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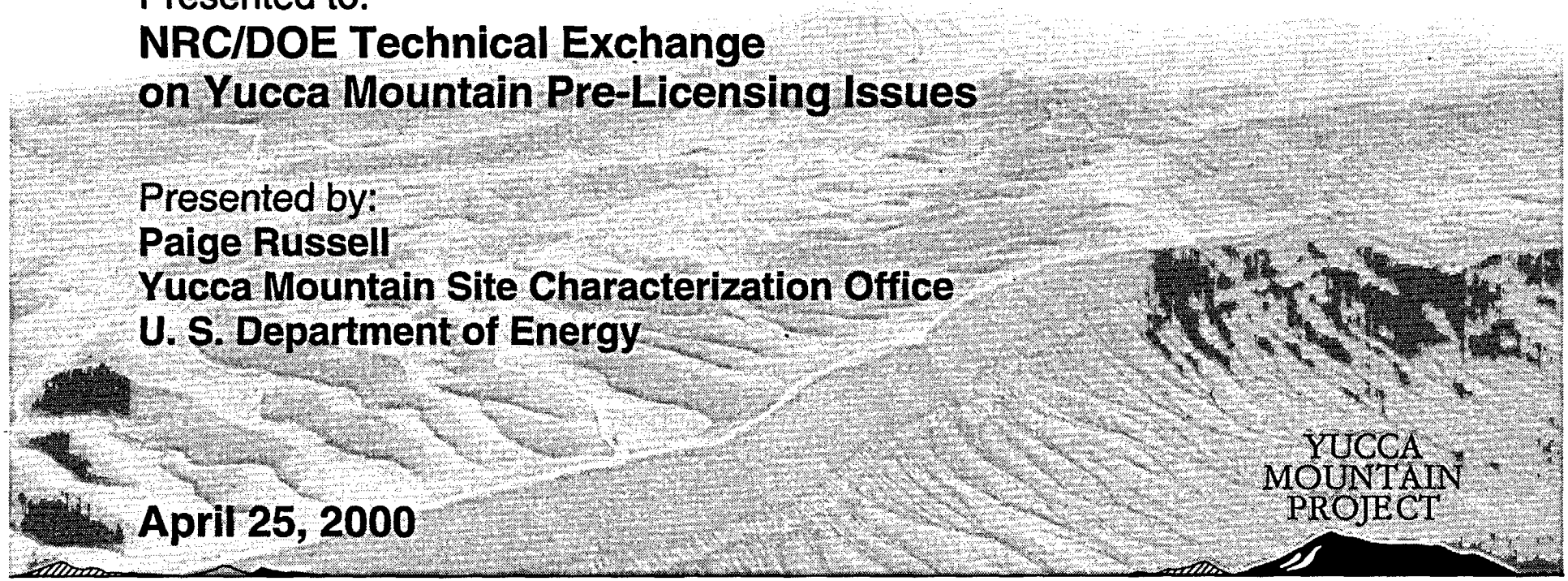
U.S. Department of Energy
Office of Civilian Radioactive Waste Management

Container Life and Source Term

Presented to:
NRC/DOE Technical Exchange
on Yucca Mountain Pre-Licensing Issues

Presented by:
Paige Russell
Yucca Mountain Site Characterization Office
U. S. Department of Energy



April 25, 2000

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Current Status

(Issue Resolution Status Report Revision 2)

- **Subissue 1 - Effects of Corrosion Processes on Lifetime of the Containers**
  - All technical acceptance criteria open
  - Some components related to corrosion of carbon steel closed
  - Concerns with corrosion of Alloy 22 remain open
- **Subissue 2 - Effects of Phase Stability of Materials and Initial Defects on the Mechanical Failure and Lifetime of the Containers**
  - All technical acceptance criteria open
  - Some components related to corrosion of carbon steel closed

Current Status
(Continued)

- **Subissue 3 - The Rate at Which Radionuclides in Spent Nuclear Fuel (SNF) Are Released from the Engineered Barrier System (EBS) Through the Oxidation and Dissolution of Spent Fuel**
  - **All acceptance criteria are open**

Current Status
(Continued)

- **Subissue 4 - The Rate at Which Radionuclides in High-Level Radioactive Waste (HLW) Glass are Leached and Released from the EBS**
  - **All technical acceptance criteria open**
  - **Issue Resolution Status Report notes that effect of colloids on release and transport, for SNF and for HLW glass, is considered closed**
  - **DOE's recent work indicates that colloids may affect transport of some radionuclides**

Current Status
(Continued)

