL-STI-2013-00118, Degradation of Cementitious Materials*

- NRC staff made the general comment that the topic report does not address why mechanical degradation mechanisms (e.g., shrinkage, thermal loading, differential settlement) were not considered. The NRC staff noted that the subject report included the following basis for the selection of degradation mechanisms discussed:

*Previous studies of cementitious material degradation in the context of low-level waste disposal have identified sulfate attack, carbonation influenced steel corrosion, and decalcification (primary constituent leaching) as the primary chemical degradation phenomena of most relevance to SRS exposure conditions (NUREG/CR-5542, WSRC-STI-2007-00607, SRNL-STI-2010-00035, and CBP-TR-2009-002-C4). (emphasis added)*

NRC staff indicated it expected to ask DOE for more of a basis for why mechanical degradation mechanisms were not incorporated into the SA.

- NRC staff made the general comment that the subject report did not appear to provide adequate basis for the selection of the Best Estimates, Nominal Values, and Conservative Estimates. NRC staff indicated it understood a lengthy technical basis for parameter values would typically be unnecessary in an initial uncertainty analysis. However, NRC stated that, in general, it is not adequate to indicate only that one value of a parameter is greater than or less than another value. In a subsequent discussion, NRC staff noted slide 40 of DOE's presentation (SRR-CWDA-2013-00093) as an example of the simple, physically-based reasoning and short explanation that might be appropriate in the context of the DOE degradation report.

- NRC staff asked for more information about the technical basis for the choice of Best Estimate, Nominal, and Conservative values for several parameters, including the fractional porosity, pore space open for gas transport, hydraulic gradient, water-to-cement ratio, and the ratio of the interior concentration to boundary concentration (i.e., in the computation of the effective diffusion coefficient). DOE replied that the values were based on engineering judgment.
- NRC staff noted that the use of the term “best estimate” in the degradation report appeared to differ from its meaning in the 2009 PA. NRC staff suggested that a formal definition for each term (Best Estimate, Nominal, and Conservative) would reduce misunderstandings and help focus future technical discussions.
- DOE showed NRC staff selected intermediate model results from the DOE Fiscal Year 2013 draft SA. DOE explained that it would assume disposal structure and saltstone hydraulic conductivity increased linearly as a function of time after an initial lag period.
- NRC staff commented that it seemed the initial lag period, prior to the linear increase in hydraulic conductivity, did not account for potential mechanical degradation mechanisms, because DOE had not explained why it did not expect mechanical degradation to take place during that lag period. NRC staff also noted that the duration of the initial lag period appeared to have a significant effect on the timing of the projected peak dose.
- DOE explained that “completely degraded” conditions meant the component degraded to the hydraulic characteristics of the surrounding soil. DOE addressed the potential concern that cementitious materials in contact with natural soil as compared to backfill (e.g., disposal structure floors as compared to disposal structure roofs) would have different degraded states. NRC staff commented that it understood this approach was designed to minimize modeling artifacts that could be created if the degraded barriers were dissimilar to the surrounding materials.

### 2.3.3 Conclusions and Follow-up Actions

NRC staff found these discussions very helpful and will continue to monitor the progress of this research and its application in the upcoming SA and future revisions to the PA. The discussion on SRNL-STI-2012-00769 will provide direct benefit to the NRC staff's publicly available technical review memo on the report expected within CY 2013. NRC staff expressed general concerns about the scope of degradation mechanisms considered in SRNL-STI-2013-00118 as well as the justification provided for Best Estimates, Nominal Values, and Conservative Estimates of parameters. No open issues or follow-up actions resulted from this discussion.

### **3.0 FOLLOW-UP ACTIONS AND OVERALL CONCLUSIONS:**

#### **3.1 Follow-up Actions from the Saltstone Production Facility Operations and Discussion of Processing Cycle**

- 2013-01-1. DOE to provide to NRC information on all current admixtures in use.
- 2013-01-2. DOE to evaluate information available regarding blast furnace slag properties and provide to NRC:
- Crystalline versus glass
  - Proportion of slag oxide types
  - Age of slag from time of grinding
  - Temperature during storage
- 2013-01-3. DOE to evaluate previously provided information regarding QA for dry feeds. Provide updated information, if any, to NRC.

#### **3.2 Follow-up Actions from the Update on DOE's Special Analysis for Saltstone and the DOE PA Maintenance Plan**

None.

#### **3.3 Follow-up Action from the Technical Discussion –Recent Research Activities**

None.

#### **3.4 Overall Conclusions**

There are no new Open Issues resulting from Observation 2013-01. The previous Open Issues are now rolled into the concerns identified by NRC in the 2012 TER (NRC, 2012a). Those NRC concerns will be rolled into the monitoring factors in the revised monitoring plan that is being drafted by NRC. Based on the results of Observation 2013-01, there is no change to the NRC conclusions in that TER – NRC continues to conclude that it does not have reasonable assurance that salt waste disposal at the SDF meets the performance objectives in 10 CFR Part 61, specifically §61.41. However, the NRC is encouraged by the progress made since publication of the TER.



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