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May 17, 2018

MEMORANDUM TO: Maria Arribas-Colon, Acting Chief
Low-Level Waste Branch
Division of Decommissioning, Uranium Recovery, and Waste Programs
Office of Nuclear Materials Safety and Safeguards

THRU: Christepher A. McKenney, Chief ***/RA A. Gross for/***
Performance Assessment Branch
Division of Decommissioning, Uranium Recovery, and Waste Programs
Office of Nuclear Materials Safety and Safeguards

FROM: Hans Arlt, Sr. Systems Performance Analyst ***/RA/***
Performance Assessment Branch
Division of Decommissioning, Uranium Recovery, and Waste Programs
Office of Nuclear Materials Safety and Safeguards

SUBJECT: TECHNICAL REVIEW: GROUNDWATER MONITORING AT AND NEAR THE PLANNED SALTSTONE DISPOSAL FACILITY (DOCKET NO. PROJ0734)

The U.S. Nuclear Regulatory Commission (NRC) staff performed a technical review of the groundwater monitoring system at and near the planned U.S. Department of Energy (DOE) Savannah River Site (SRS) Saltstone Disposal Facility (SDF) as part of the NRC monitoring of the DOE disposal actions to determine compliance with the performance objectives (POs) set forth in Subpart C of Title 10, Part 61, of the Code of Federal Regulations (10 CFR Part 61) at the SRS SDF pursuant to Section 3116(b) of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 (NDAA).

The NRC review was performed in accordance with monitoring activities described in the NRC 2013 SDF Monitoring Plan (Agencywide Documents Access and Management System (ADAMS) Accession No. ML13100A076). The 2013 SDF Monitoring Plan contains monitoring areas and each monitoring area contains one or more monitoring factors. This NRC Technical Review Report (TRR) is related to Monitoring Area (MA) 8 (Environmental Monitoring) and MA 10 (Performance Assessment Model Revisions). Within those two monitoring areas, this TRR addresses Monitoring Factor (MF) 8.02 (Groundwater Monitoring) and MF 10.02 (Defensibility of Conceptual Models).

Contact: Hans Arlt, NMSS/DUWP
301-415-5845

MF 10.02 addresses the uncertainty of conceptual models and analysis of potential alternative conceptual models under the assumption that present natural and environmental processes will remain unchanged over time. This TRR does not recommend changing either the priority or the status of MF 10.02.

MF 8.02 addresses identifying early releases of constituents from saltstone whereby the NRC staff reviews groundwater data from the groundwater monitoring system for any indication of unintentional release of contaminants. MF 8.02 is a periodic monitoring factor where the groundwater data will be monitored in perpetuity at the SDF. This TRR does not recommend changing either the priority or the status of MF 8.02.

After reviewing the SRS Z Area groundwater monitoring system, the NRC staff identified numerous new concerns regarding the groundwater monitoring system in the Z Area. This TRR recommends creating a high-priority MF 8.03 (Identification and Monitoring of Groundwater Plumes in the Z Area) under MA 8 (Environmental Monitoring) under both PO §61.41 and PO §61.42 because the periodic nature of MF 8.02 does not address those newly identified NRC staff concerns. Under MF 8.03, the specific issues related to the groundwater monitoring system in the Z Area would be monitored. The NRC staff expects to close MF 8.03 when the NRC staff determines that the groundwater monitoring system in the Z Area can: (1) identify saltstone contaminants in the groundwater in the SDF at no more than 150 ft [46 m] from a disposal structure; and (2) track the movements of the groundwater plume (e.g., know the horizontal and vertical extent of the plume; be able to follow the approximate path of the peak of the plume).

Enclosure:
Technical Review: Groundwater Monitoring at and Near the Planned Saltstone Disposal Facility

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SUBJECT: TECHNICAL REVIEW: GROUNDWATER MONITORING AT AND NEAR THE PLANNED SALTSTONE DISPOSAL FACILITY (DOCKET NO. PROJ0734), DATED MAY 17, 2018

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Technical Review: Groundwater Monitoring at and Near the Planned Saltstone Disposal Facility

Date

May 17, 2018

Reviewer

Hans Arlt, Sr. Systems Performance Analyst, U.S. Nuclear Regulatory Commission (NRC)

Purpose

The purpose of this NRC staff Technical Review Report (TRR) is to review the groundwater monitoring at and near the U.S. Department of Energy (DOE) planned Savannah River Site (SRS) Saltstone Disposal Facility (SDF) as part of the NRC monitoring of the DOE disposal actions to determine compliance with the performance objectives (POs) set forth in Subpart C of Title 10, Part 61, of the *Code of Federal Regulations* (10 CFR Part 61) at the SRS SDF pursuant to Section 3116(b) of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 (NDAA).

Background

Groundwater monitoring at and near the DOE planned SRS SDF is described in the NRC 2013 SDF Monitoring Plan (Agencywide Documents Access and Management System (ADAMS) Accession No. ML13100A076) in Monitoring Factor (MF) 8.02 (Groundwater Monitoring). The appropriateness of the conceptual model and alternative conceptual models are part of MF 10.02 (Defensibility of Conceptual Models). Conceptual model uncertainty addresses different ideas of how a site could function given current site conditions.

Summary of Information from Previous DOE and NRC Documents

Hydrogeology

In the Z Area of the SDF, the hydrological system consists of three aquifers of interest: (1) the water table or Upper Three Runs Aquifer (UTRA); (2) the Gordon Aquifer; and (3) the Crouch Branch Aquifer (below the Crouch Branch Confining Unit; see Figure 1). The UTRA and Gordon Aquifer are expected to be impacted by radionuclides from the SDF (SRR-CWDA-2014-00095; Figure B-4). Contamination is not expected to affect the deeper Crouch Branch Aquifer because of an upward flow gradient between the Crouch Branch and Gordon Aquifers near Upper Three Runs Creek. The northwest half of the SDF straddles a groundwater divide between Upper Three Runs Creek and McQueens Branch causing water and any constituents in the water to discharge to either creek depending on the SDF source location.

Retarding the downward flow and transport of groundwater recharge is the Tan Clay Confinement Zone (TCCZ). This local aquitard splits the UTRA into an upper part, referred to as the UTRA-Upper Aquifer Zone, or UTRA-UAZ, and a Lower Aquifer Zone (LAZ), referred to as the UTRA-LAZ. The presence or absence, thickness, and extent of the TCCZ are important inputs into groundwater flow and transport models that are used by the DOE to demonstrate expected compliance with applicable groundwater regulatory requirements. The DOE has explained that the methodology to identify the location of the TCCZ used pore pressure, resistivity, and corrected tip stress while the actual physical description of the sedimentary layer was much less frequently used (ADAMS Accession No. ML16147A197). A current conceptual model indicates that water travels through the unsaturated zone and flows as groundwater on top of the TCCZ along a preferential pathway so that the TCCZ can be considered a competent aquitard in Z Area (SRNS-RP-2014-01214). However, as the topography elevation decreases, groundwater will no longer flow on top of the TCCZ, and the water table in the Z Area descends from the UTRA-UAZ into the UTRA-LAZ which eventually discharges into McQueens Branch or Upper Three Runs Creek (Figure 1). Preferential pathways in linear troughs in the TCCZ have been documented on the south side of the General Separations Area (GSA) and, since Z Area is on the north side of the GSA, similar conditions are expected to exist (Blount, 2013).

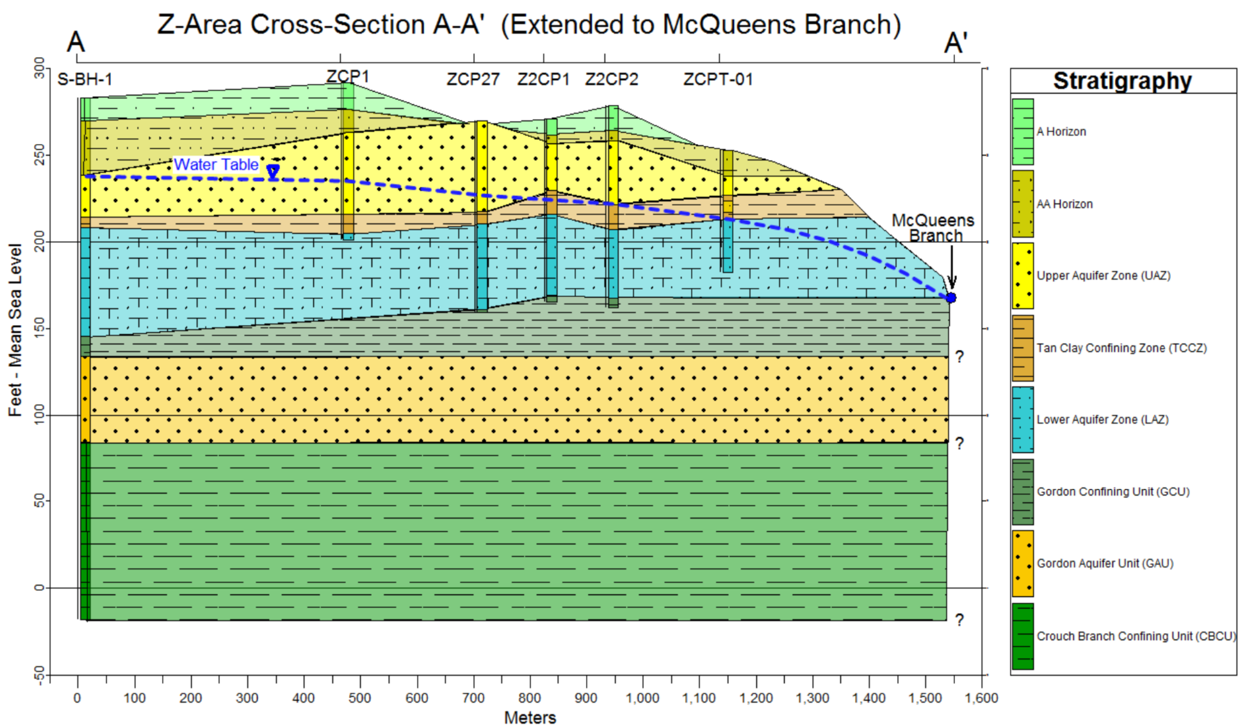


Figure 1: Z Area Cross Section (from SRNS-TR-2014-00283)

Groundwater flow is radial in this area of SRS and, as previously discussed, the Z Area straddles a groundwater divide with groundwater flowing towards the Upper Three Runs Creek or towards the McQueens Branch. As the arrow in Figure 2 demonstrates, the water table at Saltstone Disposal Structure (SDS) 1 is higher than at SDS 4, so that the groundwater flow is to the northeast. Similarly, the water table is higher at SDS 6 and groundwater flows to the northwest towards SDS 3 and SDS 5 while groundwater flow at SDS 2 is to the north. The water table elevation at the Z Area is approximately between 220 to 240 feet-above mean sea level (ft-amsl) [67 to 73 meter-above mean sea level (m-amsl)]. The DOE "Z-Area Saltstone Disposal Facility Groundwater Monitoring Report for 2016 (U)" (SRNS-TR-2016-00110) states that the hydraulic conductivity (K) of the UTRA is 13 ft/day [4.0 m/day] with an effective porosity (n) value of 25 percent. Calculations by the DOE for 2016 and 2015 provided groundwater flow rates of 184 to 344 ft/yr [56.1 to 105 m/yr] for the Z Area (SRNS-TR-2016-00110 and SRNS-TR-2015-00300, respectively).