- **Subissue 5 - The Effect of In-Package Criticality on Waste Package (WP) and EBS Performance**
  - **All technical acceptance criteria open**
- **Subissue 6 - The Effects of Alternate EBS Design Features on Container Lifetime and Radionuclide Release from EBS**
  - **All technical acceptance criteria open**
  - **Backfill no longer part of the repository design**

Key Activities

- **Fiscal Year (FY) 1998**
  - **Completed waste package materials selection for the Viability Assessment (VA) design. The corrosion-resistant material was changed from Alloy 625 to more corrosion-resistant Alloy 22**
  - **Developed new waste package barrier degradation models for input to Total System Performance Assessment (TSPA)- VA**
  - **Developed Disposal Criticality Analysis Methodology Topical Report**
  - **Continued waste package and waste form material testing**

Key Activities
(continued)

- **FY 1999**
  - Continued testing of waste package and waste form materials
  - Revised materials selection for the waste package culminating in Enhanced Design Alternative (EDA) II design. EDA II uses Alloy 22 as the outer barrier with stainless steel structural support and Titanium grade 7 for the drip shield
  - Submitted Disposal Criticality Analysis Methodology Topical Report to NRC

Key Activities
(continued)

- **FY 2000**
  - Updated waste package and waste form degradation models for TSPA - Site Recommendation (SR)
  - Completed documentation of the models in Analysis and Model Reports (AMRs) and Process Model Reports (PMRs) for waste package and waste form
  - Responded to NRC request for additional information on the Disposal Criticality Analysis Methodology Topical Report

Key Activities
(continued)

- **FY 2001**
  - Plan to complete revisions of the AMRs and PMRs, as needed
  - Plan to submit revised Disposal Criticality Analysis Methodology Topical Report to NRC
  - Plan to continue waste package and waste form materials testing, as needed
  - Plan to update waste package design, as needed

Key Technical Issue: Container Life and Source Term

KTI Subissues	Associated Factors of the Safety Case	Importance to Repository Performance
1. Effects of Corrosion Processes on Lifetime of the Containers	Waste package degradation and performance Drip shield degradation and performance	Waste package and drip shield degradation and performance are Principal Factors.
2. Effects of Phase Stability of Materials and Initial Defects on the Mechanical Failure and Lifetime of the Containers	Waste package degradation and performance Drip shield degradation and performance	
3. The Rate at Which Radionuclides in SNF are Released from the EBS Through the Oxidation and Dissolution of Spent Fuel	Dissolved radionuclide concentrations Colloid-associated radionuclide concentrations	Dissolved radionuclide concentrations and colloid-associated radionuclide concentrations are Principal Factors
4. The Rate at Which Radionuclides in HLW Glass are Leached and Released from the EBS	Dissolved radionuclide concentrations Colloid-associated radionuclide concentrations	
5. The Effect of In-Package Criticality on WP and EBS Performance	None	The FEPs associated with this subissue are not included in the process model. Data and analyses supporting this exclusion will be provided.
6. The Effects of Alternate EBS Design Features on Container Lifetime and Radionuclide Release from EBS	Waste package degradation and performance Drip shield degradation and performance	Waste package and drip shield degradation and performance are Principal Factors.

Subissue 1, Corrosion Process

- **Corrosion Modes**
  - **Variety of corrosion modes have been considered. Corrosion modes evaluated include general corrosion, localized corrosion, microbiologically influenced corrosion, stress corrosion cracking, and hydrogen-induced cracking**
  - **A range of environments has been evaluated, and bounding environments based on the evaporative concentration of J-13 water have been selected**
  - **Uncertainties are accounted for in the corrosion models**
  - **Materials selection process for waste package and drip shield include evaluation of material compatibility, expected exposure conditions, and ease of fabrication**
  - **Extensive corrosion testing program has been established, and the process model development includes the use of published data outside of the Project**

Subissue 2, Effects of Phase Stability and Initial Defects

- **Phase Stability Effects**
  - **Materials testing to evaluate phase stability effects is ongoing, and test program has been expanded to include welded and cold worked materials**
  - **Current data indicates that phase stability will not be an issue from the corrosion standpoint for the waste package outer barrier**

Subissue 2, Effects of Phase Stability and Initial Defects
(Continued)

drifts - reoriented to rockjoints in response to fracture blocks 30° from joint orientation

- **Mechanical Failure Processes**
  - **Current waste package and drip shield degradation modeling include stress corrosion cracking and hydrogen-induced cracking. Stress corrosion cracking model incorporates fabrication-related flaws**
  - **Structural analysis of the waste package shows that the failures (through-wall penetrations) due to rockfall are precluded** screened out through design 10^{-8} chance of occurring with 10 13 tons
  - **Nondestructive examination (NDE) protocol is under development to evaluate detection of fabrication defects**

Subissue 2, Effects of Phase Stability and Initial Defects
(Continued)

