January 30, 2009

Shirley J. Olinger, Manager
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Office of River Protection
P.O. Box 450, MSIN H6-60
Richland, WA 99352

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION ON UPDATE TO THE BASIS FOR EXCEPTION TO THE HANFORD FEDERAL FACILITY AGREEMENT AND CONSENT ORDER RETREIVAL CRITERIA FOR SINGLE-SHELL TANK 241-C-106, REQUEST FOR U.S. NUCLEAR REGULATORY COMMISSION REVIEW

Dear Ms. Olinger:

The U.S. Nuclear Regulatory Commission (NRC) staff has reviewed the "Update to the Basis for Exception to the Hanford Federal Facility Agreement and Consent Order Retrieval Criteria for Single-Shell Tank 241-C-106," dated April 18, 2008, and the associated documentation provided by the U.S. Department of Energy (DOE). We have attached a request for additional information (RAI). The RAI consists of information needed from DOE in order for us to complete our review. Full responses to all of the RAI questions are very beneficial in allowing the NRC staff to complete its review in a timely manner.

As we continue our review of DOE documents and RAI responses, we may develop additional comments for which we will need a DOE response.

If it would be useful to DOE, we would be happy to meet with your staff to discuss our RAIs or your responses. If you have any questions, please contact me at (301) 415-8125.

Sincerely,

/RA/

Patrice M. Bubar, Deputy Director
Environmental Protection
and Performance Assessment Directorate
Division of Waste Management
and Environmental Protection
Office of Federal and State Materials
and Environmental Management Programs

Enclosure:
Request for Additional Information

cc w/encl: See next page

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Request for Additional Information
Update to the Basis for Exception to the Hanford Federal Facility Agreement and Consent Order Retrieval Criteria for Single-Shell Tank 241-C-106

GENERAL

Comment 1

Alternative scenarios are not considered comprehensively nor documented in sufficient detail.

Basis

Section 3.5 of the U. S. Department of Energy's "Initial Single-Shell Tank System Performance Assessment for the Hanford Site" [DOE/ORP (2006)] documents the results of sensitivity analyses, whereby various parameter values are increased and/or decreased, however alternative scenarios are not considered in a comprehensive way. Alternative scenarios and subsequent changes to all potential components of the total system should be considered and analyzed. For example, a future climate in the Hanford region may be cyclic: drought-like conditions followed by more humid conditions followed again by drier conditions and so on. Such cyclic conditions may influence numerous parameters such as vegetation type, erosion rates, degradation rates, infiltration/recharge rates, and water table elevation. Changes in one parameter may affect another parameter, e.g., increased erosion will more than likely increase infiltration/recharge.

In addition, DOE/ORP (2006) references "Exposure Scenarios and Unit Factors for the Hanford Tank Waste Performance Assessment" [Rittmann (2004)] for the relevant discussion of exposure scenarios. DOE/ORP (2006) includes all but one of the exposure scenarios discussed in Rittmann (2004). No justification for exclusion of the Native American scenario was located in DOE/ORP (2006).

Path Forward

The following conceptual alternative scenarios should be considered and analyzed for their effects on the various barriers and components, or technical bases should be given as to why the following alternative scenarios need not be considered.

a.) The loss of vegetation. In section 3.4.2.4 of DOE/ORP (2006) recharge rates are assumed to not exceed 1 mm/yr. This value is dependent on wind and water erosion calculations from Appendix D of "Focused Feasibility Study of Engineered Barriers for Waste Management Units in the 200 Areas" [DOE (1996)] that do not account for periods without vegetative cover caused by range fire or drought. In addition, the factors within these equations are invariant and may not be appropriate for isolated events.
b.) A cyclic drought / moderate humid climate. Current simulations are performed with steady-state; however, natural processes rarely are in a steady-state condition for such long time frames. Varying climatic conditions may influence significant parameters. Changes in one parameter may affect another parameter, e.g., increased erosion will more than likely increase infiltration/recharge, however is not accounted for in DOE/ORP (2006).
c.) A more humid, warmer climate. Important assumptions made, e.g., steady-state vadose flow and exclusion of fast pathways, are based on the arid / semi-arid climate of the present. The potential humid, warmer climate would require a reevaluation of these assumptions.

d.) A less humid, drier climate allowing potential upward movement of moisture and contaminants in the vadose zone. Contaminants being deposited at the surface would have the potential for further transport by wind erosion and surface water runoff. The latter may lead to a concentration of radionuclides at depositional areas.
e.) Higher water table (contaminant transport within the Hanford unit) versus lower water table (contaminant transport within a lower subunit of the Cold Creek unit) with subsequent potential change in hydraulic conductivity and average linear groundwater velocity. The simulated dose would be affected by changes to the dispersion and the linear average velocity of the groundwater in which the contaminants are traveling.
f.) Episodic flow. Table 3-15 (p. 3-82) of the Initial Single-Shell Performance Assessment (SST PA) states that the impacts of episodic infiltration are considered sufficiently analyzed in “Simulations of Infiltration of Meteoric Water and Contaminant Plume Movement in the Vadose Zone at Single-Shell Tank 241-T-106 at the Hanford Site” [Smoot et al. (1989)], however, these are analyzes based on additional simulation results only. Generally, model support should not rely exclusively on the results of further numerical modeling. If the uncertainty and scenario analyses show that episodic flow has the potential to be a significant process, a stronger technical basis will be needed to support this assumption.
g.) Lateral movement of contaminants in the vadose zone in combination with clastic dikes as conducts for fast vertical transportation. Sec. 2.3.4.1.7; p. 2-27 in DOE/ORP (2006) stated that, “Thin, fine-grained layers in the Hanford formation also cause lateral migration.” In addition, “Interpreted Extent of Subsurface Contamination Resulting form the 241-BX-102 Tank Leak 200 East Area, Hanford Site, Washington” [Sobczyk (2004)] documented lateral movement of contaminants under the B-BX-BY waste management area (WMA). Clastic dikes are currently not considered fast pathways; however, perched water bodies or semi-saturated lateral movement of contaminants would have the potential to use clastic dikes as a conduit and move relatively quickly to deeper units thereby bypassing the retarding effects of the vadose zone.
h.) A technical basis is needed for excluding an igneous activity scenario (waste transported by eruption to populated zone) in an area which has seen so much igneous activity. Alterations to or destruction of the grouted tank due to igneous activities would allow contaminants to be transported by alternative means not being currently considered.
i.) Justification for exclusion of the Native American scenario should be provided, or results for the Native American scenario should be included

