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September 27, 2001
Contract No. NRC–02–97–009
Account No. 20.01402.761

U.S. Nuclear Regulatory Commission
ATTN: Mr. James Firth
Office of Nuclear Material Safety and Safeguards
Division of Waste Management
Performance Assessment and High-Level Waste Integration Branch
Mail Stop 7C–18
Washington, DC 20555

Subject: Transmittal of the Total System Performance Assessment and Integration (TSPAI) Issue Resolution Blueprint—Letter Report IM 20.01402.761.140

Dear Mr. Firth:

The purpose of this letter is to transmit "Total System Performance Assessment and Integration (TSPAI) Issue Resolution Blueprint—Letter Report", which fulfills IM 20.01402.761.140. This report describes the conduct and the results of work performed by the staff of the NRC and CNWRA in reviewing reports that support the DOE Site Recommendation. The blueprint document, which is contained in an appendix to the report, documents all Total System Performance Assessment and Integration Key Technical Issue comments arising from staff review of the Total System Performance Assessment–Site Recommendation, Analysis and Model Reports, and Process Model Reports, the responses to these comments received from the DOE, and as appropriate, the agreement that was reached with DOE to satisfy the comment. The information presented in the blueprint is contained in an Access database in which each comment corresponds to a single record. When the development of the database is complete and the data have been verified, a copy will be provided to the NRC.

If you have any technical or programmatic questions about the content of the review report, please contact Sitakanta Mohanty at (210) 522-5185 or me at (210) 522-5082.

Sincerely yours,

Gordon W. Wittmeyer, Ph.D.
Manager, Performance Assessment

GW/cw

cc: J. Linehan, B. Meehan, D. DeMarco, E. Whitt, J. Greeves, J. Piccone, T. Essig, W. Reamer, S. Wastler, J. Andersen, T. McCartin, B. Leslie, D. Esh, R. Codell, M. Lee, W. Dam, C. McKenney, M. Rahimi, R. Johnson, W. Patrick, CNWRA Directors, CNWRA Element Managers, T. Nagy (SwRI Contracts), P. Maldonaldo, O. Pensado, S. Mayer, S. Mohanty

TOTAL SYSTEM PERFORMANCE ASSESSMENT AND INTEGRATION (TSPAI) ISSUE RESOLUTION BLUEPRINT

Prepared for

U.S. Nuclear Regulatory Commission
Contract NRC–02–97–009

Prepared by

S. Mayer
S. Mohanty
O. Pensado

Center for Nuclear Waste Regulatory Analyses
San Antonio, Texas

September 2001

CONTENTS

ACKNOWLEDGMENTS

This report was prepared to document work performed by the Center for Nuclear Waste Regulatory Analyses (CNWRA) for the Nuclear Regulatory Commission (NRC) under Contract No. NRC–02–97–009. The activities reported here were performed on behalf of the NRC Office of Nuclear Material Safety and Safeguards, Division of Waste Management. The report is an independent product of the CNWRA and does not necessarily reflect the views or regulatory position of the NRC.

The coordinators wish to thank all technical staff members from the CNWRA and the NRC high-level waste program who contributed to this report by preparing comments listed in the appendix. The coordinators also wish to thank R. Benke, L. Howard, M. Smith, J. Weldy, and G. Wittmeyer for their technical reviews and B. Sagar for his programmatic review. Technical assistance provided by J.S. Paddock of Solution Consulting in developing the database is gratefully acknowledged. Thanks are also expressed to D. Moore for his editorial review and C. Weaver for her secretarial support.

QUALITY OF DATA, ANALYSES, AND CODE DEVELOPMENT

There are no original data contained in this report. Results from computer codes used in formulating some of the comments documented in this report are not explicitly stated in this report. Other calculations, such as hand calculations, meet quality assurance requirements described in the CNWRA Quality Assurance Manual.

1 INTRODUCTION

The U.S. Nuclear Regulatory Commission (NRC) together with its contractor, the Center for Nuclear Waste Regulatory Analyses (CNWRA) are involved in pre-licensing consultations with the U.S. Department of Energy (DOE). Such consultations are called for in the Nuclear Waste Policy Act of 1882 or amended and have the objective that any license application prepared by DOE will be high-quality and complete. An agreement was also reached in 1992 between the NRC and the DOE that staff-level resolution can be achieved on any potential issue during pre-licensing consultation. The purpose of staff-level issue resolution is to assure that sufficient information is available to enable the NRC to docket a license application.[1] Issue resolution at the staff level, during pre-licensing, is achieved when the staff have no further questions or comments regarding how the DOE is addressing an issue.

For issue resolution, the NRC and CNWRA staff review the DOE documents, perform independent experiment and confirmatory calculations, and document issues based on their current understanding of the site characteristics, waste form characteristics, design data, modeling approach, and analyses approaches. The results of the review efforts are then provided to the DOE periodically at technical exchanges.

The NRC and DOE already have engaged in several rounds of pre-licensing interactions on total system performance assessment, including interactions associated with the DOE Total System Performance Assessment–95 (CRWMS M&O, 1995) and Total System Performance Assessment–Viability Assessment (DOE, 1998). The NRC and the CNWRA prepared numerous written comments on these two Total System Performance Assessments, and presented the findings to the DOE. The Total System Performance Assessment–Site Recommendation (CRWMS M&O, 2000a,b), which is the latest performance assessment conducted by the DOE in support of a site suitability decision, provides the NRC and CNWRA staff with a rich resource of new information to be used in the pre-licensing interactions.

The Total System Performance Assessment issue resolution blueprint document, contained in the appendix, documents all Total System Performance Assessment and Integration Key Technical Issue comments generated by the CNWRA and NRC staff from the review of Total System Performance Assessment–Site Recommendation (CRWMS M&O, 2000a) and its supporting documents. The blueprint was developed to facilitate formal tracking of the large number of comments generated during the review. The blueprint provides material for direct interactions with the DOE; however, these comments are also expected to be used in developing sufficiency comments, preparing the integrated issue resolution status report, developing acceptance criteria, and review methods for use in the Yucca Mountain Review Plan.

The comments presented in this document were presented to the DOE at a series of technical exchanges. The first technical exchange, held on May 15–17, 2001,[2] focused on the scenario

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[1]Resolution at the staff level does not preclude an issue being raised and considered during the licensing proceedings, nor does it prejudge what the NRC staff evaluation of that issue will be after its licensing review.

[2]Reamer, C.W. "U.S. Nuclear Regulatory Commission/U.S. Department of Energy Technical Exchange and Management Meeting on Total System Performance Assessment and Integration-Features, Events, and Processes (May 15–17, 2001)." Letter (May 30) to S.J. Brocoum. Washington, DC: DOE. 2001

analysis subissue and, in particular, on the screening of features, events, and processes for performance assessment. The second technical exchange, held August 6–10, 2001,[3] focused on the remaining portions of the scenario analysis subissue and the remaining subissues within the Total System Performance Assessment and Integration Key Technical Issue.

In the following sections, the review approach and the documentation of the review findings are described. Section 2 describes the scope of the review. Section 3 describes how the review was conducted in a risk-informed manner. Section 4 describes and documents review findings. Conclusions and the path forward are presented in Section 5.

2 SCOPE OF REVIEW

The scope of the review is limited to the information available prior to the DOE release of their Science and Engineering Report (DOE, 2001). The review is not based on a complete and thorough reading of all available documents, but rather a limited, focused, risk-informed review of selected portions of DOE documents that support the Total System Performance Assessment–Site Recommendation. These documents include Analysis and Model Reports, Process Model Reports, the DOE Repository Safety Strategy (CRWMS M&O, 2000c), the Total System Performance Assessment–Site Recommendation Technical Document (CRWMS M&O, 2000a), and the Total System Performance Assessment–Site Recommendation Model Report (CRWMS M&O, 2000b).

The focus of the review is specifically guided by the objective of resolving subissues. The NRC has developed three categories to present the status of resolution. Subissues are closed if the DOE approach and available information acceptably address staff questions such that no information beyond what is currently available will likely be required for regulatory decision making at the time of any initial license application. Subissues are closed-pending if the NRC staff have confidence that the DOE proposed approach, together with the DOE agreement to provide the NRC with additional information (through specified testing, analysis, etc.), acceptably address the NRC questions such that no information beyond that provided or agreed to will likely be required at the time of the initial license application. Subissues are open if the NRC has identified questions regarding the DOE approach or information and the DOE has not yet acceptably addressed the questions or agreed to provide the necessary additional information in a potential license application. For transparency and to enable the DOE to fully understand the NRC concern, the NRC and CNWRA staff prepared specific comments (i.e., questions or concerns) under each subissue and presented them to the DOE. The DOE response by DOE is then classified as either satisfied, or not satisfied depending on whether the DOE has acceptably responded to the NRC question or concern. Staff questions may range from a transparency question (i.e., gaining clarification) to addressing a deficiency in the methodology or data preparation. If any questions or concerns under a subissue remain open, the subissue remains open.

The review findings were classified under the four Total System Performance Assessment and Integration Key Technical Issue subissues: (i) system description and demonstration of multiple barriers, (ii) scenario analysis, (iii) model abstraction, and (iv) demonstration of the overall performance objective. The review findings under each subissue were also mapped to individual

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[3]Reamer, C.W. "U.S. Nuclear Regulatory Commission/U.S. Department of Energy Technical Exchange and Management Meeting on Total System Performance Assessment and Integration (August 6 through 10, 2001)." Letter (August 23) to S.J. Brocoum. Washington, DC: DOE. 2001.

acceptance criteria. In the absence of the Yucca Mountain Review Plan, the acceptance criteria and the review methods in the Total System Performance Assessment Key Technical Issue Integrated Issue Resolution Status Report, Revision 3 (NRC, 2000) were used to provide a transparent and consistent measure for the review of data, design detail, and analyses in DOE documents. The following is a summary of the review areas.

Comments on multiple barriers addressed the system of natural and engineered barriers that would provide isolation of waste. Comments were written for three major aspects of multiple barriers: (i) identification of barriers, (ii) description of barrier capabilities to isolate waste, and (iii) the technical basis for barrier capabilities.

Comments generated from the review-of-scenario analysis included the DOE identification, classification, screening, and construction of scenarios from features, events, and processes relevant to the Yucca Mountain site. The review addressed the manner in which the DOE addressed the full range of features, events, and processes, as well as whether additional data or analyses are needed to support the scenario analysis.

Comments on model abstractions addressed the 14 Integrated Subissues, which derive their technical validity and support from those aspects of the engineered, geosphere, and biosphere subsystems shown to be most important to performance. These abstracted models are:

- Degradation of engineered barriers
- Mechanical disruption of engineered barriers
- Quantity and chemistry of water contacting waste packages and waste forms
- Radionuclide release rates and solubility limits
- Flow paths in the unsaturated zone
- Radionuclide transport in the unsaturated zone
- Flow paths in the saturated zone
- Radionuclide transport in the saturated zone
- Volcanic disruption of waste packages
- Airborne transport of radionuclides
- Climate and infiltration
- Dilution of radionuclides in groundwater due to well pumping
- Redistribution of radionuclides in soil
- Reasonably maximally exposed individual lifestyle and reference biosphere.

The review concentrated on whether the DOE has adequately addressed all five of the generic acceptance criteria specified in the Total System Performance Assessment and Integration Issue Resolution Status Report (NRC, 2000). The five generic acceptance criteria include (i) data and model justification, (ii) data uncertainties, (iii) model uncertainties, (iv) model support, and (v) integration.

Comments on the overall performance objective subissue involved evaluation of the adequacy, appropriateness, and acceptability of the (i) scenarios considered in the calculation of the expected annual dose, (ii) method the DOE will use to demonstrate that the average annual dose to the average member of the critical group in any year during the compliance period will not exceed the regulatory limit, (iii) the DOE Total System Performance Assessment is providing a credible representation of repository performance, (iv) consideration of human intrusion, and (v) comparative evaluation of alternatives to the major design features. It should be emphasized

that compliance with the proposed standards at 10 CFR Part 63 for overall performance was not considered in pre-licensing issue resolution; only the methodology for evaluating the overall performance objective was considered in this context.

A formal review of the DOE quality assurance procedure was not part of the Total System Performance Assessment review. However, comments were prepared on model validation, software verification, and technical errors or inconsistencies. References were also made to the DOE Corrective Action Reports which, had already identified deficiencies in the implementation of quality assurance procedures for validation and verification. The CNWRA and the NRC staff found technical errors and inconsistencies between the Total System Performance Assessment–Site Recommendation reports and the Analysis and Model Reports, computer codes, and hand calculations. Although these findings are documented in this report in a generic sense, a letter from the NRC to the DOE[4] covers the full scope of the findings.

3 RISK-INFORMED REVIEW

Consistent with the risk-informed approach employed in proposed 10 CFR Part 63 (NRC, 1999), the review focused on those aspects of the repository system and the DOE analyses that are most important to safety. In order to risk-inform their reviews, NRC and CNWRA staff

- Identified the major components of the DOE safety case
- Identified important scenarios
- Determined the principal barriers considered for demonstrating multiple barriers
- Considered the importance of conceptual model uncertainty within the abstraction
- Identified and evaluated the importance of major assumptions
- Identified the importance of conceptual model uncertainty
- Evaluated the importance of coupled processes
- Identified the important parameters and models controlling system behavior
- Evaluated the importance of correlations between parameters.

Staff efforts to risk-inform the review also recognized the timing of available information. Technical information on specific components of the DOE analyses was available in the form of Analysis and Model Reports before the DOE completed its Total System Performance Assessment for the current repository design and before the DOE completed its Repository Safety Strategy. Information was also available to the staff at the Appendix 7 meetings, DOE and NRC technical exchanges, and audit observation of the DOE audit of technical activities. Given the limited time available for the review of the Total System Performance Assessment–Site Recommendation, the staff reviewed technical information that addressed previous staff concerns and new risk-significant information. The staff refined their review comments as the Total System Performance Assessment–Site Recommendation (i.e., Model Report and Technical Document) and the DOE Repository Safety Strategy document, Revision 4, became available.

The staff conducted a few bounding calculations and performance assessments using the TPA code and confirmatory analyses using process-level models; however, indepth, detailed

[4] Reamer, C.W. "U.S. Nuclear Regulatory Commission/U.S. Department of Energy Conference Call Regarding Quality Assurance and Performance Assessment Issues." Letter (May 17) to S.J. Brocoum, DOE. Washington, DC: DOE. 2001.

analyses were limited. The NRC TPA code was used to risk-inform the review. In the review, the emphasis was on the DOE performance assessment. Therefore, the staff reviewed the information provided by the DOE that led to risk insights. Independent NRC calculations using the NRC TPA code (Mohanty and McCartin, 1998) were used to complement the risk insights gained by reviewing the DOE analyses. The staff also used the risk insights already gained from the NRC and CNWRA sensitivity and uncertainty analyses (Mohanty, et al., 1999) to risk-inform the review on the relative importance of model abstractions, conceptual model uncertainty, major assumptions, coupled processes, parameters (e.g., data range and distribution type), and parameter correlations. In addition, the TPA code results were used to help understand the results of the DOE Total System Performance Assessment–Site Recommendation. The staff also used other codes, such as MULTIFLO (Lichtner, et al., 2000), to conduct analyses to verify questions raised on the DOE Total System Performance Assessment. In-depth detailed calculations, however, were limited to only a few applications.

4 DOCUMENTATION OF REVIEW FINDINGS

The blueprint document contains all staff comments presented at two consecutive subissue resolution technical exchanges. The principal outcome of these technical exchanges was the establishment of agreements between the DOE and the NRC which, if met, would result in closure of the Total System Performance Assessment and Integration subissues. Due to the large number (more than 300) and complexity of the comments and concerns to be addressed within the Total System Performance Assessment and Integration Key Technical Issue, a Microsoft® Access 97 database was developed to track the staff comments, DOE responses, and the agreements reached at the technical exchanges. The information in the appendix is a hardcopy report produced from the database.

The database has numerous functions, including a powerful search capability and stylized report printing options. However, because the database is at a developmental stage, only a limited capability was used to produce the appendix. The database fields that were used in producing the appendix include (i) tracking number, (ii) references, (iii) DOE response, (iv) agreement number, and (v) agreement. These fields are explained below.

Tracking number: The tracking number system is used to uniquely identify each comment or question. Although the alphanumeric format of the tracking numbers have evolved with the review. The original tracking numbers were left intact to avoid confusion with the agreement numbers.

Comment: The comment field contains the original NRC and CNWRA comment or question forwarded to the DOE, and can be referenced by its associated tracking number.

References: The references field contains the references that were reviewed to generate the comments.

DOE Response: The DOE response field contains the original written response the DOE provided to the NRC prior to the corresponding technical exchanges. These responses were proposed by the DOE as bases for discussion at the technical exchanges toward reaching agreements.

Agreement: The agreement field either contains the text of the agreement reached to satisfy the comment, or it contains a note explaining why no official agreement was deemed necessary. Most commonly, the comment has either been discussed elsewhere, or the DOE response was considered adequate to satisfy the NRC and CNWRA comment.

Agreement number: When the NRC and CNWRA concern was systemic, the concern was provided in general form with numerous examples. The DOE chose to respond to the NRC and CNWRA comments example-by-example. For tracking these responses, the blueprint document used the same tracking number for all these responses but, for uniqueness, it also used a new agreement number to indicate that unique agreements were reached for each of the NRC and CNWRA example. Similar to other agreements, if no official agreement was needed to satisfy the NRC comment presented in the form of examples, then the agreement number field was left blank.

5 CONCLUSIONS

Consistent with the Nuclear Waste Policy Act and the agreement reached between the NRC and the DOE, staff from the CNWRA and the NRC have been reviewing the DOE pre-license documents and consulting with the DOE to assure that sufficient information is available on an issue to enable the NRC to docket a proposed license application. The NRC and CNWRA staff have conducted limited risk-informed reviews of selected portions of recently provided DOE documents. The staff have also performed their own calculations (where feasible) before raising issues based on their current understanding of the site characteristics, waste form characteristics, design data, and the DOE analysis approach. The results were provided to the DOE at two technical exchanges.

The acceptance criteria in the Total System Performance Assessment and Integration Key Technical Issue Resolution Status Report (NRC, 2000) form the basis for the risk-informed review comments documented in this report. Because information needed to fully risk-inform, the review will continue to be made available, staff will continue to update their perspective on the areas of greatest importance, and later review efforts will reflect this evolution in the understanding of the DOE analyses. Additional technical exchanges and Appendix 7 meetings may be needed to reevaluate open or close-pending subissues. The blueprint document will be updated as new information will be available. The database will also be expanded with the goal of using it as a licensing tool.

6 REFERENCES

CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR–WIS–PA–000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.

———. "Total System Performance Assessment (TSPA) Model for Site Recommendation." MDL–WIS–PA–000002. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000b.

———. "Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations." TDR–WIS–RL–000001. Revision 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000c.

———. "Total System Performance Assessment—1995: An Evaluation of the Potential Yucca Mountain Repository." B00000000–01717–2200–00136. Revision 01. Las Vegas, Nevada: TRW Environmental Safety Systems, Inc. 1995.

DOE. "Viability Assessment of a Repository at Yucca Mountain. Volume 3: Total System Performance Assessment." DOE/RW–0508/V3. Washington, DC: DOE. 1998.

———. "Yucca Mountain Science and Engineering Report." DOE/RW–0539. Washington DC: DOE. 2001.

Lichtner, P.C., M.S. Seth, and S. Painter. "MULTIFLO Version 1.2: Two-Phase Nonisothermal Coupled Thermal-Hydrological-Chemical Flow Simulator." Revision 2. San Antonio, Texas: CNWRA. 2000.

Mohanty, S., R. Codell, R.W. Rice, J. Weldy, Y. Lu, M.R. Byrne, T.J. McCartin, M.S. Jarzemba, and G.W. Wittmeyer. "System-level Repository Sensitivity Analyses Using TPA Version 3.2 Code." CNWRA 99-002. San Antonio, Texas: CNWRA. 1999.

Mohanty, S., and T. McCartin (coordinators). "Total-system Performance Assessment Version 3.2 Code: Module Descriptions and User's Guide." San Antonio, Texas: CNWRA. 1998.

NRC. "Issue Resolution Status Report Key Technical Issues: Total-system Performance Assessment and Integration." Revision 3.0. Washington, DC: NRC. 2000.

———. "Disposal of High-Level Radioactive Wastes in a Proposed Geological Repository at Yucca Mountain, Nevada: Proposed Rule." Federal Register 64(34): 8640–8679. Washington, DC: U.S. Government Printing Office. 1999.

APPENDIX

Subissue #1 - Multiple Barriers J-MB 1.1T

Tracking # J-MB 1.1T

Comment NRC Staff find the techniques used to identify barriers as presented in the Repository Safety Strategy, Rev. 4 (CRWMS M&O, 2000b) document acceptable. However, the documentation of the process used to identify the barriers needs to be clarified to show that DOE has fully identified the barriers that are important to waste isolation. For example, it is not clear if the identification of barriers (CRWMS M&O 2000a) is based on expected barrier capability or from tracing parameters from TSPA sensitivity/importance analyses back to determine the important barriers in the system.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations." TDR-WIS-RL-000001 Revision 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response The barriers that are identified as important to waste isolation for any potential license application will be distinct physical elements of the repository system that are demonstrated to contribute to waste isolation. This demonstration will be made using a set of complementary analytic techniques. The capability of the barriers to prevent or substantially delay movement of water or radionuclides will be described in any potential license application. Uncertainties in characterizing and modeling the barriers in the analyses will be delineated.

Identification of the barriers important to waste isolation in Repository Safety Strategy, Rev. 4 (CRWMS M&O 2001i) was based on elements of the system that are expected to play a role in limiting the amount of water that might enter emplacement drifts, limiting contact of water with the waste, limiting release of radionuclides from the engineered barrier system, delaying radionuclide transport to the accessible environment, or diluting radionuclide concentrations.

Reference: CRWMS M&O 2001i. Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations. TDR-WIS-RL-000001 REV 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010329.0825.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and

Integration Technical Exchange, August 6-10, 2001.

Subissue #1 - Multiple Barriers J-MB 2.1

Tracking # J-MB 2.1

Comment DOE needs to provide information on the capability of barriers to prevent or substantially delay movement of water or radionuclide materials. For example, Repository Safety Strategy, Rev. 4 (CRWMS M&O, 2000b; p. 2-5) describes barrier capability, but no diagrams are presented to support the discussion. Diagrams for barrier neutralization analyses and degraded barrier analysis (CRWMS M&O, 2000a) are based on dose and not on barrier capability to prevent or delay movement of water or radionuclides. Without this information, staff cannot assess the capability of the barriers to determine what is retained by each barrier, what is delayed by each barrier, and what moves through each barrier. The capabilities of individual barriers to prevent or delay movement of water or radionuclides (across the spectrum of radionuclides) should be discussed in the context of the important properties of the barrier (e.g. matrix diffusion, distribution coefficients).

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations." TDR-WIS-RL-000001 Revision 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response The capability of the barriers important to waste isolation will be described in any potential license application. The specific characteristics of each barrier to prevent or substantially delay movement of water or radionuclides will be included.

In addition, contribution of each of these barriers to waste isolation will be evaluated quantitatively through a set of complementary analyses. These analyses may include

* Intermediate performance analysis (CRWMS M&O 2000ar, Section 4.1)

* Pinch point analysis (CRWMS M&O 2000as, Section 4.5.3)

* Barrier robustness analysis (CRWMS M&O 2000ar, Section 5.3; CRWMS M&O 2001i, Section 3.2)

* Barrier neutralization analysis (CRWMS M&O 2000as, Section 4.5.4; CRWMS M&O 2001i, Section 3.4).

These analyses provide information clarifying the specific contribution of the barrier to the estimate of mean annual dose, the

capability of the barrier to prevent or delay the movement of water or radionuclides, the accumulation of radionuclides in the barriers, and the reduction in concentration (e.g., through dispersion). The analyses show the performance of individual radionuclides, including those most important to the estimated mean annual dose. Since the analyses are conducted with the TSPA model, uncertainty in models for processes affecting the barrier are explicitly considered. Further, time evolution of barrier performance and spatial variability of barrier characteristics are accounted for. Further interdependencies of barriers and correlations among models and parameters affecting the barriers can be addressed. Masking of one barrier by another can be addressed.

References: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

CRWMS M&O 2000as. Total System Performance Assessment-Site Recommendation Methods and Assumptions. TDR-MGR-MD-000001 REV 00 ICN 02. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000307.0384.

CRWMS M&O 2001i. Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations. TDR-WIS-RL-000001 REV 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010329.0825.

Agreement Number TSPAI.1.01

Agreement DOE will provide enhanced descriptive treatment for presenting barrier capabilities in the final approach for demonstrating multiple barriers. DOE will also provide discussion of the capabilities of individual barriers, in light of existing parameter uncertainty (e.g., in barrier and system characteristics) and model uncertainty. The information will be documented in TSPA Methods and Assumptions document, expected to be available to NRC in FY 2002, for any potential license application.

Subissue #1 - Multiple Barriers J-MB 2.2

Tracking # J-MB 2.2

Comment The methods used to distinguish the contributions of barriers that perform similar functions need to be explained. These combinations could include components of natural and engineered systems (e.g., the combination of the natural system above the repository and the drip shield) along important boundaries. The discussion of barrier capabilities needs to discuss and differentiate between the independent and the interdependent contributions of the individual barriers.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations." TDR-WIS-RL-000001 Revision 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response The use of neutralization analysis in both "one-off" and "two-off" modes assist in differentiating between the independent and interdependent contributions of individual barriers.

Agreement Number TSPAI.1.01

Agreement DOE will provide enhanced descriptive treatment for presenting barrier capabilities in the final approach for demonstrating multiple barriers. DOE will also provide discussion of the capabilities of individual barriers, in light of existing parameter uncertainty (e.g., in barrier and system characteristics) and model uncertainty. The information will be documented in TSPA Methods and Assumptions document, expected to be available to NRC in FY 2002, for any potential license application.

Subissue #1 - Multiple Barriers J-MB 2.3

Tracking # J-MB 2.3

Comment The description of the barrier capability for the drift invert is not clear, because the type of material (e.g. crushed tuff or limestone) has not been selected. The type of invert material used in the repository influences aqueous and mineral chemistry as well as diffusion rates. These processes affect radionuclide transport through the invert and may have a significant effect on the capability of the barrier.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations." TDR-WIS-RL-000001 Revision 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response The capability of barriers important to waste isolation, including the drift invert-if it is determined to be important to waste isolation-will be described in any potential license application. The characteristics of the barrier to prevent or substantially delay movement of water or radionuclides will be included. In addition, quantitative analyses will be conducted to assess contribution the barrier makes to the estimate of mean annual dose.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #1 - Multiple Barriers J-MB 2.4

Tracking # J-MB 2.4

Comment The uncertainty associated with particular barriers needs to be described. The description needs to include model uncertainty, such as the performance of the barrier assuming alternative conceptual models, and uncertainty in the attributes of the barrier (e.g., parameter uncertainty). The performance needs to be discussed in terms of barrier capability to prevent or delay movement of water or radionuclides.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations." TDR-WIS-RL-000001 Revision 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response The primary analytical tool proposed for multiple barrier analysis is the probabilistic TSPA model, which includes model and parameter uncertainty. As such, uncertainty in characterizing and modeling barriers (e.g., physically distinct components of the waste disposal system) is included in the analyses.

Agreement Number TSPAI.1.02

Agreement DOE will provide a discussion of the following in documentation of barrier capabilities and the corresponding technical bases: (1) parameter uncertainty, (2) model uncertainty (i.e., the effect of viable alternative conceptual models), (3) spatial and temporal variability in the performance of the barriers, (4) independent and interdependent capabilities of the barriers (e.g., including a differentiation of the capabilities of barriers performing similar functions), and (5) barrier effectiveness with regard to individual radionuclides. DOE will also analyze and document barrier capabilities, in light of existing data and analyses of the performance of the repository system. The information will be documented in TSPA for any potential license application expected to be available in FY 2003.

Subissue #1 - Multiple Barriers J-MB 2.5

Tracking # J-MB 2.5

Comment The DOE analyses of barriers needs to be discussed in terms of the individual barriers and their interdependence with other barriers (as appropriate). Results from the degraded barrier analyses indicate that the described capabilities are consistent with the results from the total system performance assessment. However, there appears to be inconsistency in the treatment of combinations of barriers. For example, the combination of barriers treated in Repository Safety Strategy, Rev. 4 (CRWMS M&O, 2000b) for the degraded barrier analyses are different from those used in the barrier neutralization analyses. Similarly, the combination of barriers presented in the TSPA Technical Document (CRWMS M&O, 2000a) are different from the combinations presented in the Repository Safety Strategy, Rev. 4 (CRWMS M&O, 2000b) for degraded barrier analyses and barrier neutralization analyses. It is difficult to understand the basis for, and the results of, the degraded barrier analyses and barrier neutralization analyses without a discussion of the results in terms of the independent and interdependent contributions of the barriers. Example 1: The presence of the drip shield in the degraded waste package analyses (CRWMS M&O, 2000b) could mask the effect of the waste package on radionuclide transport during the early period or at least until the drip shield fails. While such analyses (i.e., in the presence of drip shield) shows the protection afforded by the drip shield even after the waste package fails, the actual protection provided by each individual barrier in 10,000 years is not clearly identified. Example 2: It is not clear why performance improved for the degraded radionuclide concentration limits case, which represents non-mechanistic juvenile failure scenario-sensitivity to radionuclide concentration limits, between 2000 and 8000 years [see figure 3-20, p. 3-18, in Repository Safety Strategy, Rev. 4 (CRWMS M&O, 2000b)].

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations." TDR-WIS-RL-000001 Revision 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response The capability of the barriers important to waste isolation will be described in any potential license application. The specific characteristics of each barrier to prevent or substantially delay movement of water or radionuclides will be included.

In addition, contribution of each of these barriers to waste isolation will be evaluated quantitatively through a set of complementary

analyses. These analyses may include

* Intermediate performance analysis (CRWMS M&O 2000ar, Section 4.1)

* Pinch point analysis (CRWMS M&O 2000as, Section 4.5.3)

* Barrier robustness analysis (CRWMS M&O 2000ar, Section 5.3; CRWMS M&O 2001i, Section 3.2)

* Barrier neutralization analysis (CRWMS M&O 2000as, Section 4.5.4; CRWMS M&O 2001i, Section 3.4).

These analyses will directly address issues illustrated by the examples in this comment. For example, if the drip shield and waste package are identified as barriers important to waste isolation, potential masking of the performance of the waste package by the drip shield could be addressed in analyses that neutralize performance of the drip shield. As a second example, questions about relative performance of degraded barriers and neutralized barriers could be directly addressed.

References: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

CRWMS M&O 2000as. Total System Performance Assessment-Site Recommendation Methods and Assumptions. TDR-MGR-MD-000001 REV 00 ICN 02. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000307.0384.