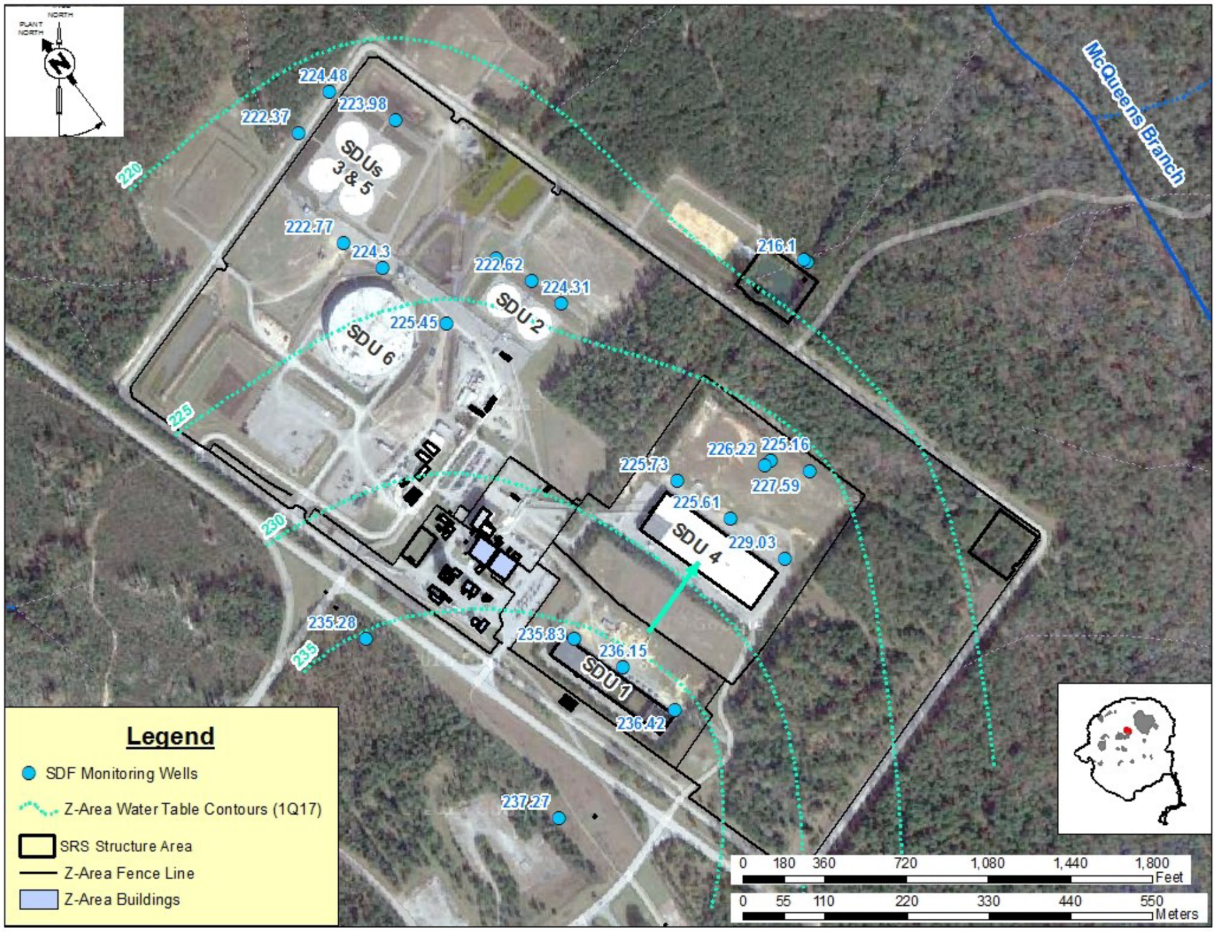


Figure 2: Approximate 2017 Water Table in Feet Above Mean Sea Level in the Z Area (from SRNS-TR-2017-00227)

Monitoring

The DOE conducts an effluent monitoring and environmental surveillance program on an ongoing basis at SRS. The data obtained through that program are summarized in an annual environmental report. A variety of environmental media, including groundwater; surface water; rainwater; air; vegetation; deer and hog meat; and soil, are monitored through that program. The most useful environmental data to monitor for the purpose of NDAA monitoring performance of the SDF is the groundwater data from the Z Area. The NRC staff expects that the groundwater will be the dominant pathway for evaluating long-term releases from the SDF and assessing compliance with PO §61.41. In assessing compliance with PO §61.42, the groundwater pathway is expected to dominate long-term doses to inadvertent intruders. The usefulness of other environmental data to SDF monitoring is somewhat limited because most of those samples are not obtained directly in the vicinity of the SDF and there are other potential sources of radioactivity at SRS, which makes it difficult to determine whether any observed concentration increases are attributable to the waste disposed of at the SDF. Potential increases in the concentration of radionuclides or other saltstone indicators (e.g., nitrate, pH, alkalinity) in groundwater samples obtained near the SDF may indicate that radionuclides are leaching from the disposal structures and that the SDF may not be performing as expected.

The monitoring well network and the DOE monitoring plan for the SDF are designed to detect releases associated with a saltstone disposal structure. The groundwater monitoring network has expanded and will expand with the construction of additional saltstone disposal structures. The Saltstone Production Facility is permitted at SRS as a wastewater treatment facility per the South Carolina Department of Health and Environmental Control (SCDHEC) regulations, and the SDF is permitted as a Class 3 Landfill per SCDHEC regulations (SCDHEC, 2011). In accordance with the Z Area SDF Class 3 Landfill Permit, the monitoring wells are sampled for the constituents and the parameters listed in Table 1 on a semiannual and biennial basis. Groundwater samples are collected and sent for analyses to laboratories certified by the SCDHEC. A threshold of 8 pCi/L was established for nonvolatile gross beta analyses as part of the "Groundwater Monitoring Plan for the Z Area Saltstone Disposal Facility" (WSRC-TR-2005-00257). Based on the DOE groundwater monitoring report for 2016 (SRNS-TR-2016-00110), if an 8 pCi/L threshold is exceeded by a well sample, then the same well is to be resampled within 30 days for strontium (Sr)-90. If the contingent Sr-90 analysis is above detection, then it is added to the list of semiannual constituents. If a 30 pCi/L threshold is exceeded by a well sample, then the same well and the applicable background well (Well ZBG 1 or Well ZBG 15D) are resampled within 30 days for the specific constituents. If any contingent constituent is above maximum background well concentrations, then it will be added to the list of semiannual constituents. If the following sample event confirms the exceedance results for a constituent, then a characterization plan to determine plume extent will be developed and submitted to SCDHEC within 60 days.

Table 1: List of Constituents Sampled at the Z Area and Associated Parameters (from SRNS-TR-2016-00312)

Semiannual Constituents	Groundwater Protection Standard	Units
pH	NA	pH
Specific Conductance	NA	µS/cm
Groundwater Elevations	NA	ft-msl
Nitrate (Nitrate/Nitrite)	10	mg/L
Gross Alpha	15	pCi/L
Gross Beta [1,2] (Nonvolatile Beta)	8 / 30	pCi/L
Gamma Spectroscopy-Emitters (Beta-Emitters)	4	mrem
Iodine-129 (I-129)	1	pCi/L
Technetium-99 (Tc-99)	900	pCi/L
Tritium	20	pCi/mL
Biennial Constituents	**Groundwater Protection Standard**	**Units**
Radium-226 (Ra-226)	5 (Ra-226 + Ra-228)	pCi/L
Radium-228 (Ra-228)	5 (Ra-226 + Ra-228)	pCi/L
Benzene	5	µg/L
Tetrachloroethylene	5	µg/L
Toluene	1000	µg/L
Trichloroethylene	5	µg/L
Contingent Analysis 1	**Groundwater Protection Standard**	**Units**
Strontium-90 (Sr-90)	8	pCi/L
Contingent Analyses 2	**Groundwater Protection Standard**	**Units**
Carbon-14 (C-14)	2000	pCi/L
Cobalt-60 (Co-60)	100	pCi/L
Cesium-137 (Cs-137)	200	pCi/L
Gross Beta (Re-analysis)	30	pCi/L
Niobium-94 (Nb-94)	707 [3]	pCi/L
Nickel-59 (Ni-59)	300	pCi/L
Nickel-63 (Ni-63)	50	pCi/L
Plutonium-241 (Pu-241)	62.6 [3]	pCi/L
Ruthenium-106 (Ru-106)	30	pCi/L
Antimony (Sb-125)	300	pCi/L
Technetium-99 (Tc-99)	900	pCi/L

[1] If Gross Beta is equal to or exceeds 8 pCi/L then Contingent Analysis 1 is analyzed for that sample.

[2] If Gross Beta is equal to or exceeds 30 pCi/L then all Contingent Analyses 2 are analyzed for that well and the background well.

[3] Proposed Drinking Water Standard.
NA = Not Applicable.

Groundwater monitoring results are compared to Practical Quantitation Limits (PQLs), background concentrations, and Groundwater Protection Standards (GWPS). PQLs are indicators of laboratory instrument sensitivity, but are not regulatory limits, nor are they risk-based. The PQL is the lowest concentration of an analyte which can be reliably quantified in a given sample. Background concentrations are based on historical data from wells (ZBG 1 and ZBG 15D) upgradient of the SDF. Comparison with background is important because several SRS facilities are upgradient of the SDF. Well ZBG 15D was installed in 2012 to provide an additional background well for the UTRA-UAZ and was sampled independently for four quarters to establish initial background concentrations as required by the DOE monitoring plan (WSRC-TR-2005-00257). Data from Well ZBG 15D is now used for background comparisons to monitoring data collected at wells downgradient of SDS 1 and SDS 4. Data from Well ZBG 1 is used for background comparisons to monitoring data collected at wells downgradient of SDS 2, SDS 3, and SDS 5.

Groundwater monitoring has been conducted at the Z Area SDF since 1987 (WSRC-TR-2005-00257) (see Figure 3 and Table 2). The Z Area SDF started operations and disposing of low-level waste by pumping saltstone to SDS 1 in June 1990 (WSRC-TR-95-0227). The DOE began to monitor the groundwater with two wells located in the UTRA-UAZ (designated Wells ZBG 1 and ZBG 2) to determine baseline chemistry, however Well ZBG 2 is now downgradient of SDS 1 and SDS 4. Wells ZBG 3, ZBG 4, and ZBG 5 were constructed in 2003 with open screens in the UTRA-LAZ downgradient of SDS 4. In addition, three wells (ZBG 6, ZBG 7, and ZBG 8) were installed immediately downgradient of SDS 1 in the UTRA-UAZ in 2007. The DOE intends to construct new wells within 100 ft [30 m] downgradient of the new saltstone disposal structures if the those saltstone disposal structures are constructed downgradient of current wells (WSRC-TR-2005-00257). Since the construction of Well ZBG 8, six wells (ZBG 9D through ZBG 14D) were installed in the UTRA-LAZ to monitor SDS 2, SDS 3, and SDS 5 (see Table 2). Concerns of potential groundwater contamination from Sedimentation Basin No. 4 initiated the installation of a shallow well (ZBG 16D) to monitor potential saturated conditions in the UTRA-UAZ and a deeper well (ZBG 16C) to monitor the UTRA-LAZ. Well ZBG 2C was installed in the UTRA-LAZ adjacent to shallow Well ZBG 2, when contaminated water was observed at Well ZBG 2. Ultimately, Well ZBG 2 was abandoned due to concerns that it may act as a pathway for contamination from the UTRA-UAZ into the UTRA-LAZ. Well ZBG 2 was replaced by the shallow Well ZBG 2D and does not dissect through the TCCZ. In 2017, four additional wells were added to the SDF monitoring network: Wells ZBG 17D, ZBG 18D, and ZBG 19D are to monitor the UTRA-UAZ for potential contaminants from SDS 6 and the future SDS 7 and SDS 8, and Well ZBG 20D is to provide additional information from the UTRA-UAZ approximately 160 ft [50 m] southeast of the old Well ZBG 2 and also downgradient of SDS 4. The current groundwater monitoring system does not include groundwater monitoring wells in the Gordon Aquifer.