Comment 2

Waste isolating capabilities of barriers need to be described and illustrated in more detail and better documented.

Basis

In order to better understand how the barrier system works as a total system, the documentation should better quantify which barriers are most effective in retarding or isolating contaminants during which time periods. The NRC has a policy of risk-informed, performance-based regulatory decision-making after identifying processes and barriers that are significant to performance. DOE/ORP (2006) provided the technical results of analyses; however more discussion is needed to understand the long-term effectiveness of the disposal system.

Path Forward

A section should be included in DOE/ORP (2006) which discusses how the disposal system functions and effectively isolates the waste found within, i.e., present a conceptual transport process model. Attempts should be made to quantify the amount of the contaminated material along each barrier of the flowpath so that those barriers are identified that retard or isolate the most contaminants for the longest time. Tables with percentages showing the amount of waste left in the grouted tank, the three Hanford units, the Cold Creek unit, and the aquifer at various time periods during the performance period would help identify the most risk-significant components of the system. If the engineered surface cover is a significant barrier, a water budget for that cover should be presented. A water balance table quantifying the output either as evapotranspiration, runoff, soil water storage, lateral drainage, or infiltration over time would quickly provide risk-insight into the most significant features and processes of the cover.

Comment 3

The Subsurface Transport Over Multiple Phases (STOMP) flow and transport model from DOE/ORP (2006) was neither described nor referenced within DOE/ORP (2006). For example, additional information regarding numerical implementation (e.g., spatial and temporal discretization) of the STOMP model is needed to improve confidence in the model.

Basis

The computer code STOMP was chosen to model flow and transport through the unsaturated and saturated zones, however no references were provided to document the construction and calibration of the resulting model.

Path Forward

Provide documentation on the STOMP flow and transport model used in DOE/ORP (2006), including information regarding numerical implementation (e.g., spatial and temporal discretization) of the model.

Comment 4

Results for the reference case and sensitivity analyses are constrained by the simulation timeframe increasing the potential for missing key radionuclides and overlooking important model sensitivities.

Basis

The performance assessment [DOE/ORP (2006)] presents results for a 10,000 year simulation period. For constituents in waste residuals with a K_d greater than 0.2 L/kg, the constituent may not travel to the WMA C fence line at detectable concentrations prior to the end of the simulation. Therefore, limited risk information is obtained for relatively semi-mobile to immobile constituents in many cases (e.g., changes to the inventory, release rates, and selection of release model may not affect calculated doses for semi-mobile and relatively immobile constituents).

Lack of consideration of the peak dose may also lead to a situation where key radionuclides are not identified due to uncertainty associated with travel times to the aquifer. Key radionuclides should be identified based on a consideration of uncertainty, and uncertainty in the dose predictions should not be a strong function of the simulation time period.

Path Forward

For reference case calculations, DOE should attempt to capture the peak dose even if the peak dose occurs beyond a 10,000 year simulation period. Likewise, for sensitivity analyses, DOE should attempt to represent the full impact that changes in model and model parameter values have on peak dose with uncertainty bounds that are not constrained by what occurs within a limited simulation period.

ENGINEERED SURFACE COVER

Comment 5

Section 1.7.3 of the SST PA (DOE/ORP, 2006) discusses a 15 foot [4.57 meter] thick Modified RCRA Subtitle C Barrier and further states that site-specific surface designs are not available. Section 4.3 references DOE (1996) details the 8 layers of the barrier (section 3.2.2) and the minimum thickness of 5.6 ft as a pre-conceptual design. Details including the specific layer thicknesses should be discussed.

Basis

The infiltration rate through the barrier is sensitive to the layer dimensions, in particular the silt loam layer. "Recharge Data Package for the 2005 Integrated Disposal Facility Performance Assessment" [Fayer and Szecsody (2004)] state that loam thicknesses less than one meter may not be able to store all of the winter precipitation and thicknesses greater than two meters may not be removed via evapotranspiration. The effects of wind and water erosion, bioturbation, etc. are dependent on more specific layer thicknesses.

Path Forward

Please provide detailed information regarding the specific structure of the barrier, including layer thicknesses for the current, conceptual cover design.

Comment 6

The importance of vegetative cover and the effects of a pea gravel admix are not clearly documented.

Basis

The vegetative cover and the associated evapotranspiration are stated as critical components of the near-surface engineered cover in section 3.2.2.2 of DOE/ORP (2006). However, the recharge calculations derived in Appendix C of Fayer and Szecsody (2004) and referenced in DOE/ORP (2006) indicate that the surface cover performance will be met regardless of vegetation.

