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Discussion of NRC Comments and Requests for Additional Information Needed to Complete Preparation of a Technical Evaluation Report for Consultation Regarding H-Area Tank Farm, Savannah River Site

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NRC CONSULTATION PROCESS

NRC Statutory Role-Consultation

- Per Ronald W. Reagan National Defense Authorization Act (NDAA) of 2005 Section 3116
- DOE to consult with NRC prior to final waste determination (WD)
- Consultation for H Tank Farm began in February 2013
- NRC staff in process of reviewing draft WD and associated performance assessment
- Primary NRC work product-Technical Evaluation Report (TER)
- Request for Additional Information (RAI)-Interim step to complete TER

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NRC Role (cont.)

- Today’s meeting is part of RAI process
- Formal RAIs were provided to DOE on July 31, 2013
- NRC will summarize comments and RAIs
- Discussion and clarification among DOE and NRC staff
- Path forward for RAI response
- Public input
- DOE response anticipated in fall 2013
- NRC completion of TER in early 2014

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NDAA Criteria

- Criterion 1: Does not require permanent isolation in a deep geologic repository for spent fuel or high-level radioactive waste;
- Criterion 2: Has had highly radioactive radionuclides removed to the maximum extent practical; and
- Criterion 3A: Does not exceed Class C concentration limits (10 CFR 61.55) and will be disposed of
  - In compliance with 10 CFR Part 61 Performance Objectives and
  - Pursuant to a State-approved closure plan or State-issued permit
- Criterion 3B: Exceeds Class C concentration limits but will be disposed of
  - In compliance with 10 CFR Part 61 Performance Objectives;
  - Pursuant to a State-approved closure plan or State-issued permit
  - Pursuant to plans developed by the Secretary in consultation with NRC

RAI Development Process

- NRC staff reviewed DOE’s draft basis for waste determination and supporting performance assessment
- NRC staff and DOE conducted a series of public meetings and technical exchanges
- Exchanges provided NRC an opportunity to gain clarification from DOE on its approaches
- RAIs informed by FTF consultation and monitoring
- RAIs available at ADAMS† accession number: ML13196A135

† Agencywide Documents Access and Management System (ADAMS), http://www.nrc.gov/reading-rm/adams.html

NRC-DOE Interactions

- March 14, 2013, ML13086A081
- April 4, 2013, ML13106A338
- April 17, 2013, ML13126A127
- May 9, 2013, ML13154A327
- May 16, 2013, ML13193A072
- June 5-6, 2013, ML13183A410
- July 3, 2013, ML13199A413

Overview of RAIs

- 30 RAIs
  - Criterion 1: 0
  - Criterion 2: 7
  - Criterion 3: 23
    - Inventory: 5
    - Waste Release and Near-Field: 14
    - Hydrology and Far-Field Transport: 4
- 13 Clarifying Comments (CC)
- Also identified issues under FTF monitoring factors (ML12212A192) that are relevant for HTF

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CRITERION 2

RAI Categories

- Impact of oxalic acid cleaning
- Selection and application of cleaning technologies
- Cleaning technology optimization and estimation of removal efficiency
- Incorporating lessons learned from FTF into future tank cleanings
- Practicality of removing additional material from the Tank 16H annulus

RAI-MEP-1: Impacts of Oxalic Acid Cleaning

Clarify limitations of oxalic acid (OA) cleaning due to downstream impacts

- Negative downstream impacts on the Defense Waste Processing Facility and Liquid Waste System
- Enhanced Chemical Cleaning technology which DOE had been pursuing is no longer funded

Path Forward:

- Clarify how limitations surrounding oxalates might impact the likelihood that OA will remain part of the technology baseline
- Clarify alternative technologies DOE may be pursuing

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RAI-MEP-2: Selection of Cleaning Technology

Update strategy for selecting cleaning technologies

- Given recent DOE technology decisions (e.g., no longer funding enhanced chemical cleaning), DOE should update their documentation of the technology baseline
- Although emphasis on highly radioactive radionuclide (HRR) removal is discussed in V-ESR-G-00003, Rev. 1, recent technology applications and selections do not appear to target highly radioactive radionuclides

Path Forward:

- Provide a description of current process for selection and evaluation of waste retrieval technologies to demonstrate removal of HRRs to maximum extent practical for tanks yet to be cleaned

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RAI-MEP-3: Implementation of Cleaning Technology