Table 2: Summary of Z Area Groundwater Monitoring Wells up to ZBG 16 (from SRR-CWDA-2014-00061)

Well	Ground Elevation (MSL)	Top of Screen Zone (MSL)	Bottom of Screen Zone (MSL)	Top of TCCZ[(a)] (MSL)	Bottom of TCCZ[(a)] (MSL)	Aquifer Zone[(a)]	Nearest CPT
ZBG 1	288.9	240.1	220.0	217.0	205.0	UAZ	ZCP1
ZBG 1A	287.8	281.0	276.0	217.0	205.0	Perched	ZCP1
ZBG 2	275.8	230.9	210.9	215.7	204.8	UAZ	Z2PC3
ZBG002C	275.3	205.3	195.3	220.0	208.5	LAZ	(b)
ZBG 3	270.0	214.0	204.0	227.3	218.7	LAZ	ZCP6
ZBG 4	271.4	215.4	205.4	224.2	212.5	LAZ	ZCP24
ZBG 5	269.8	213.8	203.8	224.2	212.5	LAZ	ZCP24
ZBG 6	286.0	226.0	211.0	217.0	205.0	UAZ	ZCP1
ZBG 7	285.2	225.2	210.2	217.0	205.0	UAZ	ZCP1
ZBG 8	286.0	228.0	213.0	217.0	205.0	UAZ	ZCP1
ZBG009D	272.7	212.7	197.7	227.6	213.5	LAZ	ZV2CP10
ZBG010D	274.5	214.5	199.5	227.6	213.5	LAZ	ZV2CP10
ZBG011D	277.8	217.8	202.8	222.2	207.7	LAZ	ZV2CP7
ZBG012D	259.2	193.7	178.7	206.0	196.0	LAZ	SDS-21A
ZBG013D	259.7	194.7	179.7	206.0	196.0	LAZ	SDS-21A
ZBG014D	264.7	190.1	175.1	206.0	196.0	LAZ	SDS-21A
ZBG015D	295.3	234.3	214.3	217.0	205.0	UAZ	ZCP1
ZBG016D	253.0	236.0	226.0	225.8	213.3	UAZ	ZCPT01
ZBG016C	252.4	207.4	197.4	225.8	213.3	LAZ	ZCPT01

CPT – Cone Penetrometer Test

MSL – Mean Sea Level

TCCZ – Tan Clay Confining Zone

UAZ – Upper Aquifer Zone - Upper Three Runs Aquifer

LAZ – Lower Aquifer Zone - Upper Three Runs Aquifer

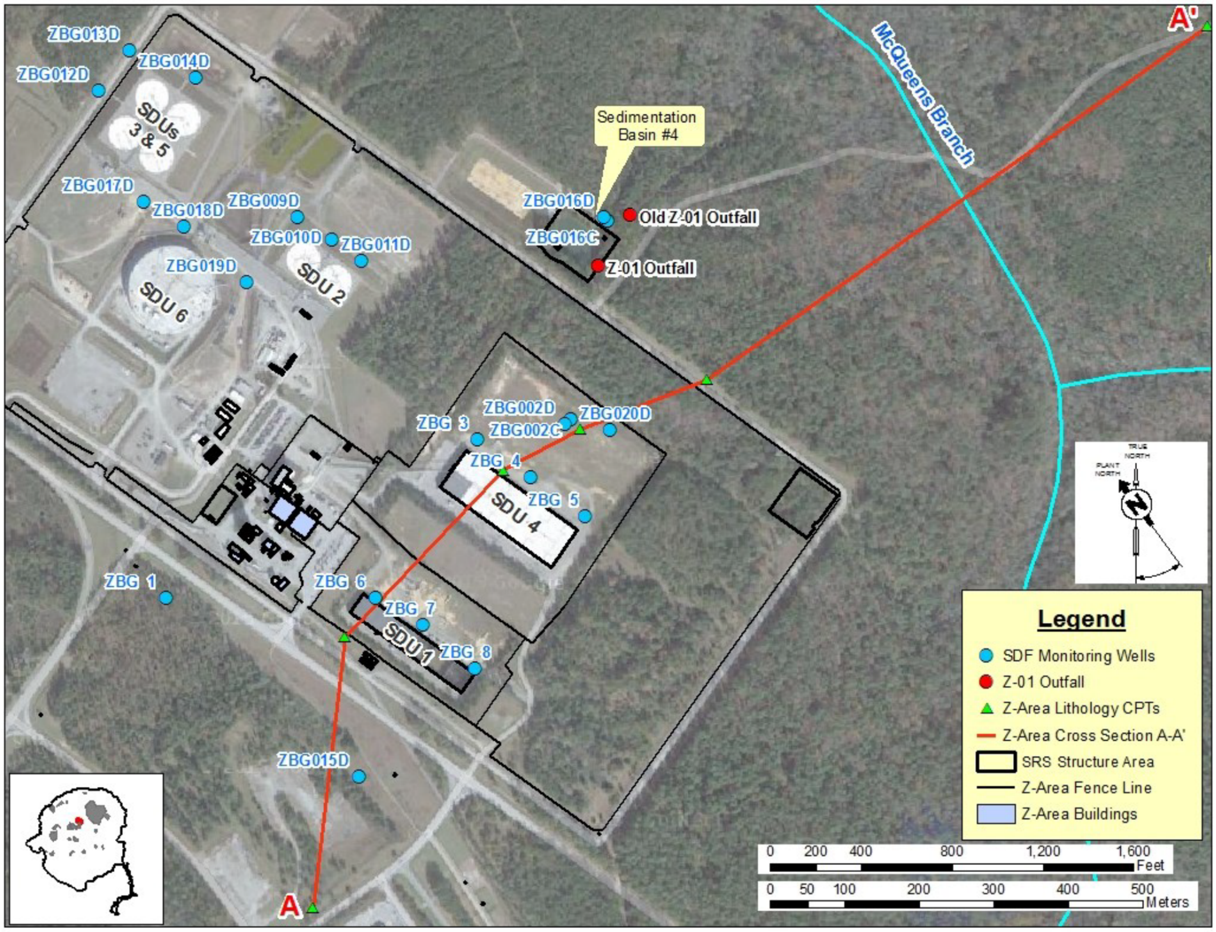


Figure 3: Groundwater Monitoring Wells in the Z Area and Z Area Cross Section A-A' (from SRNS-TR-2017-00227)

A key aspect of the DOE groundwater monitoring program is the placement of the wells (see Figure 3). For the monitoring wells to provide useful information, they must be located downgradient of the saltstone disposal structures and must be close enough to the saltstone disposal structures to see radionuclides or other indicators that may leach from the saltstone waste form. Similarly, it is important for the wells used to obtain information regarding the natural groundwater composition to be upgradient of the saltstone disposal structures. The groundwater divide on the SDF may complicate the assessment of the well locations, especially because there is some uncertainty in the location of the divide and the location can change with changes to infiltration.

Summary of Current Groundwater Monitoring Results

Groundwater samples where nonvolatile gross beta concentration values exceeded GWPS included four of the twelve direct push technology (DPT) samples from the 2015 Z Area groundwater characterization study (SRNS-RP-2015-00902) and ZBG 2, ZBG 2D, and ZBG 20D with nonvolatile gross beta concentrations greater than 30 pCi/L over multiple years after 2012. ZBG 2D and five of the twelve DPT samples exceeded the GWPS of 15 pCi/L for gross alpha in 2015 while ZBG 3 yielded a Ra-226 result of 41.1 pCi/L in 2005 although the Ra-226 result may have been a sampling or laboratory error.

ESH-WPG-2006-00132 reported that SDS 1 experienced cracks from construction and operational events dating back to 1988. Many of the cracks were sealed on the outside, and soil in areas where leakage occurred has been isolated and partially remediated; however, elevated hydrogen (H)-3 values were observed in Well ZBG 6 samples in 2007 and 2008. These samplings did not reveal additional evidence of new releases from the saltstone disposal structures. H-3, or tritium, in Well ZBG 6 may be evidence that contamination from a 1994 leak at SDS 1 has reached the water table (WSRC-TR-2008-00001). No attempt was made to delineate a tritium plume in the UTRA-UAZ.

As previously described, evidence indicates that contaminants from SDS 4 have traveled through the unsaturated zone and are transported in the saturated zone on top of the TCCZ along a preferential pathway towards ZBG 2. The DOE indicated that the source was bleed water and contaminated rainwater weeping from Cell G of SDS 4 (SRR-CWDA-2016-00052; Page 84) in the 1990s and had also determined that the contaminants from that leak had reached the unsaturated zone and saturated zone (SRR-CWDA-2016-00004). The DOE also had indicated that the release was responsible for the elevated technetium (Tc)-99 and nitrate concentrations measured in Well ZBG 2 starting in 2012. SDS 4 continued to have problems, and in 2004, contamination was found in a drainage ditch and soil adjacent to Cell G in SDS 4 (SRR-CWDA-2016-00052). The DOE told the NRC that the contamination source to the groundwater was stopped in 2008 to 2009 when the weather enclosures, or huts, were built along the sides of SDS 4 to protect the contaminated soil from infiltration (i.e., to cover the contaminated areas to prevent recharge) (ADAMS Accession No. ML16147A197). However, little technical justification was provided to support this DOE assertion. In 2009, contamination runoff had moved southeast from SDS 4 into a forested area (SRR-CWDA-2016-00052). In 2011, precipitation accumulating on top of SDS 4, may have flowed through cracks in SDS 4, and again contaminated the ground surface (ADAMS Accession No. ML15236A299). The DOE remediated the newly contaminated soil around SDS 4 and stated that the remaining contaminants were immobile and that the contaminants from that 2011 leak did not reach the saturated zone and were not present under SDS 4 (ADAMS Accession No. ML15236A299). A stormwater runoff system was built after the 2011 precipitation event, which included a drain system just under the surface that encircles SDS 4. The entire system is extensive and does not only channel the water directly from SDS 4 to the sedimentation basin by the shortest route, but also, for example, channels stormwater around the open field immediately to the east of SDS 4 (see Figure 4).

Figure 4: SDS 4 and Drainage Path to Sedimentation Basin 4 near Well ZBG 16C and Well ZBG 16D (from SRR-CWDA-2014-00054)

In 2014, higher concentration data from Well ZBG 2 initiated the development of a characterization plan for nonvolatile gross beta, Tc-99 and nitrates in the groundwater in Z Area (SRNS-RP-2014-01214). The DOE had stated that it is important to delineate the top of the TCCZ to identify features (depressions and/or troughs), where the contaminated water is most likely to exist prior to collecting groundwater samples (SRNS-RP-2015-00902). The DOE implemented a groundwater characterization plan in July 2015 that included cone penetrometer test (CPT) pushes and DPT groundwater samples to characterize the extent of the groundwater plume. The only contaminants identified by the DPT groundwater characterization samples were nonvolatile gross beta, Tc-99, and nitrates (SRNS-RP-2015-00902). Based on the 2015 CPT lithology data, a depression feature was identified on the top of the TCCZ to the north and east of SDS 4, consistent with the feature observed in the 2014 CPT data. A lower rate of 40 ft/yr [12 m/y] and an upper rate 300 ft/yr [91.4 m/yr] of flow had been used to estimate potential minimum and maximum extents of contaminated water on top of the TCCZ (SRNS-RP-2014-01214).