- **Early Failures**
  - Analysis of mechanism for early waste package failures was documented in an AMR
  - Weld flaws associated with the closure weld were determined to be the most likely condition that could lead to early failures
  - Surface-breaking weld flaw sizes and distributions were determined based on limited NDE
  - Flaw size and distributions are used as input to the stress corrosion cracking model
  - Approach to early failures is different from that of NRC

Subissues 3 and 4

- **Subissue 3: The Rate at Which Radionuclides in SNF are Released from the EBS Through the Oxidation and Dissolution of Spent Fuel**
- **Subissue 4: The Rate at Which Radionuclides in HLW Glass are Leached and Released from the EBS**
- **These are related to the Principal Factor: Radionuclide Concentrations at the Source**

Subissues 3 and 4
(Continued)

- **Consider all categories of SNF/HLW**
  - DOE has tested a range of wastes and considered all categories of wastes in the uncertainty assessments documented in the AMRs

bounding analysis

- **Justify isotope selection**
  - DOE reevaluated and documented isotope selection in an AMR (Inventory Abstraction)
- **Identify range of in-waste package environment**
  - DOE has performed reaction path calculations for a wide range of reaction rates and flows for both commercial SNF and several co-disposal waste packages

Subissues 3 and 4

(Continued)

- **Identified and considered all likely processes for SNF and HLW degradation and radionuclide release from EBS**
  - SNF matrix dissolution
  - Prompt release
  - Dry oxidation
  - Degradation and failure of fuel cladding
  - Preferential release from defense SNF
  - Glass dissolution
  - Secondary phases & colloids
  - Microbial action
  - Radionuclide release from waste package

Subissue 5, Effect of In-Package Criticality

- **DOE is addressing criticality using Disposal Criticality Analysis Methodology Topical Report and its supporting documents**
- **Expect to show criticality risk is not a significant contributor to TSPA**

Keff → agree on methodology then show no impact on consequence using TSPA

looking at random sampling of assemblies for burnup credit not planning on measuring each assembly

criticality → all screened out on probability → long lived waste package

return to ambient ~1000 years
below boiling
ambient 1000s of years

Subissue 6, Alternate EBS Design Features

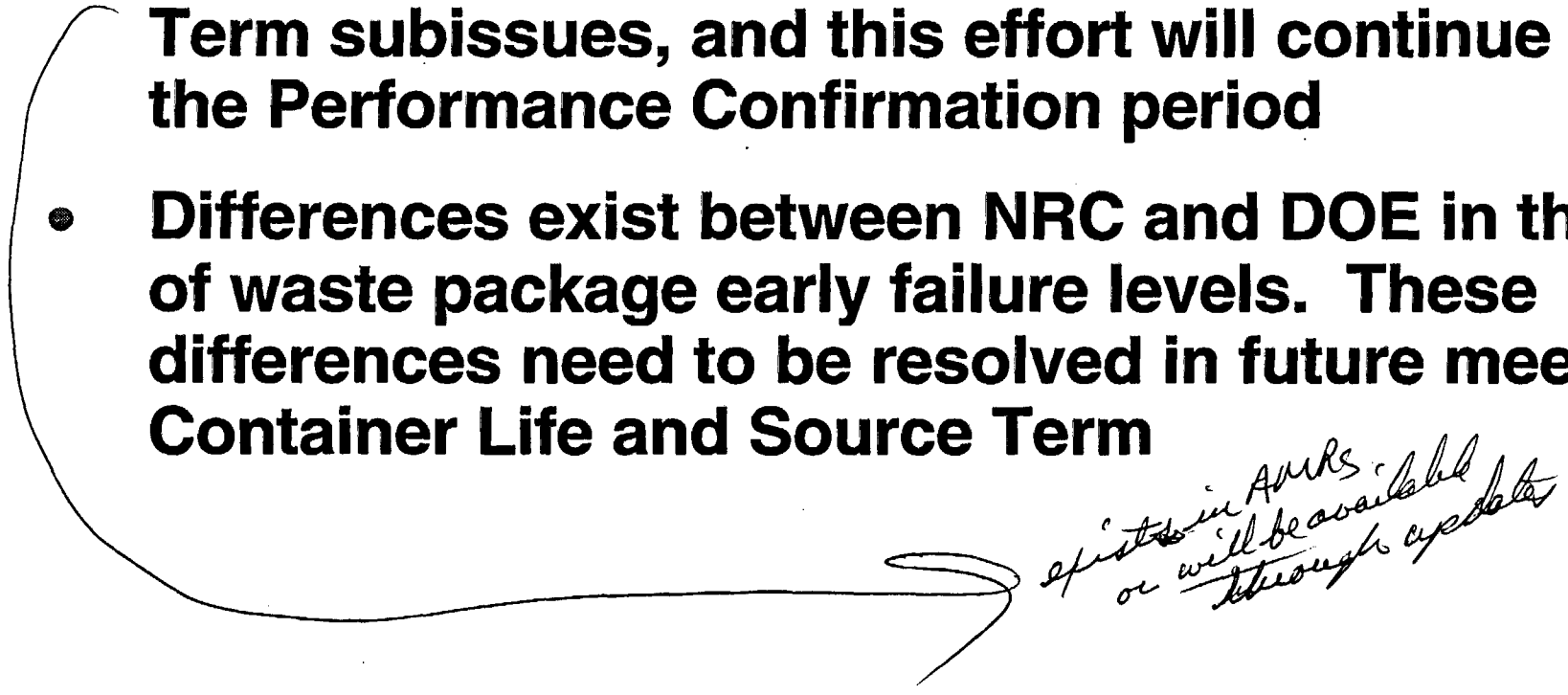
- **Effects of Drip Shield**
  - Current models conservatively assume that the environment on the surface of the waste package is same as that on the drip shield
  - The degradation model for the waste package accounts for potential crevice development under the drip shield
  - No condensation of water on the underside of the drip shield is expected based on the temperature distribution within the drift
- **Drip Shield Performance**
  - General and localized corrosion and hydrogen-induced cracking of the drip shield are addressed in two separate AMRs