Infiltration is limited by the presence of a silt loam layer and evapotranspiration, due in part to vegetation. Wind and water erosion potentially threaten the effectiveness of this layer by reducing the layer thickness to less than one meter. The addition of gravel to the surface layer improves wind and water erosion; however, it may limit the vegetative cover and potential evapotranspiration (Gee, 1997).

Recharge rates depend on the soil hydraulic properties and the associated water retention curves. Simulations carried out in Appendix D of DOE (1996) discuss the associated van Genuchten parameters for the layers of the modified RCRA cover. Several of these parameters have been adjusted to account for the pea gravel admix however, parameters α and n were not changed due to data limitations.

Path Forward

Clarify the significance of vegetation to recharge rates. If vegetation is important, provide discussion on the impact of the pea gravel admix to the vegetative cover and the resulting evapotranspiration. In addition, please evaluate the potential effect of the unknown van Genuchten parameters on recharge rates.

Comment 7

There appears to be a contradiction between the intended purpose/function of layers 1 and 2 of the planned surface barrier and the results of the sensitivity and uncertainty tests.

Basis

Table 4-2 in Fayer and Szecsody (2004) indicate that layers 1 and 2 of the planned cover would provide optimal water retention properties and supplemental soil moisture storage capacity. The extended residence time of the moisture would increase the amount of moisture removed by evapotranspiration. However, the sensitivity and uncertainty test results in sections 7.3 and 7.4 indicated that the recharge rate through the surface barrier was not sensitive to the type of plant growing on the cover or even to the presence of plants. In addition, the simulation results showed no impact when the properties of the silt loam admixture was changed. These results are puzzling considering that evaporation alone (no plant cover) would not be enough to significantly reduce the infiltration rate, and that the properties of the soil admixture are important to the water moisture retention properties and the subsequent amount of evapotranspiration.

Path Forward

Provide an explanation for the apparent contradiction between the intended purpose of layer 1 and layer 2 of the planned surface barrier and the results of the sensitivity and uncertainty tests, or describe the main process by which layers 1 and 2 reduce the amount of water flowing to layer 3.

Comment 8

Sensitivity analyses documented in DOE/ORP (2006) identified infiltration/recharge as a significant process effecting performance. However, the importance, or relevance, of bioturbation on the infiltration rate appears to be underestimated. Bioturbation is apparently considered for relatively large fauna only (Fayer and Szecsody, 2004, Sec. 7.1.1, page 7.1). More technical support is needed to demonstrate that present and future flora has roots that will extend no deeper than 1 meter (Fayer and Szecsody, 2004, Sec. 3.3, page 3.7).

Basis

Layers 1 and 2 together are intended to be 1 m thick. Roots commonly grow deeper than 1 m. Fast water pathways may be created along decaying old roots. Bioturbation is also caused by smaller fauna such as invertebrates and microorganisms, and the effects can be deeper than 1 meter. In addition, layer 2 is intended to retard the rate of infiltration by means of compaction (Table 4-2, page 4.5 in Fayer and Szecsody, 2004). Experience has shown that compacted soil will not remain compact for long time periods.

Path Forward

Provide the technical basis that smaller fauna and flora (plant roots) will not cause bioturbation deeper than 1 meter, and provide the technical basis for the use of compaction as a means to reduce the long-term (i.e., hundreds or thousands of years) infiltration rate.

Comment 9

Sufficient technical base is needed to support the assumed infiltration/recharge rate through the degraded cover.

Basis

Tc-99 concentrations appear sensitive to the recharge estimate for the degraded barrier (DOE/ORP, 2006, Sec. 4.11.1.1, p. 4-106), however the data and results provided in Fayer and Szecsody (2004) do not provide an adequate technical basis for the assumed constant infiltration/recharge rate of 1 mm/yr for 9500 years.

Path Forward

Present and potential future processes (e.g., degradation, infiltration, erosion) that work inside and on the covers should be addressed. This could include clogging of a drainage layer, bioturbation, cracking and deterioration of asphaltic concrete with asphalt coating, and other processes. These processes should also be tied into an integrated conceptual process model on how the cover operates and performs in the long term. Clearly documenting the conceptual cover process model is critical for understanding performance. Provide the technical basis and model support for the assumed infiltration/recharge rate through the degraded cover (1 mm/yr). Model support should use multiple types and sources of information and may include site specific tests, information on previous experience with similar systems, process models of barrier component performance, natural and anthropogenic analogs, independent peer review (expert elicitation), or plans to develop additional model support for engineered surface barrier system performance.

GROUNDWATER PATHWAY

Comment 10

Additional information is needed regarding the approximate dilution factors implemented by the STOMP model in the saturated zone. Also, additional information is needed on why the peak groundwater concentration ratio relative to the reference case is sensitive to changes in the hydraulic conductivity.