In addition to nonvolatile gross beta, the characterization plan included analysis for Tc-99 which the DOE stated is responsible for the elevated nonvolatile gross beta concentrations. The DOE also stated that nitrate appears to be a co-contaminant with nonvolatile gross beta (SRNS-RP-2014-01214). As of 2017, Tc-99, nonvolatile gross beta, bismuth (Bi)-214, lead (Pb)-214, radium (Ra)-226, gross alpha, hydrogen (H)-3, and nitrate exceeded the PQL in one or more Z Area monitoring wells. In 2017, Wells ZBG 2D and ZBG 20D exceeded the 8 pCi/L threshold for nonvolatile gross beta groundwater concentrations and Well ZBG 20D also exceeded the 30 pCi/L threshold. The UTRA-LAZ Wells ZBG 3, ZBG 4, and ZBG 5 had detectable levels of nonvolatile gross beta groundwater concentrations (up to 5.53 pCi/L) that exceed the maximum nonvolatile gross beta value of 2.17 pCi/L for background Well ZBG 15D, which indicates potential contamination below the TCCZ near SDS 4. UTRA-LAZ Well ZBG 2C measured nonvolatile gross beta values up to 11.50 pCi/L which exceeds to 8 pCI/L threshold. Samples from Well ZBG 2D, which replaced Well ZBG 2, continue to have elevated groundwater concentrations for nonvolatile gross beta and Tc-99. In 2017, Well ZBG 20D had a maximum Tc-99 groundwater concentration of 126 pCi/L and a maximum value of 54.7 pCi/L were observed at Well ZBG 2D. For Well ZBG 2D, these values are lower than the Tc-99 groundwater concentrations in 2015 and 2016. The DOE has indicated that the more concentrated part of the plume has now moved on to ZBG 20D (SRNS-TR-2017-00387; Page 11). Tc-99 detected in Wells ZBG 2C and ZBG 4 indicates Tc-99 contamination has migrated through the TCCZ, but at low concentrations. Figures 5 and 6 show the approximate extent of the Tc-99 plume and the area of the Z Area nonvolatile gross beta groundwater plume as of 2015.

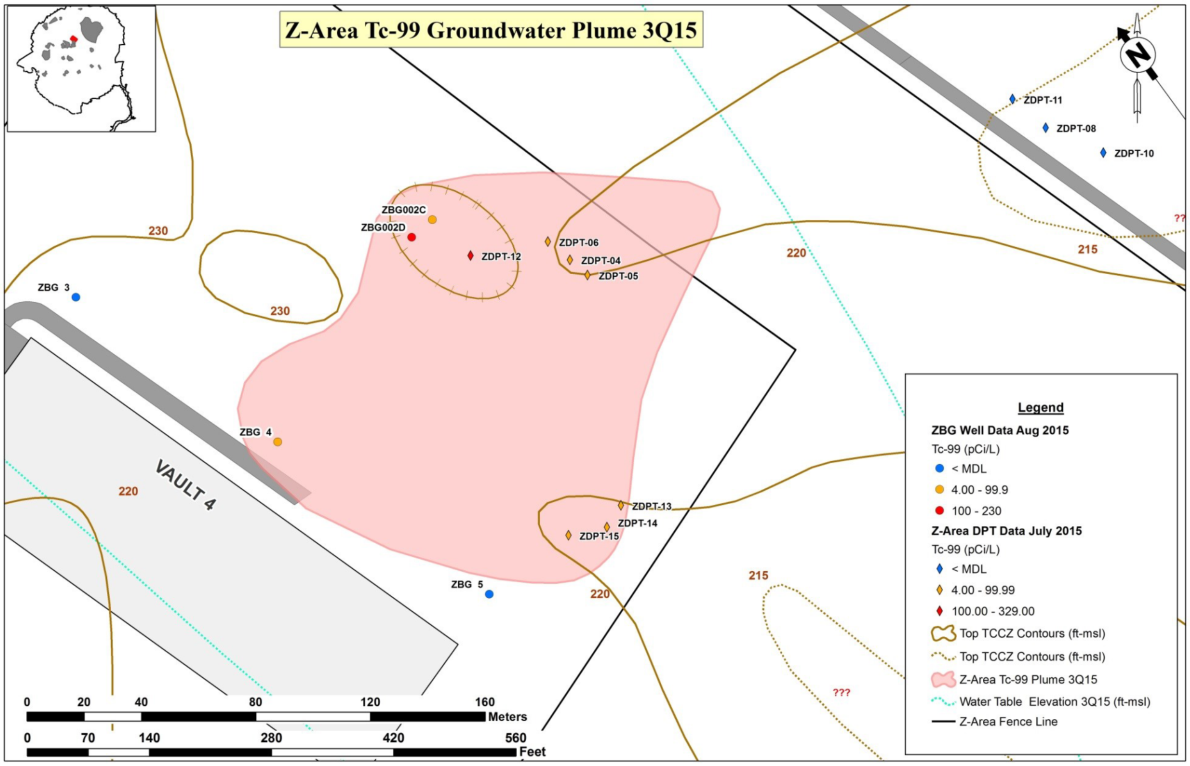


Figure 5: Approximate Extent of the Tc-99 Groundwater Plume and Contours of the Top of TCCZ in Z Area (from SRNS-RP-2015-00902)

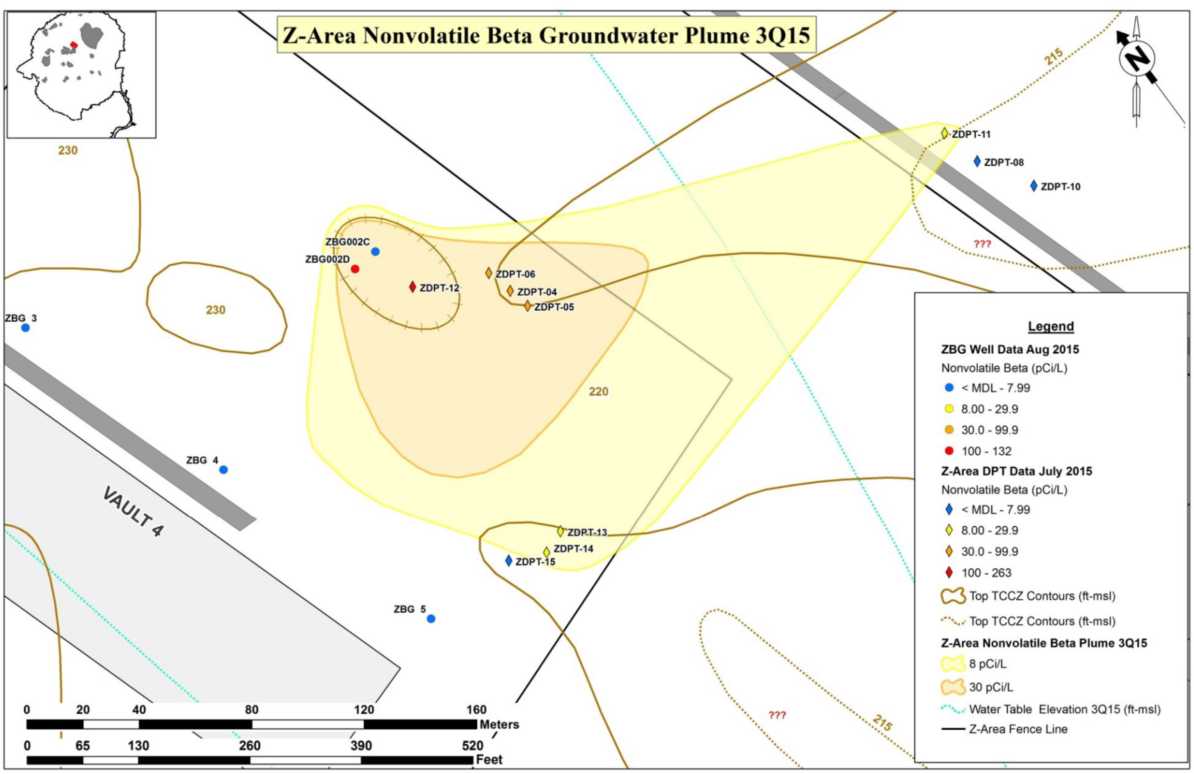


Figure 6: Approximate Extent of the Nonvolatile Gross Beta Groundwater Plume and Contours of the Top of TCCZ in Z Area (from SRNS-RP-2015-00902)

At SRS, nitrogen in the groundwater is primarily in the form of nitrate, because the groundwater is typically well oxygenated, especially in the UTRA-UAZ. All the 2017 nitrate results from ZBG 19D and ZBG 2D samples (highest 2017 value was 5.74 pCi/L) exceeded the maximum concentrations in background Wells ZBG 1 and ZBG 15D (2.03 and 1.30 mg/L, respectively). Since 2017 samples for ZBG 19D did not have detectable levels of nonvolatile gross beta or Tc-99, the DOE concluded in SRNS-TR-2017-00387 that the source of the nitrates is most likely not from saltstone material but rather from an upgradient source.

Ra-226, with a half-life of about 1,600 years, and its daughter radionuclides of Pb-214 and Bi-214, contributes to the gross alpha activity in groundwater. The 2017 maximum gross alpha groundwater concentration of 2.7 pCi/L at ZBG 4 is greater than the historic maximum of 1.48 pCi/L for background Well ZBG 15D. While the maximum Pb-214 groundwater concentration in 2016 is 101 pCi/L (from Well ZBG 3), the 2017 maximum Pb-214 groundwater concentration of 174 pCi/L at ZBG 19D is somewhat above the historic maximum of 171 pCi/L for the background well used for the southern monitoring wells (ZBG 15D). The 2017 maximum Ra-226 groundwater concentration of 1.52 pCi/L at ZBG 6 is above the historic maximum of 1.10 pCi/L for background Well ZBG 15D.

As of 2017, H-3, or tritium, is decreasing in concentration for most monitoring wells. Data from the background Wells ZBG 1 and ZBG 15D indicate H-3 in the Z Area is from an upgradient source.

Surface water and sediment contamination was detected in 2011 in Sedimentation Basin No. 4 (SRNS-TR-2017-00387). In 2004, contamination was found in a drainage ditch and soil adjacent to Cell G in SDS 4. In 2009 the contamination had moved southeast from SDS 4 into a forested area and by 2011 into Sedimentation Basin No. 4. Nine inches [23 cm] of rain in February 2013 (highest seasonal record since 1960) (SRR-WTF-2013-00012) brought additional contaminants via the stromwater runoff system from the SDS 4 area and flowed into the original sedimentation basin and then overflowed through the outfall culvert. Subsequent DOE probe surveys identified radiation above background levels in the outfall culvert area. The following year, Sedimentation Basin No. 4 was expanded with an additional basin (not shown in Figure 4). Concerns of potential groundwater contamination from Sedimentation Basin No. 4 initiated the installation of a well in the UTRA-UAZ (ZBG 16D) to monitor potential saturated conditions in the UTRA-UAZ and a deeper well in the UTRA-LAZ (ZBG 16C) to monitor the UTRA-LAZ. The screen zone for Well ZBG 16D is positioned on top of the TCCZ where saturated conditions have not been encountered since the installation of this well. Samples collected at the one shallower well (ZBG 16D) have so far indicated that there has been no impact to the groundwater from contamination in Sedimentation Basin No. 4.

<u>NRC Evaluation</u>

<u>Monitoring Factor 10.02</u>

Conceptual Models of Flow and Transport in the Z Area

During the May 2014 NRC SDF Onsite Observation Visit (OOV), the NRC staff and the DOE discussed groundwater monitoring results, (ADAMS Accession No. ML14199A219). The DOE discussed an alternative conceptual model where contamination from the saltstone disposal structures would be transported not only partially, but primarily above the TCCZ. The Z Area groundwater characterization study from 2015 showed this to be a valid conceptual model. Not only is flow and transport occurring above the TCCZ for short stretches as simulated by the DOE PORFLOW model (SRR-CWDA-2014-00095; Appendix B), but extends beyond the borders of the Z Area as sampling from ZDPT 11 and ZDPT 10 has shown. The NRC staff discussed that this modified conceptual model was different than the DOE conceptual model used in the 2009 SDF Performance Assessment (PA) (SRR-CWDA-2009-00017), where a significant fraction of contamination would be vertically transported into the UTRA-LAZ within 328 ft (100 m) of the disposal site. During the OOV, the NRC staff recommended that the DOE consider including the new alternative conceptual model in the next SDF PA because vertical transport could result in greater dilution than would occur in lateral transport across the TCCZ due to differences in the volume of mixing water. For example, although Figure B-3 in SRR-CWDA-2014-00095 clearly shows a lateral flowing PORFLOW-generated plume from SDS 4, at some point within the Z Area, the main body of the plume moves below the TCCZ. The field study in 2015 (SRNS-RP-2015-00902) demonstrated that this may not be the only conceptual model for flow and transport within the Z Area.