CRWMS M&O 2001i. Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations. TDR-WIS-RL-000001 REV 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010329.0825.

Agreement Number TSPAI.1.02

Agreement DOE will provide a discussion of the following in documentation of barrier capabilities and the corresponding technical bases: (1) parameter uncertainty, (2) model uncertainty (i.e., the effect of viable alternative conceptual models), (3) spatial and temporal variability in the performance of the barriers, (4) independent and interdependent capabilities of the barriers (e.g., including a differentiation of the capabilities of barriers performing similar functions), and (5) barrier effectiveness with regard to individual

radionuclides. DOE will also analyze and document barrier capabilities, in light of existing data and analyses of the performance of the repository system. The information will be documented in TSPA for any potential license application expected to be available in FY 2003.

Subissue #1 - Multiple Barriers J-MB 2.6

Tracking # J-MB 2.6

Comment TSPA-SR robustness analysis section 5.3.7 (CRWMS M&O, 2000a) states that the similarity of the degraded and base cases for saturated zone is attributed to the dominance in the base case average of the high-dose realizations. Barrier neutralization analyses reported in the Repository Safety Strategy, Rev. 4 (CRWMS M&O, 2000b), where all saturated zone performance is removed gives essentially the same curve as the robustness analysis. Further discussion is needed to explain the saturated zone neutralization analysis.Furthermore, the analysis indicates significant performance for matrix diffusion (and sorption in the matrix) in the unsaturated zone.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations." TDR-WIS-RL-000001 Revision 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response The summary in the TSPA-Site Recommendation document (CRWMS M&O 2000ar) examined the contribution of individual realizations to the mean annual dose estimate. The summary revealed that the mean was dominated by a few realizations. The degraded barrier analyses examined the performance of the barrier (saturated zone transport barrier in the present case) to an extreme. The extreme did not significantly change the few realizations that dominated system performance. Consequently, the mean was not significantly affected. Likewise, the neutralization analyses conducted for Repository Safety Strategy, Rev. 4 (CRWMS M&O 2001i) also showed little change to the mean because the few realizations that dominated that mean was not significantly affected. Thus, the two separate analyses had the same result for the same reason.

The degraded barrier analyses and neutralization analyses for the unsaturated zone transport barrier had the same conclusions with regard to this barrier as in the discussion above-a few realizations dominated the estimate of mean annual dose and degrading or neutralizing the barrier did not significantly affect the realizations.

However, enhancing the performance of the barrier in terms of enhanced matrix diffusion and sorption in the matrix (i.e., enhanced in the sense of taking extreme values within the probability distribution) change the realizations that dominate the mean. It is for this reason, matrix diffusion is identified as an important factor affecting the mean annual dose.

References: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

CRWMS M&O 2001i. Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations. TDR-WIS-RL-000001 REV 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010329.0825.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #1 - Multiple Barriers J-MB 2.7

Tracking # J-MB 2.7

Comment The description of the capability for individual barriers to prevent or substantially delay movement of water or radionuclide materials needs to include a discussion of the changes in barrier capability over time (throughout the 10,000 year compliance period).

The discussion should include the extent to which the conceptual models of the barriers consider cumulative degradation processes over time, processes that may significantly affect the performance of the barrier, and temporal changes within the repository system. For example, time-dependent environmental or physical-chemical variability of the system (pressure, temperature, spatial changes before, during, and after the thermal pulse); dynamic conditions (boiling zone/ refluxation; calcite-opal mobilization and precipitation in fractures, lithophysae, matrix pores; thermal-mechanical stresses inducing rockfall & drift collapse, etc.) may need to be discussed to appropriately describe the performance of particular barriers.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations." TDR-WIS-RL-000001 Revision 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response The multiple barrier analysis approach utilized the probabilistic TSPA model as the primary analytical tool. As such, temporal evolution of the system and associated variations in barrier capabilities are included in the analyses.

Agreement Number TSPAI.1.02

Agreement DOE will provide a discussion of the following in documentation of barrier capabilities and the corresponding technical bases: (1) parameter uncertainty, (2) model uncertainty (i.e., the effect of viable alternative conceptual models), (3) spatial and temporal variability in the performance of the barriers, (4) independent and interdependent capabilities of the barriers (e.g., including a differentiation of the capabilities of barriers performing similar functions), and (5) barrier effectiveness with regard to individual radionuclides. DOE will also analyze and document barrier capabilities, in light of existing data and analyses of the performance of the repository system. The information will be documented in TSPA for any potential license application expected to be available in FY 2003.

Subissue #1 - Multiple Barriers J-MB 2.8

Tracking # J-MB 2.8

Comment The description of barrier capabilities needs to include a discussion of the effects of spatial variability on the ability of the barrier to prevent or substantially delay movement of water or radionuclide materials, including a discussion of the spatial resolution in the models and data used to evaluate the performance of the barriers. For example, say 50% of the CHn is strongly sorbing and 50% is not.

As another example, in the analysis of the non-mechanistic juvenile failure scenario (Repository Safety Strategy, Rev. 4 (CRWMS M&O, 2000b), Pg. 3-15), a "what-if" analysis, one waste package was artificially set to fail after 100 years. The consequences associated with the failed waste package will be influenced by the location of the failed waste package (e.g., the characteristics of radionuclide release, water flow, and radionuclide transport in the vicinity of the failed waste package, where these characteristics may be affected by spatial heterogeneity and its representation in the model used in the analysis).

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations." TDR-WIS-RL-000001 Revision 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response The multiple barrier analysis approach utilized the probabilistic TSPA model as the primary analytical tool. As such, spatial variability in parameter values and associated barrier characteristics and capabilities are included in the analyses.

The single waste package considered in the non-mechanistic juvenile failure scenario of Repository Safety Strategy, Rev. 4 (CRWMS M&O 2001i) is not an identifiable waste package located at a single point. The location of this waste package is sampled. Consequently different realizations will have the waste package in different locations. Accordingly, spatial variability in characteristics affects the results of the complete set of realizations.

Reference: CRWMS M&O 2001i. Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations. TDR-WIS-RL-000001 REV 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010329.0825.

Subissue #1 - Multiple Barriers J-MB 2.8

Agreement Number TSPAI.1.02

Agreement DOE will provide a discussion of the following in documentation of barrier capabilities and the corresponding technical bases: (1) parameter uncertainty, (2) model uncertainty (i.e., the effect of viable alternative conceptual models), (3) spatial and temporal variability in the performance of the barriers, (4) independent and interdependent capabilities of the barriers (e.g., including a differentiation of the capabilities of barriers performing similar functions), and (5) barrier effectiveness with regard to individual radionuclides. DOE will also analyze and document barrier capabilities, in light of existing data and analyses of the performance of the repository system. The information will be documented in TSPA for any potential license application expected to be available in FY 2003.

Subissue #1 - Multiple Barriers J-MB 2.9T

Tracking # J-MB 2.9T

Comment Table 6.3-1 of the DOE's TSPA Technical Document (CRWMS M&O, 2000a) correlates barriers and process model factors. Section 5.3 of the same document identifies the barriers that are considered in the robustness analysis. Sections 3.2 and 3.4 of Repository Safety Strategy, Rev. 4 (CRWMS M&O, 2000b) also identify degraded and neutralized barrier analyses. However, the discussions of these barriers are, in several instances, mixed with process model factors such as water usage, biosphere dose conversion factors (BDCF), and backfill. Although the identification of process model factors and the associated discussions in combination with multiple barriers provide useful information, a clear distinction should be made between the discussion on process model factors and barriers.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations." TDR-WIS-RL-000001 Revision 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response Barriers important to waste isolation correspond to physical entities and not abstract process model factors. In addition, the role of process model factors affecting performance of these barriers will be discussed in any potential license application.

The analyses in Repository Safety Strategy, Rev. 4 (CRWMS M&O 2001i) were intended to identify areas considered for the postclosure safety case. Consequently, these analyses were not intended to assess the role of the barriers in preventing or substantially delaying movement of water or radionuclide materials. DOE's multiple barrier analysis approach involving the complementary use of 4 analytical techniques would focus on barriers, not on the role of process model factors in determining the mean annual dose.

Reference: CRWMS M&O 2001i. Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations. TDR-WIS-RL-000001 REV 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010329.0825.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #1 - Multiple Barriers J-MB 3.1

Tracking # J-MB 3.1

Comment Analyses providing the technical basis for assertions of barrier capabilities need to consider correlations between parameters in an appropriate way. The basis for correlations (or independence) in the models needs to be discussed appropriately.

References CRWMS M&O. "Total System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations." TDR-WIS-RL-000001 Revision 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response The multiple barrier analysis approach utilized the probabilistic TSPA model as the primary analytical tool. As such, correlation between parameters and component models was included in the analyses.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #2 - Scenario Analysis J-1

Tracking # J-1

Comment 2.1.03.11.00 (Container form) has been excluded from consideration in the total system performance assessment code (CRWMS M&O, 2001).

The varying clearance between the drip shield and different waste package designs and the concomitant effects that this may have on the consequences of rock block impacts and/or seismic excitation have not been addressed by DOE.

References CRWMS M&O. "FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation." ANL-EBS-PA-000002 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Results of recently performed thermal expansion calculations indicated a need to increase the gap between the outer barrier lid and the inner barrier lid from the current 3-mm to 6-mm. DOE agreed to provide the technical basis for the screening argument in the FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation (CRWMS M&O 2001e) which will incorporate these results (Pathforward Item 38). In addition, in the Container Life and Source Term agreement 2.8, DOE agreed to perform, prior to any potential License Application, calculations that address the effects of static loads from fallen rock on the drip shield during a seismic event for both intact and degraded conditions of the drip shield (Pathforward Item 31).

DOE believes the existing pathforward items and Container Life and Source Term agreement 2.8 identified above are sufficient to address the technical issue identified in the NRC comment.

References: CRWMS M&O 2001e. FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation. ANL-EBS-PA-000002 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010216.0004. (future revisions)

CRWMS M&O 2000j. Design Analysis for UCF Waste Packages. ANL-UDC-MD-000001 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000526.0336.

CRWMS M&O 2000g. Design Analysis for the Defense High-Level Waste Disposal Container. ANL-DDC-ME-000001 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000627.0254.

CRWMS M&O 2000i. Design Analysis for the Naval SNF Waste Package. ANL-VDC-ME-000001 REV 00. Las Vegas, Nevada: CRWMS M&O . ACC: MOL.20000615.0029.

CRWMS M&O 2000h. Design Analysis for the Ex-Container Components. ANL-XCS-ME-000001 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000525.0374.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (CLST Subissue 2 Agreement 8). FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002, will be revised upon completion of this work.

Subissue #2 - Scenario Analysis J-2

Tracking # J-2

Comment 2.1.06.05.00 (Degradation of invert and pedestal) has been screened as excluded on the basis of low consequence (CRWMS M&O, 2001).

Rock block impact orientations with the waste package will be affected by degradation of the invert. As pointed out in the comment on 2.1.07.01.00 [Rockfall (large block)], angled rock block impacts near the closure lid weld may have undesirable consequences. Furthermore, the stability of the waste package during seismic excitation will be affected by a degraded invert foundation. The corrosion of the steel pallet components should be considered when evaluating the stability of the waste package on its supporting pallet on a degraded invert foundation.

References CRWMS M&O. "EBS FEPs/Degradation Modes Abstraction." ANL-WIS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Impact of degradation on mechanical response of waste package

Additional loading combinations are being addressed in response to Container Life and Source Term agreement 2.8. Evaluations of these loading combinations will be documented in a future revision of the Design Analysis for UCF Waste Packages (CRWMS M&O 2000j), and the Design Analysis for the Ex-Container Components (CRWMS M&O 2000h).

Seismic motion of the supporting invert Seismic motion of the supporting invert is being included in the evaluations being currently performed and will be included in the next revision of the Design Analysis for the Ex-Container Components (CRWMS M&O 2000h).

The corrosion of the steel pallet components should be considered when evaluating the stability of the waste package on its supporting pallet on a degraded invert foundation. The carbon steel members of the invert are surrounded by a ballast material, which will provide some support to the waste packages for the entire regulatory period. While the carbon steel invert may not keep the waste packages in a horizontal position for the entire regulatory period, they are designed to keep the waste packages in a horizontal position for the preclosure period. One of the repository closure activities is the installation of drip shields, which would prevent direct impact of rock blocks on the waste packages.

References: CRWMS M&O 2000j. Design Analysis for UCF Waste Packages. ANL-UDC-MD-000001 REV 00. Las Vegas, Nevada:

CRWMS M&O. ACC: MOL.20000526.0336. (future revision)

CRWMS M&O 2000h. Design Analysis for the Ex-Container Components. ANL-XCS-ME-000001 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000525.0374. (future revision)

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (CLST Subissue 2 Agreement 8). Engineered Barrier System Features, Events, and Processes, ANL-WIS-PA-000002, will be revised upon completion of this work.

DOE agreed to provide the technical basis for the screening argument in the Engineered Barrier System Features, Events, and Processes, ANL-WIS-PA-000002, to address the NRC comment.

Subissue #2 - Scenario Analysis J-3

Tracking # J-3

Comment 2.1.06.01.00 (Degradation of cementitious materials in drift). The effects of degradation of cementitious materials on seepage chemistry are excluded on the basis of low consequence (CRWMS M&O, 2001a). Exclusion is based on arguments under 2.1.09.01.00 (Properties of the Potential Carrier Plume in the Waste and engineered barrier subsystem, CRWMS M&O 2001a), on the basis that chemical models show a negligible effect of grout associated with rock bolts. NRC has raised questions about these models, pertaining to the treatment of evaporation and the chemical divide phenomenon (Evolution of the Near-Field Environment tech exchange (Reamer, 2001)). Concerns about grout chemical effects are related to recent observations of dripping from rock bolt holes in the sealed cross-drift test. The argument for screening chemical effects of cementitious materials in the drift is considered not adequate.

Because degradation products may affect water chemistry, and therefore radionuclide sorption behavior, the effect of this Database entry on radionuclide transport in the unsaturated zone should also be evaluated. Currently, this entry is not addressed for the unsaturated zone (CRWMS M&O, 2001b).

It is necessary to the development of technical bases that degradation of cementitious materials has a negligible effect on water chemistry within and below the drift. Screening would be supported by addressing the following technical exchange agreements:

Evolution of the Near Field Environment, Subissue 2, Agreements 6 and 14: These agreements deal with model and lab results pertinent to the effects of engineered barrier subsystem materials, including cementitious, on water chemistry.

Radionuclide Transport, Subissue 1, Agreement 5, and Subissue 2, Agreement 10: These agreements concern the technical bases for transport parameter uncertainty distributions.

References
CRWMS M&O. "EBS FEPs/Degradation Modes Abstraction." ANL-WIS-PA-000002. Revision 01. Las Vegas, Nevada:CRWMS M&O. 2001a.
CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001b.
Reamer, C.W. "U.S. Nuclear Regulatory Commission/U.S. Department of Energy Technical Exchange and Management Meeting on Evolution of the Near-Field Environment (January 9-12,

2001)." Letter (January 26) to S. Brocoum, DOE. Washington, DC: NRC. 2001

DOE Response Although this FEP is not addressed by the Unsaturated Zone, the subject is covered by other FEPs that are addressed by the Unsaturated Zone. See FEPs 2.2.08.01.00 (Groundwater chemistry/composition in unsaturated zone and saturated zone) and 2.2.08.02.00 (Radionuclide transport occurs in a carrier plume in geosphere).

DOE will cross-reference above FEPs that address cementitious material in the next revision of the FEP Analysis/Model Reports.

An estimate of the impact on local water chemistry resulting from degradation of cementitious materials (grout) as well as the corrosion products from rockbolt degradation is being provided as part of the work being done in support of agreements Evolution of Near Field agreements 2.6, 2.10, and 2.14. The scope of these agreements takes into account evaporative concentrations and the chemical divide effect. Results of this work will be incorporated into the screening arguments for this FEP.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (ENFE Subissue 2 Agreements 6, 10, and 14, and RT Subissue 1 Agreement 5). Engineered Barrier System Features, Events, and Processes, ANL-WIS-PA-000002, will be revised upon completion of this work.

Subissue #2 - Scenario Analysis J-4

Tracking # J-4

Comment 2.1.06.05.00 (Degradation of invert and pedestal) has been screened as excluded on the basis of low consequence (CRWMS M&O, 2001).

Invert degradation is excluded on the basis of low consequence (CRWMS M&O, 2001a). The argument that changes to diffusive properties of the invert will be negligible to dose is not supported by demonstration (by sensitivity analyses) of the significant effect of diffusive release through the invert during the first 20,000 years (CRWMS M&O, 2000, Volume II, Section 3.3). The sensitivity shown in the Repository Safety Strategy also applies to the first 10,000 years. The screening argument contradicts this information. The screening argument should directly address possible effects of degradation on invert diffusive properties.

References CRWMS M&O. "EBS FEPs/Degradation Modes Abstraction." ANL-WIS-PA-000002 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.
CRWMS M&O. "Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations." TDR-WIS-RL-000001 Revision 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Impact of invert and pedestal degradation on waste package.

From an engineered barrier system modeling perspective, the pedestal is assumed to fail such that the waste package is in constant contact with the invert. Thus, no credit is taken for the potentially beneficial effect of radionuclide diffusion through a water film on the pedestal surface. Since this is a conservative assumption, no further evaluation is required.

Impact of invert degradation on diffusion through the invert

Such degradation could reduce diffusion rather than enhance it. However, as part of the screening argument for this FEP, a quantification of the impact of invert degradation on relevant parameters impacting diffusion (i.e. porosity) and the impact of these parameter changes on the invert diffusion coefficient will be provided. This will demonstrate that any invert degradation will reduce diffusion (conservative to ignore it), demonstrate that any effect on the diffusion coefficient is already covered by existing sensitivity studies, or provide the basis for an expanded sensitivity range for the invert diffusion coefficient. Updates to the Repository Safety Strategy (CRWMS M&O 2001i) will be made, if necessary.

Reference: CRWMS M&O 2001i. Repository Safety Strategy: Plan

to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations. TDR-WIS-RL-000001 REV 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010329.0825.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (CLST Subissue 2 Agreement 8). Engineered Barrier System Features, Events, and Processes, ANL-WIS-PA-000002, will be revised upon completion of this work.

DOE agreed to provide the technical basis for the screening argument in the Engineered Barrier System Features, Events, and Processes, ANL-WIS-PA-000002, to address the NRC comment.

Subissue #2 - Scenario Analysis J-5

Tracking # J-5

Comment 2.1.09.21.00 (Suspensions of particles larger than colloids) is screened as excluded from the engineered barrier subsystem transport and waste form release abstractions (CRWMS M&O, 2000, 2001). Exclusion is based on the assumption that although particles may be transported through fractures in the unsaturated zone, low groundwater velocities through the saturated zone would lead to particle settling (CRWMS M&O, 2000), suggesting inconsistency in the screening analysis. Without quantitative measures of particle size, pore size, groundwater velocity, and chemical variability, however, these qualitative assertions are difficult to evaluate. Since DOE includes colloid formation features, events, and processes in its screening analysis, and because of the large amounts of Fe particles that may be introduced in the engineered barrier subsystem, particle transport through the engineered barrier subsystem into the unsaturated zone is plausible. Exclusion of 2.1.09.21.00 may be acceptable, but it is necessary to have a more complete technical basis and calculations to support exclusion of this item on the basis of low consequence.

References CRWMS M&O. "Colloid-Associated Concentration Limits: Abstraction and Summary." ANL-WIS-MD-000012. Revision 00 ICN 01. Las Vegas, NV: CRWMS M&O. 2000.
CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response DOE believes that the current exclusion of this FEP on the basis of low consequence is appropriate. However, DOE agrees to clarify the screening argument to provide additional information on the population, size and density of particles larger than colloids potentially generated within the waste form and engineered barrier systems. Also, additional information on probable pore sizes and distributions, groundwater velocities/chemical variability within the waste form and engineered barrier systems will be provided and the potential effects of these variables on the transport of suspended particles larger than colloids will be evaluated.

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide clarification of the screening argument in the Waste Form Colloid-Associated Concentration Limits: Abstraction and Summary ANL-WIS-MD-000012, to address the NRC comment.

Subissue #2 - Scenario Analysis J-6

Tracking # J-6

Comment 2.2.07.15.00 (Advection and dispersion). As defined, this item does not apply to the unsaturated zone, and is not discussed in (CRWMS M&O, 2001). Given that advection and dispersion are key components of the U.S. Department of Energy radionuclide transport in the unsaturated zone model abstraction, the definition of 2.2.07.15.00 (Advection and dispersion) should be extended to enclose these aspects (advection and dispersion) in the unsaturated zone.

References CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response This FEP is currently a Saturated Zone FEP, and will be added as an Unsaturated Zone FEP.

Agreement Number TSPAI.2.03

Agreement Add the FEPs highlighted in Attachment 2 to the appropriate FEPs AMRs. See Comment 19 (Part 7 and 8), 20, and J-6.

DOE will add the FEPs highlighted in Attachment 2 to the appropriate FEPs AMRs. The FEPs will be added to the appropriate FEPs AMRs and the AMRs will be provided to the NRC in FY03.

Text in Attachment 2:
DOE will add this FEP to the Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, and present the DOE discussion in the screening argument.

Subissue #2 - Scenario Analysis J-7

Tracking # J-7

Comment 2.2.08.01.00 (Groundwater chemistry/composition in unsaturated zone and saturated zone) is excluded. The DOE has included the current ambient groundwater conditions in the Total System Performance Assessment - Site Recommendation abstraction of radionuclide transport in the unsaturated zone, but has excluded future changes (CRWMS M&O, 2001, 2000b). The DOE asserts that the thermal effects on chemistry are minimal, but this focuses mainly on the effects of dissolution and precipitation on hydrologic properties. The screening argument refers to a model of thermo-chemical effects on seepage water chemistry at the drift wall (CRWMS M&O, 2000a). Because modeled effects fell within the range of variation included in Total System Performance Assessment, it is asserted that effects further from the drift would be smaller, based on an unverified assumption (CRWMS M&O, 2001). This argument does not address chemical changes below the repository, which are likely to be more significant than changes above, due to interactions with engineered barrier subsystem and waste materials. Even so, predicted changes in key geochemical parameters (pH and total carbon) in seepage water are large enough to have an effect on sorption coefficients. Without the details on how expert judgement was used to derive the Total System Performance Assessment - Site Recommendation sorption parameters, it is not clear how the effects of changes in the ambient chemistry system are incorporated in the transport calculations. The technical basis for this exclusion is not satisfactory.

References
CRWMS M&O. "Drift-Scale Coupled Processes (DST and THC Seepage) Models." MDL-NBS-HS-000001 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Unsaturated Zone Flow and Transport Model Process Model Report." TDR-NBS-HS-000002. Revision 00 ICN02. Las Vegas, Nevada: CRWMS M&O. 2000b.
CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Assumption 11 is designated as needing further verification prior to any potential license application. The technical work used to resolve the Evolution of Near Field Environment agreement items 1.4, 4.3, 4.4, and Radionuclide Transport agreement 1.5 will be sufficient to provide the additional technical bases needed for the FEPs screening argument. These agreements will take into account thermal-hydrological-chemical effects on radionuclide transport out of the drift.

Agreement Number TSPAI.2.02

Subissue #2 - Scenario Analysis J-7

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (ENFE Subissue 1 Agreement 4, ENFE Subissue 4 Agreements 3 and 4, RT Subissue 1 Agreement 5, and RT Subissue 2 Agreement 10). Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, will be revised upon completion of this work.

Subissue #2 - Scenario Analysis J-8

Tracking # J-8

Comment 2.2.08.02.00 (Radionuclide transport occurs in a carrier plume in geosphere) is excluded from the Total System Performance Assessment - Site Recommendation abstraction of radionuclide transport in the unsaturated zone on the basis of low consequence (CRWMS M&O, 2001c, 2000b). The key assumption (CRWMS M&O, 2001c) is that results from the near-field thermal-hydrological-chemical coupled processes model (CRWMS M&O, 2000a) can be used to bound the effects of similar coupled processes on far-field flow and transport. This assumption has not yet been verified. Because the screening argument for this item is focused primarily on thermal effects on the chemistry of seepage water entering the emplacement drifts, it does not appear to include other potential effects (colloids, interactions with waste forms and engineered barrier subsystem materials). Also, 2.1.09.01.00 (properties of a carrier plume in the engineered barrier subsystem) is included in the engineered barrier subsystem process model report (CRWMS M&O, 2001b, 2001a), suggesting that radionuclide transport in a carrier plume should be included in transport beyond the engineered barrier subsystem. The arguments presented for exclusion of 2.2.08.02.00 (Radionuclide transport occurs in a carrier plume in geosphere) (CRWMS M&O, 2001c) do not appear to be sufficient at this time.

References
CRWMS M&O. "Drift-Scale Coupled Processes (DST and THC Seepage) Models." MDL-NBS-HS-000001 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Unsaturated Zone Flow and Transport Model Process Model Report." TDR-NBS-HS-000002. Revision 00 ICN02. Las Vegas, Nevada: CRWMS M&O. 2000b.
CRWMS M&O. "EBS FEPs/Degradation Modes Abstraction." ANL-WIS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001a.
CRWMS M&O. "Engineered Barrier System Degradation, Flow, and Transport Process Model Report." TDR-EBS-MD-000006. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001b.
CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001c.

DOE Response Assumption 11 is designated as needing further verification prior to any potential license application. The technical work used to resolve Evolution of Near Field Environment agreements 1.4, 4.3, 4.4, and Radionuclide Transport agreement 1.5 will be sufficient to provide the additional technical bases needed for the FEPs screening argument. These agreements will take into account thermal-hydrologic-chemical effects on radionuclide transport out of the drift.

Subissue #2 - Scenario Analysis J-8

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (ENFE Subissue 1 Agreement 4, ENFE Subissue 4 Agreements 3 and 4, and RT Subissue 1 Agreement 5). Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, will be revised upon completion of this work.

Subissue #2 - Scenario Analysis J-9

Tracking # J-9

Comment 2.2.08.03.00 (Geochemical interactions in geosphere [dissolution, precipitation, weathering] and effects on radionuclide transport) is excluded (CRWMS M&O, 2001, 2000b) from the Total System Performance Assessment - Site Recommendation abstraction of radionuclide transport in the unsaturated zone on the basis of low consequence. The key assumption (CRWMS M&O, 2001) is that results from the near-field thermal-hydrological-chemical coupled processes model (CRWMS M&O, 2000a) can be used to bound the effects of similar coupled processes on far-field flow and transport. This assumption has not yet been verified. Predicted mineralogical changes (CRWMS M&O, 2000a) in response to the thermal effects of the repository are small (calcite only). Predicted changes in porosity and permeability are also small. Transport through fractures is conservatively modeled in Total System Performance Assessment - Site Recommendation assuming no retardation. However, the screening argument only addresses changes in seepage water chemistry. It does not address the possibility of reduced (or enhanced) matrix diffusion through precipitation and dissolution. Diffusion into the matrix and sorption on matrix minerals can be an important retardation mechanism. The effect of small volume changes on fracture armoring and diffusion into the matrix may be important. The current screening arguments are not sufficient and will depend in part on the verification of Assumption 11 that far-field changes to radionuclide transport in the unsaturated zone will be less than calculated near-field changes (CRWMS M&O, 2001).

Effects on flow are excluded based on low consequence. Problems with modeling of drift-scale coupled processes (CRWMS M&O, 2000) used to support this screening argument have been raised by NRC. Current agreements from Evolution of the Near-Field Environment Technical Exchange (Reamer, 2001) may provide additional technical basis for the screening argument.

References
CRWMS M&O. "Drift-Scale Coupled Processes (DST and THC Seepage) Models." MDL-NBS-HS-000001 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Unsaturated Zone Flow and Transport Model Process Model Report." TDR-NBS-HS-000002. Revision 00 ICN02. Las Vegas, Nevada: CRWMS M&O. 2000b.
CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.
Reamer, C.W. "U.S. Nuclear Regulatory Commission/U.S. Department of Energy Technical Exchange and Management Meeting on Evolution of the Near-Field Environment (January 9-12,

2001)." Letter (January 26) to S. Brocoum, DOE. Washington, DC: NRC. 2001

DOE Response Assumption 11 is designated as needing further verification prior to any potential license application. The technical work used to resolve Evolution of Near Field Environment agreements 1.7, 2.6, and 1.4 will be sufficient to provide the additional technical bases needed for the FEPs screening argument. These agreements will address thermal-hydrological-chemical affects on mineral precipitation.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (ENFE Subissue 1 Agreements 4 and 7 and ENFE Subissue 2 Agreement 6). Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, will be revised upon completion of this work.

Subissue #2 - Scenario Analysis J-10

Tracking # J-10

Comment 2.2.08.06.00 (Complexation in geosphere) is excluded. The DOE has included the effects of ambient condition complexation in the Total System Performance Assessment - Site Recommendation abstraction of radionuclide transport in the unsaturated zone, but has excluded future changes (CRWMS M&O, 2001, 2000a). The effects of complexation are "...implicitly included in the radionuclide sorption coefficients", but there is no clear technical basis regarding the effects of organics or other ligands provided in establishing the Kd distributions (CRWMS M&O 2001). Experimental results reported in Triay (1997) that form much of the basis for the sorption coefficient distributions only address the effects of organics on Np and Pu sorption. The Unsaturated Zone and Saturated Zone Transport Properties Analysis and Model Report (CRWMS M&O, 2000b) does not provide any additional information on the effect of organics on other radionuclides. The current process models do not address the effects of complexation on transport parameters, and the exclusion of changes to complex formation does not have sufficient support. In addition, the screening argument refers to modeling results on repository effects on seepage chemistry, which may not be relevant to transport conditions below the repository (CRWMS M&O, 2001).

References

CRWMS M&O. "Unsaturated Zone Flow and Transport Model Process Model Report." TDR-NBS-HS-000002. Revision 00 ICN02. Las Vegas, Nevada: CRWMS M&O. 2000a.

CRWMS M&O. "Unsaturated Zone and Saturated Zone Transport Properties." ANL-NBS-HS-000019 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000b.

CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

Triay, I.R., A. Meijer, J.L. Conca, K.S. Kung, R.S. Rundberg, E.A. Strietelmeier. "Summary and Synthesis Report on Radionuclide Retardation for the Yucca Mountain Site Characterization Project." LA-13262-MS. Los Alamos, NM: Chemical Science and Technology Division, Los Alamos National Laboratory. 1997.

DOE Response Assumption 11 is designated as needing further verification prior to any potential license application. The technical work used to resolve Evolution of Near Field Environment agreements 1.4, 4.3, 4.4, and Radionuclide Transport agreement 1.5 will be sufficient to provide the additional technical bases needed for the FEPs screening argument. These agreements will take into account thermal-hydrological-chemical effects on radionuclide transport out of the drift.