Basis

Based on calculations of groundwater dilution in the saturated zone using various analytical models, the factors can change orders of magnitude based on the assignments of the hydraulic properties of the saturated zone materials (e.g., hydraulic conductivities, gradient, and average linear velocity). The peak groundwater concentration ratio relative to reference case is sensitive to changes in the hydraulic conductivity (DOE/ORP, 2006, Tab. 4-39, p. 4-140). Since this parameter is associated with uncertainty, the parameter values chosen should be discussed as should the reasons for the sensitivity to changes to the hydraulic conductivity. The saturated hydraulic conductivity range chosen (2000 – 4000 m/d) appear to be on the high end of the range for hydraulic conductivities of the Cold Creek unit and closer to the hydraulic conductivities of the Hanford Formation. In both "2003 Initial Assessments of Closure for the C Tank Farm: Numerical Simulations" [Zhang et al. (2003)] and "Modeling Data Package for an Initial Assessment of Closure for C Tank Farm" [Khaleel et al. (2003)], values closer to 0.5 m/d for the aquifer beneath Tank Farm C are chosen. Since a higher water table would allow contaminant transport to take place in the Hanford unit while a lower water table allow contaminant transport to take place in a subunit of the Cold Creek unit, the parameter assignments for the Hanford versus the Cold Creek units are very important.

Path Forward

- Provide additional information regarding the approximate dilution factors for contaminants between the unsaturated zone and at the WMA C fence line due to dilution and dispersion in the saturated zone.
- Provide the technical basis for the values of the saturated hydraulic conductivities of the future water table aquifer (Cold Creek unit).
- Provide a discussion on why the peak groundwater concentration ratio relative to reference case is sensitive to changes in the saturated hydraulic conductivity, and what hydraulic conductivity value results in the highest peak groundwater concentration ratio relative to reference case.

Comment 11

It is not clear if a dilution factor is being used to translate two-dimensional simulations into equivalent values for a three-dimensional domain.

Basis

Page 3-35 in Section 3.2.2.4.9 in DOE/ORP (2006) discusses the ratio of the two-dimensional peak concentrations for Tc-99 and U-238 to that of the three-dimensional peak. It appears that the average of the ratios presented (circa 40) was used for two-dimensional modeling results presented in DOE/ORP (2006). The results of dilution factor sensitivity analyses would bring clarity on the significance of the value used and its effects on the system. A commensurate technical basis should be associated with the estimated value of this parameter.

Path Forward

Clarify if a dilution factor is being used to translate two-dimensional simulations into equivalent values for a three-dimensional domain. If so, discuss the value being used, the technical basis for using the value, and discuss the significance of the dilution factors used on the results.

Comment 12

Sufficient technical bases are needed to support the assumptions associated with the distribution coefficients used in DOE/ORP (2006).

Basis

Page 3-18 in Section 3.2.2.4.5 in DOE/ORP (2006) states that the effects of colloidal formation are incorporated in the K_d concept. This is not normally the case, and the assumed incorporation needs to be discussed in more detail.

Saturated K_d values are higher in the saturated zone since contamination is assumed not to have affected the geochemistry of the water. Since this may significantly affect the simulation results, a technical basis should be provided for the geochemically unaltered environment of the saturated zone.

The natural (unrelated to past releases) hydrogeochemistry of the area of interest is assumed to remain unchanged for 10,000 years. Since this may significantly affect the simulation results, a technical basis should be presented.

Path Forward

Provide the technical bases for the assumptions listed above under “Basis.”

Comment 13

It is not clear how long the vadose zone in the immediate vicinity of Tank Farm C will be chemically altered due to past releases of contaminants altering the geochemical characteristics of unsaturated zone.

Basis

The geochemistry of the moisture containing units plays a significant role in the subsequent values of the distribution coefficients. Therefore, the temporal length of this geochemical alteration is important to the rate of contaminant transport.

Path Forward

Clarify how long the vadose zone will remain in an altered geochemical state and provide the technical basis for this estimate.

Comment 14

Additional information on the modeling and calibration of past releases and a discussion of the relevance of these past releases to future conditions and events should be provided.

Basis

Past contaminant releases have led to the underperformance of the vadose zone compared to future releases from tank residuals presented in the SST PA (DOE/ORP, 2006). Monitoring data shows that contaminants from past releases are much lower in the vadose zone or have already traveled to the groundwater aquifer in relatively short periods of time compared to modeling performed for future releases that show most contaminants will not reach the WMA C fence line within the timeframe of the modeling simulations. Monitoring data associated with past releases may support the use of more conservative parameter values for assessing future releases if differences in expected conditions cannot be adequately explained.

Path Forward

- Summarize modeling and calibration performed to recreate existing plume distributions from past releases.
- Discuss how the calibrated model is expected to be based on the appropriate set of parameter values if the solution is non-unique.
- Provide additional discussion on how parameter values were updated from the calibrated model for past releases to reflect future conditions (e.g. infiltration rates, source characteristics, geochemical conditions, etc) and additional explanatory text on how results for future releases are expected to be different based on assumptions regarding natural and engineered system performance in the future.

Comment 15

Additional information regarding far-field modeling results is needed to better understand, interpret, and evaluate modeling results.

Basis

Natural system performance is expected to have a large impact on dose modeling results. Sensitivity analyses show that changes to recharge rates can have a significant affect on the dose modeling predictions (DOE/ORP, 2006). System response to recharge rates is a complex function of the timing of release, timing of change in recharge rates, and availability and location of mass in the subsurface. However, limited information regarding natural system response to changes in surface recharge rates is provided. Groundwater dilution along flow paths away from source areas is expected to have a large impact on dose, yet limited information is provided on the distribution of contaminant plumes in the subsurface over time that may show affects of dispersion, lateral flow in the vadose zone, or other factors affecting contaminant concentrations in saturated groundwater.