MF 10.02 is an open, high-priority MF and addresses the uncertainty of conceptual models and analysis of potential alternative conceptual models under the assumption that present natural and environmental processes will remain unchanged over time. The NRC staff will monitor the DOE consideration of alternative conceptual models in a future PA because of the potential importance of alternative conceptual models to dose projections. For example, the TRR on high density polyethylene and drainage layers (ADAMS Accession No. ML17081A187) recommended the consideration of an alternative conceptual model, and this TRR also recommends using an alternative conceptual model based on robust evidence that flow and transport is occurring predominantly in the upper part of the aquifer zone within the Z Area. The NRC staff recommends that the DOE consider including this alternative conceptual model in the next SDF PA because it may change the location of a hypothetical receptor well and the concentration of contaminants in the water a receptor may drink.

The NRC 2013 SDF Monitoring Plan states that the NRC expects to close MF 10.02 (Defensibility of Conceptual Models) under both §61.41 and §61.42 POs after the DOE updates the PA, and the NRC determines that the conceptual models are appropriate. This TRR does not recommend changing either the priority or the status of MF 10.02.

Monitoring Factor 8.02

Previous Comments and Issues Related to Groundwater Monitoring

Previously, the NRC staff has focused on several areas of the groundwater monitoring program and MF 8.02. Specifically, the NRC staff evaluates: (1) if the current wells are adequate to assess whether leaching from saltstone has occurred; (2) if the location of the background wells are adequate to assess leaching from saltstone by comparing background concentration values with concentration values from wells downgradient of saltstone disposal structures; (3) if the number and the locations of the groundwater monitoring wells are adequate; (4) if screen well openings are at an appropriate elevation to capture contaminates in the aquifer; and (5) if groundwater monitoring data show any increase in the concentration of radionuclides or saltstone indicators. The NRC staff considers historical concentrations measured in the groundwater and measured concentrations in upgradient wells when evaluating the appropriateness of the background levels.

Source and Extent of the SDS 4 Plume

This topic was discussed during the July 2015 NRC SDF OOV and documented in that OOV Report (ADAMS Accession No. ML15236A299). As for the source of the radionuclide contaminants downgradient of SDS 4, evidence indicates that contaminants from SDS 4 have traveled through the unsaturated zone and are then transported in the saturated zone on top of the TCCZ towards ZBG 2 and beyond. Although DOE indicated that the source of radionuclides contaminating the saturated zone was bleed water and contaminated rainwater weeping from Cell G of SDS 4 in the 1990s (SRR-CWDA-2016-00052; Page 84), a thorough technical basis for this statement was lacking. In 2011, precipitation accumulating on top of SDS 4 may have flowed through cracks in SDS 4, and again contaminated the ground surface (ADAMS Accession No. ML15236A299). The DOE remediated the newly contaminated soil around SDS 4 and stated that the remaining contaminants were immobile and that the contaminants from that 2011 leak did not reach the saturated zone and were not present under SDS 4 (ADAMS Accession No. ML15236A299). However, little technical justification was provided to support this DOE assertion. A stormwater runoff system was built after the 2011 precipitation event which included a drain system just under the surface that encircles SDS 4 (ADAMS Accession No. ML15236A299). The NRC staff asked about a future field study to exclude the possibility that additional contamination was being contributed from the unlined drainage ditches near SDS 4. The DOE replied that it could not rule that out as a source because the ditches are contaminated, but the levels of contamination are much smaller than the historical soil contamination near SDS 4 (ADAMS Accession No. ML16147A197). Although the DOE indicated that the source was from Cell G in SDS 4 in the 1990s, the DOE has not provided a definitive basis for this statement. Currently, the NRC staff is not clear if the source of the contaminants in the saturated zone downgradient of SDS 4 are from a smaller cell area in the SDS 4 from the 1990s or if the entire SDS 4 was a source of constituents multiple times until the final SDS 4 stabilization project was finished in 2015 (SRR-CWDA-2016-00052). The NRC staff considers it to be important to understand the source of the groundwater contamination in order to interpret the observed movement of the groundwater plume.

Since 2012, groundwater data has shown an increase in concentration of radionuclides in Well ZBG 2 as discussed in the previous section ‘Summary of Current Groundwater Monitoring Results.’ Although the elevated nonvolatile gross beta analysis for Well ZBG 2 was originally attributed to naturally-occurring radionuclides (SRNS-TR-2012-00285; Page 5), higher measurements the following years made plain that it could not be solely attributed to naturally-occurring radionuclides. In March of 2013, the nonvolatile gross beta had already exceeded 30 pCi/L at ZBG 2 with sampling result of 68.0 pCi/L. The DOE 2010 Groundwater Monitoring Plan (WRSC-TR-2005-00257, Rev.5) stipulates data reporting and actions in case of sample results exceeding the GWPS. This plan states that, “If the follow-up sampling confirms results above 30 pCi/L for gross beta, a plan for assessing the lateral and vertical extent of the plume will be developed and submitted to SCDHEC within 60 days,” and also, “If a GWPS is exceeded, this will be reported to SCDHEC promptly, and the well will be resampled within 30 days. If the exceedance is confirmed, all wells will be sampled for the complete GWPS list (Table 1), and an assessment monitoring plan will be submitted.” Subsequently, additional sampling and a resulting Z Area groundwater characterization study documented (SRNS-RP-2015-00902) a plume (see Figures 5 and 6 in this report).

The results of the 2015 Z Area groundwater characterization study provided convincing evidence that the plume has traveled past the boundaries of the Z Area (especially the results of ZDPT 10 and ZDPT 11), and that horizontal transport is much more dominant than vertical transport. Groundwater monitoring reports have provided data showing the increase in concentrations since 2012 for both the UTRA-UAZ and the UTRA-LAZ. As previously discussed, Wells ZBG 2, ZBG 2D, and ZBG 20D have shown nonvolatile gross beta measurements above 30 pCi/L with the highest measurement recorded so far being 158.0 pCi/L, 132.0 pCi/L, and 51.9 pCi/L, respectively. This is in comparison to the groundwater monitoring wells in the UTRA-LAZ including Wells ZBG 2C, ZBG 3, ZBG 4, and ZBG 5 with highest concentration values of 11.5 pCi/L, 4.3 pCi/L, 6.7pCi/L, and 3.6 pCi/L, respectively. The highest measurements for these well samples are all below 15 pCi/L and still have not reached the UTRA-UAZ concentration level of 17 pCi/L measured in 2012. 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 travel much further in a lateral direction.

An approximate calculation shows the extent of the difference traveled. Assuming the travel time is the difference between when the samples were taken at ZDPT 10 and ZDPT 11, the year 2015, and the assumed occurrence of the unintentional release in the year 1997 (i.e., 18 yr), and that the travel distance is between SDS 4 and ZDPT 11 (i.e., 1120 ft [341 m]), then the radionuclides in the ZDPT 11 sample traveled at a rate of at least 62 ft/yr [19 m/yr]. The McQueens Branch is circa 1320 ft [402 m] downgradient of ZDPT 11 so that at a rate of 62 ft/yr [19 m/yr] it would take another 15 yr to reach that creek; however, this simple calculation has a very large uncertainty including when the unintentional release reached the groundwater, time of arrival of the first radionuclides at ZDPT 10 and ZDPT 11, travel time through the TCCZ to reach the McQueens Branch, and dilution and retardation. Even with this associated uncertainty, data indicates that the preferred pathway of radionuclide transport is lateral in the UTRA-UAZ in this part of the Z Area.

The DOE has asserted numerous times that the TCCZ acts locally as an aquitard over parts of the SDF area, but that in general, the TCCZ does not significantly impede the downward mobility of groundwater across the TCCZ (DOE Responses to Request for Additional Information (RAI) Questions Far-Field Transport (FFT)-1, FFT-3, and FFT-4 in SRR-CWDA-2016-00004). More specifically, the DOE has stated that, “Vertically, the TCCZ at the SDF varies significantly, consisting of interbedded layers of clay, sandy clay, clayey sand, and sand. Laterally, the horizon can be used for hydrogeologic correlation purposes, but does not impede the vertical movement of water on the scale of the SDF.” For the NRC staff, the results of the 2015 Z Area groundwater characterization study have clearly shown that the TCCZ slows the vertical movement of contaminants when compared to the horizontal transport.

The DOE has not demonstrated that the lateral and vertical extent of the SDS 4 plume is known. For example, it is not clear if the contaminants have reached the McQueens Branch or at what point the water table dips below the TCCZ. Also not clear is why ZDPT 7 and ZDPT 9 were dry when they are at the center of a TCCZ trough as shown in Figure 20 of SRNS-RP-2015-00902 while the higher concentrations have been in ZDPT 11, which is not in the center of the trough as shown in Figures 21 and 23 of the same report.

The Z Area groundwater report from 2016 and 2017 (SRNS-TR-2016-00312 and SRNS-TR-2017-00387, respectively) no longer include the results from the 2015 Z Area groundwater characterization study when showing the extent of the plume (see Figure 7 below). Figures 8 and 9 in the 2017 Z Area Groundwater Report show a dashed line representing the extent of the nonvolatile gross beta plume and Tc-99 plume, respectively. Both plumes are considerably smaller than the plumes showed in the 2015 Z Area Groundwater Report (i.e., Figure 6 for nonvolatile gross beta and Figure 8 for Tc-99 in SRNS-TR-2015-00300). The representations of the 2016 and 2017 plumes have been shortened to the east and the south. The DOE gave no explanation for these changes. No UTRA-UAZ data on nonvolatile gross beta and Tc-99 exists which would allow a delineation of the plumes' boundaries to the north.