Document implementation strategy for cleaning technology

- DOE’s process for determining a particular pumping/mixing strategy is not well documented
- Hanford mixing models may assist DOE in predicting the effectiveness or benefits of certain mixing strategies

Path Forward:

- Describe DOE's generic approach for a strategy, including the steps and criteria used in decision making, including a specific example of the development of the pumping/mixing strategy for a specific tank
- Clarify the timeline of the use of the mixing model at HTF that is being developed for Hanford

RAI-MEP-4: Optimization of Cleaning Technology

Document approach to optimizing cleaning technology through sampling and monitoring

- Multiple types of sampling and monitoring have been utilized in tanks that have undergone heel removal but the general process is not well documented

Path Forward:

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

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RAI-MEP-5: Removal Efficiency of Cleaning Technology

Document approach for evaluating removal efficiency of cleaning technologies

- DOE has utilized both liquid process samples and solid sludge samples collected at various points in the cleaning process for certain tanks to aid in evaluating removal efficiency
- Decision-making process for when to take specific types of samples is not well documented

Path Forward:

- Clarify DOE's approach to evaluating removal effectiveness using chemical cleaning for Tank 12H as an example
- Include generic guidelines on when it is appropriate to sample the sludge prior to chemical cleaning

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RAI-MEP-6: Lessons Learned from FTF Cleaning

Incorporate lessons learned from Tanks 5F and 6F for future cleaning

- Because the SMPs could not be operated at lower liquid levels, ineffective mixing during acid strike 2 in Tanks 5 and 6 appears to have contributed to the formation of solids during chemical cleaning
- DOE indicated that a low-volume pump has been evaluated

Path Forward:

- Clarify the timeline of the low-volume mixing pump technology
- Describe how the lessons-learned from Tanks 5 and 6 will be incorporated in future cleaning efforts

RAI-MEP-7: Tank 16H Annulus Cleaning

Analyze practicality of additional removal from Tank 16H annulus

- Mixing was poor in last cleaning effort in 1977 as exhibited by the variability in sample results and DOE ceased further cleaning efforts because the technology was not mature enough to deploy
- Waste in the annulus and/or sand pads tends to be more risk significant and NRC staff is concerned that the performance assessment may underestimate annular contamination risk

Path Forward:

- Provide information on the practicality of removing additional waste from the Tank 16H annulus to the extent necessary to reduce the risk, addressing the issues identified in RAI-NF-12 and RAI-NF-13

FTF Comments Relevant to HTF

NRC staff recommended that DOE

- Fully evaluate costs & benefits of additional HRR removal
- Evaluate HRR removal in its technology selection and effectiveness evaluations
- Continuously evaluate new technologies
- Include more specificity in its process for determining HRRs are removed to MEP

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CRITERION 3

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PERFORMANCE ASSESSMENT

Clarifying Comments

- Transparency of FEPs screening
- Impact of biosphere modeling changes from FTF to HTF Performance Assessments

FTF Monitoring Factors Relevant to HTF

- Scenario Analysis
- Parameter and Model Support

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INVENTORY

RAI Categories

- Uncertainty in annulus volumes and concentration assumptions
- Inventory adjustments
- Reflecting historical process knowledge in projected inventories

RAI-INV-1: Annular Volume Uncertainty

Annular volume uncertainty could be quantified

- Uncertainty stemming from many areas of the annulus (and duct) where visual determination of the waste level was not possible
- No multipliers used in uncertainty analysis

Path Forward:

- Provide estimates of the uncertainty of remaining volume in Tank 16H annulus and describe how this uncertainty is related to the uncertainty of the material in the annuli or other tanks

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RAI-INV-2: Representativeness of Tank 16H Annular Samples

Representativeness of Tank 16H annulus samples for Tanks 9H, 10H, and 14H is not clear

- DOE applies the concentrations of the Tank 16H annulus to Tanks 9H, 10H and 14H
- The material in the Tank 16H annulus is expected to be chemically different than the other tanks

Path Forward:

- Clarify basis for using Tank 16H annulus concentrations for others
- Describe the impact of the expected chemical differences on the inventory estimates in terms of radionuclides that could be under- or over-estimated as a result

RAI-INV-3: HTF-FTF Process Differences

Differences in HTF and FTF processes are not reflected in projected inventories

- HTF and FTF processed different waste streams, which would lead to expected differences in the inventories
- Projected inventories for certain radionuclides do not reflect differences, including radionuclides not tracked by the Waste Characterization System