Path Forward

Provide transient model results from the STOMP model to illustrate natural system response to changes in recharge rates over time. For example, provide information on the time it takes to reach equilibrium throughout the thickness of the unsaturated zone assuming step changes in recharge rates (e.g., from operational to post-closure and from in-tact to degraded surface barrier recharge conditions). Cross-sectional figures showing pressure and moisture content changes over time based on numerical modeling results would be helpful. Likewise, plume distributions over time would also be helpful in interpreting and evaluating modeling results.

AIR PATHWAY

Comment 16

Criteria for selection of exposure scenarios for gas/vapor pathways (no water infiltration case) are not clear.

Basis

Table 2 (Rittmann, 2004, p. 5) shows two scenarios for gas/vapor emanations. It is not obvious why the scenarios were limited to these two. For example, an onsite resident with a basement could have a suburban garden located over the disposal area with gas/vapor emanations.

Path Forward

Provide the technical justification for the air pathway scenarios chosen.

Comment 17

There appears to be an inconsistency between the defined diffusion coefficient and the value used for the diffusion coefficient of radon.

Basis

Page E-4 in Appendix E of Rittmann (2004) states that the diffusion coefficient has a value of 0.01 cm^2/s for low atomic number gases moving through waste and soil. However, Rn-222, which does not have a low atomic number, is given this same value. It is not clear if this inconsistency is significant.

Path Forward

Provide the technical basis for giving Rn-222 a diffusion coefficient value of a low atomic number gas, or show that the value chosen has no significant affect on the final results.

WASTE RELEASE

Comment 18

Engineered barrier degradation and its impact on waste release should be evaluated and considered in the reference case near-field release model.

Basis

The engineered systems are expected to represent a significant barrier to contaminant release into the environment. In fact, DOE sensitivity analyses show that the impact of the waste release model alone can result in almost an order of magnitude increase in the doses associated with tank residuals (DOE/ORP, 2006). Combined with degradation of the engineered surface barrier, the uncertainty associated with release rates of radiological constituents from tank residuals is expected to be large. The reference case waste release model assumes an intact waste form over a 10,000 year compliance period with diffusion-limited mass transport of contaminants from the system. Insufficient technical bases are provided for the assumptions regarding engineered barrier performance over the long time periods relied on for performance. Degradation of the cementitious waste form and its impact on hydraulic and chemical properties of the waste form over time is risk significant to waste release and should be evaluated.

Path Forward

Degradation mechanisms for the cementitious materials including sulfate and magnesium attack, carbonation, reinforcement corrosion, leaching, alkali/aggregate reactions, freeze-thaw cycling, cracking (e.g., thermal, seismic-induced), and shrinkage should be considered. Degradation mechanisms should be evaluated in light of site-specific conditions including the service environment expected for tank closures at the Hanford site. Relevant features, events, and processes affecting cementitious material degradation, including spatial and temporal transients, should also be considered (e.g., alternating freeze/thaw, wet/dry cycling, moisture profiles and distribution, climate change, and land use).

Comment 19

Alternative conceptual models for waste release based on a more realistic, degraded system should be evaluated.

Basis

Use of a diffusion-limited waste release model for the reference case is expected to have a significant impact on the release rates from the grouted tank system with sensitivity analyses showing around an order of magnitude impact on the dose results when an advective waste release model is used (DOE/ORP, 2006). Nonetheless, the full range of uncertainty associated with engineered barrier performance does not appear to be evaluated with many simplifications made to the waste release modeling, including time invariant chemical and hydraulic property assumptions (e.g., no consideration is given to changes in pore water chemistry over time and hydraulic property increases due to cementitious material degradation). Additionally, the simplified conceptual models presented in the performance assessment may not incorporate features of the real system that may lead to preferential or by-passing pathways for fluid flow.

While many conservatisms are incorporated into the modeling (e.g., no consideration of chemical barriers), other assumptions regarding engineered barrier performance are unrealistic given the long time frames involved in the performance assessment. Due to the complexity of the system and simplicity with which the system is modeled, the sensitivity analyses are not demonstrably bounding. While the risk from Tank C-106 is expected to be very low based on DOE analyses, lack of consideration of more complex system performance may have implications for other more risk-significant tank closures.

Path Forward

- Alternative conceptual models for waste release should be considered including preferential or by-passing pathways through the system (e.g., by-pass flow through joints in the tank vaults, along tank walls, through cooling coils, or along air channels or fractures in the basemat). The alternative conceptual models should consider incomplete mixing of waste with tank grout and the potential impact of increased waste release due to changes in chemical and hydraulic properties over time.
- Provide more detailed schematics and photographs of tank construction to allow review of the potential mechanisms of waste release from the grouted system.
- Provide the following reference: Goetz, T.G., 2003. Tank Farms Documented Safety Analysis, RPP-13033, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

Comment 20

Additional justification for waste release parameter values should be provided.

Basis

The engineered systems are expected to represent a very significant barrier to contaminant release into the environment. However, parameter values used in the waste release modeling and sensitivity analyses do not appear to be fully supported.

For example, the diffusion coefficient is a risk-significant parameter value for the reference case diffusion model based on DOE analyses (DOE/ORP, 2006). The reference case value of 1×10^{-09} cm^2/s may be overly optimistic for intact tank grout at the Hanford site and unrealistic for degraded grout over a 10,000 year evaluation period. The hydraulic properties of cementitious materials assumed for waste release modeling should be consistent with performance expected for the types of grout formulations proposed for Hanford tank closures (e.g., impacts of additives and other supplementary grout components on hydraulic properties should be considered).