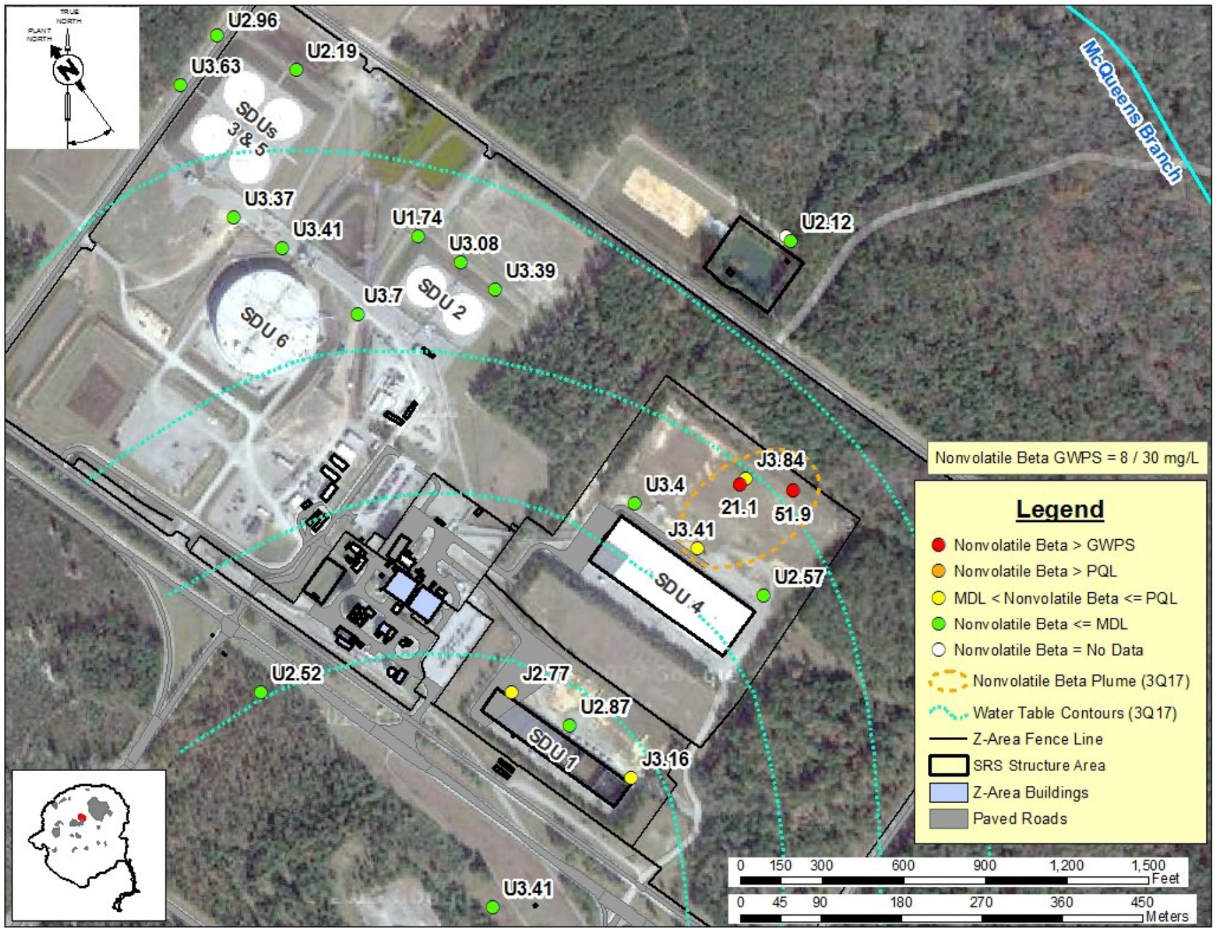


Figure 7: 2017 Nonvolatile Gross Beta Groundwater Plume from Figure 8 in SRNS-TR-2017-00387 Shown as Dashed Orange Line

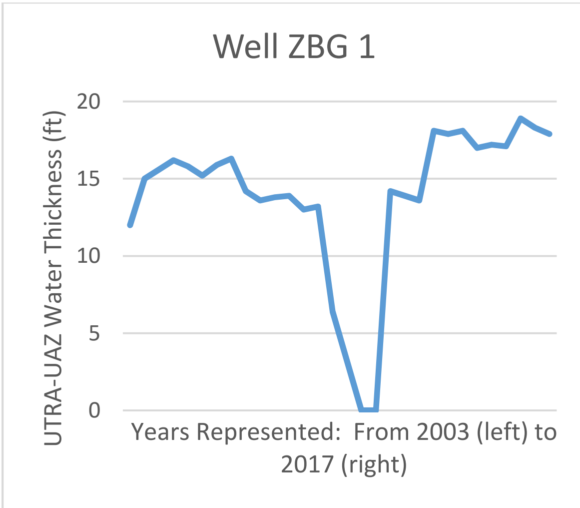
Figure 7 from the 2017 Z Area Groundwater Report shows peak concentration values for Well ZBG 2 and Well ZBG 2D having occurred back in 2015. As suggested by the DOE, this may indicate that the peak of the plume has moved on. The NRC staff is interested in knowing where the peak of the plume is currently and in what direction it is heading because that knowledge would both provide information on flow and radionuclide transport in the Z Area and allow a better evaluation of the potential safety concerns emanating from the plume. New DPT samples and/or new monitoring wells would be required to follow the peak of the plume.

In summary, the NRC staff is interested in knowing: (1) the source of the current SDS 4 plume (e.g., was it one single event near SDS 4 Cell G in 1997 or has the plume been generated by SDS 4 releasing contaminants due to a series of precipitation events over last 20 years); (2) the lateral and vertical extent of the plume; and (3) predictions of the future development of the plume (i.e., concentrations over time for different locations).

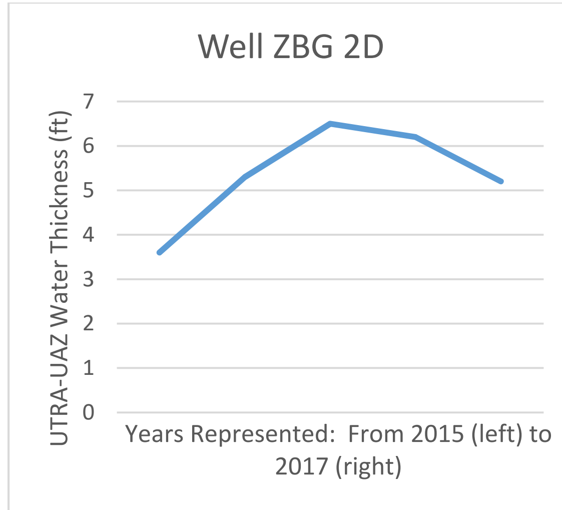
Sufficiency of the Number of Groundwater Monitoring Wells in the UTRA-UAZ

During the NRC February 2015 SDF OOV, as documented in the OOV Report (ADAMS Accession No. ML15041A562), the NRC staff questioned the DOE assumption that contamination was not present in the other locations besides the SDS 4 area and pointed out that there were very few wells screened above the TCCZ in other locations. In response, the DOE noted that in DPT samples located downgradient of SDS 4 and taken from above the TCCZ did not show elevated nitrate. However, other locations besides the SDS 4 area, such as the groundwater monitoring wells near SDS 2, SDS 3, SDS 4, and SDS 5, are only located in the UTRA-LAZ. The UTRA-UAZ below SDS 4 appears not to be saturated at least part of the time since sampling at ZDPT 1, ZDPT 2, and ZDPT 3 came up dry in September of 2014 (SRNS-RP-2014-01214). It is interesting to note that despite the partial or full-time unsaturated condition of the UTRA-UAZ near SDS 4, the contaminants from the unintentional release contaminated the UTRA-UAZ and appeared in the samples from Well ZBG 2 before they appeared in samples from the UTRA-LAZ below SDS 4. If the UTRA-UAZ is saturated and became contaminated near SDS 2, SDS 3, and SDS 5, it is unknown how long the current groundwater monitoring wells in the UTRA-LAZ would take to detect the contaminants in the UTRA-UAZ. For this reason, groundwater monitoring wells should be located in both aquifer zones when monitoring a disposal structure. Depending on the conceptual model of flow, the wells for UTRA-UAZ and for UTRA-LAZ could either be a nested monitoring well or separated in location.

It is possible that it would not be cost effective to install a groundwater monitoring well in both the UTRA-UAZ and the UTRA-LAZ if the UTRA-UAZ is dry near the locations of interest. However, the data that have been collected up to this point indicate that the UTRA-UAZ is saturated for most of the time at many locations. Figure FFT-1.3 from SRR-CWDA-2016-00004 shows the water levels in ZBG 2. Between 1987 and 2014, a total of nine samples were taken when water levels within ZBG 2 were below that of the top of TCCZ coinciding with two periods of relatively low rainfall and indicating that the UTRA-UAZ was dry. However, for the rest of that time period the UTRA-UAZ contained water. Figures 8(a) through (d) also show water thicknesses within the UTRA-UAZ for ZBG 1, ZBG 2D, ZBG 7, and ZBG 15D. Only the background well ZBG 1 had one year (2011) in which the UTRA-UAZ was dry, and the data for 2010 is missing with regard to Well ZBG 7 which is representative of the area near SDS 1. Wells ZBG 6 and ZBG 8 had similar UTRA-UAZ water thicknesses as in Well ZBG 7.



(a)



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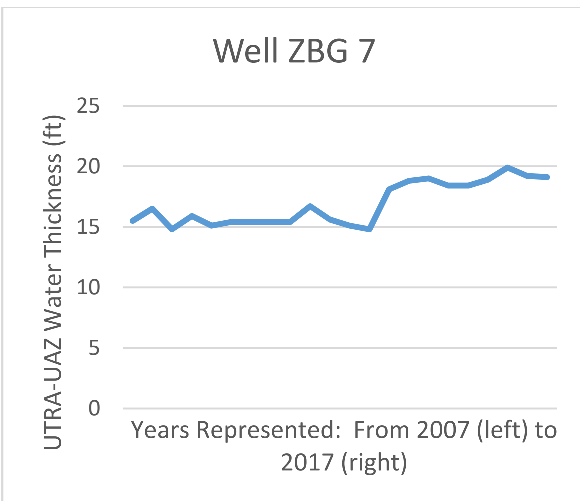
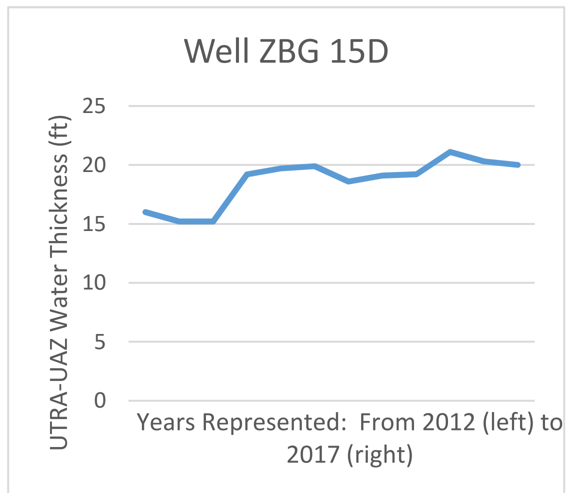


(c)



(d)

Figure 8(a)-(d): UTRA-UAZ Water Thickness (ft) for the Years 2003 to 2017 (Data from Z Area Groundwater Monitoring Reports from 2003 through 2017)

Extent, Thickness, and Topography of the TCCZ

The DOE 2009 SDF PA (SRR-CWDA-2009-00017; Page 178) stated that the TCCZ is of particular interest because "[it] acts locally as an aquitard, supporting a water table and retarding the downward flow of groundwater. The presence or absence, thickness, and extent of this unit are important inputs into groundwater flow and transport models that are in turn used to demonstrate expected compliance with applicable groundwater regulatory requirements." The NRC staff agrees with the importance of the TCCZ. However, the extent, thickness, and properties of the TCCZ are not fully known. For example, the vertical gradient of the water in and around the TCCZ, which is significant for radionuclide transport through the TCCZ, is not well known. The results of the Z Area Groundwater Characterization Data Report (SRNS-RP-2015-00902) have clearly shown how important the TCCZ can be in directing the flow of groundwater and the plume of contaminants if released to the soil. Contaminants appear to travel relatively long distances near the surface of the TCCZ and are directed by the topography of the TCCZ. When and where a hypothetical receptor may receive a dose due to radioactive waste release from one or more saltstone disposal structures appears to be strongly dependent on the topography of the TCCZ and the degree of saturation above it. Additional hydrogeological complexities add to the uncertainty with regard to understanding the flow and potential transport of radionuclides. To decrease this uncertainty, the DOE should undertake further characterization studies that have the goal of determining which factors are significant for flow and transport in the Z Area and obtaining significant parameter data for numerical simulation.

The hydrogeological system of the Z Area is more complex than what a brief review of the system may indicate. For example, the DOE document SED-GTE-2008-002 indicated that the TCCZ is present in every borehole and gave the SDF area a thickness range between 4.7 to 14.8 ft [1.4 to 4.5 m]. The Saltstone Disposal Cells No. 3 and 5 Geotechnical Investigation Report (K-ESR-Z-0002) documented the results of this geotechnical investigation. The TCCZ is referred to in the geotechnical reports as the C2 layer. The report states, "The C2 consists of medium dense yellow-brown and light green clayey fine sand interlayered with stiff yellow-brown silty clay." Figure 3 from the DOE document K-ESR-Z-0002 showed the TCCZ to be entirely missing in a section of the disposal structure area. There is a significant thinning of the horizon from right to left across the section, with the C2 layer nonexistent in the two CPTs on the left side of the section.