Agreement Number TSPAI.2.02

Subissue #2 - Scenario Analysis J-10

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (ENFE Subissue 1 Agreement 4, ENFE Subissue 4 Agreements 3 and 4, and RT Subissue 1 Agreement 5). Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, will be revised upon completion of this work.

Subissue #2 - Scenario Analysis J-11

Tracking # J-11

Comment 2.2.08.07.00 (Radionuclide solubility limits in the geosphere) is excluded from the Total System Performance Assessment - Site Recommendation abstraction of radionuclide transport in the unsaturated zone on the basis of low consequence (CRWMS M&O, 2001, 2000). The DOE screening argument assumes that radionuclide solubility limits in the geosphere may be different and indicates that radionuclide solubility limits in the geosphere are conservatively ignored with respect to solubility reduction in the far-field (CRWMS M&O, 2000). This argument makes valid points, but the possibility of increasing solubility limits should also be considered. Solubility limits in the geosphere will be determined by interaction between the contaminant plume and the host rock.

References CRWMS M&O. "Unsaturated Zone Flow and Transport Model Process Model Report." TDR-NBS-HS-000002. Revision 00 ICN02. Las Vegas, Nevada: CRWMS M&O. 2000.
CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Changing solubility limits could affect radionuclide release from the waste form (in the waste emplacement drift) but cannot affect the unsaturated zone, given the assumptions used for unsaturated zone radionuclide transport. All radionuclides that pass from the engineered barrier system to the Unsaturated Zone are aqueous or colloidal and are assumed to remain in the dissolved or colloidal state unless sorbed to rock surfaces. There are no precipitation/dissolution processes for radionuclides; they are either mobile (aqueous or colloidal) or sorbed. The conservative assumption is that there is no precipitate in the unsaturated zone associated with the radionuclides. Therefore, increasing solubility limits will have no effect.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:

Subissue #2 - Scenario Analysis J-11

This issue is addressed by existing agreements between DOE and NRC (ENFE Subissue 4 Agreement 3). Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, will be revised upon completion of this work.

Subissue #2 - Scenario Analysis J-12

Tracking # J-12

Comment 2.2.10.01.00 (Repository-induced thermal effects in geosphere) is excluded from the Total System Performance Assessment-Site Recommendation abstraction of radionuclide transport in the unsaturated zone on the basis of low consequence (CRWMS M&O, 2001, 2000b). The screening argument is only partially supported by near-field thermo-chemical modeling for a limited number of hydrochemical constituents and minerals (CRWMS M&O, 2000a), and is not directly related to effects on radionuclide transport. The technical basis for the screening is not sufficient at this time and future evaluation of the exclusion of 2.2.10.01.00 (Repository-induced thermal effects in geosphere) will depend in part on the verification of Assumption 11 that far-field changes to radionuclide transport in the unsaturated zone will be less than calculated near-field changes (CRWMS M&O, 2001).

References CRWMS M&O. "Drift-Scale Coupled Processes (DST and THC Seepage) Models." MDL-NBS-HS-000001 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Unsaturated Zone Flow and Transport Model Process Model Report." TDR-NBS-HS-000002. Revision 00 ICN02. Las Vegas, Nevada: CRWMS M&O. 2000b.
CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Assumption 11 is designated as needing further verification prior to any potential license application. The technical work used to resolve Evolution of Near Field Environment agreements 1.4, 4.3, 4.4, and Radionuclide Transport agreement 1.5 will be sufficient to provide the additional technical bases needed for the FEPs screening argument. These agreements will take into account thermal-hydrological-chemical effects on radionuclide transport out of the drift.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Subissue #2 - Scenario Analysis J-12

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (ENFE Subissue 1 Agreement 4, ENFE Subissue 4 Agreements 3 and 4, and RT Subissue 1 Agreement 5). Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, will be revised upon completion of this work.

Subissue #2 - Scenario Analysis J-13

Tracking # J-13

Comment 2.2.10.06.00 [Thermo-chemical alteration (solubility, speciation, phase changes, precipitation/dissolution)] is excluded from the Total System Performance Assessment - Site Recommendation abstraction of radionuclide transport in the unsaturated zone on the basis of low consequence (CRWMS M&O, 2001, 2000b). Thermal effects on chemistry at the mountain scale are expected to be low on the basis of near-field coupled thermal-hydrological-chemical models that indicate the thermal effects of the repository result in only small changes in major hydrochemical constituents and limited changes in mineralogy. However, the model results in the cited report (CRWMS M&O, 2000a) only consider a few components in hydrochemistry important to container life (e.g., pH, total carbon, Ca), is limited to calcite precipitation/dissolution, and addresses only seepage water chemistry. Thermo-chemical effects on transport beneath the repository, which could reflect the influence of engineered barrier subsystem and waste form materials, are not considered. In addition, although the assumption that far-field changes are likely to be less than near-field changes is reasonable, it has not been verified (CRWMS M&O, 2001). The technical basis is not sufficient at this time to demonstrate low consequence. The evaluation of this exclusion will depend in part on the verification of Assumption 11 that far-field changes to radionuclide transport in the unsaturated zone will be less than calculated near-field changes (CRWMS M&O, 2001).

References
CRWMS M&O. "Drift-Scale Coupled Processes (DST and THC Seepage) Models." MDL-NBS-HS-000001 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Unsaturated Zone Flow and Transport Model Process Model Report." TDR-NBS-HS-000002. Revision 00 ICN02. Las Vegas, Nevada: CRWMS M&O. 2000b.
CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Assumption 11 is designated as needing further verification prior to any potential license application. The technical work used to resolve Evolution of Near Field Environment agreements 1.4, 4.3, 4.4, and Radionuclide Transport 1.5 will be sufficient to provide the additional technical bases needed for the FEPs screening argument.. These agreements will take into account thermal-hydrological-chemical effects on radionuclide transport out of the drift.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19

(Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (ENFE Subissue 1 Agreement 4, ENFE Subissue 4 Agreements 3 and 4, and RT Subissue 1 Agreement 5). Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, will be revised upon completion of this work.

Tracking # J-14

Comment 2.2.10.07.00 (Thermo-chemical alteration of the Calico Hills unit) is excluded from the Total System Performance Assessment - Site Recommendation abstraction of radionuclide transport in the unsaturated zone on the basis of low consequence (CRWMS M&O, 2001). The screening argument is based on prediction of small changes in aqueous geochemistry and mineralogy in response to coupled thermal-hydrological-chemical processes in the near-field (CRWMS M&O, 2000a). Thermo-chemical changes in the far-field, including the Calico Hills unit will be even less significant (Assumption 11, CRWMS M&O, 2001). The screening argument indicates that temperatures in the zeolite-bearing Calico Hills unit will not be high enough to cause significant zeolite alteration. Because the radionuclide transport abstraction assumes no retardation in fractures, this exclusion may be appropriate. Again, final evaluation of this exclusion will depend in part on the verification of Assumption 11 that far-field changes to radionuclide transport in the unsaturated zone will be less than calculated near-field changes (CRWMS M&O, 2001). Alteration of the uppermost nonwelded layers below the repository could significantly reduce the fraction of matrix flow below the repository. Nonwelded vitric horizons, either basal Topopah Springs vitrophyre or the uppermost Calico Hills unit, cover nearly half of the repository. In the southwestern portion of the repository footprint, the nonwelded, nonaltered tuffs lie as little as 45 m below the repository. The screening argument (CRWMS M&O, 2001) includes the assertion that temperatures in the Calico Hills unit will remain below 70°C, which is not high enough to cause significant zeolite alteration. According to the cited reference, however, it appears temperatures can exceed 70°C (up to 85°C is estimated from figures in cited section of CRWMS M&O, 2000b) where the nonwelded, nonaltered tuff is closest to the repository.

References
CRWMS M&O. "Drift-Scale Coupled Processes (DST and THC Seepage) Models." MDL-NBS-HS-000001 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Mountain Scale Coupled Processes." MDL-NBS-HS-000007. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000b.
CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Assumption 11 is designated as needing further verification prior to any potential license application. The technical work used to resolve Evolution of Near Field Environment agreements 1.4, 4.3, 4.4, and Radionuclide Transport 1.5 will be sufficient to provide the additional technical bases needed for the FEPs screening

argument. These agreements will take into account thermal-hydrological-chemical effects on radionuclide transport out of the drift.

Alteration temperature of 85°C for zeolite is given in the Yucca Mountain Site Description - Section 6 Geochemistry, Section 6.1.5.3.1, page 6.1-129.

Reference: Yucca Mountain Site Description, Revision 00, September 1998 - (Document Id B00000000-01717-5700-00019) Book 3, Frontmatter And Section 6 - Geochemistry

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (ENFE Subissue 1 Agreement 4, ENFE Subissue 4 Agreements 3 and 4, and RT Subissue 1 Agreement 5). Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, will be revised upon completion of this work.

DOE also stated that alteration of vitric rock has not been addressed and will need to be included in the overall thermal-hydrological-chemical analyses.

Subissue #2 - Scenario Analysis J-15

Tracking # J-15

Comment 2.2.10.09.00 (Thermo-chemical alteration of the Topopah Spring basal vitrophyre) is excluded from the Total System Performance Assessment - Site Recommendation abstraction of radionuclide transport in the unsaturated zone on the basis of low consequence (CRWMS M&O, 2001, 2000b). The screening argument is based on prediction of small changes in aqueous geochemistry and mineralogy in response to coupled thermal-hydrological-chemical processes in the near-field (CRWMS M&O, 2000a). Thermo-chemical changes in the far-field, including the Topopah Spring basal vitrophyre, are expected to be even less significant (CRWMS M&O, 2001). Although the assumption that far-field changes are likely to be less than near-field changes (Assumption 11) is reasonable, it has not been verified (CRWMS M&O, 2001). It is important to note that the near-field analyses (CRWMS M&O, 2000a) are performed with a focus on seepage chemistry and how it might affect container life, rather than with the purpose of considering thermal effects on radionuclide transport. The technical basis is not sufficient at this time to demonstrate low consequence to radionuclide transport. Because the Total System Performance Assessment-Site Recommendation radionuclide transport abstraction assumes no retardation in fractures, this exclusion may be appropriate. Again, final evaluation of this exclusion will depend on the verification of Assumption 11 that far-field changes to radionuclide transport in the unsaturated zone will be less than calculated near-field changes (CRWMS M&O, 2001).

Alteration of the uppermost nonwelded layers below the repository could significantly reduce the fraction of matrix flow below the repository. Nonwelded vitric horizons, either basal Topopah Spring vitrophyre or the uppermost Calico Hills unit, cover nearly half of the repository. In the southwestern portion of the repository footprint, the nonwelded, nonaltered tuffs lie as little as 45 m below the repository. The screening argument for 2.2.10.07.00 (CRWMS M&O, 2001) includes the assertion that temperatures in the Calico Hills unit will remain below 70°C, which is not high enough to cause significant zeolite alteration. According to the cited reference, however, it appears temperatures can exceed 70°C (up to 85°C is estimated from figures in cited section of CRWMS M&O, 2000dd) where the nonwelded, nonaltered tuff is closest to the repository. Temperatures would be higher in the overlying Topopah Spring basal vitrophyre than in the Calico Hills.

References
CRWMS M&O. "Drift-Scale Coupled Processes (DST and THC Seepage) Models." MDL-NBS-HS-000001 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000a.

CRWMS M&O. "Unsaturated Zone Flow and Transport Model

Process Model Report." TDR-NBS-HS-000002. Revision 00 ICN02. Las Vegas, Nevada: CRWMS M&O. 2000b.
CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Assumption 11 is designated as needing further verification prior to any potential license application. The technical work used to resolve Evolution of Near Field Environment agreements 1.4, 4.3, 4.4, and Radionuclide Transport 1.5 will be sufficient to provide the additional technical bases needed for the FEPs screening argument. These agreements will take into account thermal-hydrological-chemical effects on radionuclide transport out of the drift.

See response for J-14 above. Alteration of vitric rock has not been addressed and will need to be included in the overall thermal-hydrological-chemical analyses.

Regarding the maximum predicted temperatures in the CHn, the Mountain-Scale Coupled Processes Analysis/Model Report (CRWMS M&O 2000af, p. 94) states: "At the top of the CHn hydrogeologic unit, the maximum temperature rises to 75-80ºC for a period between 2000 and 7000 years."

Reference: CRWMS M&O 2000af. Mountain-Scale Coupled Processes (TH) Models. MDL-NBS-HS-000007 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990721.0528.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (ENFE Subissue 1 Agreement 4, ENFE Subissue 4 Agreements 3 and 4, and RT Subissue 1 Agreement 5). Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, will be revised upon completion of this work.

Subissue #2 - Scenario Analysis J-16

Tracking # J-16

Comment 1.2.07.01.00 (Erosion/denudation) is screened as excluded on the basis of low consequence (CRWMS M&O, 2001). It is considered that the rationale for excluding from unsaturated zone on the basis of low consequence is incomplete. It is necessary to consider onset and extent of erosion caused by construction and characterization activity at the ground surface and its long term effect on shallow infiltration.

References CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response DOE will include reference to the site Reclamation Implementation Plan, YMP/91-14 for post-closure to address this aspect of the FEP.

Reference: YMP 2001. Reclamation Implementation Plan. YMP/91-14, Rev. 2. Las Vegas, Nevada: Yucca Mountain Site Characterization Office. ACC: MOL.20010301.0238.

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide clarification of the screening argument in the Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, to address the NRC comment.

Subissue #2 - Scenario Analysis J-17

Tracking # J-17

Comment 1.2.10.02.00 (Hydrologic response to igneous activity). Excluded based on low consequence (CRWMS M&O, 2001). Argument to exclude focuses on intrusive events. It should be noted that extrusive events could increase shallow infiltration over the repository in two ways: (1) lava flow would modify or dam a wash overlying the repository, (2) volcanic fragment and ash layer, which would be highly permeable, may act to trap infiltrating water, shield it from evaporation, and reduce transpiration all leading to increased shallow infiltration across the repository. There is no data to support or exclude the temporal extent of increased shallow infiltration, though could be bounded from decades to thousands of years.

References CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response DOE will consider revisiting the low consequence arguments concerning extrusive volcanic events on infiltration (including effects on surface vegetation) for this FEP. Consideration will be given to including low probability arguments.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide the technical basis for the screening argument in the Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, screening argument to address the NRC comment

Subissue #2 - Scenario Analysis J-18

Tracking # J-18

Comment 1.3.04.00.00 (Periglacial effects). Excluded by low probability (CRWMS M&O, 2001). While other periglacial processes will not likely occur at Yucca Mountain, the freeze/thaw process is currently active. Freeze/thaw mechanical erosion will likely increase as the climate cools. However, the magnitude of erosion will not likely be significant even during the cooler climate condition. The screening argument should clarified to acknowledge the current freeze/thaw process.

References CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response DOE will clarify the screening argument in next revision of FEPs Analysis/Model Report to acknowledge the current freeze/thaw process.

Reference: BSC 2001b. Features, Events, and Processes in UZ Flow and Transport. ANL-NBS-MD-000001 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010423.0321.

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide clarification of the screening argument in the Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, to address the NRC comment.

Subissue #2 - Scenario Analysis J-19

Tracking # J-19

Comment 2.1.05.01.00 (Seal physical properties). Excluded based on low consequence (CRWMS M&O, 2001). It is difficult to assess this item solely based on the screening argument provided. The assessment can be done once the actual design (ventilation tunnel locations) is released, backfill is described, and the analysis of runoff and flooding incorporated into the screening argument 2.1.05.02.00 (Groundwater flow and radionuclide transport in seals) and 2.1.05.03.00 (Seal degradation). Excluded based on low consequence, using screening argument for 2.1.05.01.00 (Seal physical properties). The adequacy of the screening argument cannot be assessed until the actual design (ventilation tunnel locations) is released, backfill is described, and the analysis of runoff and flooding is incorporated into the screening arguments.

References CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response As indicated in the May 2001 FEPs Technical Exchange, DOE will adopt a more rigorous configuration controls as the design advances. These controls will identify FEP screening argument that could potentially change when design changes occur.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #2 - Scenario Analysis J-20

Tracking # J-20

Comment 2.2.07.05.00 (Flow and transport in the unsaturated zone from episodic infiltration). Excluded based on low consequence (CRWMS M&O, 2001b). Screening argument asserts that episodic infiltration is expected to be attenuated by flow in the paintbrush nonwelded tuff layer such that unsaturated zone flow beneath this layer is effectively steady-state. Analyses to support this assertion, however, have only considered episodic infiltration with an average of 5 mm/yr infiltration flux. Area-average infiltration flux over the proposed repository horizon at YM is expected to exceed 20 mm/yr during future wetter climate conditions.

References CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response The technical work used to resolve Unsaturated and Saturated Flow under Isothermal Conditions agreement 4.4 will be sufficient to provide the additional technical bases needed for the FEPs screening argument. This agreement will address episodic flow in the repository. An analysis of 36 Cl will be included with respect to fast pathways through the PTn.

Treatment of undetected features in PTn can be addressed through an analysis of 36Cl measurements in the TSw (which identifies fast pathways through the PTn). This will be added to the FEP argument.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (USFIC Subissue 4 Agreement 4). Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, will be revised upon completion of this work.

Subissue #2 - Scenario Analysis J-21

Tracking # J-21

Comment 2.2.11.02.00 (Gas pressure effects) is excluded based on low consequence and low probability (CRWMS M&O, 2001). Consistency is needed in the screening arguments. Buildup of water vapor pressure withing rock matrix blocks due to waste heat has not been considered. Gas pressure can build up within matrix blocks which have low permeability. This can increase the boiling point and keep water in the liquid phase at higher temperatures. Flashing to vapor as liquid water leaves the matrix block can result in mineral deposition that can later affect flow pathways.

References CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response The technical arguments for this issue (related to repository heating) are addressed as part of the thermal-hydrological-chemical analyses. Additional technical work related to the Evolution of Near Field agreements 1.5, 1.7 and 2.16 will be sufficient to provide the additional technical bases needed for the FEPs screening argument. These agreements will address thermal-hydrological-chemical affects on mineral precipitation. DOE will cross-reference this FEP with FEPs treating thermal-hydrological-chemical effects: 2.2.08.02.00 (Geochemical interactions in geosphere (dissolution, precipitation, weathering) and effects on radionuclide transport), 2.2.10.01.00 (Repository induced thermal effects in geosphere) and 2.2.10.06.00 (Thermo-chemical alteration (solubility, speciation, phase changes, precipitation/dissolution)).

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (ENFE Subissue 1 Agreements 5 and 7, and ENFE Subissue 4 Agreement 3). Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, will be revised upon completion

of this work.

Subissue #2 - Scenario Analysis J-22

Tracking # J-22

Comment 1.2.04.02.00 (Igneous activity causes changes to rock properties) is screened as excluded from the radionuclide transport in the unsaturated zone abstraction, on the basis of low consequence (CRWMS M&O, 2000b, 2001). Although several of the arguments presented (scale, duration) may be reasonable, natural analogs (CRWMS M&O, 2000a) suggest time scales of thousands of years (Ratcliff et al., 1984) and alteration scales of tens of meters. Furthermore, modeling studies of the effects of silica redistribution on fracture porosity and permeability (CRWMS M&O, 2000a) have yielded conflicting results (Matyskiela, 1997), suggesting additional clarification is needed. Probability may also be an aspect to use in developing an screening argument for 1.2.04.02.00, provided it is consistent with the probabilities used for the igneous disruptive scenario.

References
CRWMS M&O. "Natural Analogs for the Unsaturated Zone." ANL-NBS-HS-000007. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Unsaturated Zone Flow and Transport Model Process Model Report." TDR-NBS-HS-000002. Revision 00 ICN02. Las Vegas, Nevada: CRWMS M&O. 2000b.
CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.
Matyskiela, W. "Silica Redistribution and Hydrologic Changes in Heated Fractured Tuff." Geology. Vol. 25. pp. 1115-1118. 1997.
Ratcliff, C.D., J.W. Geissman, F.V. Perry, B.M. Crowe, and P.K. Zeitler. "Paleomagnetic Record of a Geomagnetic Field Reversal from Late Miocene Mafic Intrusions." Science. Vol. 266. pp. 412-416. 1994.

DOE Response DOE will consider probability arguments to exclude larger intrusive events that may induce hydrothermal activity and pervasive alteration of country rock. The particular issues raised by the work of Matyskiela (1997) will be addressed through the Evolution of Near Field agreements 1.7, 1.5, and 4.3. The agreements will include a resolution of the differences in behavior predicted by Matyskiela (1997) and Hardin (1998), Near Field/Altered Zone Models MOL.19980504.0577).

References: Matyskiela, W. 1997. "Silica Redistribution and Hydrologic Changes in Heated Fractured Tuff." Geology, 25, (12), 1115-1118. Boulder, Colorado: Geological Society of America. TIC: 236809.

Hardin, E.L. 1998. Near-Field/Altered-Zone Models Report. UCRL-ID-129179 DR. Livermore, California: Lawrence Livermore

National Laboratory. ACC: MOL.19980504.0577.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (ENFE Subissue 1 Agreement 4, ENFE Subissue 4 Agreements 3 and 4, and RT Subissue 1 Agreement 5). Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, will be revised upon completion of this work.

Subissue #2 - Scenario Analysis J-23

Tracking # J-23

Comment 1.2.06.00.00 (Hydrothermal activity). Excluded on the basis of low consequence for basaltic magmatism, and low probability for silicic magmatism (CRWMS M&O, 2001). A consistent approach for the screening arguments is needed. Screening argument is considered incomplete as (i) past hydrothermal activity in the Yucca Mountain region is not clearly related to basaltic igneous activity, and (ii) probability screening arguments in CRWMS M&O (2001) are incomplete with respect to silicic magmatism. In addition, the DOE cites unpublished work by the U.S. Geological Survey and University of Nevada, Las Vegas that reportedly demonstrates hydrothermal activity was a site characteristic until about 2 Ma. Additional unpublished work by Dublyanski and others, however, does not support this conclusion. None of the unpublished work, however, has supported the conclusion that the likelihood of hydrothermal activity at YM during the next 10,000 yr is clearly less than 1 in 10,000. Absent a clear linkage to the consequences of basaltic igneous activity, or a demonstrated technical basis for probability values below 1 in 10,000 in 10,000 yr, the DOE has an incomplete technical basis to screen 1.2.06.00.00 from further consideration.

References CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response The technical work used to resolve Evolution of Near Field agreement 2.3 will be sufficient to provide the additional technical bases needed for the FEPs screening argument.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (ENFE Subissue 2 Agreement 3). Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, will be revised upon completion of this work.

Subissue #2 - Scenario Analysis J-24

Tracking # J-24

Comment 1.2.04.07.00 (Ashfall). The screening argument in (CRWMS M&O, 2001) for ashfall impacting the saturated zone [i.e., secondary 1.2.04.07.01 (Soil Leaching Following Ashfall)] includes a three order of magnitude error in the calculation of the concentration of radionuclides in the well water. Although conservative assumptions are used in the analysis, the error found in Table 6-1 would cause the calculated dose to be 16.1 rem, instead of 16.1 mrem, and would not support a low consequence screening argument.

References CRWMS M&O. "Features, Events, and Processes in SZ Flow and Transport." ANL-NBS-MD-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response The NRC comment regarding Table 6-1 and a three order of magnitude error in the calculation of the radionuclide concentrations is correct.

The present analysis conservatively assumes instantaneous transport of radionuclides through the unsaturated zone to the water table. Simplified calculations of expected transport times through the unsaturated alluvium for short-to moderately short-lived radionuclides (e.g., Sr-90, Cs-137, Pu-238) indicate a reduction in mass for these radionuclides by many orders of magnitude. Consequently, these radionuclides can be removed from consideration in the analysis presented in Table 6-1. The screening argument will be expanded to consider loss of radionuclide mass by radioactive decay during transport through the unsaturated zone. The error noted in the calculation of the radionuclide concentrations in Table 6-1 will be corrected for the more restricted list of radionuclides and the results will be used as support for the low consequence screening argument. The expanded screening argument and corrected calculations will be documented in a revised version of the Saturated Zone FEPs Analysis/Model Report (CRWMS M&O 2001c).

Reference: CRWMS M&O 2001c. Features, Events, and Processes in SZ Flow and Transport. ANL-NBS-MD-000002 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010214.0230.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14,

J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide the technical basis for the screening argument in the Features, Events, and Processes in SZ Flow and Transport, ANL-NBS-MD-000002 screening argument to address the NRC comment.

Subissue #2 - Scenario Analysis J-25

Tracking # J-25

Comment 1.2.02.02.00 (Faulting). Changes of fault characteristics has been screened as excluded on the basis of low consequence (CRWMS M&O, 2001); and formation of new faults has been excluded on the basis of low probability. 1.2.02.03.00 (Fault Movement Shears Waste Container) has been excluded on the basis of low probability.1.2.03.02.00 (Seismic Vibration Causes Container Failure) has been excluded on the basis of low consequence (CRWMS M&O, 2001). In these items, DOE's screening argument relies, in large part, upon the median values of fault displacements and ground motions for postclosure (less than 10-6/year), rather than the mean values. The screening arguments do not provide sufficient technical justification for staff review. The staff considers that the mean more reliably incorporates uncertainty and is a more reasonable and prudent statistical measure than the median. DOE has agreed to address this concern in a forthcoming Request for Additional Information.

References CRWMS M&O. "Features, Events, and Processes: Screening for Disruptive Events." ANL-WIS-MD-000005. Revision 00 ICN 01. CRWMS M&O. 2001.

DOE Response DOE will address this concern in the forthcoming Request for Additional Information.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (SDS Subissue 1 Agreement 2) and an NRC letter dated August 3, 2001. Features, Events, and Processes: Screening for Disruptive Events, ANL-WIS-MD-000005 will be revised upon completion of this work.

Subissue #2 - Scenario Analysis J-26

Tracking # J-26

Comment The screening argument for 1.2.02.03.00 (Fault Movement Shears Waste Container) is based, in part, on specific setback distances that will be used by U.S. Department of Energy in the repository design (CRWMS M&O, 2001). The setback distances are a function of fault displacement magnitudes. Thus, the setback values used in the design may need to be reassessed after the displacement issue is resolved.

References CRWMS M&O. "Features, Events, and Processes: Screening for Disruptive Events." ANL-WIS-MD-000005. Revision 00 ICN 01. CRWMS M&O. 2001.

DOE Response DOE will address this concern in the forthcoming Request for Additional Information.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (SDS Subissue 1 Agreement 2) and an NRC letter dated August 3, 2001. Features, Events, and Processes: Screening for Disruptive Events, ANL-WIS-MD-000005 will be revised upon completion of this work.

Subissue #2 - Scenario Analysis J-27

Tracking # J-27

Comment 1.2.03.01.00 (Seismic activity) has been screened as excluded on the basis of low consequence of effects on such components as drip shield and waste package, and included with regard to effects on cladding (CRWMS M&O, 2001). The distributions for ground-motion parameters were developed using the Probabilistic Seismic Hazard Assessment expert elicitation. There are apparent discrepancies among these input parameters from several experts. DOE has agreed to address this concern in a forthcoming Request for Additional Information.

References CRWMS M&O. "Features, Events, and Processes: Screening for Disruptive Events." ANL-WIS-MD-000005. Revision 00 ICN 01. CRWMS M&O. 2001.

DOE Response DOE will address this concern in the forthcoming Request for Additional Information.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (SDS Subissue 2 Agreement 1) and an NRC letter dated August 3, 2001. Features, Events, and Processes: Screening for Disruptive Events, ANL-WIS-MD-000005, will be revised upon completion of this work.

Subissue #2 - Scenario Analysis SA-3

Tracking # SA-3

Comment 2.2.10.03.00 (Natural geothermal effects). It is stated that natural geothermal effects are included because the current geothermal gradient is addressed in the SZFT model (CRWMS M&O, 2001). However, this discussion does not address the potential for spatial and temporal variation in that gradient, which is part of the description of 2.2.10.03.00. Resolution of this issue is necessary to address the issue of changes in the geothermal gradient in 2.2.10.13.00 [Density-driven groundwater flow (thermal)].

References CRWMS M&O. "Features, Events, and Processes in SZ Flow and Transport." ANL-NBS-MD-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Response same as 2.2.10.13.00 - Density-driven groundwater flow from natural thermal effects due to hydrothermal activity could result in greater dilution of radionuclide concentrations due to convection, as discussed in the section on Feature, Event and Process 1.2.06.00.00 in the Saturated Zone Features, Events and Processes Analysis/Model Report (CRWMS M&O 2001f). In addition, potential impacts due to increased groundwater flow rates in the Saturated Zone are captured within the range of uncertainty in specific discharge analyzed in the Saturated Zone site-scale flow and transport model for Total System Performance Assessment-Site Recommendation (CRWMS M&O 2000aq). Specific discharge in the Saturated Zone is scaled upward by a factor of 10 for a significant number of realizations of the Saturated Zone flow and transport system (CRWMS M&O. 2000ar).

References

CRWMS M&O 2001f. Features, Events, and Processes in SZ Flow and Transport. ANL-NBS-MD-000002 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010214.0230. CRWMS M&O 2000ar. Uncertainty Distribution for Stochastic Parameters. ANL-NBS-MD-000011 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000526.0328.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The

technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing DOE/NRC agreement (USFIC Subissue 5 Agreement 13). The Features, Events, and Processes in SZ Flow and Transport, ANL-NBS-MD-000002, will be updated as necessary to reflect the results of this existing agreement.

Subissue #2 - Scenario Analysis SA-4

Tracking # SA-4

Comment 1.2.06.00.00 (Hydrothermal activity). In (CRWMS M&O, 2001), this item is excluded on the basis of low consequence. For saturated zone transport, the argument is that the adopted Kd distributions account for possible lithologic changes and thermal effects, with reference to CRWMS M&O (2000). However, the latter document does not provide a clear technical basis that the Kds were derived in such a fashion. In addition, though the screening argument is based on low consequence, there is a reference at the conclusion of the Supplemental Discussion to the low probability of hydrothermal activity (CRWMS M&O, 2001). Resolution of this issue is necessary to address the issue of changes in the geothermal gradient in 2.2.10.13.00 [Density-driven groundwater flow (thermal)]. The DOE should provide a stronger technical basis for the assertion that possible hydrothermal effects on Kd values are accounted for in the total system performance assessment.