Subissue 6, Alternate EBS Design Features
(Continued)

- **Effects of Design changes**
  - Current waste package design is relatively thinner than the VA design, so the surface radiation levels are expected to be higher
  - Potential for radiolysis-enhanced corrosion of the outer barrier has been evaluated using hydrogen peroxide additions to the test media. The threshold for localized corrosion was not exceeded
  - Backfill has been removed from the repository design. This reduces temperature of spent nuclear fuel cladding

Summary

- DOE is in general agreement with the subissues
- DOE is conducting materials testing and modeling program to address the Container Life and Source Term subissues, and this effort will continue through the Performance Confirmation period
- Differences exist between NRC and DOE in the area of waste package early failure levels. These differences need to be resolved in future meetings on Container Life and Source Term



Backup

Key Technical Issue: Container Life and Source Term		
Acceptance Criteria	**CLST IRSR Rev. 2 Status**	**DOE Comment**
Subissue 1: Corrosion Process		
1 - DOE has identified and considered likely modes of corrosion for container materials, including dry-air oxidation, humid-air corrosion, and aqueous corrosion processes, such as general corrosion, localized corrosion, MIC, SCC, and hydrogen embrittlement, as well as the effect of galvanic coupling.	The following components of this subissue are considered closed at the staff level: 1. dry oxidation of carbon steel 2. aqueous corrosion of carbon steel 3. microbial influenced corrosion (MIC) of carbon steel 4. stress corrosion cracking of carbon steel 5. galvanic coupling Issues still to be addressed for Alloy-22	All likely modes of corrosion have been considered and modeled in the WP PMR. The constituent models of this PMR include process models for dry-air oxidation, humid-air corrosion, stress corrosion cracking, hydrogen induced cracking, and aqueous corrosion processes, such as general corrosion, localized corrosion, and microbial influenced corrosion. Galvanic coupling effects have been minimized.
2 - DOE has identified the broad range of environmental conditions within the WP emplacement drifts that may promote the corrosion processes listed previously, taking into account the possibility of irregular wet and dry cycles that may enhance the rate of container degradation.	Open	The corrosion models in the WP PMR include environmental thresholds that can be used to switch between dominant modes of corrosion.
3 - DOE has demonstrated that the numerical corrosion models used are adequate representations, taking into consideration associated uncertainties, of the expected long-term behaviors and are not likely to underestimate the actual degradation of the containers as a result of corrosion in the repository environment.	Open	Uncertainties are accounted for in corrosion rates reported in the WP PMR.

Key Technical Issue: Container Life and Source Term		
Acceptance Criteria	**CLST IRSR Rev. 2 Status**	**DOE Comment**
4 - DOE has considered the compatibility of container materials, the range of material conditions, and the variability in container fabrication processes, including welding, in assessing the performance expected in the container's intended waste isolation function.	Open	The effects of welding and thermal aging on the corrosion resistance of the waste package materials have been accounted for in the WP PMR.
5 - DOE has justified the use of data collected in corrosion tests not specifically designed or performed for the YM repository program for the environmental conditions expected to prevail at the YM site.	Open	Models in the WP PMR are based on bounding environmental conditions (temperature, humidity, chemistry, etc.) expected in the proposed repository. In addition to the data generated from long-term and short-term corrosion tests, the process model development also includes data generated outside the Yucca Mountain. These data in general include testing in environments not directly applicable to Yucca Mountain and therefore are used as corroborative information.