Path Forward:

- Clarify how DOE estimated the inventories for radionuclides not included in the WCS (including whether FTF data was used for HTF projections)
- Please also explain the differences in inventory projections from the expectations described in SRNL-STI-2012-00479, Rev. 3

RAI-INV-4: Representativeness of Tank 16H Annulus Samples

The representativeness of 2010 Tank 16H annulus samples is not clear

- DOE uses the concentration of the four samples taken in 2010 (all from outside of the ventilation duct) to represent all of the Tank 16H annulus material
- It is not clear why results from the samples taken in 2006 (from inside and outside the duct) were not used to help inform the projected inventory calculations

Path Forward:

- Clarify why the 2006 samples were not used
- Provide justification for why the concentration of the samples taken from outside the ventilation duct adequately represents the concentration of material inside the duct

RAI-INV-5: Inventory Adjustments

Cesium, strontium, and zirconium inventory adjustments require further justification

- DOE estimates Zr-93 by using a ratio of Sr-90 to Zr-93 of 58,000:1 developed from sludge batch samples, but actual measured results do not reflect this ratio
- DOE reduces the cesium, strontium, and zirconium inventories for all tank types by one order of magnitude based on process samples, but final characterization does not reflect an overestimation, but rather an underestimation in many cases

Path Forward:

- Provide additional justification for the assumed ratio and for reducing the inventories by an order of magnitude

FTF Monitoring Factors Relevant to HTF

- Final Inventory and Risk Estimates
- Residual Waste Sampling
- Residual Waste Volume
- Ancillary Equipment Inventory
- Waste Removal (As it Pertains to ALARA)

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RELEASE AND NEAR-FIELD TRANSPORT

RAI Categories

- Steel Corrosion/Cementitious Degradation – 2
- Representation of reducing capacity in grout
- Composition of water contacting the grout and residual waste – 2
- Selection of solubility controlling phases for key radionuclides – 4
- Modeling of preferential pathways through the annulus of Type I and II tanks – 4
- Appropriateness of an unsaturated model to represent saturated conditions

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RAI-NF-1: Oxygen Availability for Chloride-Induced Corrosion

Provide support for implicit conclusion that steel liner remains essentially passive due to limited oxygen availability

- Steel corrosion rates in contact with chloride solution essentially passive due to limited availability of oxygen
- Modeling implies that corrosion is uniform and reduction and oxidation reactions occur at same location
- Possibility of separation of cathodic and anodic regions (e.g., vault rebar, transfer lines, across water table)

Path Forward: Provide basis for implicit conclusion that steel remains essentially passive in light of oxygen variations

RAI-NF-2: Diffusion Coefficients through Vault Concrete

Provide a basis that diffusion coefficients through tank vault concrete bound permeability changes resulting from carbonation

- Modeling assumes a fixed effective diffusion coefficient for carbon dioxide and oxygen
- Rebar corrosion, due to volume expansion is known to crack concrete

Path Forward: Provide basis that diffusion coefficients for oxygen and carbon dioxide through tank vault concrete adequately consider effects of volume expansion from corrosion of reinforcing steel

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RAI-NF-3: Longevity of Reducing Conditions

Provide additional support for using pyrite as proxy for reductants in geochemical modeling

- Modeling assumes pyrite (FeS_2) represents reducing capacity of grout
- Other reduced sulfur species present in blast furnace slag might not be adequately accounted for by use of pyrite as surrogate
- More soluble reduced sulfur species could deplete reducing capacity of the grout more quickly than modeled

Path Forward: Provide additional support that pyrite is a reasonable proxy for grout reducing capacity in the geochemical modeling

RAI-NF-4: Conditioning of water contacting waste

Provide basis for assuming water contacting waste will consist of 10% water conditioned by overlying grout

- Modeling assumes water contacting waste is a mixture of water that is conditioned by reducing grout (10%) and unconditioned (90%)
- Basis for ratio approximates modeled lateral-to-vertical groundwater flow for current conditions
- Engineered barriers or preferential pathways may limit contact of waste by conditioned water

Path Forward: Provide basis for conditioning of water contacting the waste under closed conditions

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RAI-NF-5: Dissolved Oxygen of Groundwater

Concentration of dissolved oxygen in the groundwater for geochemical modeling may be underestimated