An additional example of the hydrogeological complexity is when the NRC staff discussed the surface topography of the TCCZ and the results of the Z Area Groundwater Characterization Data Report (SRNS-RP-2015-00902) with DOE staff during the NRC April 2016 SDF OOV, as documented in the OOV Report (ADAMS Accession No. ML15236A299). Although the DOE had described the Well ZBG 2 area as acting as a sump, and Figure 23 from SRNS-RP-2015-00902 showed such a depression, the contaminants seem to be flowing past Well ZBG 2 as indicated by the concentration values downgradient of the wells ZBG 2 and ZBG 2D. At that time, the DOE indicated that they did not have a satisfactory explanation and that much is still not known (ADAMS Accession No. ML16147A197).

The DOE has stated (SRR-CWDA-2016-00004), and the NRC staff is aware, that the horizon within the TCCZ is complex and does not consist of a single competent clay layer but of many non-continuous layers of different sediments types such as silty sand, sandy silt, silt, and clay. In addition, the TCCZ appears at various elevations across the SDF. In some instances the bottom of the TCCZ is higher in elevation than the top of the TCCZ in nearby wells. Perched water may also exist and flow above the TCCZ as seen in the data obtained from Well 1A and recorded in the DOE Z Area groundwater reports up to 2006 adding to the hydrogeologic complexity of the of the Z Area.

The TCCZ in Z Area is not well defined and the dose implications are not clear to the NRC staff because of uncertainty regarding lateral transport and sorption due to that layer. Due to the significance on flow and transport of radioactive material, additional information is needed about the extent, thickness, and topography of the TCCZ in the entire Z Area, including, if saturated, information on the vertical gradient within the TCCZ if the UTRA-UAZ is saturated.

Treating the UTRA-UAZ and the UTRA-LAZ as Separate Hydrogeologic Units

The DOE has stated in the past that they do not recognize a significant difference between the UTRA-UAZ and the UTRA-LAZ such that they should be treated as two separate hydrogeological units. For example, the DOE stated that, "All of this information indicates there is hydraulic connectivity across the TCCZ, therefore, both the UAZ and LAZ should be treated as the saturated zone for SDF modeling purposes" (SRR-CWDA-2016-00004). Consequently, the DOE has not been monitoring the UTRA-UAZ and the UTRA-LAZ as two separate units, but as one unit. For example and as previously mentioned, the screen intervals for the groundwater monitoring wells for SDS 2, SDS 3, SDS 4, and SDS 5 are open only in the UTRA-LAZ, and the assumption is made that any unintentional release of radionuclides from one of the disposal units will quickly move through the TCCZ and be detected in the samples from the monitoring wells. Groundwater monitoring wells are placed either in the UTRA-UAZ or the UTRA-LAZ, and the only nested wells that exist in the Z Area are Wells ZBG 2C and 2D and Wells ZBG 16C and 16D. All groundwater data gathered are treated as originating from the same unit so that water table maps or potentiometric surface maps are constructed with the same data set. Eleven of the 20 groundwater monitoring wells are located in the UTRA-LAZ; therefore, water level measurements from those wells show a potentiometric surface rather than the UTRA-UAZ water table level. The DOE has presented such potentiometric surface maps of the UTRA-LAZ in the past (WSRC-TR-96-0399, Rev. 1, Vol. 2: Figure 15). Until 2015, hydraulic gradients were calculated using a combination UTRA-UAZ and UTRA-LAZ water elevation points, but DOE groundwater reports now exclusively use UTRA-UAZ data for these calculations.

As a technical justification for the general practice of treating the two aquifer zones as one unit, the DOE has pointed to the water table shown within a figure of a Z Area cross section found in SRR-CWDA-2016-00004 (Figure FFT-1.7). Figure FFT-1.7 shows most, but not all, of the information from the original Figure 5 in SRNS-TR-2015-00300. The DOE has described this water table as mimicking the topography with very smooth contours (also see Figure 1 in this TRR), which is what would be expected of water table wells if the TCCZ was not a significant impedance to flow. However, the information in the original figure contains errors and lacks information in certain areas. For example, the water table is represented by five data points: ZBG 15D, ZBG 7, ZBG 4, ZBG 2D, and ZBG 16C. While the water table is well represented on the left side of the figure, data from the well nest ZBG 16 and from ZCPT 1 were used in error to represent the area near the McQueens Branch. That data is not located near the Z Area cross section A-A' as seen in Figure 2 in SRNS-RP-2015-00902, even so, water table data from Well ZBG 16C and the stratigraphy from ZCPT 1 were used in the cross section. Unlike Well ZBG 16C, ZDPT 11 and ZDPT 8 are relatively near ZCPT 9 which is on the A-A' cross section line (also see Figure 3 in this TRR) and data from these samples could provide additional information. Water from ZDPT 11 was taken above the TCCZ and at a depth of approximately 213 ft-amsl [65 m-amsl] while the top of the TCCZ of the nearby ZCPT 8 is given at 212.74 ft-amsl [64.8 m-amsl] (Table 2 and Table 1 from SRNS-RP-2015-00902, respectively). This places the TCCZ lower that what is represented by ZCPT 1 as seen in Figure 1 with a water table above the TCCZ and in the UTRA-UAZ. The source of the data used to represent the water table and the stratigraphy between the ZCPT 9 area and the McQueens Branch, and therefore the transition of the water table from the UTRA-UAZ to the UTRA-LAZ, as seen in Figure FFT-1.7 from SRR-CWDA-2016-00004, is not given or omitted.

Figure FFT-1.4 in SRR-CWDA-2016-00004 shows a strong correlation between the UTRA-UAZ water levels in ZBG 2 and the UTRA-LAZ water levels in ZBG 3, ZBG 4, and ZBG 5. The NRC staff agrees with the DOE that there is a hydraulic connectivity across the TCCZ; however, the NRC staff disagrees with the DOE that all water table and piezometric measurements can be used without consideration of whether individual measurements represent the UTRA-UAZ or the UTRA-LAZ. Figure FFT-1.4 shows that it is not uncommon for the water levels at ZBG 2 to be as high or higher than the water levels of ZBG 3, ZBG 4, and ZBG 5 even though the latter wells lie roughly 300 ft [91 m] upgradient of ZBG 2. Figures 3 and 4 in the 2017 Z Area Groundwater Report (SRNS-TR-2017-00387) also show higher values for the new Well ZBG 20D located in the UTRA-UAZ than ZBG 3, ZBG 4, and ZBG 5 for both the first quarter and the third quarter of 2017, and if the UTRA-UAZ and the UTRA-LAZ were treated as one water table aquifer, then it could be interpreted to mean that the groundwater flow is from the ZBG 2 area to SDS 4.

The DOE also presented the water table elevation from the first quarter of 2015 for ZBG 2 located in the UTRA-UAZ and ZBG 2C located in the UTRA-LAZ. The difference between the two water table measurements was a mere 0.3 ft [0.1 m] indicating, and as DOE states, that "they represent the same aquifer." However, although the wells were described as being directly adjacent to each other, the stratigraphy is surprisingly different for adjacent wells as can be seen by comparing the elevation of the top of the TCCZ for Well ZBG 2 at 215.7 ft-amsl [65.75 m-amsl] with Well ZBG 2C at 220.0 ft-amsl [67.06 m-amsl] (SRR-CWDA-2014-00061, Attachment 2), or a difference of 4.3 ft [1.3 m]. A better comparison of water table elevations between the two aquifer zones may be between Well ZBG 2D located in the UTRA-UAZ and Well ZBG 2C which has shown an average difference between 2 – 2.5 ft [0.61 – 0.76 m] in the years 2016 and 2017.

Discussions between the NRC staff and the DOE relating to this topic have occurred in the past including during the April 2016 NRC SDF OOV, as documented in the OOV Report (ADAMS Accession No. ML16147A197). The NRC staff recommended that the DOE: (1) create a water table map by using actual water table measurements from the UTRA-UAZ; and (2) create a potentiometric surface map by using potentiometric measurements from the UTRA-LAZ. During the OOV, the DOE agreed that wells in the UTRA-UAZ and UTRA-LAZ should not be represented together in water table maps of Z Area and indicated that there was an effort to change that practice.

Groundwater Monitoring Wells Needed in the UTRA-LAZ for Background Water Concentration Values

The DOE had reinterpreted the location of the groundwater divide in the Z Area in the 2007 Groundwater Monitoring Report (WSRC-TR-2008-00001; Figure 4). Since the installation of a new background well in 2012 (ZBG 15D), the background concentration values used by the DOE to compare with concentration values obtained from the groundwater monitoring wells within the UTRA-UAZ are considered by the NRC staff to be appropriate; however, not for the UTRA-LAZ. Both monitoring wells for background values (Wells ZBG 1 and ZBG 15D) are located in the UTRA-UAZ. There are currently no monitoring wells obtaining background values for the UTRA-LAZ although eleven of the 20 groundwater monitoring wells are located in the UTRA-LAZ. The 2015 Z Area groundwater characterization study, and previous discussions in this report, make clear that the UTRA-UAZ and the UTRA-LAZ should be treated as separate hydrogeologic units and, as such, separate background monitoring wells are needed for the UTRA-LAZ.

Monitoring Potential Contamination from the Unlined Sedimentation Basins No. 4

SRNS-TR-2012-00767 documented the environmental results from the Sedimentation Basin Number 4. As previously discussed, SDS 4 had a history of moisture developing on the wall exterior due to preexisting construction cracks in addition to water accumulating in the gaps that formed between the saltstone monolith and vault wall exterior. Gutters, downspouts, and an underground conveyance pipe were installed around SDS 4 to carry stormwater into ditches directed towards Sedimentation Basin No. 4.

Given that in 2009 the contamination runoff from SDS 4 had moved southeast into a forested area (SRR-CWDA-2016-00052), the possibility may exist that some part of the stormwater runoff drainage system between SDS 4 and the sedimentation basin as seen in Figure 4 in this TRR is contaminated. The NRC staff is interested in being informed of the findings of any contamination when and if the DOE ever decides to remove and/or replace the underground conveyance pipe and ditch system around SDS 4 and to Sedimentation Basin No. 4.

The radiological results of the environmental monitoring of basin water (SRNS-TR-2012-00767) showed an increasing trend for cesium (Cs)-137 from 2010 to 2012 and an increasing trend for Tc-99 from 2007 to 2012. The maximum Cs-137 concentration observed was 1300 pCi/L during July 2012, which is 43% of the DOE Derived Concentration Standard of 3000 pCi/L for liquid releases. The maximum Tc-99 concentration observed was 28.9 pCi/L, 0.07% of the DOE Derived Concentration Standard of 44,000 pCi/L for liquid releases. The increase during 2011 coincided with the timeframe when additional stormwater drains were directed to the basin from the SDS 4 area.

The 2014 installed groundwater monitoring wells ZBG 16D and ZBG 16C are close to each other and downgradient of Sedimentation Basin No. 4. ZBG 16D is above the TCCZ and dry and ZBG 16C is screened below the TCCZ and as of yet has not yielded higher contaminant concentration values. During the technical discussion of groundwater data during the 2016 NRC SDF OOV, as documented in the OOV Report (ADAMS Accession No. ML15236A299), the SCDHEC staff raised a concern that contaminants will migrate from the unlined sedimentation basin into the groundwater. The NRC staff will continue to monitor contaminant concentrations in Well ZBG 16C which is downgradient of the sedimentation basin; however, it is the typically dry Well ZBG 16D which may be the well of greater use in detecting any initial leak from the unlined basin if it should occur. As shown by the experience gathered from monitoring wells ZBG 3, ZBG 4, and ZBG 5, the contaminants from the unintentional release from SDS 4 contaminated the UTRA-UAZ downgradient of SDS 4 despite unsaturated conditions in the UTRA-UAZ near SDS 4, and appeared in the samples from Well ZBG 2 before they appeared in samples taken from the UTRA-LAZ below SDS 4. This conceptual model of flow may be true for the area near the basin also, that is, a pulse of infiltrating water may bring contaminants down through the UTRA-UAZ and then flow on top of the TCCZ before they are detected in Well ZBG 16C. Unlike the SDS 4 area, however, this area does have a monitoring well in the UTRA-UAZ (Well ZBG 16D) near the sediment basis and the contaminant release may be detected earlier than with the SDS 4 release.