References CRWMS M&O. "Uncertainty Distribution for Stochastic Parameters". ANL-NBS-MD-000011. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.
CRWMS M&O. "Features, Events, and Processes in SZ Flow and Transport." ANL-NBS-MD-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response The approach taken to assigning uncertainty distributions for Kd in the Saturated Zone transport model is to use the most conservative (i.e., lowest Kd values) from among the different volcanic rock types reported in CRWMS M&O (2000as). By taking the most conservative distribution of Kd for all volcanic rock types (including some that have experienced volcanic hydrothermal alteration, such as zeolitization), the Saturated Zone transport analysis implicitly incorporates the consideration of potential future hydrothermal alteration in a conservative manner. It is recognized that the analysis of Kd distributions in CRWMS M&O (2000as) does not directly discuss the issue of hydrothermal alteration, but does include analysis of Kd distributions for zeolitic volcanic units. The reference to low probability at the end of the Supplemental Discussion section is extraneous to the argument of low consequence and will be removed in the next revision of the Saturated Zone Features, Events, and Processes Analysis/Model Report. This comment is addressed in Radionuclide Transport agreement KRT0210. The agreement states in part, AConsistent with the less structured approach for informal expert judgement acknowledged in NUREG-1563 guidance and consistent with AP-3.10Q, DOE will document how it derived the transport distributions for performance assessment. The information obtained from agreement KRT0210 will respond to this comment in full and no

additional work is needed. The Saturated Zone Features, Events, and Processes Analysis/Model Report will be revised, to support any potential License Application, to include the new information obtained from agreement KRT0210.

References:

CRWMS M&O 2000as. Unsaturated Zone and Saturated Zone Transport Properties (U0100). ANL-NBS-HS-000019 REV00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL20000829.0006.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing DOE/NRC agreements (RT Subissue 1 Agreement 5 and Subissue 2 Agreement 10). The Features, Events, and Processes in SZ Flow and Transport, ANL-NBS-MD-000002, will be updated as necessary to reflect the results of these existing agreements.

Subissue #2 - Scenario Analysis SA-5

Tracking # SA-5

Comment 2.1.09.21.00 (Suspension of particles larger than colloids). The analysis and model report on features, events, and processes in the saturated zone (CRWMS M&O, 2001a) states that these particles will be included and treated as colloids. However, 2.1.09.21.00 (Suspension of particles larger than colloids) is not addressed in the analogous analysis model report for the unsaturated zone (CRWMS M&O, 2001b) and noted as excluded under two other model components in the Yucca Mountain Project Database (CRWMS M&O, 2001c). Furthermore, it is not clear how the effects of particles are included with colloids. 2.1.09.21.00 (Suspension of particles larger than colloids) should be addressed under the scope of (CRWMS M&O, 2001b) and the integration of its disposition across the engineered barrier subsystem, unsaturated zone, and saturated zone should be clarified.

References CRWMS M&O. "Features, Events, and Processes in SZ Flow and Transport." ANL-NBS-MD-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001a.
CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.
CRWMS M&O. "Yucca Mountain FEP Database." TDR-WIS-MD-000003 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001c.

DOE Response It should be noted that particles larger than colloids are not included in the Total System Performance Assessment-Site Recommendation (CRWMS M&O 2000aq) analysis and have been explicitly excluded by the waste form and near field environment components of the Total System Performance Assessment. This feature, event and process is identified as potentially included in the Saturated Zone to the extent that it cannot be shown to have sufficiently low consequence to the Saturated Zone component of the analysis. The point is that radionuclides associated with particulate matter (colloids or larger) are treated as colloids in the Saturated Zone analysis, if they are deposited in the Saturated Zone from other components of the Total System Performance Assessment. However, suspension of particles larger than colloids has been excluded from the analysis at the source. If particles larger than colloids are included in the Near Field Environment, Waste Form, and Unsaturated Zone models they will also be included in the Saturated Zone transport model and will be modeled conservatively using the colloid transport model. Likewise if they are excluded in the Near Field Environment, Waste Form, or Unsaturated Zone they will not be included in the Saturated Zone transport model. As indicated in the response to feature, event and

process 1.4.06.01.00 (Altered soil or surface water chemistry) above, the treatment of any feature, event and process will be consistent throughout the Total System Performance Assessment components.

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide clarification for the screening argument in the Features, Events, and Processes in SZ Flow and Transport, ANL-NBS-MD-000002, to address the NRC comments.

Subissue #2 - Scenario Analysis SA-6

Tracking # SA-6

Comment Assumptions labeled as To-Be-Verified were found in the following reports: CRWMS M&O (2000), CRWMS M&O (2001a), and CRWMS M&O (2001b).

It is necessary to disclose plans to verify these assumptions and identify the data and analyses that will be used in the verification.

References CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.
CRWMS M&O. "FEPs in Thermal Hydrology and Coupled Processes." ANL-NBS-MD-000004 Revision 00 ICN1. Las Vegas, Nevada: CRWMS M&O. 2001a
CRWMS M&O. "Features, Events, and Processes in SZ Flow and Transport." ANL-NBS-MD-000002 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001b

DOE Response Initiation, tracking, resolution and closure of To Be Verified's in technical products are procedurally controlled per procedure AP-3.15Q. Resolution of this issue is being addressed at DOE and NRC Management meetings.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Technical Exchange on Features, Events, and Processes, May 15-17, 2001.

Subissue #2 - Scenario Analysis SA-7

Tracking # SA-7

Comment 1.4.06.01.00 (Altered soil or surface water chemistry). This item is excluded on the basis of low probability (CRWMS M&O, 2001b), but it is not addressed under the scope of document ANL-NBS-MD-000002 (CRWMS M&O, 2001a). The probability argument is not supported by a calculation or estimate. This item is possibly relevant for the Integrated Subissue Radionuclide Transport in the Saturated Zone because of possible changes in groundwater chemistry.

References CRWMS M&O. "Features, Events, and Processes in SZ Flow and Transport." ANL-NBS-MD-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001a.
CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response The basis for excluding this Feature, Event and Process (FEP) is provided in the Unsaturated Zone (FEPs) Analysis/Model Report (BSC 2001d). This FEP is not considered in the Saturated Zone flow and transport since it has been excluded in the Unsaturated Zone flow and transport, i.e., any effect in the Saturated Zone would be less than that in the Unsaturated Zone.

Reference: BSC 2001d. Features, Events, and Processes in UZ Flow and Transport. ANL-NBS-MD-000001 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010423.0321.

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide clarification of the screening argument in the Features, Events, and Processes in SZ Flow and Transport, ANL-NBS-MD-000002, to address the NRC comments. The AMR will also address the aggregate affects of 1.4.06.01.00 (Altered soil or surface water chemistry) on UZ and SZ.

Subissue #2 - Scenario Analysis SA-8

Tracking # SA-8

Comment 1.2.04.07.00 (Ashfall). DOE assumes that ashfall blankets the region between the repository and the compliance boundary (CRWMS M&O, 2001). Radionuclides associated with ashfall are then assumed to be transported instantaneously into the saturated zone. DOE presented only the case for uniform distribution. Moreover, parameter values and models used in the Ashfall analysis are not clear. Some parameters used in the model are not well documented and other parameters such as the number of waste package that fail are not viewed as conservative. DOE should provide additional bases for the choice of models and parameters used to screen this item.

References CRWMS M&O. "Features, Events, and Processes in SZ Flow and Transport." ANL-NBS-MD-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response The uniform distribution of ashfall along the flow path from the repository to the receptor is a stylized, conservative representation of volcanic ash distribution on the land surface that allows a relatively simple analysis of potential impacts. It is conservative to assume that all of the volcanic ash would be concentrated on a relatively narrow band of the land surface within the capture zone of the well(s) providing groundwater to the hypothetical farming community. The range of waste packages as a result of a volcanic eruption is 3 to 39. The number of waste packages that are assumed to fail in the ashfall analysis is the median number of packages from the Total System Performance Assessment-Site Recommendation modeling (CRWMS M&O 2000aq). The expected behavior with respect to the number of waste package failures is used in the ashfall analysis.; There is no regulatory requirement that conservative parameter values be used in every aspect of the screening analysis. DOE believes no additional work is needed in this regard.

References:

CRWMS M&O 2000aq. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001005.0282.

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be

provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide clarification of the screening argument in the Features, Events, and Processes in SZ Flow and Transport, ANL-NBS-MD-000002, to address the NRC comment.

Subissue #2 - Scenario Analysis SA-9

Tracking # SA-9

Comment 2.2.10.06.00 [Thermo-chemical alteration (solubility, speciation, phase changes, precipitation/dissolution)]. This item is excluded on the basis of low consequence (CRWMS M&O 2001) with reference to the screening argument for 2.2.7.10.00 in the UZ FEPs AMR (BSC 2001). The argument that repository thermal effects on Saturated Zone radionuclide transport will be minimal is based on a to-be-verified assumption (BSC 2001). There is no explicit technical basis presented that rock alteration or temperature effects on geochemical properties and processes will negligibly affect Saturated Zone transport. In addition, it is asserted in the Saturated Zone FEPs AMR (CRWMS M&O 2001) that any such effects would be within the bounds of uncertainty ranges established for transport properties such as Kd. However, the relevant AMR (CRWMS M&O 2000) does not provide a clear technical basis that this is the case. DOE's current technical justification is inadequate. The DOE should provide additional technical justification to fully exclude 2.2.10.06.00 [Thermo-chemical alteration (solubility, speciation, phase changes, precipitation/dissolution)].

Same comment applies to 2.2.10.08.00 (Thermo-chemical alteration of the saturated zone).

References CRWMS M&O. "Features, Events, and Processes in SZ Flow and Transport." ANL-NBS-MD-000002 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.
BSC. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: Bechtel SAIC Company. 2001.
CRWMS M&O. "Unsaturated Zone and Saturated Zone Transport Properties." ANL-NBS-HS-000019 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The rationale for excluding this Feature, Event and Process from the Saturated Zone does rest on the conclusions of the unsaturated zone features, events and processes screening analysis that it can be excluded on the basis of low consequence. This rationale is reasonable and appropriate. If the higher temperature conditions in the unsaturated zone near the repository are insufficient to have a significant consequence on radionuclide transport, then the smaller temperature rise in the saturated zone would also have no significant consequences. However, it is recognize that this conclusion is based on a To Be Verified assumption in the unsaturated zone and if the screening decision is changed for the unsaturated zone, the screening decision and justification for the saturated zone would need to be revisited. This comment is addressed in Radionuclide Transport agreement

KRT0210. The agreement states in part, "Consistent with the less structured approach for informal expert judgement acknowledged in NUREG-1563 guidance and consistent with AP-3.10Q, DOE will document how it derived the transport distributions for performance assessment ... ." The information obtained from agreement KRT0210 will respond to this comment in full and no additional work is needed. The Saturated Zone Features, Events and Processes Analysis/Model Report will be revised, to support any potential License Application, to include the new information obtained from the Radionuclide Transport agreement KRT0210.

References:

BSC 2001d. Features, Events, and Processes in UZ Flow and Transport. ANL-NBS-MD-000001 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010423.0321.
CRWMS M&O 2000as. Unsaturated Zone and Saturated Zone Transport Properties (U0100). ANL-NBS-HS-000019 REV00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL20000829.0006.

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide clarification of the screening argument in the Features, Events, and Processes in SZ Flow and Transport, ANL-NBS-MD-000002, to address the NRC comment.

Subissue #2 - Scenario Analysis SA-10

Tracking # SA-10

Comment 2.3.11.04.00 (Groundwater discharge to surface) is excluded on the basis of low consequence (CRWMS M&O, 2001). Modeling shows that spring discharge within the 20-km radius is not likely, yet past discharges have occurred within the 20-km radius (e.g., paleospring deposits at 9S and 1S). See discussion of 1.3.07.02.00 (water table rise). Any screening argument that spring discharges are outside of the proposed compliance area is insufficient. Additional technical justification is required to fully exclude 2.3.11.04.00.

References CRWMS M&O. "Features, Events, and Processes in SZ Flow and Transport." ANL-NBS-MD-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response No groundwater discharge at springs along the saturated zone flow path from the repository (within 20 km) is anticipated for glacial climatic conditions, as indicated by the lack of paleospring deposits in this area and by regional-scale groundwater flow modeling results (D=Agnese et al. 1999). Paleospring deposits at the southern end of Crater Flats indicate that groundwater discharge has occurred in this area under past glacial conditions and would alter the groundwater flow to some extent. However, these potential discharge points are over 10 km to the west of the present groundwater flow path and are not expected to be a source of potential radionuclide releases to the accessible environment.

References:

D=Agnese, F.A.; O=Brien, G.M.; Faunt, C.C.; and San Juan, C.A. 1999. Simulated Effects of Climate Change on the Death Valley Regional Ground-Water Flow System, Nevada and California. Water-Resources Investigations Report 98-4041. Denver, Colorado: U.S. Geological Survey. TIC: 243555.

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide clarification of the screening argument in the Features, Events, and Processes in SZ Flow and Transport,

ANL-NBS-MD-000002, to address the NRC comment.

Subissue #2 - Scenario Analysis SA-11

Tracking # SA-11

Comment 1.3.07.01.00 (Drought/water table decline). According to information in CRWMS M&O, 2001, this item is excluded due to low consequence. DOE states that "a lower water table could result in less travel through the alluvial aquifer and as a result, less sorption and retardation of the contaminant plume." However, no evidence is presented that precludes a watertable decline. Current flow models assume that groundwater flow through the saturated alluvium is relatively shallow. As water tables decline, how will flow through the alluvium be affected? Is it possible that a larger component of flow will be through the deep carbonate system? Will the upward gradient observed at some locations be affected? Are there distinct pathways that are dependent on the elevation of the water table? It is likely that the transport times will stay the same or increase due to water table decline, but the exclusion argument provided seems insufficient. Additional technical justification is required to fully exclude 1.3.07.01.00 (Drought/water table decline).

References CRWMS M&O. "Features, Events, and Processes in SZ Flow and Transport." ANL-NBS-MD-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response The possibility of shorter flow path lengths in the alluvium (due to hydrogeologic uncertainty or potential decline in the water table) is captured in Saturated Zone site-scale model simulations for Total System Performance Asessment-Site Recommendation (CRWMS M&O 2000ar). The general pattern of groundwater flow is not expected to change with water table decline in the Saturated Zone. The regional-scale groundwater flow is controlled by the topographic distribution of recharge and discharge areas, as well as the large-scale distribution of hydrogeologic units and structural features. It is reasonable to expect that there would be relatively minor changes in the shallow groundwater flow paths with water table decline, but major features of the Saturated Zone flow system (e.g., the upward gradient from the carbonate aquifer) are expected to remain stable in the case of either water table decline or water table rise. This comment is addressed in Radionuclide Transport and Unsaturated and Saturated Flow Under Isothermal Conditions agreement KRT0208 and KUZ0504 respectively. The agreements state in part, ADOE will provide additional information to include Nye county data as available, to further justify the uncertainty distribution of flow path lengths in alluvium Y@ The information obtained from agreement KRT0208 will respond to this comment in full and no additional work is needed. The Saturated Zone Features, Events and Processes Analysis/Model Report (CRWMS M&O 2001f) will be revised, to support any potential License Application, to include the new information obtained from

agreement KRT0208.

References:

CRWMS M&O 2000ar. Uncertainty Distribution for Stochastic Parameters. ANL-NBS-MD-000011 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000526.0328.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing DOE/NRC agreements (RT Subissue 2 Agreement 8 and USFIC Subissue 5 Agreement 4). The Features, Events, and Processes in SZ Flow and Transport, ANL-NBS-MD-000002, will be updated as necessary to reflect the results of these existing agreements and clarify the screening argument.

Subissue #2 - Scenario Analysis SA-12

Tracking # SA-12

Comment 2.2.10.13.00 [Density-driven groundwater flow (thermal)]. The saturated zone features, events, and processes analysis and model report (CRWMS M&O, 2001) addresses this item in two parts: repository-induced effects ("excluded," low consequence) and natural geothermal effects ("included"). Exclusion of repository effects on flow based on DOE analyses is accepted. Natural effects are included only to the extent that the "natural geothermal gradient" is applied in the SZFT model. However, changes in thermal gradients are excluded on the basis of low consequence, with reference to 1.2.06.00.00 (Hydrothermal activity) and 1.2.10.02.00 (Hydrologic response to igneous activity) (CRWMS M&O, 2001). A clear technical basis is not provided under these items that all possible changes in thermal gradients will be localized. The screening argument for 1.2.06.00.00 focuses on geochemical effects (see separate entry), while 1.2.10.02.00 is focused on highly localized igneous intrusions. How these arguments apply to 2.2.10.13.00 is not entirely clear.

References CRWMS M&O. "Features, Events, and Processes in SZ Flow and Transport." ANL-NBS-MD-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Density-driven groundwater flow from natural thermal effects due to hydrothermal activity could result in greater dilution of radionuclide concentrations due to convection, as discussed in the section on Feature, Event and Process 1.2.06.00.00 in the Saturated Zone Features, Events and Processes Analysis/Model Report (CRWMS M&O 2001f). In addition, potential impacts due to increased groundwater flow rates in the saturated zone are captured within the range of uncertainty in specific discharge analyzed in the saturated zone site-scale flow and transport model for Total System Performance Assessment-Site Recommendation. Specific discharge in the saturated zone is scaled upward by a factor of 10 for a significant number of realizations of the saturated zone flow and transport system (CRWMS M&O. 2000ar).

References:

CRWMS M&O 2001f. Features, Events, and Processes in SZ Flow and Transport. ANL-NBS-MD-000002 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010214.0230. CRWMS M&O 2000ar. Uncertainty Distribution for Stochastic Parameters. ANL-NBS-MD-000011 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000526.0328.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as

summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by an existing DOE/NRC agreement (USFIC Subissue 5 Agreement 13). The Features, Events, and Processes in SZ Flow and Transport, ANL-NBS-MD-000002, will be updated to clarify the screening argument and to reflect the results of this existing agreement.

Subissue #2 - Scenario Analysis SA-13

Tracking # SA-13

Comment 2.2.10.02.00 (Thermal convection cell develops in saturated zone) is screened as excluded on the basis of low consequence (CRWMS M&O, 2001). DOE indicates that temperatures at the water table are expected to approach 80°C. The DOE further points out that the resulting concern is that thermally driven water flow in the upper tuff aquifer could increase groundwater velocities relative to the system without heat sources. Additional justification for exclusion is necessary.

References CRWMS M&O. "Features, Events, and Processes in SZ Flow and Transport." ANL-NBS-MD-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response The screening argument, for excluding this Feature, Event and Process, is that thermally driven groundwater flow in the Saturated Zone will not significantly alter the range of uncertainty in specific discharge that is already included in the Saturated Zone site-scale flow and transport model for Total System Performance Assessment-Site Recommendation and therefore will not significantly alter the expected dose. To account for uncertainties, pecific discharge in the Saturated Zone is scaled upward by a factor of 10 for a significant number of realizations of the Saturated Zone flow and transport system (CRWMS M&O. 2000ar). In addition, for nominal-case behavior in Total System Performance Assessment-Site Recommendation there is negligible transport of radionuclides through the Unsaturated Zone during the period of significant thermal perturbation.

References:

CRWMS M&O 2000ar. Uncertainty Distribution for Stochastic Parameters. ANL-NBS-MD-000011 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000526.0328.

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide clarification of the screening argument in the Features, Events, and Processes in SZ Flow and Transport,

ANL-NBS-MD-000002, to address the NRC comment.

Subissue #2 - Scenario Analysis SA-18

Tracking # SA-18

Comment The Biosphere Analysis Model Report on features, events, and processes (CRWMS M&O, 2001) indicates that any future changes in 1.4.07.01.00 (Water management activities) can be excluded based on the proposed 10 CFR Part 63. This item includes well pumping from an aquifer as a water management activity. The conclusion that changes to water management activities may be excluded is not supportable by the regulation. The draft regulation indicates that the behaviors and characteristics of the farming community shall be consistent with current conditions of the region surrounding the Yucca Mountain site and that climate evolution shall be consistent with the geologic record. As the climate becomes wetter and cooler, the farming community is likely to pump less water out of the aquifer, consistent with sites analogous to the predicted future climate of Yucca Mountain. This reduction in pumping would not be considered a change in the behavior or characteristics of the critical group since the community would still be raising similar crops using similar farming methods.

References CRWMS M&O. "Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEP)." ANL-MGR-MD-000011. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response This Feature, Event and Process (FEP) can be excluded on the basis of the proposed regulation as this FEP deals with the use of man-made structures and not specifically with the use of groundwater. Since these features do not currently exist in the vicinity of the location of the critical group, not considering them is consistent with the current conditions. The use of groundwater, via well(s), and the changes associated with climate evolution are specifically related to FEP 1.4.07.02.00 "Wells" and is not considered to be part of this FEP. Effect of climate change, FEP 1.3.01.00.00, on water use is considered and addressed in Nominal Case Biosphere Dose Conversion Factor Analysis/Model Report.

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:

Subissue #2 - Scenario Analysis SA-18

DOE agreed to provide clarification of the screening argument in the Features, Events, and Processes in SZ Flow and Transport, ANL-NBS-MD-000002, to address the NRC comment.

Tracking # SA-19

Comment DOE has selected a subset of the full list of features, events, and processes as applicable for biosphere screening in (CRWMS M&O, 2001). Some entries that are potentially applicable to biosphere dose conversion factor calculations (that should at least be considered for screening) have not been included in the scope of the document ANL-MGR-MD-000011 (CRWMS M&O, 2001). These include:
2.3.11.04.00 (Groundwater discharge to surface)
1.3.07.02.00 (Water table rise)
3.2.10.00.00 (Atmospheric transport of contaminants)
1.2.04.01.00 (Igneous activity)
2.2.08.01.00 (Groundwater chemistry/composition in unsaturated zone and saturated zone) (i.e., chemical species can impact dose coefficient selection)
2.2.08.11.00 (Distribution and release of nuclides from the geosphere)
3.1.01.01.00 (Radioactive decay and ingrowth) and
1.2.04.07.00 (Ashfall).

References CRWMS M&O. "Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEP)." ANL-MGR-MD-000011. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Feature, Event and Process (FEP) 1.3.07.02.00 "Water table rise" and FEP 2.3.11.04.00 "Groundwater discharge to surface". The processes addressed in FEPs 1.3.07.02.00 & 2.3.11.04.00 are not directly related to the biosphere and are not evaluated by the Biosphere FEP Analysis/Model Report (CRWMS M&O 2001e). Effects of any surface discharge or water table rise in the compliance area, if any, would be addressed within FEP 3.3.05.11.00 "Radiation doses". The effects of climate change within the compliance area, if any, on the processes addressed in these FEP will be evaluated in support of any potential license application.

FEP 3.2.10.00.00 "Atmospheric transport of contaminants" - Those FEP, which deal with the mechanics of atmospheric transport of contaminants as a result of a volcanic event, are discussed, considered and evaluated within the scope of the Disruptive Event FEP Analysis/Model Report (CRWMS M&O 2000i). The effects of other atmospheric transport processes, such as wind erosion and resuspension, are currently considered in calculation of Biosphere Dose Conversion Factors. Specifically, wind erosion is considered under FEP #s 1.2.07.01.00, 1.2.07.02.00, and 2.3.02.02.00.

FEP 1.2.04.01.00 "Igneous activity" - As described in Freeze et al. 2001, the YMP Primary FEP Description, the Originator FEP

Description, and the secondary FEP descriptions, this FEP is focused on the consequences of igneous activity in the geosphere. This FEP is not directly relevant to the biosphere and, as a result, does not need to be evaluated in the Biosphere FEP Analysis/Model Report. FEP 2.2.08.02.00 "Groundwater chemistry/composition in unsaturated zone and saturated zone" - As cited Freeze et al. 2001, this FEP corresponds to a FEP titled "Radionuclide transport occurs in a carrier plume in the geosphere". The Yucca Mountain Project Primary FEP Descriptor, Originator Descriptor and associated secondary FEP descriptors all relate to transport in the geosphere. This FEP is not directly relevant to the biosphere and, as a result, it does not need to be evaluated in the Biosphere FEP Analysis/Model Report. DOE agrees that chemical species can effect the dose coefficient selection. In the analyses of radiation doses, FEP 3.3.05.01.00 ,which is considered in the Biosphere FEP Analysis/Model Report (CRWMS M&O 2001e), this effect is bounded by selecting the highest dose coefficient factor.

FEP 2.2.08.11.00 "Distribution and release of radionuclides from the geosphere" - As stated in the both the Yucca Mountain Project Primary FEP Description and the Originator Description, this FEP is focused exclusively on the transport of radionuclides in the groundwater. The release of radionuclides in groundwater, as cited in the Biosphere FEP Analysis/Model Report (CRWMS M&O 2001e), is considered via a well, FEP 1.4.07.02.00. This FEP is not directly relevant to the biosphere and, as a result, does not need to be evaluated in the Biosphere FEP Analysis/Model Report.

FEP 3.1.01.01.00 "Radioactive decay and ingrowth" - DOE is reconsidering citing this as an applicable FEP. Although this FEP is not cited as an applicable FEP in the Biosphere, the analyses of radiation dose, FEP 3.3.05.01.00, was addressed in the Biosphere FEP Analysis/Model Report (CRWMS M&O 2001e) and did include the consideration of radioactive decay and progeny ingrowth along the various pathways to man.

FEP 1.2.04.07.00 "Ashfall" - DOE is reconsidering citing this as an applicable FEP. Although this FEP is not cited as an applicable FEP in the Biosphere, the analysis of radiation dose, FEP 3.3.05.01.00, was addressed in the Biosphere FEP Analysis/Model Report (CRWMS M&O 2001e) and did include ashfall for the disruption event scenario.

Agreement Number TSPAI.2.01, TSPAI.2.02, TSPAI.2.03

Agreement Check detailed information in Attachment 2, included at the bottom, for clarification of formal agreements.

TSPAI.2.01- Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

TSPAI.2.02 - Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

TSPAI.2.03 - Add the FEPs highlighted in Attachment 2 to the appropriate FEPs AMRs. See Comment 19 (Part 7 and 8), 20, and J-6.

DOE will add the FEPs highlighted in Attachment 2 to the appropriate FEPs AMRs. The FEPs will be added to the appropriate FEPs AMRs and the AMRs will be provided to the NRC in FY03.

Text in Attachment 2:
DOE will provide a technical basis in the Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEPs), ANL-MGR-MD-000011, to address the NRC comment for FEP 2.3.11.04.00 (Groundwater discharge to surface), FEP 1.3.07.02.00 (Water table rise), and FEP 2.2.08.11.00 (Distribution and release of nuclides from the geosphere).

No further action is required for FEP 3.2.10.00.00 (Atmospheric transport of contaminants) and FEP 1.2.04.01.00 (Igneous activity).

DOE agreed to provide clarification of the screening argument in the Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEP), ANL-MGR-MD-000011, for FEP

2.2.08.02.00 (Groundwater chemistry/composition in unsaturated zone and saturated zone).

DOE will add links to the Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEP), ANL-MGR-MD-000011, for FEP 3.1.01.01.00 (Radioactive decay and ingrowth), and FEP 1.2.04.07.00 (Ashfall).

Subissue #2 - Scenario Analysis SA-20

Tracking # SA-20

Comment 2.2.08.07.00 (Radionuclide solubility limits in the geosphere). The Yucca Mountain Project Database (Rev 00 ICN 01; CRWMS M&O, 2001) does not indicate that 2.2.08.07.00 (Radionuclide solubility limits in the geosphere) is relevant to the biosphere. This item is relevant for limiting the quantity of radioactive material that can leach radionuclides out of the soil or tephra deposit in the biosphere compared to the quantity of radionuclides that would be predicted to leach out of the deposit using only leach rate limits.

References CRWMS M&O. "Yucca Mountain FEP Database." TDR-WIS-MD-000003 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response The Feature, Event and Process (FEP) as described in the FEP database is specific to "Geosphere." The Biosphere as described in the Biosphere Process Model Report excludes processes in the geosphere, therefore this FEP is not considered in the Biosphere.

The concern for limiting the quantity of radioactive material that can leach from soil or tephra deposits does have relevance to the biosphere. The process of leaching in which solubility limits apply is addressed in FEP 2.3.02.02.00, "Radionuclide Accumulation in soil."

For the nominal scenario (groundwater contamination), the process depends on the radionuclide build-up in soil, which includes leaching, and partition coefficient (ratio of concentrations in liquid and solid matter). The process would be applicable to the leaching of the contamination from volcanic ash. However for volcanic release, the Biosphere model does not consider contamination removal by leaching and is thus bounding and conservative. In this scenario the dominant pathway is inhalation from resuspended particulate matter. The inclusion of leaching (with solubility limits) as a transport mechanism from the surfacial layer of contaminated ash (where all resuspension originates) into the deeper layers (where the contamination cannot be resuspended and is thus not available for inhalation) can only reduce the dose contribution from the primary pathway.

Agreement Number TSPAI.2.03

Agreement Add the FEPs highlighted in Attachment 2 to the appropriate FEPs AMRs. See Comment 19 (Part 7 and 8), 20, and J-6.

DOE will add the FEPs highlighted in Attachment 2 to the appropriate FEPs AMRs. The FEPs will be added to the appropriate FEPs AMRs and the AMRs will be provided to the NRC in FY03.

Text in Attachment 2:
DOE will add this item to the Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEP), ANL-MGR-MD-000011, and present the DOE discussion in the screening argument.

Subissue #2 - Scenario Analysis SA-21

Tracking # SA-21

Comment 2.3.13.01.00 (Biosphere characteristics) screening argument indicates YM region lacks permanent surface water (CRWMS M&O, 2001). Is this statement consistent with the geologic record of past climate change in the area?

References CRWMS M&O. "Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEP)." ANL-MGR-MD-000011. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response As described in Section 7.1 of the Yucca Mountain Site Description (CRWMS M&O 2000aw), the region around Yucca Mountain lacks permanent surface water bodies (see Feature, Event and Process 2.3.04.01.00 Surface Water Transport and Mixing). Intermittent sources of water on the Nevada Test Site were not considered since access to the Nevada Test Site is controlled and such sources would not be available to members of the critical group. At the present time, the presence of an intermittent seep or spring at the proposed location of the critical group has not been identified and is considered unlikely given the depth to groundwater (>90 meters) at that location. DOE considers that this issue is conservatively addressed in the current analysis of the nominal scenario.

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide clarification of the screening argument in the Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEP). ANL-MGR-MD-000011 to address the NRC comment.

Subissue #2 - Scenario Analysis SA-24

Tracking # SA-24

Comment 2.3.13.02.00 (Biosphere transport) contains only two secondary entries related to surface water, gas, and biogeochemical transport processes (CRWMS M&O, 2001). The Yucca Mountain Project feature, event, and process description and the originator description are different and call into question whether the focus of this item is transport processes, alterations during transport, or both.

References CRWMS M&O. "Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEP)." ANL-MGR-MD-000011. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response The objective of the Features, Events and Processes (FEPs) Database, as cited in Freeze et al. 2001, is to document a manageable number of primary FEPs that encompass, through comprehensively worded Yucca Mountain Project primary FEP descriptions, all of the relevant issues. To ensure completeness, a Yucca Mountain Project primary FEP description must include those issues identified in the Originator FEP. For this particular FEP, the statement "Once in the biosphere, radionuclides may be transported through and between the different compartments of the biosphere" inherently captures the intent of the Originator FEP Description phrase "Within the biosphere ..." The treatment of the this FEP in the biosphere is both transport processes and alterations during transport.