The assumed mixing length in the diffusion-limited waste release model is also expected to be a risk-significant parameter value. A stronger basis for the assumed 0.825 m mixing length for the diffusion-limited waste release model is needed (waste residuals are assumed to be distributed throughout the 18 inches of clean grout above the bottom of the tank and the thickness of the basemat underlying the tank at the start of the simulation).

The values used for velocity and moisture content used in the advection waste release sensitivity analysis case were not specified in the documentation. Additional details regarding these parameter values should be provided including any associated modeling used to calculate flow velocities through the tank grout. For example, if moisture characteristic curve parameters are used to calculate velocities through an unsaturated system, the details of the supplemental modeling and parameter values used should be provided.

Consideration of increased infiltration through the system (given uncertainties in performance of the surface cover) should also be considered in evaluating tank system performance for the advective waste release sensitivity analysis case.

Path Forward

Additional justification and support for model parameters including effective diffusion coefficients, mixing length, velocity, and moisture content should be provided. If additional information is available in reference documents (e.g., engineering calculations or design files) to support the waste release model simulations, these references can be provided.

Comment 21

Sensitivity analyses are not complete and may not cover the full range of uncertainty associated with engineered barrier performance.

Basis

The selection of waste release model and model parameters has a significant impact on the dose results based on the sensitivity analysis presented in DOE's performance assessment (DOE/ORP, 2006). However, the ranges of risk-significant parameter values used in the sensitivity analysis do not appear to be fully supported and it is not clear that the full range of uncertainty associated with the near-field release model was evaluated. For example, the maximum value for the diffusion coefficient of $1x10^{-08}$ cm^2/s used in the sensitivity analysis is not expected to encompass the full range of uncertainty expected for this parameter value and is not expected to be representative of degraded conditions. The sensitivity analyses do not include evaluation of the uncertainty associated with the mixing length in the diffusion-limited waste release model. Consideration of uncertainty in this parameter value is expected to have a significant impact on the uncertainty associated with the reference case waste release model.

While DOE attempted to simulate a "bounding" waste release modeling case, the impact of use of an advection model versus a diffusion model on the dose results may have been lessened if flow through the system is constrained to such low values that waste release is nonetheless, effectively diffusion-limited. While the performance assessment indicates that the advective waste release model results in an effective slug release (DOE/ORP, 2006), no information is provided on the flow rates through the system in the advective case, the sensitivity of flow rates were not evaluated, and the fractional release rates over time for the advective versus diffusive waste release models were not provided as a basis for comparison.

The discretization of the advective waste release model may also have an impact on the dose modeling results. The performance assessment states that ten cells were used to represent moderate dispersion (DOE/ORP, 2006). However, no information is provided to support this statement.

With such a complicated system it is difficult to determine the combined affect of making many pessimistic and overly optimistic assumptions regarding waste release from the engineered system. Therefore, the contribution of engineered barrier system performance to overall system performance is difficult to discern. Likewise, the uncertainty of the dose modeling predictions to engineered system performance is difficult to determine given the limited analysis of sensitivity of dose results to changes to waste release model and parameters. Waste release modeling should either be realistic or demonstrably conservative and in the absence of additional analysis, this demonstration has not been clearly made.

Path Forward

An evaluation of a wider range of uncertainty in reference case model parameters is needed including consideration of uncertainty with the assumed mixing length. Intermediate output from the release calculations (e.g., fractional release rates) for the diffusion and advection cases are needed to assess engineered barrier system performance. DOE should also provide documentation to demonstrate that the number of cells does not result in excessive dispersion.

Justification for the moisture content and flow velocities should be provided and uncertainty in these parameter values considered for the advective waste release sensitivity analysis simulation. The combined affect of engineered surface barrier and tank grout failure could be considered with larger flow rates through the system assumed in the advective waste release sensitivity analysis simulation. Current cumulative impacts of failed barriers do not address these type of scenarios (e.g., see Table 4-52 in the performance assessment [DOE/ORP (2006)]).

REMOVAL TO THE MAXIMUM EXTENT PRACTICAL

Comment 22

Additional information should be provided to support the post-retrieval inventory developed for single-shell tank 241-C-106 (Tank C-106) including the screening process used to identify key radionuclides.

Basis

As the inventory estimates have a direct impact on risk calculations, the inventory estimates developed for Tank C-106 should be fully supported. Inventory estimates for radiological constituents remaining in Tank C-106 based primarily on sampling data are provided in the Stage II Data Retrieval Report (CH2M Hill Hanford Group, 2007). However, limited information is provided regarding the screening process used to identify primary contaminants of potential concern that were targeted for sampling.

Review of potential key radionuclides identified in performance assessments for other waste-incidental-to-reprocessing sites identified several constituents that do not appear in the inventory list (e.g., Sn-126, Pb-210, Ra-226, Ra-228, Ac-227, Pa-231, and Pu-242). The basis for elimination of these radionuclides is not clear (i.e., due to unavailability of toxicity information or due to non-detection). The Stage II Retrieval Data report (CH2M Hill Hanford Group, 2007) indicates that no radionuclides were removed from the list based on non-detection but also states that short-lived daughter products are not included. However, no specific information is provided on the half-life cut-off value for exclusion of short-lived radionuclides and on how daughter products eliminated as primary contaminants of potential concern in decay chains are treated in the analysis (e.g., are impacts from short-lived daughter products present in decay chains considered with the parent radionuclide).