Key Technical Issue: Container Life and Source Term		
Acceptance Criteria	**CLST IRSR Rev. 2 Status**	**DOE Comment**
6 - DOE has conducted a consistent, sufficient, and suitable corrosion testing program at the time of the LA submittal. In addition, DOE has identified specific plans for further testing to reduce any significant area(s) of uncertainty as part of the performance confirmation program.	Open	The DOE has established a corrosion test program that addresses all anticipated modes of corrosive attack of the waste package. In addition, the Project will continue testing of materials both in the laboratory and in the field. This part of the testing program is covered in the Performance Confirmation Plan.
7 - DOE has established a defensible program of corrosion monitoring and testing of the engineered subsystem components during the performance confirmation period to assure they are functioning as intended and anticipated.	Open	This acceptance criterion will be addressed as part of the Performance Confirmation Program currently under development.
Subissue 2: Material failure		
1 - DOE has identified and considered the relevant mechanical failure processes that may affect the performance of the proposed container materials.	Open	All relevant mechanical degradation modes, including HIC and SCC as two possible mechanical failure modes have been considered in the WP PMR.
2 - DOE has identified and considered the effect of material stability on mechanical failure processes for the various container materials as a result of prolonged exposure to the expected range of temperatures and stresses, including the effects of chemical composition, microstructure, thermal treatments, and fabrication processes.	Open	The WP PMR presents data showing that Alloy 22 has adequate phase stability to serve as a waste package material, provided that the temperature is not allowed to exceed 260°C. Expected range of temperature and stresses, chemical composition, microstructure, thermal treatments,

Key Technical Issue: Container Life and Source Term		
Acceptance Criteria	**CLST IRSR Rev. 2 Status**	**DOE Comment**
		and fabrication processes are all related to the material stability and have been considered in modeling in the PMR.
3 - DOE has demonstrated that the numerical models used for container materials stability and mechanical failures are effective representations, taking into consideration associated uncertainties, of the expected materials behavior and are not likely to underestimate the actual rate of failure in the repository environment.	Open	Uncertainties, assumptions, and limitations of the specific models are addressed in WP PMR and the related AMRs. The analysis also takes into account quantifiable uncertainties and variability of the degradation model for the possible ranges of corrosion parameters and exposure conditions.
4 - DOE has considered the compatibility of container materials and the variability in container manufacturing processes, including welding, in its WP failure analyses and in the evaluation of radionuclide release.	Open	The design now accounts for material compatibility. Variabilities in processes used for weld stress mitigation are also accounted for in the SCC models for both laser peening and induction annealing techniques.
5 - DOE has identified the most appropriate methods for nondestructive examination of fabricated containers to detect and evaluate fabrication defects in general and, particularly, in seam and closure welds.	Open	An NDE protocol is under development and will be used for DS and waste package inspection. Such inspection will limit the size of manufacturing defects as a means of helping prevent SCC and HIC. Materials used in waste package construction will be tested electrochemically, to assure that materials used are not unexpectedly susceptible to localized corrosion.

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Acceptance Criteria	**CLST IRSR Rev. 2 Status**	**DOE Comment**
6 - DOE has justified the use of material test results not specifically designed or performed for the YM repository program for environmental conditions (i.e., temperature, stress, and time) expected to prevail at the proposed YM repository.	Open	Various AMRs supporting the WP PMR, such as the AMR on degradation of stainless steel, provide discussion for the use of material test results from published data not specifically designed or performed for the Yucca Mountain repository program for environmental conditions expected to prevail at the proposed Yucca Mountain repository.
7 - DOE has conducted a consistent, sufficient, and suitable material testing program at the time of the LA submittal. In addition, DOE has identified specific plans for further testing to reduce any significant area(s) of uncertainty as part of the performance confirmation program.	Open	This acceptance criterion will be addressed as part of the Performance Confirmation Program currently under development.
8 - DOE has established a defensible program of monitoring and mechanical testing of the engineered subsystems components, during the performance confirmation period, to assure they are functioning as intended and anticipated, in the presence of thermal and stress perturbations.	Open	This acceptance criterion will be addressed as part of the Performance Confirmation Program currently under development.
Subissue 3: Radionuclide Release from Spent Fuel		
1 - DOE has considered all categories of SNF planned for disposal at the proposed YM repository.	Open	Many types of SNF to be emplaced have been considered and are discussed in Section 3.3 and 3.5 of the Waste Form (WF) Degradation PMR.