Agreement Number TSPAI.2.04

Agreement Provide a clarification of the description of the primary FEP. See Comments 24, 31, and 33.

DOE will clarify the description of the primary FEPs, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03

Text in Attachment 2:
DOE agreed to clarify the description of the primary FEP in the Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEPs), ANL-MGR-MD-000011, to address the NRC comment.

Tracking # SA-25

Comment 2.4.07.00.00 (Dwellings) includes a secondary entry, household cooling, which has an inappropriate screening argument (CRWMS M&O, 2001). The screening argument indicates that since the use of an evaporative cooler would only increase the inhalation and direct exposure pathways, and these pathways are only minor contributors to the current dose conversion factors, the use of evaporative coolers can be screened. However, the direct exposure and inhalation doses from evaporative coolers are the result of significantly different processes than the direct exposure and inhalation doses from radionuclides deposited on soils and could have a more significant dose impact.

References CRWMS M&O. "Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEP)." ANL-MGR-MD-000011. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Household (evaporative) cooling is not expected to result in a significant increase in the relative contribution of the inhalation and external pathways to the expected annual dose. For the nominal case (ANL-MGR-MD-000009, Rev 01), which considers indoor exposure as a fraction of the outdoor exposure, the external pathway and the inhalation pathway generally contribute only a small fraction of the Biosphere Dose Converaion Factor. Given the fact that household cooling is used approximately 50% of the time and that people spend less than 50% of their time indoors, any increase in the relative contribution of the external and inhalation pathways to the expected annual as a result of household cooling is expected to be negligible.

For the Disruptive Event (CRWMS M&O 2000p), groundwater is uncontaminated. Therefore, use of evaporative cooling would not present any additional source of indoor exposure in significant effect on the expected annual dose.

DOE considers effects of this secondary Feature Event and Process to be adequately covered in the current analyses of Biosphere Dose Conversion Factors for the two scenarios.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as

summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide the technical basis for the screening argument in the Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEP), ANL-MGR-MD-000011, to address the NRC comment.

Subissue #2 - Scenario Analysis SA-26

Tracking # SA-26

Comment The Analysis and Model Report on Biosphere features, events, and processes (CRWMS M&O, 2001) states that 3.3.08.00.00 (Radon and daughter exposure) is screened as excluded on the basis that the parent radionuclide (Th-230) will not reach the critical group in 10,000 years in the base case scenario (CRWMS M&O, 2001, 2000). This rationale, however, does not apply to the direct release scenario where transport times are much shorter.

References CRWMS M&O. "Disruptive Event Biosphere Dose Conversion Factor Analysis." ANL-MGR-MD-000003. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.
CRWMS M&O. "Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEP)." ANL-MGR-MD-000011. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Inventory Abstraction Analysis/Model Report (CRWMS M&O 2000aj) does not identify either Th-230 or Ra-226 as a significant radionuclide, i.e. one of the radionuclides required to account for 95% of the dose, for the inhalation or ingestion pathway within 10,000 years after repository closure. The inventory abstraction analysis has been revised and may be considered in subsequent biosphere analyses.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide the technical basis for the screening argument in the Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEP), ANL-MGR-MD-000011, to address the NRC comment.

Tracking # SA-29

Comment 2.1.06.07.00 (Effects at material interfaces) is screened as excluded on the basis of low consequence (CRWMS M&O, 2001). The basic chemical processes that occur at phase boundaries (principally liquid/solid) are included in other features, events, and processes. Solid/solid contact either does occur or could occur between the drip shield and the invert and/or backfill (if included in the Yucca Mountain Project design); between the waste package and the invert and/or backfill (if included in the Yucca Mountain Project design); between the pedestal and the waste package and/or drip shield; and between the waste form and any of the other engineered barrier subsystem component materials. Since these materials are all relatively inert, no solid/solid interaction mechanisms have been identified that are significant relative to the basic seepage water induced corrosion of the engineered barrier subsystem components and hence this process is excluded on the basis of low consequence. However, interfaces between solid phases in contact with an aqueous phase can accelerate degradation processes such as crevice corrosion of waste package or galvanic coupling of drip shield to steel components [see screening arguments for 2.1.03.01.00 (Corrosion of waste containers) and 2.1.03.04.00 (Hydride cracking of waste containers and drip shields)].

References CRWMS M&O. "FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation." ANL-EBS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Any electrochemical coupling of Alloy 22 with 316NG will result in increased corrosion degradation of 316NG and enhanced performance of Alloy 22. The similarity of the corrosion potentials of Alloy 22 and Titanium Grade 7 indicates that even if electrical contact were established, it would be of little consequence to the degradation characteristics of the waste package or the drip shield. Analyses (CRWMS M&O 2000a) indicate that crevice corrosion of the waste package outer barrier or the drip shield will not occur under repository-relevant exposure conditions. Galvanic coupling of the drip shield to steel components is discussed in Feature, Event and Process 2.1.03.04.00, Hydride Cracking of Waste Containers and Drip Shields and is determined to have no consequence to the performance of the drip shield.

Interfaces between the waste package and the pallets are not included because the same material is used for the construction.

Reference:

CRWMS M&O 2000a. Abstraction of Models for Pitting and

Crevice Corrosion of Drip Shield and Waste Package Outer Barrier. ANL-EBS-PA-000003 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000526.0327. CRWMS M&O 2001h. FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation. ANL-EBS-PA-000002 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010216.0004.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by an existing agreement (CLST subissue 6 Agreement 1). DOE agreed to provide clarification of the screening argument in the FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002, as necessary upon completion of the agreement item.

Subissue #2 - Scenario Analysis SA-30

Tracking # SA-30

Comment 2.1.03.05.00 (Microbially mediated corrosion of waste container). Screened as included for waste package, and as excluded for drip shield on the basis of low consequence (CRWMS M&O, 2001). Quantitative data on microbially influenced corrosion of drip shield materials such as Ti grades 7 and 16 are not available from the literature. If microbially influenced corrosion of the drip shield occurs it would not have an effect on dose. Accelerated corrosion rates of drip shield have been evaluated and shown not to have an effect on dose (CRWMS M&O, 2000).

References CRWMS M&O. "Total System Performance for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN1. Las Vegas, Nevada: CRWMS M&O. 2000.
CRWMS M&O. "FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation." ANL-EBS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Microbial induced corrosion of Titanium Grade 7 has not been reported in the literature. Hence, the microbial induced corrosion of the drip shield was screened out. Accelerated corrosion of drip shield under the seismic event will be addressed and documented under Container Life and Source Term agreement KCL0208.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Technical Exchange on Features, Events, and Processes, May 15-17, 2001.

Tracking # SA-31

Comment There is no FEP addressing the response of the drip shield to static loads and seismic excitation. It is necessary to account for the degradation of the capability of the drip shield to avoid water infiltration due to the interaction of seismic excitation with dead loads (such as those caused by rock fall or naturally occurring backfill) on the drip shield, and it is recommended to add a new FEP.

FEP 1.2.03.02.00 (Seismic vibration causes container failure) assesses the effect of ground motion on the waste package and drip shield, without consideration of possible pre-existing static loads. The screening argument for FEP 2.1.06.06.00 (Effects and degradation of drip shield) in CRWMS M&O, 2001 states that

"... seismic activity will not induce SCC of the waste packages or drip shields, regardless of magnitude, since a sustained tensile stress is required for SCC and an earthquake is only temporary in nature (CRWMS M&O 2000, Section 5, Assumption 1)."

The above assumption does not account for the possibility of static loads affecting the drip shield and possibly, the waste package.

References

CRWMS M&O. "Stress Corrosion Cracking of the Drip Shield, the Waste Package Outer Barrier, and the Stainless Steel Structural Material." ANL-EBS-MD-000005 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

CRWMS M&O. "FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation." ANL-EBS-PA-000002 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response

Agreement Number TSPAI.2.04

Agreement Provide a clarification of the description of the primary FEP. See Comments 24, 31, and 33.

DOE will clarify the description of the primary FEPs, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03

Text in Attachment 2:
DOE agreed to clarify the description of the primary FEP in the FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002, to address the NRC comment.

Subissue #2 - Scenario Analysis SA-32

Tracking # SA-32

Comment 2.1.13.01.00 (Radiolysis) is excluded based on low consequence (CRWMS M&O, 2000, 2001).
[Waste Package]:Alpha, beta, gamma and neutron irradiation of air saturated water can cause changes in chemical conditions (Eh, pH, and concentration of reactive radicals) and positive shifts in corrosion potential due to the formation of hydrogen peroxide. DOE, on the bases of experimental work concluded that radiolysis will not lead to localized corrosion of Alloy 22. However, additional work by the DOE is necessary to complete the evaluation of the critical potentials related to localized corrosion of Alloy 22.
[Waste Form Miscellaneous]:Screening argument considers only radiolysis of water to produce hydrogen and oxidants. No consideration of the formation of nitric acid resulting from radiolysis in presence of air. Spent fuel is expected to have higher dissolution rates at lower pH, thus ignoring nitric acid may underestimate radionuclide release. Potential production of nitric acid from radiolysis of N2 in air should be considered. It is necessary to consider potential effect of acid environments on the corrosion of Alloy 22 and Ti.

References CRWMS M&O. "Miscellaneous Waste Form FEPs." ANL-WIS-MD-000009. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.
CRWMS M&O. "FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation." ANL-EBS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Container Life and Source Term agreement KCL0302 states in part, AY(DOE) will address specific NRC questions regarding radiolysis, incoming water, localized corrosion, corrosion products, transient effects, and a sensitivity study on differing dissolution rate of components." And Container Life and Source Term agreement KCL0303 states in part, "(DOE to) provide a more detailed calculation on the in package chemistry effects of radiolysis ..." DOE believes that the Analysis/Model Report, In-Package Chemistry for Waste Forms (BSC 2001b) provided information on the effect on in-package chemistry of nitric acid produced by radiolysis, consistent with the Container Life and Source Term agreements KCL0302 and KCL0303. The Miscellaneous Waste Form Features, Events and Processes Analysis/Model Report (CRWMS M&O 2001i) will be revised, to support any potential License Application, to reflect this new information.

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide additional information on critical potentials for localized corrosion in the DOE/NRC CLST Technical Exchange (9/12-13/2000).

DOE agreed to provide clarification of the screening argument in the FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002, to address the NRC comment.

Subissue #2 - Scenario Analysis SA-33

Tracking # SA-33

Comment FEP(s) related to the effect of trace metal cations on Alloy-22 and Ti corrosion and stress corrosion should be added to database, given results recently reported by Barkatt and Gorman (2000).

References A. Barkatt and J.A. Gorman, Tests to Explore Specific Aspects of the Corrosion Resistance of C-22, Nuclear Waste Technical Review Board Meeting, August 1, 2000, Carson City, NV, 2000.

DOE Response The project has reviewed the results reported in Barkatt and Gorman (2000) and has concluded that the testing conditions used were not relevant to Yucca Mountain Project.

However existing Container Life and Source Term agreements (KCL0101, KCL0110, and KCL0601) are intended to evaluate the effects of introduced materials on water chemistry and deleterious trace element concentrations on the corrosion behavior of titanium, similar to the electrochemically based studies on Alloy 22.

Consideration will be given to adding a new feature, event and process or augmenting an existing feature, event and process to account for the effects of trace elements on Alloy-22 and Titanium corrosion and stress corrosion.

DOE believes the existing Container Life and Source Term agreements identified above are sufficient to address the technical issue identified in the NRC comment without any new agreement items.

Agreement Number TSPAI.2.04

Agreement Provide a clarification of the description of the primary FEP. See Comments 24, 31, and 33.

DOE will clarify the description of the primary FEPs, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03

Text in Attachment 2:
DOE agreed to clarify the description of the primary FEP in the FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002, to address the NRC comment.

Tracking # SA-34

Comment 2.1.03.02.00 (Stress corrosion cracking of Waste Containers). Screened as included for waste package but as excluded for drip shield on the basis of low consequence (CRWMS M&O, 2001). The screening argument states that"...Source of stress for cracks is due to cold work stress and cracks caused by rockfall. However these cracks tend to be tight (i.e., small crack opening displacement) and fill with corrosion products and carbonate minerals. These corrosion products will limit water transport through the drip shield and thus not contribute significantly to overall radionuclide release rate from the underlying failed waste packages..." The screening argument for drip shield is weak. Simplified calculations by DOE indicate cracks will take considerable time to fill with corrosion products (CRWMS M&O, 2000). Cracks that develop in the DS may propagate and/or "open up" when subjected to subsequent loads caused by rockfall/drift collapse and/or seismic excitation allowing significant ground water infiltration through the drip shield.

References CRWMS M&O. "FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation." ANL-EBS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.
CRWMS M&O. "Stress corrosion cracking of the Drip Shield, the Waste Package Outer Barrier and the Stainless Steel Structural Material." ANL-EBS-MD-000005 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response It is agreed that simplified calculations by DOE indicate cracks will take considerable time to fill with corrosion products ([CRWMS M&O 2000ap), however, quantitative bounding analyses have been underway to determine whether calcite and other minerals can precipitate at a sufficiently high rate to plug cracks resulted from stress corrosion cracking. The calculation depends mainly on two parameters: the evaporation at the surface of the waste package or drip shield in particular in the vicinity of cracks and the precipitation rate of minerals (BSC 2001c) . The analyses consider calcite and amorphous silica as minerals that potentially precipitate within the stress corrosion cracks. The analyses consider two end-member scenarios for potential water flow characteristics in the cracks: film flow and water bridging across the crack opening (BSC 2001c, Section 5.3.3). The water bridging scenario employs highly conservative assumptions such as no corrosion of the crack wall, no mixing of the bridging water with the outside environment, no water transport along the crack wall, and no consideration of mineral precipitate in the presence of fine particulates of corrosion products along the crack wall.

The analysis results show that for the film flow scenario, cracks are

plugged by mineral precipitates within a decade (BSC 2001c, Tables 6-3 and 6-5). For the conservative scenario (i.e., water bridging scenario), plugging of stress corrosion cracks takes 600 to 1,000 years if the stress corrosion crack opening occurs prior to 20,000 years (BSC 2001c, Tables 6-4 and 6-6). Considering the conservatism employed in the water bridging scenario, the time to plugging the cracks would be sooner than the bounding estimates. In general the analysis results support the assumption for the stress corrosion crack plugging by precipitates in Total System Performance Assessment-Site Recommendation REV 00 (CRWMS M&O 2000aq).

The ability of the additional loading combinations to initiate and/or propagate preexisting cracks are being addressed in response to Container Life and Source Term agreement KCL0208. Evaluations of the ability of these loading combinations to initiate and/or propagate preexisting cracks will be documented in a future revision of the Design Analysis for Uncanistered Fuel Waste Packages (CRWMS M&O 2000n), and the Design Analysis for the Ex-Container Components (CRWMS M&O 2000l).

Reference: CRWMS M&O 2000ap. Stress Corrosion Cracking of the Drip Shield, the Waste Package Outer Barrier, and the Stainless Steel Structural Material. ANL-EBS-MD-000005 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001102.0340.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is covered by an existing DOE/NRC agreement (CLST Subissue 2 Agreement 8). DOE will update the FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002, screening argument upon completion of the agreement.

Subissue #2 - Scenario Analysis SA-35

Tracking # SA-35

Comment 2.1.03.08.00 (Juvenile and early failure of waste containers). Screened as included for manufacturing and welding defects in waste container degradation analysis, and as excluded for manufacturing defects in drip shield degradation analysis, early failure of waste package and drip shield from improper quality control during the emplacement (CRWMS M&O, 2001). The screening argument states that the "Major effect of pre-existing manufacturing defects is to provide sites for crack growth by stress corrosion cracking. Tensile stress is required to have stress corrosion cracking. Because all fabrication welds of DS are fully annealed prior to emplacement, drip shields are not subject to stress corrosion cracking earthquakes are insignificant to cause stress corrosion cracking (stresses are temporary in nature)." Manufacturing defects in the drip shield and early failures of the Waste package and drip shield from improper quality control during emplacement can be excluded based on negligible consequence to dose." The bases for this assessment is that slap down analysis of a 21-PWR waste package resulted in stresses in the waste package material that were less than 90 percent of the ultimate tensile strength. The impact energy associated with emplacement error is substantially less than that expected in a vertical tip over, emplacement errors are "not expected to result in any damage." The results of the Slap-down analysis are cited as the screening analyses of several features, events, and processes. The damage reported in the Slap down analyses is concerning. While the impact energy of emplacement errors may be substantially less than those experienced in the slap-down analyses, a proper assessment of the extent of Waste package damage as a result of emplacement errors should be performed.

References CRWMS M&O. "FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation." ANL-EBS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response The potential early failure mechanisms discussed in CRWMS M&O 2000d indicates that improper heat treatment of waste packages should be included in the waste package degradation and Total System Performance Assessment analysis. Manufacturing defects in the waste package outer barrier closure welds are also considered as in past analyses.

Exclusion of the drip shield failures due to manufacturing flaws is not based on slap down analysis but o the fact that they will be annealed to eliminated fabrication stresses. The slap down analyses pertain to waste package failures and the early failure Analysis/Model Report addresses the probabilities and effects of handling damages. Reference: CRWMS M&O 2000d. Analysis of

Mechanisms for Early Waste Package Failure. ANL-EBS-MD-000023 REV 02. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001011.0196.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
Manufacturing defects associated with the drip shield will be addressed during the resolution of an existing agreement item for the waste package (CLST Subissue 2, Agreement 7). The FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002, will be updated to reflect the results of this agreement.

Mechanical integrity of the drip shield will be addressed during the resolution of an existing agreement item for the waste package (CLST Subissue 2, Agreement 6). The FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002, will be updated to reflect the results of this agreement.

Rockfall effects on the drip shield will be addressed during the resolution of an existing agreement item for the waste package (CLST Subissue 2, Agreement 8). The FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002, will be updated to reflect the results of this agreement.

The FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002, will be revised to address damage from improper quality control and emplacement of the drip shield. The criteria for damage to waste package during emplacement will be addressed by administrative procedures for emplacement operations that will be developed prior to operation of the facility.

Subissue #2 - Scenario Analysis SA-36

Tracking # SA-36

Comment 2.1.09.03.00 (Volume increase of corrosion products) is screened as excluded on the basis of low consequence (CRWMS M&O, 2001). The presence of waste package corrosion products with higher molar volume than the uncorroded material that may change the stress state in the material being corroded is excluded in the case of waste package based on low consequence. However, it may have an effect on corrosion processes such as SCC of outer container after its initial breaching that may affect radionuclide release [see 2.1.03.07.00 (Mechanical Impact on the Waste Container and Drip Shield)]. The possibility of additional sources of stress arising from the formation of corrosion products should be evaluated in regard to stress corrosion cracking. See comment for 2.1.11.05.00 (Differing thermal expansion of repository components).

References CRWMS M&O. "FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation." ANL-EBS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Analyses cited in Degradation of Stainless Steel Structural Material (CRWMS M&O 2000j, Section 6.1), indicate that even under very conservative assumptions, the growth of this corrosion product will not exceed 93 ?m after 10,000 years. This oxide layer is not thick enough to produce enough pressure to cause mechanical damage to the Alloy 22 container.

Reference: CRWMS M&O 2000j. Degradation of Stainless Steel Structural Material. ANL-EBS-MD-000007 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000329.1188.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide the technical basis for the screening argument in the FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002, to

address the NRC comment.

Tracking # SA-37

Comment 2.1.07.05.00 (Creeping of metallic materials in the engineered barrier subsystem) has been excluded from consideration in the total system performance assessment code (CRWMS M&O, 2001a, 2001b). Although DOE correctly points out in the screening argument (CRWMS M&O, 2001b) that ". . .the deformation of many titanium alloys loaded to yield point does not increase with time," (American Society for Metals International, 1990), it still does not specifically address the potential for creeping of titanium grades 7 and 24. For example, some titanium alloys have been shown to creep at room temperatures (Ankem, S., et al., 1994). Creeping of the titanium drip shield subjected to dead loads caused by fallen rock blocks and/or drift collapse could significantly reduce the clearance between the drip shield and waste package over time. As a result, the drip shield may cause substantial damage to the waste package during its dynamic response to subsequent seismic loads. In addition, creeping could potentially cause separation of the individual drip shield units.

References
American Society for Metals International. 1990. Properties and Selection: Nonferrous Alloys and Special-Purpose Materials, Specific Metals and Alloys. Volume 2 of Metals Handbook. 10th Edition. Metals Park, Ohio: American Society for MetalsAnkem, S., C.A. Greene, and S. Singh. "Time Dependent Twinning During Ambient Temperature Creep of a Ti-Mn Alloy." Scripta Metallurgica et Materialia. Vol. 30. No. 6. pp. 803-808. 1994.
CRWMS M&O. "EBS FEPs/Degradation Modes Abstraction." ANL-WIS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001aP.
CRWMS M&O. "FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation." ANL-EBS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001b.

DOE Response Treatment of creep of the drip shield is appropriate for the static loads and temperatures expected. Prior calculations assuming the presence of backfill and rockfall on top of the backfill showed the static loads on the drip shield to be low (<25% of yield strength). However, this calculation will be revised to eliminate the backfill effects. In addition, the potential for creep of Titanium drip shield under the static load will be explicitly addressed in the future revision of the Design Analysis for the Ex-Container Components, (CRWMS M&O 2000l) as part of the Container Life and Source Term agreement KCL0208.

Additional loading combinations are being addressed in response to Container Life and Source Term agreement KCL0208. Evaluations of these loading combinations will be documented in a future revision of the Design Analysis for UCF Waste Packages

(CRWMS M&O 2000n), and the Design Analysis for the Ex-Container Components, (CRWMS M&O 2000l)

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
Treatment of creep of the drip shield will be addressed as part of an existing agreement related to drip shield rockfall analyses (CLST Subissue 2 Agreement 8). DOE agreed to provide the technical basis for the screening argument in the FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002.

Tracking # SA-38

Comment 2.1.11.05.00 (Differing thermal expansion of repository components) has been excluded from consideration in the total system performance assessment code (CRWMS M&O, 2001a, 2001c). The technical basis for excluding differing thermal expansion effects on repository performance is not comprehensive nor adequate. For example, according to the screening arguments (CRWMS M&O, 2001b),

"... the difference in temperature between the inside of the waste package inner barrier (316NG) and the outside of the waste package outer barrier (Alloy 22) never exceeds 2°C. As an illustrative example, using the coefficients of thermal expansion for the two materials discussed above [i.e., Alloy 22 and 316NG] and a bounding 5°C (or 5 K) temperature difference between them, the calculated strain is 2.15x10-5 m/m. This strain is so small that thermal expansion of waste package barriers will result in a negligible effect on expected mean dose rate.

A ~1 mm gap will prevent the resultant stress due to the differing thermal expansion coefficients of the waste package materials from reaching a critical level that could lead to stresses in the waste package barriers. The Waste Package Operation Fabrication Process Report (CRWMS M&O, 2000b, Section 8.1.8) requires a loose fit between the outer barrier (Alloy 22) and the inner shell (316NG stainless steel) to accommodate the differing thermal expansion coefficients, and so 2.1.11.05.00 (Differing thermal expansion of repository components) can be excluded for the waste packages based on low consequence to the expected annual dose."

The quoted rationale is not technically correct and does not address the limited clearance between the inner and outer barriers of the waste package in the axial direction, which may be as small as 2-mm according to design drawings (CRWMS M&O, 2000a). In addition, the differential thermal expansion between various invert components and the drift wall (which they are attached to) has not been addressed.

2.1.11.05.00 (Differing thermal expansion of repository components) is excluded on the basis of low consequence (CRWMS M&O. 2001a, 2001c). Peak temperature of waste package 278°C with backfill and 176°C without backfill with 0.5 meter spacing and 50-yr ventilation. Screening argument is that the temperature differential between inner type 316NG barrier and outer Alloy 22 barrier is 5°C and the corresponding strain of 2.15x10-5 m/m. This calculation is performed using the difference

between thermal expansion coefficients for 316NG and Alloy 22 using the maximum expected temperature difference between the waste package barriers. There will be at least a 1 mm gap between the barriers so no thermal stresses are predicted.

The calculation should use a temperature of the waste package rather than the difference between waste package barriers. The clearance between the inner type 316NG and the outer Alloy 22 is specified in the waste package design and fabrication process report to be 0 to 4 mm (CRWMS M&O. 2000b). It is implicit that this clearance is specified at ambient temperature (i.e., 25°C) because (i) no temperature is specified and (ii) the outer Alloy 22 waste package outer barrier will be heated to 700 F (371°C) for inner 316NG cylinder installation. Using a temperature of 186°C the calculated strain is 7.99x10-4 m/m. For waste package with clearance gaps of 1 mm or less at 25°C, thermal stresses will occur as a result of the difference in thermal expansion.

References

CRWMS M&O. "Design Analysis for the Ex-Container Components." ANL-XCS-ME-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000a.

CRWMS M&O. "Waste Package Operations Fabrication Process Report." TDR-EBS-ND-000003. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2000b.

CRWMS M&O. "EBS FEPs/Degradation Modes Abstraction." ANL-WIS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001a.

CRWMS M&O. "Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEP)". ANL-MGR-MD-000011. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001b.

CRWMS M&O. "FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation." ANL-EBS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001c.

DOE Response

Tensile stresses due to differential thermal expansion between waste package barriers are eliminated by the introduction of a gap between the barriers. This is done to eliminate tensile stresses due to differential thermal expansion from contributing to stress corrosion cracking of the waste package barriers. With this source of stress eliminated, it does not contribute to calculated dose rates due to waste package failure.

Thermal expansion calculations already performed and in the process of documentation have indicated a need to increase the gap between the outer barrier lid and the inner barrier lid from the current 3-mm to 6-mm in the next revision to the waste package design concepts. These modifications are underway and will be

included in next revisions to the Design Analysis for the UCF Waste Packages (CRWMS M&O 2000n), Design Analysis for the Defense High Level Waste Disposal Containers (CRWMS M&O 2000k), and Design Analysis for the Naval SNF Waste Package (CRWMS M&O 2000m).

A more comprehensive listing of interfaces where differing thermal expansion may be of relevance in the Engineered Barrier System will be developed. For each such location, the amount of differential expansion will be estimated relative to the potential impact of such expansion on Engineered Barrier System component performance. This will provide a quantified basis for the Exclude B Low Consequence screening.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide the technical basis for the screening argument in the FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002, screening argument to address the NRC comment.

Tracking # SA-39

Comment 2.1.06.06.00 (Effects and Degradation of Drip Shield). Excluded based on low consequence (CRWMS M&O, 2001b). The drip shield is an important component of the engineered barrier subsystem and its function and degradation is explicitly considered in the total system performance assessment. The degradation of the drip shield due to corrosion processes is considered directly in the model abstraction for waste package degradation, whereas remaining aspects of drip shield behavior are considered as part of the engineered barrier subsystem analysis. For the secondary feature-event-process 2.1.06.06.01 (Oxygen embrittlement of Ti drip shield), DOE argues that it is explicitly considered in the screening argument, but no discussion is presented. It is noted that this issue is most relevant to mechanical failure of the drip shield, which is discussed under 2.1.07.01.00 (rockfall) and 2.1.07.02.00 (mechanical degradation or drift collapse).Although physical and chemical degradation processes have been included into the Total System Performance Assessment, their effects on the ability of the drip shield to withstand dead loads (caused by drift collapse and/or fallen rock blocks), rock block impacts, and seismic excitation is not accounted for in the screening arguments (CRWMS M&O, 2001a, 2001b). In (CRWMS M&O, 2000) it is stated that the impact of rockfall on the degraded drip shield has been screened as excluded until more detailed structural response calculations for the drip shield under various rock loads are available. No references are provided in this document as to when and where these analyses will be available.

References
CRWMS M&O. "AMR EBS Radionuclide Transport Abstraction." ANL-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.
CRWMS M&O. "EBS FEPs/Degradation Modes Abstraction." ANL-WIS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001a.
CRWMS M&O. "FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation." ANL-EBS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001b.

DOE Response In the current revision of the FEPs Screening of Process and Issues in Drip Shield and Waste Package Degradation (CRWMS M&O 2001h), oxygen embrittlement of titanium results from diffusion of interstitial oxygen into the metal at higher temperatures (>340?C) (ASM International 1987, p. 681). The time to failure depends on the alloy composition, material thickness, and stress state. For the thermal hydrologic time history files used in the Total System Performance Assessment analyses, the waste package surface temperatures never exceed 186°C (CRWMS M&O 2000b, Section 6.3.1), which is less than the threshold temperature of

340°C. Therefore, oxygen embrittlement of the titanium drip shields is excluded on the basis of low consequence to the expected annual dose.

Reference

ASM International 1987. Corrosion. Volume 13 of Metals Handbook. 9th Edition. Metals Park, Ohio: ASM International. TIC: 209807.

CRWMS M&O 2000b. Abstraction of NFE Drift Thermodynamic Environment and Percolation Flux. ANL-EBS-HS-000003 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001206.0143.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
The ability of the additional loading combinations to initiate and/or propagate preexisting cracks are being addressed in existing agreements (CLST Subissue 2 Agreements 8 and 9). DOE agreed to provide the technical basis for the screening argument in the FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002.

Subissue #2 - Scenario Analysis SA-40

Tracking # SA-40

Comment FEP 2.1.02.21.00 (Stress corrosion cracking [SCC] of cladding). Included but only the SCC caused by fission products that operates from the inside out of the cladding (FEP 2.1.02.21.01). The occurrence of SCC caused by the action of chemical or salts present inside the WP and acting from the outside in, even that is considered in another secondary FEP (FEP 2.1.02.21.02), it is not discussed in the screening arguments. Therefore, no justification is offered in the database for the exclusion of SCC occurring from the outside in. In the Table 2 of the Clad Degradation - FEPs Screening Arguments (CRWMS M&O, 2000) this secondary FEP is listed as included.

References CRWMS M&O. "Clad Degradation - FEPs Screening Arguments." ANL-WIS-MD-000008 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response At the May 15-17, 2001 Technical Exchange, NRC stated that the FEP is appropriately addressed under CLST Agreement 3.7.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Technical Exchange on Features, Events, and Processes, May 15-17, 2001.

Subissue #2 - Scenario Analysis SA-41

Tracking # SA-41

Comment 2.1.02.20.00 (Pressurization from helium production causes cladding failure). Included as a process of internal gas pressure buildup that increases the cladding stress contributing to delayed hydride cracking and strain (creep?) failures (CRWMS M&O, 2000). The wording could be more precise in the text where it is clarified that helium production from alpha decay is the main source of pressure buildup.