NRC considers those radionuclides that have the largest impact on dose to members of the public, including inadvertent intruders, workers, and the environment, key radionuclides [see "NRC Staff Guidance for Activities Related to U.S. Department of Energy Waste Determinations, Draft Final Report for Interim Use" *(* NRC, 2007)]. Uncertainty in the performance assessment or risk calculations should be considered when developing the list of key radionuclides. For example, performance assessment calculations could capture the peak dose even if the peak dose occurs beyond the 10,000 year timeframe to account for uncertainty in the travel times to the WMA C fence line to ensure that all key radionuclides are identified. Key radionuclides for members of the public, inadvertent intruders, and workers should be explicitly listed in the documentation. The screening process should be sufficiently conservative to ensure that all key radionuclides are identified and evaluated in the performance assessment.

Path Forward

Additional information should be provided regarding the screening approach used to identify primary contaminants of potential concern targeted for sampling and analysis. To the extent that this information is provided in supporting reference materials, references can be provided.

Comment 23

Additional information should be provided regarding development of the post-retrieval inventory estimates for Tank C-106 including the sufficiency of the number and location of solid residual samples.

Basis

The residual inventory for the tanks has a direct impact on the dose results. Inventory estimates should be fully supported to increase confidence in the performance assessment results. The inventory estimates for Tank C-106 are primarily based on sampling of primary contaminants of potential concern identified in RPP-13889 (CH2M Hill Hanford Group, 2004). Limited information is provided in the Stage II Retrieval Data report (CH2M Hill Hanford Group, 2007) summarizing data quality objectives and the sufficiency of the sampling approach to support development of inventory estimates and decision-making related to waste retrieval. Additional justification is needed regarding the assumption of homogeneity of the residual waste that was used as a basis for determining the sufficiency of a single sample location to develop inventory estimates for Tank C-106. Information regarding the expected degree of mixing of waste residuals during waste retrieval campaigns should be provided to support DOE's assumption regarding homogeneity of the waste. Additional information regarding process history and any other characterization efforts would also help to support inventory estimates based on multiple lines of evidence.

Path Forward

Additional information (or reference documents) should be provided regarding the development of the inventory for Tank C-106 including data quality objectives, post-retrieval sampling and analysis plans, and sampling results. Additional information to support the assumption regarding homogeneity of the waste including (i) waste retrieval technology performance data,

(ii) information on process history and (iii) additional characterization efforts for Tank C-106 that were not included in the Stage II Retrieval Data report (CH2M Hill Hanford Group, 2007) should also be included. To the extent that sampling has been performed for other tanks with similar waste streams or waste retrieval activities, statistical evaluation of data obtained from multiple sampling locations would be helpful in justifying the assumption regarding homogeneity of the waste following waste retrieval activities.

Comment 24

Additional information is needed to support the demonstration that wastes have been processed or will be processed to remove key radionuclides to the maximum extent that is technically and economically practical.

Basis

DOE Order 435.1 requires that wastes have been processed or will be processed to remove key radionuclides to the maximum extent that is technically and economically practical to make a determination that wastes are incidental-to-reprocessing and can be safely managed as low-level waste. Identification of key radionuclides and evaluation of the ability of retrieval alternatives to remove these key radionuclides is of primary importance in assessing the cost effectiveness of additional removal (NRC, 2007).

Insufficient information was provided to determine the ability of the selected waste retrieval technology and alternatives to remove key radionuclides. For example, it appears from data presented in Table 2-1 of the Stage II Retrieval Data Report (CH2M Hill Hanford Group, 2007) that the retrieval technology may have been less effective at removing Sr-90 in the 1998-1999 and 2003 sluicing campaigns than in removing Cs-137 based on the ratio of Sr-90 to Cs-137. Provide additional data and discussion regarding the ability of retrieval alternatives to remove other key radionuclides.

Declining solid residual volumes were used as a basis for demonstrating that waste retrieval proceeded to the maximum extent technically and economically practical; however, detailed information on the amount and types of radioactivity removed from the tank was not provided. While declining removal efficiencies of solids is important, it is not clear that amount of solids removed from the system is the singular measure of risk reduction. For example, if oxalic acid is effective in dissolution of solid residuals with preferential removal of key radionuclides in the liquid phase, the system may still be effective in reducing risk even if declining removal efficiencies of solid residuals occurs. Additional information could be provided to indicate how the selected waste retrieval technology is expected to operate to remove waste residuals (e.g., information could be provided on the types of solid phases present in the tanks and the effectiveness of oxalic acid to react with these solid phases to dissolve waste and reduce solid residual particle size to facilitate sluicing).

Path Forward

Provide pre- and post-inventory estimates for key radionuclides for the 1998-1999 and 2003 waste retrieval campaigns, if available. Provide information on the effectiveness of oxalic acid additions to preferentially remove certain key radionuclides from tank residuals. To the extent that this information is included in reference documents, the reference documents can be provided (e.g., RPP-17158 [CH2M HILL Hanford Group, Inc., 2003]).

The basis for termination of waste retrieval operations should be clearly communicated and related to risk reduction as informed by the performance assessment calculations. Indicate if the current waste retrieval technology is effectively accomplishing bulk removal of solids or if preferential removal of radionuclides through acid dissolution is occurring. Demonstrate that solids removal efficiency is a direct measure of declining performance of the system with respect to removal of key radionuclides and associated risk reduction.

INADVERTENT INTRUSION

Comment 25

Linkage between DOE/ORP (2006) and Rittmann (2004) needs to be described and illustrated in more detail and better documented.