Key Technical Issue: Container Life and Source Term

Acceptance Criteria	CLST IRSR Rev. 2 Status	DOE Comment
2 - DOE has adequately justified the selection of radionuclides tracked in the release models from SNF and their related release parameters.	Open	With the issuance of draft regulations 10 CFR 63 and 40 CFR 197 (64 FR 46976), the selection of radioisotopes was reevaluated and is discussed in Section 3.1 of WF PMR.
3 - DOE has identified the range of environmental conditions to be expected inside breached WPs.	Open	The range of environmental conditions expected inside the WPs are addressed in the WF PMR.
4 - DOE has identified and considered likely processes for SNF degradation and the release of radionuclides from the EBS, as follows: dissolution of the irradiated UO_2 matrix, with the consequent formation of secondary minerals and colloids; prompt release of radionuclides; degradation in the dry air environment; degradation and failure of fuel cladding; preferential dissolution of intermetallics in DOE SNF; and release of radionuclides from the WP emplacement drifts.	Open	Several sections of the WF PMR, address dissolution of the irradiated UO_2 matrix; modeling of the degradation and failure of fuel cladding including topics of prompt release of radioisotopes and degradation of UO_2 and cladding in the dry air environment (this topic was also a FEP); dissolution of DOE SNF; and formation of colloids. The part of this criterion that deals with release of radioisotopes from the WP emplacement drifts is addressed in the EBS PMR.
5 - DOE has demonstrated that the numerical models used for SNF degradation and radionuclide release from the EBS are adequate representations, including consideration of uncertainties, of the expected SNF performance and are not likely to overestimate the actual performance in the repository environment.	Open	The models in the WF PMR were designed to avoid over estimation of performance. In general, the models are regression analyses of experimental data at repository conditions, bounding representations

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		of experimental data, or assume very aggressive degradation to bound uncertainty. Bounding representations of numerical simulations explicitly include a function to represent uncertainty, define an uncertain distribution, or use bounding values for radioisotope solubility.
6 - DOE has considered the compatibility of SNF and the internal components of the WP, such as the basket materials, in the evaluation of radionuclide releases. Specifically, the SNF should not compromise the performance of the WP.	Open	Compatibility of internal components, the SNF, and the waste package has been considered in selection of materials for the waste package and internals.
7 - DOE has justified the use of SNF test results not specifically collected for the YM site for the environmental conditions expected to prevail after breaching of the containers at the YM site.	Open	In several cases, the WF degradation PMR uses test results of the degradation of SNF not specifically collected for the Yucca Mountain site to corroborate the YMP data (e.g., CSNF Matrix Degradation Component). In the case of the CSNF Cladding Degradation Component, the extensive data collected over the past 30 years on cladding failure mechanisms are used. This use, however, is evaluated under specific QA procedures that address qualification of unqualified data and appropriateness of data for its intended use.

Key Technical Issue: Container Life and Source Term		
Acceptance Criteria	**CLST IRSR Rev. 2 Status**	**DOE Comment**
8 - DOE has conducted a consistent, sufficient, and suitable SNF corrosion and radionuclide release testing program at the time of the LA submittal. In addition, DOE has identified specific plans for further testing to reduce any significant area(s) of uncertainty as part of the *performance confirmation program.*	Open	As explained in Sections 3.3 and 3.5, of the WF PMR, the foundation of the commercial SNF and DOE SNF degradation rates for the TSPA-SR is the testing program conducted. A Performance Confirmation Plan has been developed that establishes the test and analysis requirements to confirm, with reasonable assurance, that the performance objective for the *period after permanent repository* closure is met.
9 - DOE has established an adequate program of monitoring radionuclide release from the WP during the performance confirmation period, to assure that assumptions and calculations of SNF dissolution and radionuclide release from the WP are appropriately substantiated.	Open	A Performance Confirmation Plan has been developed that establishes the test and analysis requirements to confirm, with reasonable assurance, that the performance objective for the period after permanent repository closure is met.
Subissue 4: Degradation of High Level Waste Glass		
1 - DOE has taken into account all types of HLW glass planned for YM disposal.	Open	Consideration of the several types of HLW to be placed into the potential Yucca Mountain is discussed in Section 3.6 of the WF PMR.
2 - DOE has adequately justified the selection of radionuclides tracked in the release models from HLW glass and their related	Open	After issuance of draft regulations 10 CFR 63 and 40 CFR 197