- Low dissolved oxygen prolongs reducing conditions
- Data from P27D, which is anomalously low relative to other SRS wells
- Screening depth or locally impacted groundwater may be possible causes for low value

Path Forward: Evaluate impact of variation in dissolved oxygen across SRS or collect additional measurements from HTF

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RAI-NF-6: Plutonium Solubility

Assumed solubility values for plutonium are not well supported

- Modeling assumes $PuO_{2(am,hyd)}$ controls solubility
- More soluble plutonium carbonate phases possible in Tank 18F samples and conversion to $PuO_{2(am,hyd)}$ under closed conditions may be inhibited.
- Insufficient support for E_h threshold for increased plutonium solubility and that water contacting waste will remain less than threshold during oxidizing conditions

Path Forward: Provide additional support for assumed solubility-limiting phase based on characterization data and that E_h of water contacting waste will remain below solubility transition threshold

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RAI-NF-7: Technetium Co-precipitation with Iron

Insufficient basis for assuming 100% of technetium co-precipitates with iron

- DOE cites Hanford evidence of Tc co-precipitation with iron
- Assumes tank washing will remove all of the more soluble Tc-99
- Not demonstrated that tank washing will remove all the more soluble Tc-99 and that the remaining Tc-99 will be co-precipitated with iron

Path Forward: Provide experimental support for assumption that technetium solubility is controlled by iron co-precipitation under all chemical conditions.

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RAI-NF-8: Precipitation of Radionuclides from Annuli

Application of solubility limits to radionuclides that migrate upwards from annular regions to the contaminated zone is not well supported

- Radionuclides associated with waste in annuli are not solubility limited in model
- Modeling applies solubility limits to radionuclides that migrate into the contaminated zone
- Technetium constrained to low solubility associated with iron co-precipitation

Path Forward: Assess the sensitivity of solubility control for annular inventory that migrates into contaminated zone on tank releases and provide basis for solubility limits applied

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RAI-NF-9: Uncertainty in Solubility Values

Solubility values do not adequately account for uncertainty in probabilistic modeling

- Discrete distribution modeled to account for uncertainty
- Lack of direct evidence supporting solubility limiting phases selected to represent uncertainty
- Uncertainty in NEA database exceeds range considered in probabilistic modeling

Path Forward: Revise probability distributions with more defensible values and provide revised results from probabilistic analysis

RAI-NF-10: Lack of Preferential Pathway in Base Case

Assumption of no preferential pathways in base case is not well supported

- Probabilistic modeling assumes no possibility for preferential pathways in 75% of realizations
- Historical evidence of waste release (16H) and observations of groundwater in-leakage suggest likelihood may be greater
- While grouting may help limit preferential pathways, shrinkage and degradation will tend to promote preferential pathways

Path Forward: Provide additional basis for likelihood of preferential pathways, explicitly include in base case, or report conditional results for cases independently

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RAI-NF-11: Flow Through Preferential Pathways for Fully/Partially Submerged Tanks

Limiting flow of water through preferential pathways to infiltrate may underestimate release of shorter-lived radionuclides

- Water flowing through preferential pathway in alternative cases is limited to infiltrate through closure cap, which limits early infiltration
- Operational experience suggests groundwater in-leakage could occur earlier, potentially allowing significant releases of short-lived radionuclides

Path Forward: Evaluate potential release of radionuclides due to groundwater in-leakage via a preferential pathway through fully and partially submerged tanks

RAI-NF-12: Contact of Annular Contamination by Preferential Pathways – Type I

Lack of a preferential pathway through annular contamination for Tanks 9H and 10H is not well supported

- Preferential pathway does not contact annular waste for Tanks 9H and 10H
- Chemical conditions associated with matrix flow through reducing grout would limit mobility of redox-sensitive radionuclides, whereas, flow through a preferential pathway may not be as thoroughly conditioned

Path Forward: Evaluate release scenario due to groundwater in-leakage into and out of the annuli of Tanks 9H and 10H

RAI-NF-13: Contact of Annular Contamination by Preferential Pathways – Type II

Extent of contact between annular contamination and preferential pathways is not clear

- Modeling results suggest significant diffusion from sand pads into basemats and/or contaminated zones prior to release
- Diffusion enhanced by a high coefficient, large concentration gradients, small path lengths, no liners, and limited flow through preferential pathway due to closure cap performance
- Steel liner remnants and groundwater in-leakage may limit diffusion