References CRWMS M&O. "Clad Degradation - FEPs Screening Arguments." ANL-WIS-MD-000008 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response At 100,000 years, the pressure, stresses, and stress intensities are a factor of 2.38 higher than at 100 years (values reported in the Clad Degradation B Summary and Abstraction Analysis/Model Report, CRWMS M&O 2001a). These values are still less than the threshold stress intensity values for stress corrosion cracking from Chlorine, Iodine, and Bromine at room temperature. Hence, the conclusions in the original Analysis/Model Report remain unchanged; stress corrosion cracking is not expected even with alpha decay, the main source of Helium production and pressure buildup, for 100,000 years.

The role of helium buildup in cladding degradation will be included in the next revision of the Clad Degradation Summary and Abstraction Analysis/Model Report (CRWMS M&O 2001a).

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide clarification of the screening argument in the Clad Degradation - FEPs Screening Arguments, ANL-WIS-MD-000008 to address the NRC comment.

Tracking # SA-42

Comment 2.1.08.07.00 (Pathways for unsaturated flow and transport in the waste and engineered barrier system) evaluates unsaturated flow and radionuclide transport that may occur along preferential pathways in the waste and engineered barrier subsystem (CRWMS M&O, 2000). The DOE indicates that preferential pathways are already "included" via "a series of linked one dimensional flowpaths and mixing cells through the engineered barrier subsystem, drip shield, waste package and into the invert (CRWMS M&O, 2000)." Staff are concerned that preferred pathways in the engineered barrier subsystem are not being evaluated at the appropriate scale. Water has been observed to drip preferentially along grouted rock bolts in the enhanced characterization of repository block, for example, demonstrating that the introduced materials themselves can influence the location of preferred flow pathways. Interactions with engineered materials, such as cementitious and metallic components, can have a significant effect on evolved water and gas compositions. Because the description of 2.1.08.07.00 states that "Physical and chemical properties of the engineered barrier subsystem and waste form, in both intact and degraded states, should be considered in evaluating [preferential] pathways", staff expect the screening arguments to be based on an evaluation of these topics (NRC, 2000).

References
CRWMS M&O. "Miscellaneous Waste Form FEPs." ANL-WIS-MD-000009. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.
NRC. "Issue Resolution Status Report. Key Technical Issue: Evolution of the Near Field Environment" Revision 3. Washington, DC: Nuclear Regulatory Commission. 2000.

DOE Response

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:

Subissue #2 - Scenario Analysis SA-42

This issue is addressed by an existing DOE/NRC agreement (ENFE Subissue 2 Agreement 6, 10, and 14). The Engineered Barrier System Features, Events, and Processes. ANL-WIS-PA-000002, will be updated upon completion of these agreement items.

Subissue #2 - Scenario Analysis SA-43

Tracking # SA-43

Comment 2.1.02.27.00 (Localized corrosion perforation from fluoride). Included because fluoride is present in YM waters and zirconium corrodes in environments containing fluoride (CRWMS M&O, 2000). It is argued that localized corrosion caused by fluoride is included in the model abstraction for cladding degradation to account for modeling uncertainty of the in-package chemistry since conditions for corrosion induced by fluoride were considered more likely to occur relative to other processes examined.

References CRWMS M&O. "Clad Degradation - FEPs Screening Arguments." ANL-WIS-MD-000008 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by an existing DOE/NRC agreement (CLST Subissue 3 Agreement 7). DOE agreed to provide clarification of the screening argument in the Clad Degradation - FEPs Screening Arguments, ANL-WIS-MD-000008 to address the NRC comment.

Tracking # SA-44

Comment 2.1.02.16.00 (Localized corrosion [pitting] of cladding). Included because localized corrosion by pits could produce penetration of cladding (CRWMS M&O, 2000). Even though localized corrosion is included in the commercial spent nuclear fuel cladding degradation model abstraction, the effect of chloride ions as pitting promoters is not considered in the analysis of localized corrosion done by the DOE. It is stated that pitting corrosion is promoted by concentrated chloride and fluoride solutions at very low pHs and very high oxidation potentials, but these conditions are not predicted to occur in the bulk solution inside waste packages. However, it accepted that certain processes such as microbial induced corrosion, galvanic coupling, radiolysis in a humid environment, and evaporation may generate locally concentrated solutions of aggressive species or pH decreases such that a model for localized corrosion is necessary.

References CRWMS M&O. "Clad Degradation - FEPs Screening Arguments." ANL-WIS-MD-000008 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The localized corrosion model will be modified to include pitting by chlorides. This model will be used in future cladding abstractions for Total System Performance Assessment-License Application. Probability distributions for pH will also be included in the analysis. This comment is addressed in agreements KCL0306 and KCL0307. Container Life and Source Term agreement KCL0306 states in part, A(DOE) to provide additional technical basis for the (cladding) failure rate and how the rate is affected by localized corrosion." And Container Life and Source Term agreement KCL0307 states in part, "(DOE) to provide data to address chloride induced localized corrosion and stress corrosion cracking under the environment predicted by in-package chemistry modeling." The Analysis/Model Reports: Clad Degradation B Summary and Abstraction, ANL-WIS-MD-000007 (CRWMS M&O 2001a) and Clad Degradation B FEPs Screening Arguments, ANL-WIS-MD-000008 (CRWMS M&O 2000h) will also be revised, incorporating the results from agreement KCL0307 to support any potential License Application, to reflect this new information.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by an existing DOE/NRC agreement (CLST Subissue 3 Agreement 7). DOE agreed to provide clarification of the screening argument in the Clad Degradation - FEPs Screening Arguments, ANL-WIS-MD-000008 to address the NRC comment.

Subissue #2 - Scenario Analysis SA-45

Tracking # SA-45

Comment FEP 2.1.02.19.00 (Creep rupture of cladding). Included as perforation mechanism for the CSNF cladding degradation component (CRWMS M&O, 2000). Distribution of cladding temperatures and hoop stresses used to evaluate the propensity to hydride reorientation and embrittlement (see FEP 2.1.02.22.00) should be consistent with those for creep and SCC calculations.

References CRWMS M&O. "Clad Degradation - FEPs Screening Arguments." ANL-WIS-MD-000008 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response

Agreement Number

Agreement At the May 15-17, 2001 Technical Exchange, the NRC stated that it is currently reviewing information pertaining to this FEP and that, if necessary, NRC would formally request additional information from DOE.

Subissue #2 - Scenario Analysis SA-46

Tracking #	SA-46
Comment	FEP 2.1.02.24.00 (Mechanical failure [of cladding]). Included as a failure process resulting from external stresses such as ground motion during earthquakes assuming a frequency of 1.1x10-6 events/year that cause failure of all cladding that is available for unzipping (CRWMS M&O, 2000). On the contrary, cladding failure arising from rock fall is not included in the model abstraction assuming integrity of the WP for 10,000 years (See FEP 2.1.07.01.00).
References	CRWMS M&O. "Clad Degradation - FEPs Screening Arguments." ANL-WIS-MD-000008 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.
DOE Response	
Agreement Number	
Agreement	At the May 15-17, 2001 Technical Exchange, the NRC stated that the FEP was discussed in an NRC letter dated August 3, 2000, related to Structural Deformation and Seismicity KTI and did not need to be addressed at this meeting

Tracking # SA-47

Comment 2.1.02.17.00 (Localized corrosion [crevice corrosion] of cladding). Excluded based on low probability of occurrence (CRWMS M&O, 2000a). Experimental evidence is cited to indicate that crevice corrosion has not been observed in zirconium alloys exposed to chloride solutions, including NRC and CNWRA results. There is a need to develop a better understanding of localized corrosion of zirconium alloys before confirming this conclusion because the data are limited. In the report on Clad Degradation- Local Corrosion of Zirconium and Its Alloys Under Repository Conditions (CRWMS M&O, 2000b) it is noted that crevice corrosion may occur in the presence of fluoride ions.

References CRWMS M&O. "Clad Degradation - FEPs Screening Arguments." ANL-WIS-MD-000008 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Clad Degradation - Local Corrosion of Zirconium and its Alloys under Repository ConditionsJuly 17, 2001." ANL-EBS-BMD-000012. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response DOE will continue to review new crevice corrosion literature as part of the execution of Container Life and Source Term agreement KCL0307. Agreement KCL0307 states in part, "(DOE) to provide data to address chloride induced localized corrosion and stress corrosion cracking under the environment predicted by in-package chemistry modeling." The Analysis/Model Reports: Clad Degradation B Summary and Abstraction, ANL-WIS-MD-000007 and Clad Degradation B FEPs Screening Arguments, ANL-WIS-MD-000008 will be revised, incorporating information from agreement KCL0307, including a summary of any significant new crevice corrosion literature, in time to support any potential License Application

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide clarification of the screening argument in the Clad Degradation – FEPs Screening Arguments, ANL-WIS-MD-000008 to address the NRC comment using data relevant to the

proposed repository.

Tracking # SA-48

Comment 2.1.01.04.00 (Spatial Heterogeneity of Emplaced Waste) is screened as excluded on the basis of low consequence (CRWMS M&O, 2000). Waste placed in Yucca Mountain will have physical, chemical, and radiological properties that will vary. The effect of spatial heterogeneity of the waste on repository-scale response is excluded based on low consequence but the heterogeneity within a waste package is implicitly included in the evaluation of in-package temperature used to determine perforation of the commercial spent nuclear fuel cladding. However, spatial variability that may affect degradation of engineering barrier, such as conditions leading to crevice corrosion vs passive corrosion of outer container, is not considered in this feature-event-process.

References CRWMS M&O. "Miscellaneous Waste Form FEPs." ANL-WIS-MD-000009. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Spatial heterogeneity of the waste is addresses below. Spatial variability that may affect degradation of the waste package will be addressed as part of the resolution of the Container Life and Source Term agreement KCL0101. The scope of the agreement includes the evaluation of the range of chemical environments on the waste package.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
Spatial variability that may affect degradation of the waste package will be addressed as part of the resolution of an existing agreement (CLST Subissue 1 Agreement 1). The scope of the agreement includes the evaluation of the range of chemical environments on the waste package.

Subissue #2 - Scenario Analysis SA-49

Tracking # SA-49

Comment 2.1.02.15.00 (Acid corrosion of cladding from radiolysis). Included as part of localized corrosion model on the basis that the formation of HNO3 and H2O2 ions(sic) by radiolysis can enhance corrosion of cladding (CRWMS M&O, 2000). It is stated, however, that zirconium has excellent corrosion resistance to HNO3 and concentrated H2O2. The arguments are poorly worded stating that radiolysis is not expected to occur until waste package failure and then the gamma dose will be very low to produce sufficient HNO3 and H2O2 to promote general corrosion but localized corrosion could be possible. The argument of local acidic pH causing localized corrosion of cladding is in contradiction with experimental evidence showing that zirconium alloys are resistant to corrosion in reducing and oxidizing acids. In addition, it is in contradiction with arguments to screen out pitting corrosion by chloride anions {see 2.1.02.16.00 [Localized corrosion (pitting) of cladding]}. In the Basis for Screening undue consideration is given to alkaline conditions arising from concrete liner whereas the possibility of very acidic conditions (pH< 2) are not discussed.

References CRWMS M&O. "Clad Degradation - FEPs Screening Arguments." ANL-WIS-MD-000008 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Radiolysis by itself is not expected to damage the cladding. Radiolysis as a possible cause of pH reduction and coupled with FeCl3 pitting is a possible mechanism for cladding failure. A new cladding localized corrosion model addressing radiolysis and low pH (pH < 2) will be developed in time to support any potential License Application. This comment is addressed in Container Life and Source Term agreement KCL0307. Agreement KCL0307 states in part, A(DOE) to provide data to address chloride induced localized corrosion and stress corrosion cracking under the environment predicted by in-package chemistry modeling.@ The Analysis/Model Reports: Clad Degradation B Summary and Abstraction, ANL-WIS-MD-000007 (CRWMS M&O 2001a) and Clad Degradation B FEPs Screening Arguments, ANL-WIS-MD-000008 (CRWMS M&O 2000h) will be revised, incorporating information from agreement KCL0307, in time to support any potential License Application.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by an existing DOE/NRC agreement (CLST Subissue 3 Agreement 7). DOE agreed to provide clarification of the screening argument in the Clad Degradation - FEPs Screening Arguments, ANL-WIS-MD-000008 to address the NRC comment.

Subissue #2 - Scenario Analysis SA-50

Tracking # SA-50

Comment 2.1.02.13.00 (General corrosion of cladding). Excluded based on low probability of occurrence (CRWMS M&O, 2000). Although general corrosion of cladding could expose large areas of irradiated fuel matrix and produce hydrides it is argued that it is a very slow process. The arguments are based on extrapolation to low temperatures at test data obtained at temperatures above 250°C and in measurements of oxide thickness from specific fuel rods after reactor operation and exposure to water in reactor pool storage.

References CRWMS M&O. "Clad Degradation - FEPs Screening Arguments." ANL-WIS-MD-000008 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The distributions of fuel characteristics developed in the Analysis/Model Report: Initial Cladding Condition (CRWMS M&O 2000ah) addresses fuel burnup to 75 MWd/kgU and oxide thickness to 120 μm, 20 μm above the NRC allowable limit of 100 μm. The distribution developed has 10.1% of the rods exceeding the NRC limit and 2.55% at 120 μm. These projections adequately address the general corrosion of the higher burnup fuels. In all calculations involving stress, the oxide thickness is subtracted off of the wall thickness (no structural credit for oxides). The Clad Degradation Features, Events and Processes Analysis/Model Report (CRWMS M&O 2000h) will be revised to reflect this information.

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide clarification of the screening argument in the Clad Degradation Features, Events and Processes Analysis/Model Report, ANL-WIS-MD-000008, to address the NRC comment.

Tracking # SA-51

Comment 2.1.02.14.00 (Microbially induced corrosion of cladding). Included as part of localized corrosion model on the basis that microbial activity may induce local pH decreases and the local acidic environment may produce multiple penetrations of the cladding (CRWMS M&O, 2000). It is stated, however, that microbially induced corrosion resulting from sulfide produced by sulfate reducing bacteria and organic acid producing bacteria is not expected to occur due to resistance of zirconium to these species. The arguments are poorly worded stating that microbially induced corrosion is not expected to occur (not probable or credible) because microbial activity is screened out at the scale of the repository model as a significant bulk process.The argument of local acidic pH causing localized corrosion of cladding is in contradiction with experimental evidence showing that zirconium alloys are resistant to corrosion in reducing and oxidizing acids. In addition, it is in contradiction with arguments to screen out pitting corrosion by chloride anions {see 2.1.02.16.00 [Localized corrosion (pitting) of cladding]}. Screening arguments for inclusion or exclusion should be consistent with screening decisions for related entries [see 2.1.02.15.00 (Acid corrosion of cladding from radiolysis). A third group of bacteria iron oxidizers should be considered in the analysis also (NRC, 2001).

References CRWMS M&O. "Clad Degradation - FEPs Screening Arguments." ANL-WIS-MD-000008 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.
NRC. "Issue Resolution Status Report. Key Technical Issue: Container Life and Source Term." Revision 3. Washington, DC: NRC. 2001.

DOE Response The impact of microbial induced corrosion on the cladding environment and corrosion will be re-evaluated and documented during the execution of the Container Life and Source Term agreement KCL0307. Agreement KCL0307 states in part, "(DOE) to provide data to address chloride induced localized corrosion and stress corrosion cracking under the environment predicted by in-package chemistry modeling." The Analysis/Model Reports: Clad Degradation B Summary and Abstraction, ANL-WIS-MD-000007 (CRWMS M&O 2001a) and Clad Degradation B FEPs Screening Arguments, ANL-WIS-MD-000008 (CRWMS M&O 2000h) will be revised, incorporating information from agreement KCL0307, in time to support any potential License Application.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44,

48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by an existing DOE/NRC agreement (CLST Subissue 3 Agreement 7). DOE agreed to provide clarification of the screening argument in the Clad Degradation - FEPs Screening Arguments, ANL-WIS-MD-000008 to address the NRC comment.

The new cladding local corrosion model will reference the In-Drift Microbial Communities AMR, ANL-EBS-MD-000038, which includes discussion of iron oxidizing bacteria. The Clad Degradation - FEPs Screening Arguments, ANL-WIS-MD-000008 AMR will be revised to be consistent with the updated Summary-Abstraction AMR.

Tracking # SA-53

Comment 2.1.02.22.00 (Hydride embrittlement of cladding). Excluded based on low probability of occurrence (CRWMS M&O, 2000). DOE screening argument states that the in-package environment and cladding stresses are not conductive to hydride cracking. The NRC staff believes that reorientation of pre-existing hydride and embrittlement depend on temperature in addition to the required stresses. Clarification is needed on the cladding temperature and stress distributions used in the analysis. Several secondary features, events, and processes related to various processes leading to hydrogen entry into the cladding are listed below:

2.1.02.22.01 (Hydride embrittlement from zirconium corrosion [of cladding]). Excluded due to low probability of occurrence because the hydrogen pickup as a result of cladding corrosion is very low due to the low corrosion rate and the relatively small pickup fraction. The experimental hydrogen pickup fraction is given and it is argued that the corrosion rate is very low. The conclusion attained by the DOE regarding failure of cladding as a result of hydrogen pickup due to general corrosion is acceptable. However, the screening arguments can be better justified using quantitative arguments for the corrosion rate under disposal conditions.

2.1.02.22.02 (Hydride embrittlement from waste package corrosion and hydrogen absorption [of cladding]). Excluded due to low probability of occurrence because the hydrogen generated by corrosion of waste package and waste package internals and present as a molecule in gas or dissolved in water is not directly absorbed by the cladding. It is argued on the basis of experimental data that hydrogen absorption occurred through the reaction with water and not from the dissolved molecular hydrogen. The conclusion attained by the DOE regarding failure of cladding as a result of absorption of hydrogen gas generated by corrosion of waste package materials is acceptable. However, the screening arguments can be better organized.

2.1.02.22.03 (Hydride embrittlement from galvanic corrosion of waste package contacting cladding). Excluded due to low probability of occurrence because corrosion of waste package internals will not result in hydriding of cladding. It is argued using some experimental data as basis that galvanic coupling to carbon steel will not be conducive to hydrogen charging because corrosion products will interrupt the electrical contact. It is claimed also that the Ni content both in Zircaloy 2- and -4 is not sufficient to induce the necessary hydrogen charging. The conclusion attained by the DOE regarding failure of cladding as a result of

hydrogen entry due to galvanic coupling with internal components of the waste package is in general acceptable. However, the screening arguments could be better supported by more relevant experimental data.

2.1.02.22.04 (Delayed hydride cracking [of cladding]) Excluded due to low probability of occurrence. The analysis is based on the use of calculated values for the distribution of the stress intensity factor which are compared with the threshold stress intensity for irradiated Zircaloy-2. The conclusion attained by the DOE regarding failure of cladding as a result of DHC is acceptable. However, the DOE analysis of DHC is based on material properties of cladding containing mostly circumferential hydrides. DOE needs to provide cladding temperatures and stress distributions and demonstrate that they are insufficient to cause hydride reorientation.

2.1.02.22.05 (Hydride reorientation [of cladding]). Excluded due to low probability of occurrence because tested fuel rods did not exhibit hydride reorientation at stresses higher than those expected at the repository temperatures. It is argued, in addition, that any hydride reorientation stresses will be insufficient for hydride embrittlement and clad failure. Therefore hydride reorientation has not been included in the model abstraction for cladding degradation. DOE agreed to provide updated documentation on the distribution of cladding temperatures and hoop stresses, critical parameters needed to evaluate the propensity to hydride reorientation and embrittlement. See the primary 2.1.02.22.00 (Hydride Embrittlement of Cladding).

2.1.02.22.06 (Hydride axial migration [of cladding]). Excluded based on low probability since it is unlikely that sufficient hydrogen can be moved to the cooler ends of the fuel rods because of a lack of large temperature gradients in the waste packages. Based on studies for storage up to 90 years, it is concluded that the temperature gradients are not sufficient to induce redistribution of hydrides. The conclusion attained by the DOE regarding redistribution of hydrides caused by temperature gradients is acceptable. The screening arguments, however, should include the combined effects of stress and temperature.

2.1.02.22.07 (Hydride embrittlement from fuel reaction [causes failure if cladding]). Excluded based on low probability of occurrence because hydride embrittlement from fuel reaction is only observed in boiling water reactors and a high temperature steam environment is required for failure propagation, conditions which are unlikely even after waste package failure. The

conclusion is acceptable because it is not a credible failure mechanism. However, the screening arguments are, to say the least, confusing.

References CRWMS M&O. "Clad Degradation - FEPs Screening Arguments." ANL-WIS-MD-000008 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response This response is applicable to Features, Events and Processes 2.1.02.22.00 through 2.1.02.22.07.

The next revision to the Clad Degradation Features, Events and Processes Analysis/Model Report (ANL-WIS-MD-000008 will update the discussion of each component of hydride embrittlement in the 8 Features, Events and Processes (2.1.02.22.00 through 2.1.02.22.07) with emphasis on providing better organized, more quantitative discussion and the combined effects of both stress and temperature. .2.1.02.22.07 will be changed from exclude to include based on recent experimental evidence.

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide clarification of the screening argument in the Clad Degradation - FEPs Screening Arguments, ANL-WIS-MD-000008 to address the NRC comment.

Subissue #2 - Scenario Analysis SA-54

Tracking # SA-54

Comment 2.1.09.02.00 (Interaction with corrosion products) was excluded in the engineered barrier subsystem (except for colloid-related effects) on the basis of low consequence (CRWMS M&O, 2001). As noted in the NRC and U.S. Department of Energy technical exchange on Evolution of the Near-Field Environment, changes in seepage water chemistry resulting from interactions with engineered materials and their corrosion products were not adequately addressed in (CRWMS M&O, 2000). Water has been observed to drip preferentially along grouted rock bolts in the enhanced characterization of repository block, for example, demonstrating that the introduced materials themselves can influence the location of preferred flow pathways. Seepage waters that have interacted with engineered materials and their corrosion products, can have a significant effect on evolved water and gas compositions.

References CRWMS M&O. "EBS Physical and Chemical Environmental Model AMR." ANL-EBS-MD-000033. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2000.
CRWMS M&O. "EBS FEPs/Degradation Modes Abstraction." ANL-WIS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response An estimate of potential heterogeneity in seepage water chemistry due to localized interactions with Engineered Barrier System components and their corrosion products in addition to the potential for such seepage interacting with Engineered Barrier System components and accelerating Engineered Barrier System degradation processes will be addressed as part of agreement KEN0206. An evaluation of the impact of the range of local chemistry (e.g., dripping of equilibrated evaporated cement leachate and corrosion products) conditions at the drip shield and waste package considering the chemical divide phenomena that may propagate small uncertainties into large effects. The DOE will evaluate the range of local chemical conditions at the drip shield and waste package (e.g. local variations in water composition associated with cement leaching or the presence of corrosion products), considering potential evaporative concentration and the chemical divide effect whereby small differences in initial composition could cause large differences in brine characteristics.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14,

J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by an existing DOE/NRC agreements (ENFE Subissue 2 Agreement 6, 10, and 14). The Engineered Barrier System Features, Events, and Processes, ANL-WIS-PA-000002, will be updated upon completion of these agreement items.

Tracking # SA-55

Comment 2.1.09.07.00 (Reaction kinetics in waste and engineered barrier subsystem).
[Engineered Barrier Subsystem]: Item screened as excluded on the basis of low consequence (CRWMS M&O, 2001). Consideration of chemical reactions, such as radionuclide dissolution/ precipitation reactions and reactions controlling the reduction-oxidation state is included by considering reaction kinetics in the in-package equilibrium model but excluded based on low consequence for the engineered barrier subsystem. However, these processes may affect the composition of the near field environment, particularly for trace elements, and the effect on corrosion of container materials could be indirect and should be considered.

[Waste Form Misc]: Item screened as excluded on the basis of low consequence (CRWMS M&O, 2000). Adequate technical bases have not been provided to demonstrate that the combination of transport processes and reaction kinetics in the engineered barrier subsystem will not adversely impact performance by altering the composition of water contacting the drip shield and waste package.

References CRWMS M&O. "Miscellaneous Waste Form FEPs." ANL-WIS-MD-000009. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.
CRWMS M&O. "EBS FEPs/Degradation Modes Abstraction." ANL-WIS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response In the Near Field agreement KEN0211, the DOE will provide additional technical basis for the treatment of precipitation-dissolution kinetics by the in-drift geochemical models, in a revision to the Engineered Barrier System: Physical and Chemical Environment Model Analysis/Model Report (CRWMS M&O 2000w). The technical basis will include reaction progress simulation for laboratory evaporative concentration tests, and will include appropriate treatment of time as related to the residence times associated with the abstractions used to represent in-drift processes in Total System Performance Assessment.

In addition, agreement KEN0208 indicates that DOE will provide additional technical basis for the suppression of individual minerals predicted by equilibrium models, in a revision to the Engineered Barrier System: Physical and Chemical Environment Model Analysis/Model Report (CRWMS M&O 2000w)

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as

summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by an existing DOE/NRC agreements (ENFE Subissue 2 Agreement 5, 8, 11, and 12). The Engineered Barrier System Features, Events, and Processes, ANL-WIS-PA-000002, will be updated upon completion of these agreement items.

Tracking # SA-56

Comment 2.1.07.06.00 (Floor Buckling) has been screened as excluded in (CRWMS M&O, 2001) and EBS Radionuclide Transport Abstraction (CRWMS M&O, 2000) based on analyses documented in Repository Ground Support Analysis for Viability Assessment (CRWMS M&O, 1998), which indicate that floor heave from thermal-mechanical effects would not exceed about 10 mm. However, to address concerns raised by U.S. Nuclear Regulatory Commission staff about the appropriateness of the thermal-mechanical properties used in DOE calculations (such as the analyses cited above), the DOE has agreed to revise its assessment of floor buckling [repository design and thermal-mechanical effects Agreement 3.9 (DOE and U.S. Nuclear Regulatory Commission Technical Exchange on repository design and thermal-mechanical effects, February 6-8, 2001, Las Vegas, Nevada)]. Note that the screening argument relies on analyses that DOE has agreed to revise to address outstanding NRC concerns in repository design and thermal-mechanical effects Agreements 3.2-3.13 (repository design and thermal-mechanical effects Technical Exchange, February 6-8, 2001, Las Vegas, Nevada).

References
CRWMS M&O. "Repository Ground Support Analysis for Viability Assessment." BCAA00000B01717B0200B0004. Revision 01. Las Vegas, Nevada: CRWMS M&O. 1998.
CRWMS M&O. "AMR EBS Radionuclide Transport Abstraction." ANL-WIS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.
CRWMS M&O. "EBS FEPs/Degradation Modes Abstraction." ANL-WIS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response The information on the buckling or heave of the floor of an emplacement drift can be inferred from computer output files generated for ground control analyses, such as Ground Control for Emplacement Drifts for Site Recommendation (CRWMS M&O 2000ae). The topic was not addressed in ground control analyses in an explicit manner because it has no direct implications on ground control. An ICN is currently being issued to Ground Control for Emplacement Drifts for Site Recommendation, and the preliminary results using latest thermal properties indicate that the maximum differential movement of the invert area is well within 10 mm.

The Repository Design and Thermal Mechanical Effects agreement on floor heave, KRD0309: "DOE will provide appropriate analysis that shows rock movements in the floor of the emplacement drift are within the range acceptable for preclosure

operations. The analysis results will be provided in a revision to the Ground Control for Emplacement Drifts for Site Recommendation (CRWMS M&O 2000ae) (or other document) supporting any potential license application," will be addressed in detail in additional ground control analyses necessary for Key Techncial Resolution resolution.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing DOE/NRC agreements (RDTME Subissue 3 Agreements 2 - 13). DOE agreed to include the analysis of floor buckling for post-closure conditions, consistent with the site-specific parameters and loading conditions used to satisfy RDTME Subissue 3, Agreements 2-13. The Engineered Barrier System Features, Events, and Processes, ANL-WIS-PA-000002, will be revised to include this information.

Tracking # SA-57

Comment 1.1.02.03.00 (Undesirable materials left) is screened out on the basis of low consequences (CRWMS M&O, 2001). Although a report cited by the DOE (CRWMS M&O, 1995) provides an analysis of acceptable upper bounds on materials introduced into the repository, no analysis has been conducted to determine if the current design will meet these limits. An assumption that the limits will be adhered to during the preclosure period is considered inadequate to exclude 1.1.02.03.00. DOE should provide adequate technical basis for the effect of introduced materials on water chemistry.

References CRWMS M&O. " Waste Isolation Evaluation: Tracers, Fluids, and Materials, and Excavation Methods for Use in the Package 2C Exploratory Studies Facility Construction." BABE00000B01717B2200B00007. Revision 04. Las Vegas, Nevada: CRWMS M&O. 1995.
CRWMS M&O. "EBS FEPs/Degradation Modes Abstraction." ANL-WIS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response An inherent assumption in the licensing and construction process, as stated in the features, events and processes (FEPs) Analysis/Model Report, is that the repository will be built as designed, and that the quality control requirements will be adhered to, monitored, and enforced per the NRC=s regulations. A review of the current repository design will be conducted to provide estimates of the quantities of Aundesirable materials@ (organics, cementitious materials, etc.) to be used in the current design pre-closure phase relative to the limits discussed in the referenced document. This review will also consider the assessment of trace material impact on Engineered Barrier System groundwater chemistry (both within the drift as well as the plume leaving the drift) being conducted as part of the Engineered Barrier System Thermo-hydrologic chemical modeling.

Operational process controls, such as, (1) providing procedural assurance that future operational actions will be done according to a plan, and (2) including in FEPs analysis a reasonable estimate of the uncertainty associated with our ability to implement the plan exactly, is sufficient to account for the potential of undesirable conditions.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70,

78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide the technical basis for the screening argument in the Engineered Barrier System Features, Events, and Processes, ANL-WIS-PA-000002, to address the NRC comment. This will include a technical basis for the use of the Waste Isolation Evaluation: Tracers, Fluids, and Materials, and Excavation Methods for Use in the Package 2C Exploratory Studies Facility Construction. BABE00000-01717-2200-00007 Rev 04.

Subissue #2 - Scenario Analysis SA-58

Tracking # SA-58

Comment Screening arguments were labeled with the word Preliminary in (CRWMS M&0, 2001a) {FEPs 2.1.07.01.00 [Rockfall (Large Block)]; 1.2.02.01.00 (Fractures); 1.2.02.02.00 (Faulting); 1.2.03.01.00 (Seismic activity); etc}, and in (CRWMS M&0, 2001b). Attachment I of this latter document includes 61 FEPs arguments that are considered preliminary. It is stated that "future modeling and analysis efforts may enhance these considerations, and in this sense they are preliminary."

It is necessary to disclose plans to release screening arguments with improved technical bases.

References CRWMS M&O. "Features, Events, and Processes: Screening for Disruptive Events." ANL-WIS-MD-000005 Revision 00 ICN1. Las Vegas, Nevada: CRWMS M&O. 2001a.
CRWMS M&O. "EBS FEPs/Degradation Modes Abstraction. ANL-WIS-PA-000002 Revision 01." Las Vegas, Nevada: CRWMS M&O. 2001b.