New SDF Monitoring Factor on Early Identification and Monitoring of Groundwater Plumes in the Z Area

MF 8.02 is an open, periodic MF (i.e., a MF related to data that the NRC staff expects to review on a periodic basis) and addresses identifying early releases of radionuclides from saltstone whereby the NRC staff reviews groundwater data from the groundwater monitoring system for any indication of unintentional release of contaminants. The DOE conducts an effluent monitoring and environmental surveillance program on an ongoing basis. The most useful environmental data in assessing compliance with PO §61.41 is the groundwater data from the Z Area because the NRC staff expects that the groundwater will be the dominant pathway for long-term releases from the SDF. Increased concentrations of radionuclides or contaminants in the groundwater samples obtained near the SDF may indicate that radionuclides are leaching from the disposal structures and that the SDF is not performing as expected. In assessing compliance with PO §61.42, the groundwater pathway is expected to dominate long-term doses to inadvertent intruders. MF 8.02 is a periodic monitoring factor where the groundwater data will be monitored in perpetuity at the SDF. This TRR does not recommend changing either the priority or the status of MF 8.02.

After reviewing the SRS Z Area groundwater monitoring system, the NRC staff identified numerous new concerns regarding the groundwater monitoring system in the Z Area. Those NRC staff concerns are (1) the current locations and the current number of groundwater monitoring wells in the upper part of the aquifer system in order to detect saltstone disposal structure leaks or any unintentional release to the subsurface relatively early; (2) the current locations and the current number of groundwater monitoring wells to adequately follow the development of the SDS 4 plume within the Z Area, and (3) the current lack of groundwater wells to obtain background concentration values from the UTRA-LAZ. This TRR recommends creating a high-priority MF 8.03 (Identification and Monitoring of Groundwater Plumes in the Z Area) under MA 8 (Environmental Monitoring) under both PO §61.41 and PO §61.42 because the periodic nature of MF 8.02 does not address those newly identified NRC staff concerns. Under MF 8.03, the specific issues related to the groundwater monitoring system in the Z Area would be monitored. The NRC staff expects to close MF 8.03 when the NRC staff determines that the groundwater monitoring system in the Z Area can: (1) identify contaminants in the groundwater from a saltstone disposal structure at or before the point of compliance as identified in Revision 5 of WSRC-TR-2005-00257 (i.e., no more than 150 ft [46 m] from the saltstone disposal structure); and (2) track the movements of the groundwater plume (e.g., know the horizontal and vertical extent of the plume; be able to follow the approximate path of the peak of the plume). Note that the contaminants from the previously described SDS 4 plume were first detected in the groundwater at approximately twice the distance of the above-mentioned point of compliance.

The NRC staff recommends designating the new MF 8.03 as high-priority for the following reasons: (1) during the operational period of a disposal facility, the NRC staff expects additional geologic, hydrologic, or other disposal site data pertinent to the long-term containment of emplaced low-level radioactive wastes to be collected that will support the model results of technical analyses; (2) a PA and intruder assessment need to be supported by a program of tests, experiments, and analyses to evaluate and verify the accuracy of information used to demonstrate that the Part 61 POs are met before disposal site closure. An important element of such a model support program would include the verification that engineered barriers and other defense-in-depth protections were constructed as designed and will perform within limits assumed during licensing.

The NRC staff determined that the currently operational saltstone disposal structures (i.e., SDS 1 through SDS 6) are good examples of engineered barriers designed to isolate waste for a longer time period. A PA and intruder assessment use sets of data and assumptions when simulating likely outcomes of system performance. Ideally, the expected performance would be supported and confirmed by additional geologic, hydrologic, or other disposal site data collected up to the institutional control period. If expected performance cannot be confirmed, or is contradicted, a technical analysis may need to be updated. Conditions that could trigger an update of the technical analyses could include new information on engineered barrier performance or monitoring data that are inconsistent with current analyses. For example, design flaws in SDS 1 and SDS 4 caused radionuclides to be released into the environment. The importance of groundwater monitoring, which provided the data to document the release, was demonstrated. Assumptions relied upon for the expected performance of SDS 1 and SDS 4, and the technical analyses at that time, needed to be updated.

As discussed above, model support is an important component of a PA and technical analyses in that it may be able to verify past assumptions and model output results. Similarly, environmental monitoring data can be used to confirm performance results for future technical analyses or at least provide a measure of confidence in the model outcomes. Simulation results can be compared with groundwater monitoring data while the PA process is ongoing, thereby allowing updates to occur during the analysis instead of requiring an update of a flawed technical analysis after its completion and after the PA results had been documented.

The SDS 4 Plume as a Calibration Goal

A PA is a type of systematic risk analysis that addresses the following four questions: (1) what can happen; (2) how likely is that to happen; (3) what are the resulting impacts of that happening; and (4) how do those impacts compare to specifically defined standards. The purpose of a PA is to inform decisions that need to be made and provide a level of confidence for stakeholders and interested parties that those decisions are appropriate. The current scope and extent of the plume originating from SDS 4 would not have been predicted with the current PORFLOW and GoldSim models that were documented in the DOE "Fiscal Year 2014 Special Analysis for the Saltstone Disposal Facility at the Savannah River Site" (SRR-CWDA-2014-00006). The DOE stated in SRR-CWDA-2016-00004 (Page 171) that, "The DOE does plan to update the General Separations Area database and the resulting aquifer flow and transport PORFLOW modeling. This update will incorporate any new information with respect to Z Area hydrology (e.g., the subsurface structure in the TCCZ) and site-specific plumes shall be reviewed to inform the assumed dispersivity values." The update to the GSA database has now been completed and the NRC staff agrees with the DOE decision to use site-specific plumes to obtain parameter values. The past behavior of the SDS 4 plume should be simulated and the current position and concentrations of the plume used as a calibration target. Successfully calibrating the concentration and position of the plume would provide additional confidence in the accuracy of the DOE's current models.

In addition, a well calibrated flow model specific to the Z Area, may narrow down the range of horizontal saturated hydraulic conductivity values that have been used in the Z Area SDF groundwater reports for the UTRA-UAZ. These values have ranged from 1.7 to 13 ft/d [0.52 to 4.0 m/d] with resultant groundwater flow rates between 14 ft/yr [4.3 m/yr] in 1997 to 344.2 ft/yr [105 m/yr] in 2015. If the higher hydraulic conductivity value is not supported, then a numerical model may be simulating unrealistically high dilution. The DOE document 'Hydraulic Property Data Package for the E-Area and Z-Area Soils, Cementitious Materials, and Waste Zones' from September 2016 (WSRC-STI-2006-00198) had recommended in Table 5-14 that saturated hydraulic conductivity values be taken from WSRC-TR-96-0399, Rev. 1. Horizontal saturated hydraulic conductivity values in that report ranged from circa 4 ft/d [1 m/d] (WSRC-TR-96-0399, Rev. 1; Figure 31) to 7.5 ft/d [2.3 m/d] (WSRC-TR-96-0399, Rev. 1; Page iv); however, those values were modified higher during the calibration exercise for SRS GSA PORFLOW Model, as documented in WSRC-TR-2004-00106. The Z Area is on the periphery of this regional model and it is not clear to the NRC staff that the modeling results from the GSA flow model are a better technical basis then field data obtained near SDF.

NRC Conclusions

For MF 10.02:

- The Z Area groundwater characterization study (SRNS-RP-2015-00902) documented lengthy flow and transport occurring on top of the TCCZ. The DOE should consider including that alternative conceptual model in the next update to the SDF PA.

For MF 8.02:

- The DOE groundwater monitoring system in the Z Area is providing useful information on the hydrogeological system in the Z Area. MF 8.02 is a periodic monitoring factor where the groundwater data will be monitored in perpetuity at the SDF.

For MF 8.03:

- Due to the following new NRC staff concerns regarding the groundwater monitoring system in the Z Area: (1) the locations and the number of groundwater monitoring wells in the upper part of the aquifer system in order to detect saltstone disposal structure leaks or any unintentional release to the subsurface relatively early; (2) the locations and the number of groundwater monitoring wells to adequately follow the development of the plume within the Z Area, and (3) the lack of groundwater wells to obtain background concentration values from the UTRA-LAZ, this TRR recommends creating a new, high-priority MF 8.03 (Identification and Monitoring of Groundwater Plumes in the Z Area) under MA 8 (Environmental Monitoring) under both PO §61.41 and PO §61.42.

- The NRC staff expects to close MF 8.03 when the NRC staff determines that the groundwater monitoring system in the Z Area can: (1) identify saltstone contaminants in the groundwater in the SDF at no more than 150 ft [46 m] from a disposal structure; and (2) track the movements of the groundwater plume (e.g., know the horizontal and vertical extent of the plume; be able to follow the approximate path of the peak of the plume).

Further Conclusions

- The Z Area groundwater characterization study documented a plume in SRNS-RP-2015-00902. Based on the information described in this TRR, 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 (e.g., did the plume originate from one single event near SDS 4 Cell G in 1997 or has the plume been generated by SDS 4 releasing contaminants due to a series of precipitation events over last 20 years) 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.

- Based on the information described in this TRR, the NRC staff determined that the number of groundwater monitoring wells in the UTRA-UAZ is not adequate. Although contaminants from saltstone would first appear in the UTRA-UAZ, groundwater monitoring wells located near SDS 2, SDS 3, SDS 4, and SDS 5 are only located in the UTRA-LAZ. Due to the findings in SRNS-RP-2015-00902 and given the hydrogeological influence of the TCCZ, groundwater monitoring wells near saltstone disposal structures should be located in both the UTRA-UAZ and the UTRA-LAZ.

- Based on the information described in this TRR, the NRC staff determined that, due to the significance on flow and transport of radioactive material, the DOE should provide additional information about the extent, thickness, and topography of the TCCZ in the entire Z Area, including information on the vertical gradient within the TCCZ within the Z Area if the UTRA-UAZ is partially saturated.

- The NRC staff determined that the 2015 Z Area groundwater characterization study (SRNS-RP-2015-00902) demonstrated that the UTRA-UAZ and the UTRA-LAZ are separate hydrogeologic units and, as such, background monitoring wells are needed for the UTRA-LAZ. The current number of groundwater monitoring wells to obtain background concentration values for the UTRA-LAZ is not adequate because no monitoring wells are currently obtaining background values for the UTRA-LAZ, although 11 of the 20 groundwater monitoring wells are located in the UTRA-LAZ.

- Based on the information described in this TRR, the NRC staff determined that the UTRA-UAZ and the UTRA-LAZ as should be treated as separate hydrogeologic units. As such, NRC staff recommends to: (1) create a water table map by using actual water table measurements from the UTRA-UAZ; and (2) and to create a separate potentiometric surface map by using potentiometric measurements from the UTRA-LAZ.

- The NRC staff will monitor the results of the Well ZBG 16D and Well ZBG 16C for any indications of contaminants leaking from the unlined Sedimentation Basins No. 4.

- If and when the DOE decides to remove and/or replace the underground conveyance pipe and drainage ditch system between SDS 4 and Sedimentation Basin No. 4, the NRC staff requests to be informed of the DOE findings regarding contamination.

- The Z Area is on the periphery of the GSA regional model and it is not clear to the NRC staff that the modeling results from the GSA flow model are a better technical basis then field data obtained near SDF.

- The NRC staff agrees with the DOE decision to use site-specific plumes to obtain parameter values. The DOE should simulate the past behavior of the SDS 4 plume and should use the current position and concentrations of the plume as a calibration target. Successfully calibrating the concentration and position of the plume would provide additional confidence in the accuracy of the DOE current models.

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