Path Forward: Assess extent to which preferential pathways affect waste in the sand pads and its significance

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RAI-NF-14: Modeling of Saturated Zone in Near-Field

Basis for modeling tank releases under unsaturated conditions for fully/partially submerged tanks is not well supported

- Releases from tanks located within or below the water table are modeled with an unsaturated flow and transport near-field model before loading into the HTF/PORFLOW model used for saturated transport
- Unsaturated modeling may increase travel times to a potential receptor or reduce release rates in certain cases

Path Forward: Clarify approach and evaluate impact of simulating releases using an unsaturated modeling approach

Clarifying Comments

- Groundwater in-leakage to fully/partially submerged tanks
- Mineralogy of the hydrated grout assumed for geochemical modeling
- Basis for cement-leachate impacted sorption model parameters
- Grouting plans for transfer lines
- Validity of chloride diffusion boundary conditions supporting corrosion modeling

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FTF Monitoring Factors Relevant to HTF

- Solubility Limiting Phases/Limits and Validation
- Chemical Transition Times and Validation
- Groundwater Conditioning
- Shrinkage and Cracking
- Grout Performance
- Basemat Performance
- Use of Stabilizing Grout (As It Pertains to ALARA)
- Model and Parameter Support

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HYDROLOGY AND FAR-FIELD TRANSPORT

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RAI Categories

- Calibration
  - Results
  - Targets
  - Process

RAI-FF-1: HTF/PORFLOW Calibration

The HTF/PORFLOW model may not be well calibrated

- GSA/FACT and GSA/PORFLOW model documentation suggest that the model is not well calibrated local to HTF
- Dose predictions could be over- or under-estimated depending on source location and radionuclide due to poor model calibration

Path Forward:

- Provide additional detail regarding residuals and calibration statistics local to HTF.
- Perform validation exercises using environmental monitoring data, source release information, and modeling tools.

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RAI-FF-2: Representativeness of Calibration Targets for Post-Closure Conditions

Calibration targets may not represent post-closure conditions

- Operational sources and sinks may have existed at HTF and influenced calibration targets.
- Calibration targets may not be representative of average, post-closure conditions.

Path Forward:

- Evaluate listed and potential operational sources and sinks at HTF and their potential impact on calibration targets.
- Develop new calibration targets and recalibrate the model, if necessary.
- Evaluate the impact of calibration uncertainty on the Performance Assessment results.

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RAI-FF-3: Hydraulic Conductivity Assignments

Hydraulic conductivity assignments during GSA/PORFLOW calibration lack support.

- Adjustments to hydraulic conductivity during model calibration may not have a strong basis.
- Changes in hydraulic conductivity could lead to significant changes in the HTF flow field.
- Dose predictions could be under- or over-estimated based on such factors as source location and radionuclide.

Path Forward:

- Clarify the horizontal and vertical extent of hydraulic conductivity adjustments at HTF during model calibration.
- Provide additional support for hydraulic conductivity assignments at HTF.
- Evaluate the impact of hydraulic conductivity uncertainty on the Performance Assessment results.

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RAI-FF-4: Time-Variant Recharge and Flow

HTF/PORFLOW lacks consideration of time-variant recharge and flow

- Climatic fluctuations and engineered barrier degradation could have a significant impact on recharge rates and the HTF flow field.
- Releases could occur from submerged or partially submerged tanks prior to engineered barrier failure.

Path Forward:

- Evaluate the impact of climatic fluctuations on the HTF flow field.
- Evaluate the impact of the fully functioning and degrading engineered closure cap on the HTF flow field.
- Evaluate the impact of engineered barrier degradation on HTF releases and the HTF flow field over time.

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Clarifying Comments

- Degree of vertical spreading from tank sources and differences in vertical dispersion between east and west tanks.
- Degree of transverse spreading and utilization of transverse dispersivity to simulate changing flow directions particularly for western sources.
- Effective dilution factors applied at end of the flow path in probabilistic modeling to account for increased velocity.
- Effective dilution factors for various source terms and radionuclides in probabilistic modeling.

FTF Monitoring Factors Relevant to HTF

- Natural Attenuation of Plutonium
- Calcareous Zone Dissolution
- Near- and Far-Field Model Integration
- Transparency of Model Calibration
- Exposure Point Location

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Clarifying Comments

- Consideration of alternative cases in intruder analyses
- Results for alternative case E