DOE Response

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide clarification of the screening argument in the Engineered Barrier System Features, Events, and Processes, ANL-WIS-PA-000002, to address the NRC comment.

Subissue #2 - Scenario Analysis SA-59

Tracking # SA-59

Comment 2.1.08.04.00 (Cold Traps) screened as excluded on the basis of low consequence (CRWMS M&O, 2001). Emplacement of waste in the drifts creates thermal gradients within the repository that may result in condensation forming on the roof of the drifts or elsewhere in the engineered barrier subsystem, leading to enhanced dripping on the drip shields, waste packages, or exposed waste material. Cold traps are excluded on the basis of low consequence (CRWMS M&O, 2001). The DOE's Multiscale Thermohydrologic Model does not account for mass transport along the length of drifts. The only Multiscale Thermohydrologic Model submodel that includes thermal hydrology (i.e., mass transport) is a cross-section of a drift so it accounts for potential condensation only along the radial axis.

References CRWMS M&O. "EBS FEPs/Degradation Modes Abstraction." ANL-WIS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Thermal Effects on Flow agreement KTE0205 states that technical support for the inclusion or exclusion of the cold trap effect in the various scale models will be documented in the Multi-scale Thermal Hydrological Model. The analysis will consider repository edge effects and in-drift geochemical environment abstraction. The magnitude of such enhancement relative to the seepage flux will be considered relative to its impact on drip shield and waste package failure and on waste form dissolution and radionuclide transport. This will provide a quantified basis for the Exclude B Low Consequence screening.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by an existing DOE/NRC agreement (TEF Agreement Subissue 2 Agreement 5). The Engineered Barrier System Features, Events, and Processes, ANL-WIS-PA-000002, will be revised upon completion of this agreement.

Subissue #2 - Scenario Analysis SA-60

Tracking # SA-60

Comment The exclusion of 2.1.12.01.00 (Gas generation) and 2.1.12.05.00 (Gas generation from concrete) in (CRWMS M&O, 2001, 2000) is unacceptable, because adequate technical bases have not been provided to justify the characterization of chemical environments in the engineered barrier subsystem in terms of bulk water and gas compositions. The possibility of existence of local heterogeneity in gas composition in the drift, altering the chemistry of the DS/waste package environment and adversely impacting repository performance should be explored. Local variations in the efficiency of advection/diffusion processes, relative to reaction rates, should be evaluated.

References CRWMS M&O. "Miscellaneous Waste Form FEPs." ANL-WIS-MD-000009. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.
CRWMS M&O. "EBS FEPs/Degradation Modes Abstraction." ANL-WIS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Engineered Barrier System will estimate the potential heterogeneity in local gas composition within the drift, due to gas generation from corrosion, microbial action, and concrete degradation. Based on such bounding estimates of compositional heterogeneity, the impact on local chemistry and key reaction rates will also be estimated.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is partially addressed by an existing DOE/NRC agreement (ENFE Subissue 2 Agreement 6). DOE agreed to provide the technical basis for the screening argument in the Engineered Barrier System Features, Events, and Processes, ANL-WIS-PA-000002, to address the NRC comment.

Tracking # SA-61

Comment 2.2.10.12.00 (Geosphere dry-out due to waste heat). Necessary to develop screening argument for this item under scope of unsaturated zone Flow and Transport FEP AMR (CRWMS M&O, 2001b). Elevated thermal effects on shallow infiltration due to changes in soil water content were not addressed for 2.2.10.12.00 (Geosphere dry-out due to waste heat). U.S. Department of Energy study of a natural thermal gradient on YM addresses this item (CRWMS M&O, 1998). 2.2.10.12.00 (Geosphere dry-out due to waste heat) is screened as included in (CRWMS M&O, 2001a) for issues related to Near Field Environment, but does not address its effects on infiltration.

References CRWMS M&O. "Final Report: Plant and Soil Related Processes along a Natural Thermal Gradient at Yucca Mountain, Nevada." B00000000B01717B5705B00109. Revision 00. Las Vegas, Nevada: CRWMS M&O. 1998.
CRWMS M&O. "Features, Events, and Processes in Thermal Hydrology and Coupled Processes." ANL-NBS-MD-000004. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001a.
CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response DOE will cite the suggested reference for this question and include this feature, event and process in the next revision of the Features, Events, and Processes in Unsaturated Zone Flow and Transport Analysis/Model Report (ANL-NBS-MD-000001, BSC 2001d)

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE agreed to provide the technical basis for the screening argument in the Features, Events, and Processes in the Features, Events, and Processes in UZ Flow and Transport, ANL-NBS-MD-000001, to address the NRC comment.

Subissue #2 - Scenario Analysis SA-62

Tracking # SA-62

Comment 2.2.01.02.00 (Thermal and other waste and engineered barrier subsystem-related changes in the adjacent host rock) is screened as excluded on the basis of low consequence (thermal-mechanical effects) and low probability (thermal-hydrological-chemical and backfill effects) (CRWMS M&O, 2001). Changes in host rock properties result from thermal effects or other factors related to emplacement of the waste and engineered barrier subsystem, such as mechanical or chemical effects of backfill. Properties that may be affected include rock strength, fracture spacing and block size, and hydrologic properties such as permeability. The screening argument did not consider mechanical degradation of the rock mass, such as fracture-wall rock alteration owing to long-term exposure to heat, moisture, and atmospheric conditions. Such degradation would increase the severity of mechanical failure, (Ofoegbu G.I., 2000). However, DOE is expected to reevaluate its assessment of long-term mechanical degradation to satisfy outstanding DOE and NRC agreements (repository design and thermal-mechanical effects Agreements 3.11 and 3.19). In the analyses, it is necessary to account for long-term mechanical degradation of the host rock mass in its assessment of drift degradation, rockfall, and changes in hydrological properties; and their effects on repository performance.

References CRWMS M&O. "Features, Events, and Processes in Thermal Hydrology and Coupled Processes." ANL-NBS-MD-000004. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001.
Ofoegbu G.I. "Thermal-Mechanical Effects on Long-Term Hydrological Properties at the Proposed Yucca Mountain Nuclear Waste Repository." CNWRA 2000-03. San Antonio, TX: CNWRA. 2000.

DOE Response The current Total System Performance Assessment increases the quantity of seepage that enters an intact drift by 50% to account for the degradation of the drift. This value was based on a sensitivity study performed in the seepage model. Although the drift is not expected to degrade everywhere, this 50% increase in seepage flow is used at all locations.

In addition, the subject matter introduced by this question is the basis for two Repository Design and Thermal Mechanical Effects agreements between DOE and NRC (KRD0311 and KRD0319).

In the Repository Design and Thermal Mechanical Effects agreement KRD0311, the DOE will justify the preclosure ground support system design (including the effects of long term degradation of rock mass and joint strength properties) in a revision to the Ground Control for Emplacement Drifts for Site-

Recommendation (CRWMS M&O 2000ae) (or other document) supporting any potential license application.

In the Repository Design and Thermal Mechanical Effects agreement KRD0319, the DOE states its belief that the Drift Degradation Analysis is consistent with current understanding of the Yucca Mountain site and the level of detail of the design to date. As understanding of the site and the design evolve, DOE will: (1) provide revised Discrete Region Key-Block Analysis (DRKBA) analyses using appropriate range of strength properties for rock joints from a design parameters analysis report (or other document), accounting for their long-term degradation; (2) provide an analysis of block sizes based on the full distribution of joint trace length data from the Fracture Geometry Analysis for the Stratigraphic Units of the Repository Host Horizon(CRWMS M&O 2000ad), supplemented by available small joint trace length data; (3) verify the results of the revised DRKBA analyses using: (a) appropriate boundary conditions for thermal and seismic loading; (b) critical fracture patterns from the DRKBA Monte Carlo simulations (at least two patterns for each rock unit); (c) thermal and mechanical properties for rock blocks and joints from a design parameters analysis report (or other document); (d) long-term degradation of joint strength parameters; and (e) site-specific ground motion time histories appropriate for post-closure period. This will be documented in a revision to the Drift Degradation Analysis (CRWMS M&O 2000t). Based on the results of the analyses above and subsequent drip shield calculation revisions, DOE will reconsider the screening decision for inclusion or exclusion of rockfall in performance assessment analysis. Any changes to screening decisions will be documented in analyses prior to any potential License Application.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
TM effects on fractures will be addressed by existing agreements

between DOE and NRC (RDTME Subissue 3 Agreement 20 and 21). The FEPs in Thermal Hydrology and Coupled Processes, ANL-NBS-MD-000004, will be revised upon completion of this work.

Long term degradation of the host rock is addressed by existing agreements between DOE and NRC (RDTME Subissue 3 Agreement 11 and 19).

DOE will provide an improved technical basis for 2.2.01.02.00 (Thermal and other waste and EBS-related changes in the adjacent host rock) by performing a postclosure drift deformation analysis that incorporates postclosure loads and rock properties using relevant information from existing agreements (RDTME Subissue 3 Agreements 2 - 13). The Engineered Barrier System Features, Events, and Processes, ANL-WIS-PA-000002, will be revised to include this information.

Tracking # SA-63

Comment 2.1.09.12.00 (Rind (altered zone) formation in waste, engineered barrier subsystem, and adjacent rock). Included (thermal-hydrological-chemical model), and screened as excluded (thermal-hydrological model, effects on transport) on the basis of low consequence (CRWMS M&O, 2001). Thermo-chemical processes alter the rock forming the drift walls mineralogically. These alterations have hydrologic, thermal and mineralogic properties different from the current country rock.

References CRWMS M&O. "Features, Events, and Processes in Thermal Hydrology and Coupled Processes." ANL-NBS-MD-000004. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response This technical issue introduced by this comment is the subject of an existing near field agreement KEN0103. KEN0103 commits to gathering information on the quantity of unreacted solute mass that is trapped in dry-out zone in TOUGHREACT simulations, as well as how this would affect precipitation and the resulting change in hydrologic properties. The DOE provided to NRC documentation of model validation, consistent with the DOE quality assurance requirements, in the Drift-Scale Coupled Processes (Drift-Scale Test and Thermal-hydrological-chemical Seepage) Analysis/Model Report (CRWMS M&O 2001c) in March 2001. In accordance with agreement KEN0103, DOE will provide information on the quantity of unreacted solute mass that is trapped in the dryout zone in TOUGHREACT simulations in the Drift-Scale Coupled Processes (Drift-Scale Test and Thermal-hydrological-chemical Seepage) Models Analysis/Model Report Rev 02. This information will be used to provide the basis for inclusion or exclusion of the subject scenario.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (ENFE Subissue 1 Agreement 3). FEPs in Thermal Hydrology

and Coupled Processes, ANL-NBS-MD-000004 will be revised upon completion of this work.

Subissue #2 - Scenario Analysis SA-64

Tracking # SA-64

Comment FEP 2.2.10.06.00 (Thermo-chemical alteration (solubility speciation, phase changes, precipitation/dissolution)). Item excluded on the basis of low consequence (CRWMS M&O, 2001). Changes in the groundwater temperature in the far-field, if significant, may change the solubility and speciation of certain radionuclides. This would have the effect of altering radionuclide transport processes. Relevant processes include volume effects associated with silica phase changes, precipitation and dissolution of fracture-filling minerals (including silica and calcite), and alteration of zeolites and other minerals to clays.

References CRWMS M&O. "Thermal hydrology and coupled processes features, events, and processes." ANL-NBS-MD-000004 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response

Agreement Number TSPAI2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
This issue is addressed by existing agreements between DOE and NRC (ENFE Subissue 1 Agreement 3). The FEPs in Thermal Hydrology and Coupled Processes, ANL-NBS-MD-000004 will be revised upon completion of this work.

Subissue #2 - Scenario Analysis SA-65

Tracking # SA-65

Comment 2.1.11.02.00 (Nonuniform heat distribution/edge effects in repository). Included (thermal-hydrological and thermal-hydrological-chemical aspects) is screened as excluded (thermal-mechanical effects) on the basis of low consequence (CRWMS M&O, 2001). Temperature inhomogeneities in the repository lead to localized accumulation of moisture. Uneven heating and cooling at repository edges lead to non-uniform thermal effects during both the thermal peak and the cool-down period.

References CRWMS M&O. "Features, Events, and Processes in Thermal Hydrology and Coupled Processes." ANL-NBS-MD-000004. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Repository wide non-uniform heating effects are the subject of Thermal Effects on Flow agreement KTE0205 this work will represent the cold-trap effect in the appropriate models or provide the technical basis for exclusion of it in the various scale models.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
Repository wide non-uniform heating effects are the subject of existing DOE/NRC agreements (TEF Subissue 2 Agreement 5, RDTME Subissue 3 Agreement 20 and 21). The FEPs in Thermal Hydrology and Coupled Processes, ANL-NBS-MD-000004 will be revised upon completion of this work.

THM continuum modeling will address non-uniform effects at a mountain scale. This information will be provided in the Coupled Thermal-Hydrologic-Mechanical Effects on Permeability Analysis and Model Report AMR, ANL-NBS-HS-000037.

Subissue #2 - Scenario Analysis SA-66

Tracking # SA-66

Comment 2.2.06.01.00 [Changes in stress (due to thermal, seismic, or tectonic effects) change porosity and permeability of rock] is screened as excluded on the basis of low consequence and low probability (for one secondary entry) (CRWMS M&O, 2001b). Even small changes in the fracture openings cause large changes in permeability. The rock deforms according to the rock stress field. Changes in the groundwater flow and in the temperature field will change the stress acting on the rock which will in turn change the groundwater flow. 2.2.06.01.00 [Change in stress (due to thermal, seismic, or tectonic effects) change porosity and permeability of rock] is excluded as having low consequence to dose (CRWMS M&O, 2001a). However, the DOE analyses used to support the screening argument (CRWMS M&O, 2000) did not consider water-flux diversion toward a drift from the adjacent pillar caused by increased aperture of subhorizontal fractures in the pillar from thermal-mechanical response. Such flux diversion would cause increased water flow to the drifts.

References CRWMS M&O. "AMR Fault Displacement Effects on Transport in the Unsaturated Zone." ANL-NBS-HS-000020. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.
CRWMS M&O. "Features, Events, and Processes in Thermal Hydrology and Coupled Processes." ANL-NBS-MD-000004. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001a.
CRWMS M&O. "Features, Events, and Processes: Screening for Disruptive Events." ANL-WIS-MD-000005. Revision 00 ICN 01. CRWMS M&O. 2001b.

DOE Response Thermal-mechanical effects may result in changes in fracture apertures in support pillars between drifts. If the horizontal fractures open up more than the vertical fractures, it may be possible that flow could divert towards the drifts. DOE is presently performing process-model simulations using both continuum and discrete fracture models to analyze the effects of thermal-hydrologic-mechanical coupled processes with regard to drainage in the pillars and flow in the vicinity of the drifts. Furthermore, DOE is performing thermal-hydrological/ thermal-hydrological-chemical/ thermal-hydrological-mechanical analyses to quantify uncertainties in the thermal seepage model. Based on the results, DOE will revisit the Feature, Event and Process screening arguments. Interim results are reported in the Supplemental Science and Performance Analysis.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44,

48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
The thermal mechanical effects on rock properties are addressed by an existing DOE/NRC agreement (RDTME Subissue 3 Agreement 20 and 21). The FEPs in Thermal Hydrology and Coupled Processes, ANL-NBS-MD-000004 and the Features, Events, and Processes: Screening for Disruptive Events. ANL-WIS-MD-000005 will be revised upon completion of this work.

Subissue #2 - Scenario Analysis SA-67

Tracking # SA-67

Comment 2.2.10.05.00 (Thermo-mechanical alteration of rocks above and below the repository) is screened as excluded on the basis of low consequence (CRWMS M&O, 2001). Thermal-mechanical compression at the repository produces tension-fracturing in the paintbrush nonwelded tuff and other units above the repository. These fractures alter unsaturated zone flow between the surface and the repository. Extreme fracturing may propagate to the surface, affecting infiltration. Thermal fracturing in rocks below the repository affects flow and radionuclide transport to the saturated zone.

References CRWMS M&O. "Features, Events, and Processes in Thermal Hydrology and Coupled Processes." ANL-NBS-MD-000004. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response See response to Feature, Event and Process 2.2.01.01.00

Agreement Number TSPAI.2.01

Agreement Provide clarification of the screening arguments, as summarized in Attachment 2. See Comment # 5, 7, 8, 9, 10, 13, 18, 19 (Part 5), 21, 32, 41, 47, 50, 53, 58, 67, J-5, J-16, and J-18

DOE will clarify the screening arguments, as summarized in Attachment 2, for the highlighted FEPs. The clarifications will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
DOE has planned work to analyze the effects of thermal-hydrologic-mechanical coupled processes with regard to drainage in the pillars and flow in the vicinity of the drifts, and thermal-hydrological/ thermal-hydrological -chemical/ thermal-hydrological-mechanical analyses to quantify uncertainties in the thermal seepage model. In addition, THM continuum modeling will address thermal mechanical effects in rocks above and below the repository at a mountain scale in an update to the Coupled Thermal-Hydrologic-Mechanical Effects on Permeability Analysis and Model Report AMR, ANL-NBS-HS-000037. DOE will clarify the screening arguments in the FEPs in Thermal Hydrology and Coupled Processes, ANL-NBS-MD-000004 upon completion of this work.

Subissue #2 - Scenario Analysis SA-68

Tracking # SA-68

Comment 1.2.02.01.00 (Fractures). Included (seepage). Excluded on the basis of low consequence (permanent effects) (CRWMS M&O, 2001). Generation of new fractures and re-activation of preexisting fractures may significantly change the flow and transport paths. Newly formed and reactivated fractures typically result from thermal, seismic, or tectonic events. Thermally induced changes in stress may result in permeability changes between drifts that could act to divert flow toward drifts. Also see comment on 2.2.06.01.00 [Changes in stress (due to thermal, seismic, or tectonic effects) change porosity and permeability of rock].

References CRWMS M&O. "Features, Events, and Processes in Thermal Hydrology and Coupled Processes." ANL-NBS-MD-000004. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Thermal-mechanical effects may result in changes in fracture apertures in support pillars between drifts. If the horizontal fractures open up more than the vertical fractures, it may be possible that flow could divert towards the drifts.

DOE is presently performing process-model simulations using both continuum and discrete fracture models to analyze the effects of thermal-hydrologic-mechanical coupled processes with regard to drainage in the pillars and flow in the vicinity of the drifts. Furthermore, DOE is performing thermal-hydrological/ thermal-hydrological -chemical/ thermal-hydrological-mechanical analyses to quantify uncertainties in the thermal seepage model. Based on the results, DOE will revisit the Feature, Event and Process screening arguments. Interim results are reported in the Supplemental Science and Performance Analysis.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
The thermal mechanical effects on rock properties are addressed

by an existing DOE/NRC agreement (RDTME Subissue 3 Agreement 20 and 21). The FEPs in Thermal Hydrology and Coupled Processes, ANL-NBS-MD-000004 will be revised upon completion of this work.

Tracking # SA-69

Comment 2.2.01.01.00 (Excavation and construction-related changes in the adjacent host rock). Included (initial effects on seepage) and screened as excluded (permanent thermal-hydrological-chemical and thermal-mechanical effects) on the basis of low consequence (CRWMS M&O, 2001). Stress relief, leading to dilation of joints and fractures, is expected in an axial zone of up to one diameter width surrounding the tunnels.

References CRWMS M&O. "Features, Events, and Processes in Thermal Hydrology and Coupled Processes." ANL-NBS-MD-000004. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Thermal-mechanical effects may result in changes in fracture apertures in support pillars between drifts. If the horizontal fractures open up more than the vertical fractures, it may be possible that flow could divert towards the drifts. DOE is presently performing process-model simulations using both continuum and discrete fracture models to analyze the effects of thermal-hydrologic-mechanical coupled processes with regard to drainage in the pillars and flow in the vicinity of the drifts. Furthermore, DOE is performing thermal-hydrological/ thermal-hydrological-chemical/ thermal-hydrological-mechanical analyses to quantify uncertainties in the thermal seepage model. Based on the results, DOE will revisit the Feature, Event and Process screening arguments. Interim results are reported in the Supplemental Science and Performance Analysis.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
The thermal mechanical effects on rock properties are addressed by an existing DOE/NRC agreement (RDTME Subissue 3 Agreement 20 and 21). The FEPs in Thermal Hydrology and Coupled Processes, ANL-NBS-MD-000004 will be revised upon completion of this work.

Tracking # SA-70

Comment 2.2.10.04.00 (Thermo-Mechanical alteration of fractures near repository) is screened excluded on the basis of low consequence (CRWMS M&O, 2001a, 2001b). See discussion under 2.2.06.01.00 [Changes in stress (due to thermal, seismic, or tectonic effects) change porosity and permeability of rock].Heat from the waste causes thermal expansion of the surrounding rock, generating compressive stresses near the drifts and extensional stresses away from them. The zone of compression migrates with time.

References CRWMS M&O. "Features, Events, and Processes in Thermal Hydrology and Coupled Processes." ANL-NBS-MD-000004. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001a. CCRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response See response to Feature, Event and Process 2.2.01.01.00

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
The thermal mechanical effects on rock properties are addressed by an existing DOE/NRC agreement (RDTME Subissue 3 Agreement 20 and 21). The FEPs in Thermal Hydrology and Coupled Processes, ANL-NBS-MD-000004, will be revised upon completion of this work.

Tracking # SA-74

Comment 2.1.14.01.00 (Criticality in waste and engineered barrier subsystem) was preliminarily excluded in the document (CRWMS M&O, 2001a, 2000b) based on low probability. A preliminary screening status was assigned because the criticality calculations were not complete for (i) DSNF following igneous intrusion and (ii) near-field and far-field criticality of all waste types following igneous disruption. The excluded screening status will be regarded unacceptable until concerns on the calculation of the probability for criticality are addressed. Since the probability of criticality depends on the presence of a breach of the waste package barriers, most of the discussion of criticality probability is focused on the probability of waste package failure. U.S. Department of Energy has referenced the document, Probability of Criticality in 10,000 Years (CRWMS M&O, 2000d) for addressing the criticality probability due to early failure by stress corrosion cracking, waste package damage following igneous intrusion, and seismic events. DOE has referenced the screening argument for rockfall (2.1.07.01.00) for screening the damage to the waste package and drip shield from seismically-induced rockfall. In general, DOE needs to address the concerns raised on the waste package and mechanical disruption related features, events, and processes, and the issues raised at the container life and source term technical exchange before it can conclude that there is no waste package breach before 10,000 years.The concerns on the probability calculation in the document, Probability of Criticality in 10,000 Years (CRWMS M&O, 2000d) are:

(i) the conclusion of waste package failure probability of 2.7 x 10 - 11 due to stress corrosion cracking, based on the equation in Section 6.1.1, is contrary to the total system performance assessment results which indicate the first waste package failure, using the upper-bound curve, due to SCC at approximately 10,000 years.

(ii) the screening argument for 1.2.03.02.00 (Seismic Vibration Causes Container Failure), fails to consider the appropriate combinations of dead loads (caused by drift collapse and/or fallen rock blocks), rock block impact, and seismic excitation or the ability of these loads to initiate cracks and/or propagate preexisting cracks.

(iii) the screening argument for seismic events does not consider the indirect effects, such as causing dents which could aid in the collection and channeling of water or tilting the waste packages, which would result in the greater height of the water within the waste package. Seismic shaking, combined with a sloped waste package, may also allow materials to accumulate at one end of a waste package and form a more reactive geometry.

(iv) the screening argument for seismically-induced rockfall

damaging the drip shield and waste package includes several deficiencies as documented in the staff review of the Drift Degradation Analysis (CRWMS M&O 2000à) Analysis and Model Report and 2.1.07.01.00 [Rockfall (large block)] Other concerns related to the impact of rockfall on the waste package are reflected in the comments on the related features, events, and processes.

(v) the calculation of the criticality probability does not fully consider mechanisms that could result in accelerated degradation of the fuel during an igneous event, such as burning of Zircaloy or creep of the fuel at high temperatures.

(vi) the analysis of damage to Zone 2 waste packages (CRWMS M&O, 2000d) fails to consider long term exposure to high temperatures changing the microstructure of Alloy 22 and reducing the mechanical strength of the material (e.g., Rebak et al., 1999) or the differences in thermal expansion between the inner alloy 316 NG SS and Alloy 22 causing significant hoop-stress on waste package walls, in addition to the internal pressurization effects analyzed in CRWMS M&O (2000c). Analyses in CRWMS M&O (2000d) also do not consider potentially adverse chemical reactions, such as sulfidation reactions, in response to magmatic degassing or contact with basaltic magma. These processes could cause a more significant breach than the 10 cm2 hole currently assumed for waste packages located in DOE Zone 2 during basaltic igneous events.

(vii) the calculation does not consider any changes to drift by the magma, such as magma solidifying in the lower part of the drift, causing ponding above and around the waste package or fractures forming in the cooled magma that may provide preferential pathways to the waste package. Finally, the unsaturated flow may be modified by the presence of 1170°C magma so current parameters may no longer be valid.

(viii) the Criticality Probability document is inconsistent when discussing the water content of the magma in Section 5.3.2. The text indicates that the magma would consist of a very conservative 5 weight percent water content, but Table 5-1 lists the water content as only 0.05 weight percent. The computer files provided with the document that contained the actual calculations used a more realistic water content of 1.6%. A water content of 5 weight percent would clearly be very conservative, but justification needs to be provided if a lower water content is utilized in the calculations.

References

CRWMS M&O. "Drift Degradation Analysis AMR." ANL-EBS-MD-000027. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2000a.

CRWMS M&O. "Features, Events, and Processes: System-Level and Criticality." ANL-WIS-MD-000019 Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000b.

CRWMS M&O. "Natural Analogs for the Unsaturated Zone." ANL-NBS-HS-000007. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000c.

CRWMS M&O. Probability of Criticality in 10,000 Years. CAL-EBS-NU-000014. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000d.

CRWMS M&O. "Features, Events, and Processes: Screening for Disruptive Events." ANL-WIS-MD-000005. Revision 00 ICN 01. CRWMS M&O. 2001a.

Rebak, R.B., T.S.E. Summers, and R.M. Carranza. "Mechanical properties, microstructure, and corrosion performance of C-22 alloy aged at 260C to 800C." Materials Research Society, Boston Meeting, Paper QQ 14.4. 1999.

DOE Response DOE's process for evaluating criticality is stated in the Disposal Criticality Analysis Methodology Topical Report, (YMP 2000). The process includes calculating the probability and consequences of potential criticality events, based on mechanisms at the site, and evaluating them using the Total System Performance Assessment processes, including Features, Events and Processes (FEPs) screenings. DOE will finish the criticality calculations following an igneous event or develop an argument as to why the consequences to the source from such an igneous event can be ignored. Furthermore, DOE will re-evaluate the criticality FEPs, should the reevaluation (as agreed to in the Container Life and Source Term agreement K0106) of the waste package FEPs, related to seismicity and rock fall, show that waste packages will fail prior to 10,000 years.

Specifically, agreement KCR0106 indicates that DOE will perform a "what if" (non-risk-informed) evaluation that determines the consequences of criticality for a non-mechanistic, waste package failure during the 10,000 year regulatory period. The results of this evaluation are not part of the normal Total System Performance Assessment process, and thus will not be included as part of the FEPs process. The results will be used as a sensitivity evaluation.

The probability of 2.7 x 10 -11 is per waste package. The probability of a waste package failure in the first 10,000 years with ~11,000 packages is 3.2 x 10-7. The probability results for stress corrosion cracking based failure shown in Probability of Criticality before 10,000 Years (CRWMS 2000am, Section 6.1.1, page 19) are based on the information from Analysis of Mechanisms for Early Waste Package Failure (CRWMS 2000d, page 43) with inputs from Abstraction of Models of Stress Corrosion Cracking of Drip Shield and Waste Package Outer Barrier and Hydrogen Induced Corrosion of Drip Shield (CRWMS 2000aaa, page 28).

DOE will examine the apparent discrepancy of waste package failure at 10,000 yearsr in the Total System Performance Assessment at the 95th percentile with the calculational mean probability of 3.2 x 10-7 and if necessary, supercede this waste package failure probability

The criticality FEPs screening is based on the current inputs for waste package failure. When the inputs are revised to address additional concerns (e.g., dead loads, indirect effects of rock block impacts, tilting of breached waste packages) then the criticality FEPs screening will be reassessed. The NRC concerns will be addressed when the seismic vibration Feature, Event and Process is modified (Container Life and Source Term agreement KCL0114). In addition, DOE will evaluate the rockfall effect and dead weight effects on the waste package. Other pertinent rockfall agreements are KCL0201, KCL0202, KCL0208, KCL0301, KRD0317, and KRD03019.

The criticality FEPs screening is based on the current inputs for waste form degradation. When the inputs are revised to address additional concerns, then the criticality FEPs screening will be reassessed.

With respect to cladding degradation, DOE notes that within zone 2 all of the cladding is perforated and all the drip shields are removed, thus cladding damage is already accounted for. In addition, DOE may argue that the combination of criticality and igneous intrusion on the source-term can be neglected based on low consequence in a future revision of this Feature, Event and Process.

The effect of temperature with respect to damage to Zone 2 waste packages was addressed in the Analysis/Model Report Dike Propagation Near Drifts; (CRWMS &O 2000o). Reference to this Analysis/Model Report will be made in the future. As explained in 3.10.2.3.2 of the Total System Performance Assessment-Site Recommendation (CRWMS M&O 2000aq), the failure size of the lid weld varies between 1 cm2 and 1 x 104 cm2 (cross section of a lid) with a mean of 10 cm2. This failure is applied to all containers in zone 2.

DOE notes that in zone 2 the shields have been removed and so a direct path to the waste package is possible. Furthermore, in Total System Performance Assessment-Viability Assessment (DOE 1998), the effect of dikes on fluid flow in the saturated zone was evaluated. The influence was negligible. DOE will cite this work in a future revision as indirect evidence that the secondary effects of

igneous intrusion have only a secondary effect on dose. In addition, DOE may argue that the combination of criticality and igneous intrusion can be neglected based on low consequence in a future revision of this Feature, Event and Process.

DOE has examine the inconsistency and determined the value listed in Table 5-1 for water content in magma is a typo (water fraction was listed instead of water wt%). The 5-wt% value listed in the rest of the document is correct. It is based on a conservative number from Characterize Eruptive Processes at Yucca Mountain, Nevada ANL-MGR-GS-000002 REV 00 (CRWMS 2000e, Section 6.2.2, pg. 28). DOE has reviewed its computer files and the value used was 5 wt%. DOE needs to look at the computer files supplied to the NRC to be able to identify the source of the 1.6-wt% number

Agreement Number

Agreement At the May 15-17, 2001 Technical Exchange, the NRC stated that current agreements related to criticality cover concern and no additional action by the DOE is necessary.