Key Technical Issue: Container Life and Source Term		
Acceptance Criteria	**CLST IRSR Rev. 2 Status**	**DOE Comment**
release parameters.		(64 FR 46976), the selection of radionuclides was reevaluated. Section 3.1 of WF PMR and associated AMR provide justification for the radionuclides and parameters to be tracked in release models
3 - DOE has identified the range of environmental conditions to be expected inside breached WPs containing HLW glass and eventually certain types of SNF as in the co-disposal WPs.	Open	The Waste Form Degradation Model discusses and captures the range of environmental conditions expected inside the waste packages.
4 - DOE has identified and considered likely processes for the degradation of HLW glass and the release of radionuclides from the EBS, i.e., dissolution of the primary phase; formation of secondary minerals and colloids; microbial action; and radionuclide releases and transport from the WP emplacement drifts.	Open. However, the IRSR notes effect of colloids on release and transport, for SNF and for high-level radioactive waste (HLW) glass is considered closed at the staff level.	WF PMR addresses dissolution of the HLW glass and uses of experimental data on the formation of colloids from HLW. Microbial action is the topic of a FEP that applies both to SNF and HLW degradation. Release and transport of radionuclides from the emplacement drifts is discussed in the EBS PMR.
5 - DOE has demonstrated that the numerical models used for determining the rate of dissolution of HLW glass and the rate of radionuclide release from the EBS are adequate representations, taking into consideration the associated uncertainties, of the expected HLW glass performance, and are not likely to underestimate the actual rate of degradation of the HLW glass and the subsequent rate of release in the repository environment.	Open	The degradation model in WF PMR is a bounding representation of experimental results at different pH values. Furthermore, representations of numerical simulations explicitly include a function to represent uncertainty of the pH. The HLW model was designed to avoid under-

Key Technical Issue: Container Life and Source Term		
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		estimation of rate of degradation and release. In the discussion of this criterion in Section 5.4.5 of the IRSR, NRC expressed a concern that, "DOE has not considered field data on naturally occurring glasses, combined with experimental data and models on dissolution of HLW glasses, to demonstrate that long-term dissolution behavior under repository conditions can be represented by extrapolation of results from short-term laboratory tests." The DOE has considered data on naturally occurring glasses and successfully compared the paragenetic sequence observed to that found for HLW glass. DOE has used a bounding value for a variety of experimental data on dissolution of HLW glass to bolster confidence in the prediction of long-term behavior. Therefore, DOE has not been overly optimistic in its use of short-term data for modeling of long-term HLW glass dissolution.
6 - DOE has assessed the compatibility of HLW glass with internal components of the WP in the evaluation of radionuclide release,	Open	The compatibility of internal components, the HLW, and the WP

Key Technical Issue: Container Life and Source Term

Acceptance Criteria	CLST IRSR Rev. 2 Status	DOE Comment
taking into consideration co-disposal with DOE-owned SNF in the same WP. Specifically, HLW glass should not compromise the performance of the WP.		components has been considered in and corrosion of the internal selection of materials for the waste package and its internal parts.
7 - DOE has justified the use of test results for HLW glass not specifically collected for the YM site for environmental conditions expected to prevail after breaching of the containers at the YM site.	Open	In several cases, the WF Degradation PMR uses test results of the degradation of HLW not specifically collected for the Yucca Mountain site to expand the range of applicability and corroborate the YMP data. This use is evaluated under specific QA procedures that address qualification of unqualified data and appropriateness of data for its intended use.
8 - DOE has conducted a consistent, sufficient, and suitable HLW glass and radionuclide release corrosion testing program at the time of the LA submittal. In addition, DOE has identified specific plans for further testing to reduce any significant area(s) of uncertainty as part of the performance confirmation program.	Open	The foundation of the HLW degradation rates for the TSPA related to the site recommendation is the testing program conducted. A Performance Confirmation Plan has been developed that establishes the test and analysis requirements to confirm, with reasonable assurance, that the performance objective for the period after permanent repository closure is met.
9 - DOE has established an adequate program of monitoring radionuclide release from the WP during the performance	Open	A Performance Confirmation Plan has been developed that establishes the

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confirmation period to assure that assumptions and calculations regarding HLW glass dissolution and radionuclide release are appropriately substantiated.		test and analysis requirements to confirm, with reasonable assurance, that the performance objective for the period after permanent repository closure is met.
Subissue 5: Effects of In-package Criticality on Waste Package		
1 - DOE has used sound technical bases for selecting the design criteria for components to mitigate any potential effects of in-package criticality on the repository performance. These design criteria may include development of subcritical limit, probability and consequence of criticality, and any other design criteria considered being necessary by DOE.	Open	Note: In-package criticality and related acceptance criteria are addressed in DOE's *Disposal Criticality Analysis Methodology Topical Report* and its supporting references.
2 - DOE has identified all the features, events, and processes that may increase the reactivity of the system inside the WP. The acceptance criteria provided for the Scenario Analysis subissue in the Total System Performance Assessment and Integration (TSPAI) IRSR must also be considered.	Open	
3 - DOE has identified the configuration classes and configurations that have potential for nuclear criticality. If models are used to develop the configurations, approach and accuracy in modeling verification and validation will be evaluated.	Open	
4 - DOE has developed a technically defensible, transparent, and traceable method in assigning probability values to each of the scenario classes, scenarios, configuration classes, and configurations.	Open	