Basis

In numerous places (e.g., page 3-92, Section 3.5.4.5) statements are provided that state that the dose factors calculated in Rittmann (2004) are used for DOE/ORP (2006). No statements of modification of the assumptions or values used in Rittmann (2004) are provided and these statements would suggest that no modification were made. However, a few of the assumptions in Rittmann (2004) are either not consistent with the reference case or are optional variables for use to calculate the exhumed waste concentrations. Modification of the approach or alternate values could lead to important changes in the exhumed waste concentration, which will result in a linear increase (or decrease) in the estimated dose to intruder.

In calculating the activity concentration of well boring tailings, Rittmann (2004) simplifies the calculation by assuming that the density of the waste and the soil is similar. In a grouted tank, three different volumes of exhumed material are involved - waste, soil and grout. No assessment of the simplification in Rittmann (2004) is included and no indication of the method used by DOE/ORP (2006) - either the Rittmann (2004) simplified calculation (page 21) or the more exact calculation is discussed.

Rittmann (2004) discusses an optional parameter (F_{AVAIL}) to modify ingestion and inhalation factors based on the form of the waste. Use of this linear factor reduces the ingestion and inhalation dose factors.

Path Forward

The following parameters and assumptions should be described as to how the DOE/ORP (2006) and Rittmann (2004) are consistent in use.

- The method of calculating the activity concentrations in the well drilling tailings should be described.
- If F_{AVAIL} was utilized, it should be documented, specifying for the value used, and whether the value changes with time of intrusion.
- Clarify whether the dose factors used by Rittmann were modified in the performance assessment. If they were modified, provide a justification for this revision.

Comment 26

Additional factors to limit external exposure are not justified in sufficient detail.

Basis

IA3.3 of Rittmann (2004) provides the justification and development of the external exposure times for the various scenarios. The second paragraph on page A-40 discusses modifications to correct the external dose rates from the radionuclide-specific infinite plane exposure factors used. However, no reference or basis is provided for the statements made.

In the second to last paragraph, Rittmann (2004) uses NUREG/CR-5512, Volume 1, Section 6.7.4 (Kennedy and Strenge 1992), which assigns an indoor shielding factor of 0.33 based on literature review of atmospheric deposition of radionuclides. However, in the later NUREG/CR-5512, Volume 3, Section 6.2.4 (Beyeler et al. 1999), much higher factors (e.g., less shielding) are estimated than used in NUREG/CR-5512, Volume 1 (Kennedy and Strenge 1992).

Path Forward

The basis for the infinite plane correction factor should be provided, using, at minimum, energy ranges consistent with key radionuclides for intrusion calculations. Additional justification is also required for the indoor shielding factor to demonstrate that the assumed value is appropriate for the exposure scenarios.

SUPPLEMENTARY

Comment 27

The future direction of groundwater flow under Tank Farm C will not be known for certain and may not align evenly with the tank rows assumed in DOE/ORP (2006).

Basis

The direction of groundwater flow is expected to return to a natural state before anthropogenic influences changed the water regime. However, the exact direction of the flow is not known once it reaches a quasi-steady state. If the groundwater flow is due east at some point in the future, the superposition of the tanks at Tank Farm C would be different from the superposition assumed in DOE/ORP (2006).

Path Forward

Give a technical basis for excluding an alternative superposition, e.g., low probability of occurrence or low consequence if it does occur.

Comment 28

An enhanced recharge rate of 50 mm/yr appears to be on the low end of the range for recharge rates under irrigated lands.

Basis

Alternatives to the "reference case" included irrigated farming at the end of passive institutional controls with the cover assumed removed. An infiltration rate of 1 mm/yr was increased to 50 mm/yr and the peak groundwater concentration ratio relative to reference case increased to 13.94 (DOE/ORP, 2006, Tab. 4-32, p. 4-111, & Tab. 7-10, p. 7-15). However, even an enhanced recharge rate of 50 mm/yr appears too low for an irrigated field. For example, "Estimates of Deep Percolation Beneath Native Vegetation, Irrigated Fields, and the Amargosa-River Channel, Amargosa Desert, Nye County, Nevada" [Stonestrom et al. (2003)] estimated that deep percolation rates beneath irrigated fields in the Amargosa Desert area ranged from 100 to 500 mm/yr.

Path Forward

Provide a technical basis for using 1.0 - 50 mm/yr as a recharge rate range under irrigated lands.

Additional Supplementary Comments

1. Text of the Stage II Retrieval Data report contains some apparent inconsistencies with respect to use of the detection limit (Appendix A) versus half the detection limit (Appendix E and F) to calculate inventories for those radionuclides where greater than 50% of the samples were below the detection limit. It appears that the risk calculations in the Stage II Retrieval Data Report (CH2M Hill Hanford Group, 2007) used half the detection limit for those constituents where greater than 50% of the samples were non-detect, including key radionuclides I-129 and C-14 (as well as Pu-238 which is important for the intruder analysis), although Appendix A inventories are based on use of the detection limit. Use of half the detection limit for the risk calculations should be justified. Discuss the adequacy of the detection limit for performance assessment calculations, and the need for and efficacy, if needed, of reduced detection limits for risk significant radionuclides.

2. The data and approach used to develop inventory estimates needs further explanation. While uncertainty in the inventory estimates due to sampling and measurement error, and other factors appear to be considered, detailed information regarding development of uncertainty estimates for the tank inventory is not provided. A statement is made that there is no inventory on the tank walls; however, no information is provided to support this statement. In addition, details regarding the approach used to estimate the inventory for stiffener rings and abandoned tank equipment is needed.

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