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Acceptance Criteria	**CLST IRSR Rev. 2 Status**	**DOE Comment**
5 - DOE has developed appropriate computer models, input parameters, and determined quantitative values for calculating the effective neutron multiplication factor (k_{eff}), including appropriate biases and uncertainties in the model.	Open	
6 - DOE has developed appropriate computer models, evaluated input parameters, and determined quantitative values for calculating the radionuclide inventory, heat, kinetic energy, and other parameters that would change as a result of k_{eff} exceeding the subcritical limit developed under Criterion (1).	Open	
7 - DOE has determined the risk contribution from the in-package criticality to the total repository system performance appropriately.	Open	
Subissue 6: Alternate EBS Design Features		
1 - DOE has identified and considered the effects of backfill, and the timing of its emplacement, on the thermal loading of the repository, WP lifetime (including container corrosion and mechanical failure), and the release of radionuclides from the EBS.	Open	The current design does not include backfill. The effects of the backfill are not considered in determining the environment on the surface of drip shield and waste package.
2 - DOE has identified and considered the effects of ceramic coating on WP lifetime, including negative consequences as a result of breakdown of the ceramic coating (cracking, spalling, or delamination) in response to the action of environment, manufacturing defects, mechanical impacts and stresses arising from a multiplicity of sources, and the potential for enhanced localized corrosion of the containers that might occur at cracks or perforations in the ceramic coating layers.	Open	This criterion is no longer applicable, as the current design for the repository does not include ceramic coatings.

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Acceptance Criteria	**CLST IRSR Rev. 2 Status**	**DOE Comment**
3 - DOE has evaluated the compatibility of ceramic coating materials with outer overpack materials and the combined effect of ceramic coating with backfill on container lifetime.	Open	See comment on Criterion 2.
4 - DOE has identified and considered the effects of drip shields (with backfill) on WP lifetime, including extension of the humid-air corrosion regime, environmental effects, breakdown of drip shields and resulting mechanical impacts on WP, the potential for crevice corrosion at the junction between the WP and the drip shield, and the potential for condensate formation and dripping on the underside of the shield.	Open	The effects of the drip shield have been considered and evaluated in the analysis of waste package performance. This aspect is discussed in Section 3.2.3 of Waste Package PMR. The analysis conservatively assumes that the environment on the surface of the waste package is not affected by the presence of the drip shield. Degradation model for the waste package takes into account potential for crevice corrosion and degradation due to mechanical failure and assumes exposure to drift environment with no protection by drip shield against water dripping. The effects of the backfill with respect to changes in water chemistry are also not assumed since the current design does not include backfill.
5 - DOE has evaluated the effect of design changes in container wall thickness that may increase (-radiolysis of the water contacting WPs and, therefore, enhance the possible occurrence of localized corrosion processes.	Open	Experiments have been performed with Alloy 22 to accurately mimic the effects of gamma radiolysis. It is known that gamma radiolysis of aqueous electrolytes produces hydrogen peroxide, and that

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		hydrogen peroxide increases the open circuit corrosion potential of stainless steels. There has been concern that such effects could push the corrosion potential close to the threshold potential for the initiation of LC. Laboratory experiments have shown that the maximum increase in corrosion potential due to hydrogen peroxide in concentrated repository ground waters is approximately 200 mV, and insufficient to exceed the threshold for initiation of localized corrosion.
6 - DOE has identified the chemical composition of the water in the environment surrounding the WPs and its evolution with time.	Open	This has been done through both evaporative concentration and thermodynamic calculation.
7 - DOE has justified the use of test results for drip shields, ceramic coatings, and backfill materials not specifically collected for the YM site for the environmental conditions expected to prevail at the proposed YM repository.	Open	At the present time, the ceramic coating is not part of the drip shield or waste package design.
8 - DOE has conducted a consistent, sufficient, and suitable corrosion testing program at the time of the LA submittal. In addition, DOE has identified specific plans for further testing to reduce any significant area(s) of uncertainty as part of the performance confirmation program.	Open	This acceptance criterion will be addressed as part of the Performance Confirmation Program currently under development.

Yucca Mtn - NRC concern is SCC from similar environment leading to localized corrosion of zircaloy cladding

TSPA-SR - full suite of inputs for no backfill
AMRs will be changed to reflect no backfill

has revisited FEPs based on no backfill change through RSS workshop