Subissue #2 - Scenario Analysis SA-75

Tracking # SA-75

Comment A number of features, events, and processes that could potentially influence the evolution of an igneous event intersecting the repository have not been identified as being relevant for disruptive events. These include:

1.1.02.00.00 (Excavation/Construction) - changes to the rock around the repository due to excavation and construction could affect dike/repository interactions and influence how a dike behaves near the surface. Additionally, repository features such as ventilation shafts could provide a path to the surface that would bypass the repository.

1.1.04.01.00 (Incomplete Closure) - if the design of the repository includes a seal at the end of the drifts strong enough to contain magma which is relied upon for performance calculations, failure to complete these seals could significantly affect repository performance.

2.1.03.12.00 (Canister Failure (Long-Term)) - for intrusive volcanism, credit is taken for the waste packages remaining mostly intact other than an end cap breach following magma interactions. The only waste package failure mechanism that is investigated to take this credit is internal gas pressure buildup. Other waste package failure mechanisms such as differential expansion of the inner and outer waste packages and phase changes in the Alloy 22 due to the long term exposure to elevated temperatures are not considered.

2.1.07.02.00 (Mechanical Degradation or Collapse of Drift) - could affect magma-repository interactions and affect the dose as a result of an igneous event.

2.3.01.00.00 (Topography and Morphology) - the topography may affect dike propagation near the surface and dike propagation probably should be discussed under this features, events, and processes.

References CRWMS M&O. "Features, Events, and Processes: Screening for Disruptive Events." ANL-WIS-MD-000005. Revision 00 ICN 01. CRWMS M&O. 2001a.
CRWMS M&O. "Yucca Mountain FEP Database." TDR-WIS-MD-000003 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001b.

DOE Response The following Features, Events and Processes (FEPs) will be discussed at the May 18, 2001, Igneous Activity Appendix 7 Meeting.

FEP 1.1.02.00.00 (Excavation/Construction). It is not clear which specific rock changes due to excavation and construction with which the NRC is concerned. Changes in stress due to excavation and their possible effects on dike interactions with the drift are addressed in the Dike Propagation Near Drifts Analysis/Model Report (CRWMS M&O 2000o, Section 6.3.1). This effect is considered in the evaluation of FEP 1.2.04.03.00, Igneous Intrusion into the Repository, and thus consideration under FEP 1.1.02.00.00 is not needed. Magma flow through drifts to a ventilation shaft and then to the surface is not considered in the current DOE analysis.

FEP 1.1.04.01.00 (Incomplete Closure) B The DOE analysis documented in the Dike Propagation Near Drifts Analysis/Model Report (CRWMS M&O 2000o) does not assume or rely upon drift seals to contain magma. Rather, the high energy nature of the system causes the drifts to become plugged or clogged with debris and materials from pyroclastic flows, cooling magma, and repository components. Therefore, consideration of FEP 1.1.04.01.00 with respect to igneous intrusion is not needed.

FEP 2.1.03.12.00 (Canister Failure (Long-Term). The effect of magma on waste packages is considered under FEP 1.2.04.04.00, "Magma Interacts with Waste." Therefore, consideration of FEP 1.1.04.01.00 with respect to igneous intrusion is not needed.

The end-cap breach is used because it is the locus for the largest stress and deformation resulting from increased heat and pressure. The end cap weld damage is used as a "surrogate" as a means to estimate the extent of damage. As stated in the igneous consequence modeling Analysis/Model Report in Section 6.2

"Although the mean value can be thought of conceptually as corresponding to a 1-mm-wide crack that propagates for 1 m along a weld, or a 2-mm-wide crack that extends 50 cm, it was not chosen to represent any specific dimensions of a weld failure. Rather, it was chosen as an approximation of the size of opening necessary to permit rapid gas flow and pressure equilibration. Sampling the area of the breach from a distribution that includes much larger hole sizes is intended to account for both uncertainty regarding the nature of the magmatic fluids and the package response and spatial variability in the extent of damage within the drifts."

DOE has evaluated this issue under the FEPs "Igneous Intrusion Into the Repository" or "Magma Interacts with Waste.

Consideration under FEP 2.1.03.12.00 is not needed.

FEP 2.1.07.02.00 (Mechanical Degradation or Collapse of Drift) -

To address this comment, DOE needs to know by what process the NRC believes collapse of the drift will increase dose determined for igneous disruption of a repository. Any effects of drift collapse can be covered in the screening evaluation for FEP 1.2.04.03.00, "Igneous Intrusion into the Repository."

FEP 2.3.01.00.00 (Topography and Morphology) - To address this comment, the DOE needs to know in what manner the NRC believes topography will affect dike propagation. Any effects can be covered in the screening evaluation for the FEP 1.0.04.06.00, "Basaltic Cinder Cone Erupts Through the Repository."

Agreement Number

Agreement None yet available.

Subissue #2 - Scenario Analysis SA-76

Tracking # SA-76

Comment Detailed processes related to the interaction of the ascending dike with the repository drift are not described as FEPs. Instead, the FEP database includes only general categories like "Magma interacts with waste" and "Igneous Activity". This very high level treatment of the igneous FEPs likely has caused the DOE to miss many of the FEPs that are relevant to repository/dike interactions and interactions between magma and waste packages and fuel, particularly for Type 2 waste package failures (waste packages that fail, but whose contents are not removed by the event) and the determination of the number of waste packages affected. FEPs related to magma/repository interactions that are not included in the FEP database include: mechanical and fluid dynamics at the dike tip; fragmentation; vesiculation; plume dynamics; effect of drip shield on magma/repository interactions; geologic factors; threshold flow characteristics; gas segregation; alternate models of vent formation; effects of air shafts and drifts; consideration of flow segregation; localization of magma; recirculation of magma; and evolution of flow conditions. Canister/magma interactions that appear to have been missed include hoop stress due to differential expansion of the inner and outer waste packages; melting of materials; thermal shock; and phase changes in the Alloy 22 due to the long-term exposure to elevated temperatures. Fuel/magma interactions that may have been missed could include: cladding burning at high temperatures in the presence of air; cladding/fuel chemical reactions causing damage to the fuel form (no credit is taken for cladding); dissolution of fuel in magma; mechanical shear; oxidation (during and post-eruption); reworking of spent fuel in conduit; and evolution of flow conditions.

References CRWMS M&O. "Yucca Mountain FEP Database." TDR-WIS-MD-000003 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response

Agreement Number

Agreement None yet available.

Tracking # SA-77

Comment 2.1.07.02.00 (Mechanical degradation or collapse of drift) has been screened as excluded (CRWMS M&O, 2001a, 2001b) based on (CRWMS M&O, 2000), which indicates that the emplacement drifts would essentially maintain their integrity through the period of regulatory concern. DOE is expected to revise the Drift Degradation Analysis to satisfy Repository design and thermal-mechanical effects Agreements 3.17 and 3.19 (DOE and NRC Technical Exchange on repository design and thermal-mechanical effects, February 6-8, 2001, Las Vegas, Nevada).At this stage, the screening argument is considered closed-pending given the existence of the repository design and thermal-mechanical effects Agreements 3.17 and 3.19.It should be noted, however, that the current state of knowledge on unsupported openings in fractured rock indicates that majority of drifts are likely to collapse soon after cessation of maintenance. This opinion is consistent with the conclusion of the DOE expert panel on drift stability (Brekke, T.L., et al, 1999) and to recent analyses of the behavior of unsupported drifts in fractured rock during seismic loading from an earthquake (Hsiung, S.M., et al., 2001). Drift collapse could have implications on temperature, chemistry, seepage into drifts, and drip shield performance.

References
Brekke T.L., E.J. Cording, J. Daemen, R.D. Hart, J.A. Hudson, P.K. Kaiser, and S. Pelizza. Panel Report on the Drift Stability Workshop, Las Vegas, Nevada, 9-11 December, 1998. Yucca Mountain Site Characterization Project 1999.

CRWMS M&O. "Drift Degradation Analysis AMR." ANL-EBS-MD-000027. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2000.

CRWMS M&O. "EBS FEPs/Degradation Modes Abstraction." ANL-WIS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001a.

CRWMS M&O. "Features, Events, and Processes: Screening for Disruptive Events." ANL-WIS-MD-000005. Revision 00 ICN 01. CRWMS M&O. 2001b.

Hsiung S.M. and G.-H. Shi. 2001. Simulation of earthquake effects on underground excavations using discontinuous deformation analysis (DDA). To appear in Proceedings 38th U.S. Rock Mechanics Symposium, Washington, DC: 7-10 July, 2001.

DOE Response The screening decisions were based solely on the results of the Drift Degradation Analysis and will be revisited once the analysis to resolve the Repository Design Thermal Mechanical Effects agreement KRD0319 has been completed. NRC should consider providing an advanced copy of the cited paper (Hsuing and Shi 2001) since it is not currently available.

The referenced expert panel report on drift stability also clearly states on page 2-3 that "Fracture propagation during cooling and tectonic events appears to have been arrested by the lithophysae so that continuous joints, which could form large rock blocks and overbreak, are largely absent. Overbreak or rock loosening in the form of slabs or block was almost nonexistent in the lithophysal zones in both the 7.6-meter diameter North Ramp and the 5-meter diameter Cross Drift." This would suggest that NRC's concerns about fracture length and the possible formation of extensive slabs of rock expressed during multiple Key Technical Issues is at conflict with the findings of this panel as well.

DOE requests that the NRC provide a specific citation (section/conclusionary statement) from the expert panel report that they feel is in conflict with the Drift Degradation Analysis.

Agreement Number

Agreement The point is intended as a comment. No additional DOE action is required. RDTME Subissue 3, Agreements 17 and 19, address concern on drift collapse.

Tracking # SA-78

Comment 1.2.03.02.00 (Seismic Vibration Causes Container Failure). The Seismic Vibration Causes Container Failure features, events, and processes has been excluded from consideration in the total system performance assessment code (CRWMS M&O, 2001a, 2001b). The screening argument cites preliminary seismic analyses of the drip shield and waste package as the basis for this screening decision (CRWMS M&O, 2000a). Because these analyses were not available at the time of this review, it is not clear as to whether the appropriate combinations of dead loads (caused by drift collapse and/or fallen rock blocks), rock block impacts, and seismic excitation were considered. Moreover, the ability of these loads to initiate cracks and/or propagate preexisting cracks may not have been adequately addressed. In addition, DOE has not demonstrated that the drip shield, pallet, and/or waste package will respond in a purely elastic manner when subjected to the aforementioned loading conditions.The screening argument for 1.2.03.02.00 also states that "... it does not appear credible that the drip shield would be breached, because the drip shield has been designed to withstand up to a 6-MT rockfall." based on the rockfall on drip shield analyses performed by the DOE (CRWMS M&O, 2000b). DOE, however, has not adequately demonstrated that the drip shield has in fact been designed to withstand 6-MT rock blocks {see the comments on 2.1.07.01.00 [Rockfall (large block)], 2.1.07.02.00 (Mechanical Degradation or Collapse of Drift), and 2.1.07.05.00 (Creeping of metallic materials in the engineered barrier subsystem) for additional discussion relevant to rockfall and seismic analyses}. Also see comment on 1.2.02.02.00 (Faulting)

References
CRWMS M&O. "Input Request for Seismic Evaluations of Waste Packages and Emplacement Pallets." Input Transmittal 00230.T. Las Vegas, Nevada: CRWMS M&O. 2000a.

CRWMS M&O. "Rock Fall on Drip Shield." CAL-EDS-ME-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000b.

CRWMS M&O. "Features, Events, and Processes: Screening for Disruptive Events." ANL-WIS-MD-000005. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001a.

CRWMS M&O. "FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation." ANL-EBS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001b.

DOE Response The screening argument is based on 1) The design criteria to address preclosure seismic events (it is assumed that these criteria will be met) and 2) The net effect of damage to the waste package (i.e. stated in terms of equivalent drop height) that would occur from median 10-8 accelerations of 3.2 g, is met by the preclosure

drop height requirement for the initial conditions of the waste package. As NRC has noted, multiple combinations and degradation of material properties have not yet been considered. Pending the results of additional analysis to address agreements from the Container Life and Source Term, Repository Design and Thermal Mechanical Effects and Structural Deformation and Seismicity Key Technical Issue technical exchanges, the screening decision is subject to review. DOE will document its approach to post-closure seismic issues in response to Structural Deformation and Seismicity agreements KSD0102 and KSD0203.

With regard to specific issues raised:

Additional loading combinations are being addressed in response to Container Life and Source Term agreement KCL0208. Evaluations of these loading combinations will be documented in a future revision of the Design Analysis for UCF Waste Packages (CRWMS M&O 2000n), and the Design Analysis for the Ex-Container Components (CRWMS M&O 2000l).

The ability of the additional loading combinations to initiate and/or propagate preexisting cracks are being addressed in response to Container Life and Source Term agreement KCL0208. Evaluations of the ability of these loading combinations to initiate and/or propagate preexisting cracks will be documented in a future revision of the Design Analysis for UCF Waste Packages (CRWMS M&O 2000n), and the Design Analysis for the Ex-Container Components (CRWMS M&O 2000l). DOE believes that only tensile stresses contribute to the initiation and propagation of the stress corrosion cracks.

A purely elastic response of the drip shield, pallet, and/or waste package under the aforementioned loading conditions is not a design requirement. Therefore, there has been no attempt to demonstrate that these components respond in an elastic manner. Plastic deformation is reported when the evaluations indicate such. The potential for stress corrosion cracking will be addressed.

The drip shield, in new condition, has been shown to withstand the impact of a 6-metric ton rock block without rupture. Additional loading conditions are being evaluated in response to Container Life and Source Term agreements including point load rockfall (KCL0202), potential embrittlement of the drip shield (KCL0208), wall thinning due to corrosion (KCL0208), and multiple rock blocks (KCL0208). These evaluations will be documented in a future revision of the Design Analysis for the Ex-Container Components (CRWMS M&O 2000l).

Subissue #2 - Scenario Analysis SA-78

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
Existing agreements from the Container Life and Source Term (Subissue 2 agreements 2 and 8), Repository Design and Thermal Mechanical Effects (Subissue 3 agreements 17 and 19) and Structural Deformation and Seismicity (Subissue 1 agreement 2 and Subissue 2 agreement 3) address related work. DOE agreed to provide clarification of the screening argument in the FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002, and Features, Events, and Processes: Screening for Disruptive Events, ANL-WIS-MD-000005.

Subissue #2 - Scenario Analysis SA-79

Tracking # SA-79

Comment 2.1.07.01.00 [Rockfall (Large Block)]. [Disruptive event & waste package]: The effects of Rockfall (Large Block) on the drip shield and waste package has been screened as excluded (CRWMS M&O, 2001a, 2001b, 2001c). The Drift Degradation Analysis (CRWMS M&O, 2000b) Analysis Model Report (analysis and model report) indicates that thermal loading, seismicity, and time-dependent mechanical degradation of the host rock would have minor effect on the integrity of the drifts through the entire period of regulatory concern. However, several deficiencies associated with this analysis were identified by the NRC staff at the NRC and DOE repository design and thermal-mechanical effects technical exchange [see the comments on 2.1.07.02.00 (Mechanical Degradation or Collapse of Drift) for additional discussion pertaining to the DOE rockfall analyses]. As was pointed out at the container life and source term and repository design and thermal-mechanical effects technical exchanges, the rockfall on drip shield analyses (CRWMS M&O, 2000c) did not consider (i) the temperature effects on mechanical material behavior, (ii) seismic motion of the supporting invert, (iii) point load impacts, (iv) appropriate material failure criteria, (v) material degradation processes, (vi) multiple rock block impacts, and (vii) boundary conditions that account for the potential interactions between the drip shield and gantry rails. Consequently, U.S. Department of Energy has not adequately demonstrated that the drip shield has been designed to withstand 6, 10, or 13-MT rock block impacts.Because the framework for the invert is constructed from carbon steel, their potential degradation may affect the orientation of the waste packages over time. In other words, the invert floor cannot be expected to keep the waste packages in a horizontal position for the entire regulatory period. As a result, rock block impacts on the waste package may occur at angles that are not perpendicular to the waste package longitudinal axis. Angled rock block impacts near the closure lid welds may have significantly different results than non-angled impacts. This is a new scenario that has not been presented to DOE. [Cladding]: Mechanical failure of cladding due to rockfall is excluded based on low probability because rockfall on intact waste package will not cause rod failure (CRWMS M&O, 2000a). Main screening argument is based on intact waste package. However, the discussion is confusing because arguments based on the presence of backfill are also used in quantitative estimates. Although the conclusion can be acceptable due to presence of intact waste package, the screening arguments should be improved on the bases of appropriate calculations.

References CRWMS M&O. "Clad Degradation - FEPs Screening

Arguments." ANL-WIS-MD-000008 Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Drift Degradation Analysis AMR." ANL-EBS-MD-000027. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2000b.
CRWMS M&O. "Rock Fall on Drip Shield." CAL-EDS-ME-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000c.
CRWMS M&O. "EBS FEPs/Degradation Modes Abstraction." ANL-WIS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001a.
CRWMS M&O. "FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation." ANL-EBS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001b.
CRWMS M&O. "Features, Events, and Processes: Screening for Disruptive Events." ANL-WIS-MD-000005. Revision 00 ICN 01. CRWMS M&O. 2001c.

DOE Response The revised Clad Degradation: Summary and Abstraction Analysis/Model Report (ANL-WIS-MD-000007 REV 00, ICN 01, CRWMS M&O 2001a) was forwarded to the NRC as part of the Container Life and Source Term Agreement KCL0306. The revised Analysis/Model Report expanded the mechanical failure model to include cladding failure from rock overburden as the waste package deteriorates. The issue of rockfall is addressed in Container Life and Source Term agreement KCL0310. The Analysis/Model Report will be further revised as necessary to incorporate new information on rockfall, in time to support any potential License Application.

Agreement Number TSPAI.2.02

Agreement Provide the technical basis for the screening argument, as summarized in Attachment 2. See Comment # 3, 4, 11, 12, 19 (Parts 1, 2, and 6), 25, 26, 29, 34, 35, 36, 37, 38, 39, 42, 43, 44, 48, 49, 51, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 78, 79, J-1, J-2, J-3, J-4, J-7, J-8, J-9, J-10, J-11, J-12, J-13, J-14, J-15, J-17, J-20, J-21, J-22, J-23, J-24, J-25, J-26, and J-27.

DOE will provide the technical basis for the screening argument, as summarized in Attachment 2, for the highlighted FEPs. The technical basis will be provided in the referenced FEPs AMR and will be provided to the NRC in FY03.

Text in Attachment 2:
Existing agreements from Repository Design and Thermal Mechanical Effects agreements (Subissue 3 agreements 17 and 19) and Container Life and Source Term (subissue 2 agreements 2, 3 and 8) address related work. DOE agreed to provide

clarification of the screening argument in the FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002, and Features, Events, and Processes: Screening for Disruptive Events, ANL-WIS-MD-000005.

Subissue #2 - Scenario Analysis SA-IA-1

Tracking # SA-IA-1

Comment 2.3.02.02.00 (Radionuclide Accumulation in Soil) is included for irrigation deposition only, however, this screening argument is too limited since it excludes transport of volcanic ash from other areas to the critical group location (CRWMS M&O, 2001). DOE has indicated that redistribution will be accounted for by conservatively assuming that the wind is blowing towards the critical group and maintaining a high mass load in years following the event. DOE has not provided a demonstration that these conservatisms actually bound the effects of redistribution. Similar comment applies to 2.3.02.03.00 (Soil and Sediment Transport). In the screening argument it is claimed that 100% south-blowing wind direction assumption accounts for aeolian and fluvial transport processes. Additional technical basis for this statement is needed. 2.3.13.02.00 (Biosphere Transport) excludes transport in surface water. 2.3.11.02.00 (Surface Runoff and Flooding) and 2.3.01.00.00 (Topography and Morphology) require consideration of effects on redistribution of radionuclides following an igneous event.

References CRWMS M&O. "Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEP)". ANL-MGR-MD-000011. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response DOE has agreed to revisit the issue of surface-redistribution of contaminated ash and soil as part of the resolution of agreement item for Igneous Activity Agreement KIA0206. Specifically, DOE has agreed to develop a linkage between soil removal rate and surface remobilization processes characteristics of the Yucca Mountain region and to document its approach to include uncertainty related to surface-redistribution processes in Total System Performance Assessment-Site Recommendation (CRWMS M&O 2000aq). Section 14.3.6.7 of Supplemental Science and Performance Analyses (DOE 2001, in progress), will provide an overview of the work that may be conducted to address this issue. (Response applicable to each listed feature, event and process) No additional work is required beyond the existing agreement.

Agreement Number

Agreement None yet available.

Subissue #2 - Scenario Analysis SA-ENFE-1

Tracking # SA-ENFE-1

Comment 2.2.10.06.00 [Thermo-chemical alteration (solubility speciation, phase changes, precipitation/dissolution)]. DOE has not provided the technical basis for excluding entrained colloids in the analysis of 2.2.10.06.00 [Thermo-chemical alteration (solubility speciation, phase changes, precipitation/dissolution)] or an alternative database entry (CRWMS M&O, 2001). DOE has not considered possible entrainment of colloids and particulates in convecting/advecting boiling fluids or by otherwise vigorous water movement in the drift.

References CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response

Agreement Number ENFE.1.06

Agreement Provide the technical basis for excluding entrained colloids in the analysis of FEP 2.2.10.06.00 (Thermo-Chemical Alteration) or an alternative FEP. The DOE will provide the technical basis for screening entrained colloids in the analysis of FEP 2.2.10.06.00 in a future revision of the Features, Events, and Processes in UZ Flow qnd Transport AMR (ANL-NBS-MD-000001), expected to be available in FY 02.

Subissue #2 - Scenario Analysis SA-USFIC-1

Tracking # SA-USFIC-1

Comment 2.2.07.18.00 (Film flow into drifts) is screened as included on the basis of low consequence (low film flow rates). Higher film flow rates into drifts are considered included (CRWMS M&O, 2001). Technical bases for the screening argument for 2.2.07.18.00 will derive from work needed to satisfy the Unsaturated and Saturated Flow Under Isothermal Conditions Subissue 4 Agreement 2.

References CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response

Agreement Number USFIC.4.02

Agreement Include the effect of the low-flow regime processes (e.g., film flow) in DOE's seepage fraction and seepage flow, or justify that it is not needed. DOE will include the effect of the low-flow regime processes (e.g., film flow) in the seepage fraction and seepage flow, or justify that it is not needed. These studies will be documented in Seepage Models for PA Including Drift Collapse AMR, MDL-NBS-HS-000002, expected to be available to NRC in FY 2003.

Subissue #2 - Scenario Analysis SA-ENFE-2

Tracking # SA-ENFE-2

Comment 1.2.06.00.00 (Hydrothermal Activity). This item is excluded in the unsaturated zone on the basis of low consequence and low probability (CRWMS M&O, 2001). The DOE has not yet provided sufficient technical bases for models explaining elevated temperatures in the unsaturated zone from about 12 Ma to 2 Ma, or adequately addressed the timing and mode of formation of the Type B faults which record elevated temperatures.

References CRWMS M&O. "Features, Events, and Processes in UZ Flow and Transport." ANL-NBS-MD-000001 Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response

Agreement Number ENFE.2.03 .

Agreement Provide the technical basis for FEP 1.2.06.00 (Hydrothermal Activity), addressing points (a) through (e) of NRC Subissue 2 slide handed out at the January 2001 ENFE technical exchange. The DOE will provide additional technical bases for the screening of FEP 1.2.06.00 (Hydrothermal Activity), in a future revision of the Features, Events, and Processes in UZ Flow and Transport AMR, ANL-NBS-MD-000001, expected to be available in FY 02. Within these technical bases, the DOE will address NRC comments [points (a) through (e)] presented on the NRC Subissue 2 slide handed out at the January 2001 ENFE technical exchange or provide justification that it is not needed.

Subissue #3 - Model Abstraction ENG 1.1.1

Tracking # ENG 1.1.1

Comment The general corrosion of a waste package is resampled part way through the degradation calculation. Technical basis is needed that the resampling of corrosion rates part way through the degradation calculation appropriately represents the physical processes occurring and that the results obtained when applying such a technique are in agreement with the original data (e.g. failure distribution and surface area failed over time).

References NRC. "Issue Resolution Status Report. Key Technical Issue: Total System Performance Assessment and Integration." Revision 3. Page 194. Washington, DC: NRC. 2000.

DOE Response The "resampling" is used to account for the dual closure lid waste package design used in TSPA-Site Recommendation (CRWMS M&O 2000ar). The closure lids are properly modeled as two separate entities (i.e., the model parameters are sampled for each closure lid). The remainder of the waste package outer barrier is indeed modeled as being composed of two "pseudo-barriers." Since failure of the closure lid weld regions determines the waste package failure time, the pseudo-barrier modeling approach used for the remainder of the waste package outer barrier is of little consequence to the expected mean annual DOSE rate. It is also expected that the current modeling approach does not affect significantly the waste package degradation analysis results and the peak DOSEs. It should be noted that in reality, general corrosion rates of the patches are likely to switch over time (i.e., rather than corroding at the same rate) throughout such a long exposure time period, and the current approach with the re-sampling of the rates a half way through is considered still highly conservative in light of the first breach time. Details of the justification for the insignificant consequence of the re-sampling of the general corrosion rate a half way through to the waste package degradation analyses will be documented in a future revision of the Waste Package Degradation Analysis/Model Report (CRWMS M&O 2000az).

Reference: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

CRWMS M&O 2000az. WAPDEG Analysis of Waste Package and Drip Shield Degradation. ANL-EBS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001208.0063.

Agreement Number TSPAI.3.02

Agreement DOE will provide the technical basis for resampling the general

corrosion rates and the quantification of the impact of resampling of general corrosion rates in an update to the WAPDEG Analysis of Waste Package and Drip Shield Degradation AMR (ANL-EBS-PA-000001). This AMR is expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction ENG 1.1.2

Tracking # ENG 1.1.2

Comment The model abstraction for the transport of water through stress corrosion cracks in the drip shield and diffusive transport of radionuclides through the stress corrosion cracks in the waste packages are also based on a beneficial FEP (2.1.03.10.00 Container Healing) that was included for the EBS in the TSPA- SR (Table B-12 p. B-37) and the Engineered Barrier System Process Model Report even though it has been excluded on the basis of low consequence in the Drip shield and Waste Package FEPs AMR as well as the Engineered Barrier System FEPs AMR

The screening argument in the FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation, ANL-EBS-PA-000002 Rev 01, (February, 2001), specifically addresses transport of both water and radionuclides and states in FEP 2.1.03.10.00 "Plugging (or healing) of corrosion holes or pits in the waste container by corrosion products and mineral precipitates is a possible process in the repository. However there are large uncertainties associated with the quantification of the effect of the processes on water flow and radionuclide transport through the openings. Because of this, potential performance credit from the plugging (or healing) of the corrosion penetration openings are not taken into account in the TSPA analysis. Therefore this FEP is excluded based on low consequence to the expected annual dose."

The model abstraction for transport through stress corrosion cracks in the drip shield and waste packages should be consistent with the FEP screening arguments. The technical basis for the tight crack geometries that prevent advective transport through stress corrosion cracks in the waste package should be provided.

References
CRWMS M&O. "Engineered Barrier System Degradation, Flow and Transport Process Model Report." TDR-EBS-MD-000006. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.
CRWMS M&O. "FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation." ANL-EBS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.
CRWMS M&O. "Engineered Barrier System Features, Events, and Processes." ANL-WIS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response The arguments of the tightness of stress corrosion cracks and plugging of the cracks by corrosion products and mineral precipitates were used to screen out the drip shield stress corrosion cracking. Recent analysis has shown that these cracks are expected to be plugged by mineral precipitates (e.g., calcite) within a few decades (BSC 2001d, Tables 6-3 and 6-5). The very limited flow of water through the plugged cracks would not

compromise the intended function of the drip shield (i.e., diversion of dripping water). Moisture would still be available from the humid air in the emplacement drift, and condensation of water occur on the waste package surface provided the humidity of the surrounding air in the emplacement drift is high enough. The water condensation would be greatly enhanced if the waste package surface were contaminated with dust and/or hygroscopic salts. Therefore, the plugged stress corrosion cracks in the drip shield would not affect the intended function of the drip shield, and the drip shield stress corrosion cracking has been screened out (CRWMS M&O 2001e).

The TSPA-Site Recommendation assumes (CRWMS M&O 2000ar) diffusion is the dominant transport process for radionuclide release through the plugged stress corrosion cracks in the waste package. It is acknowledged that the screening arguments for FEP 2.1.03.10.00 (Container Healing) need to be updated to incorporate the latest analysis for the SCC crack plugging and to be consistent with the TSPA analysis. The waste package FEPs Analysis/Model Report (CRWMS M&O 2001e) will be revised to update the screening argument.

References: BSC 2001d. Plugging of Stress Corrosion Cracks by Precipitates. CAL-EBS-MD-000017 REV 00A. Las Vegas, Nevada: Bechtel SAIC Company. Submit to RPC.

CRWMS M&O 2001e. FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation. ANL-EBS-PA-000002 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL20010216.0004.

CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045

Agreement Number TSPAI.3.03

Agreement DOE will provide the technical basis for crack arrest and plugging of crack openings (including the impact of oxide wedging and stress redistribution) in assessing the stress corrosion cracking of the drip shield and waste package in an update to the Stress Corrosion Cracking of the Drip Shield, Waste Package Outer Barrier, and the Stainless Steel Structural Material AMR, ANL-EBS-MD-000005, in accordance with the scope and schedule for existing agreement item CLST 1.12.

Subissue #3 - Model abstraction ENG 1.3.1

Tracking # ENG 1.3.1

Comment DOE should explain why crevice samples yield higher corrosion rates than non-crevice samples in the Long Term Corrosion Testing experiments. Is it possible that enhanced corrosion rates as a result of a less protective film are occurring in the crevice area? Is the equation to compute corrosion rates (CRWMS M&O, 2000, Equation 3-15) adequate if there are small regions of enhanced dissolution? Equation 3-15 in (CRWMS M&O, 2000) is

$$r = w/(d*A*t)$$

r = corrosion rate (m/yr)
w = weigh loss (kg)
d = Alloy 22 density (kg/m3)
A = surface area of coupon sample (m2, 30.65 and 57.08 cm2 for weight loss and crevice samples, respectively, CRWMS M&O, 2000, p 3-41)
t = duration of weight loss test (yr)

A corrosion rate derived using Equation 3-15 can be interpreted as an average rate on the surface of the sample. It is not clear that this average is a valid corrosion rate in case of existence of small regions with high dissolution rates.

References CRWMS M&O. "Waste Package Degradation PMR." TDR-WIS-MD-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Container Life and Source Term agreement 1.4 will address the higher corrosion rates in crevice samples versus non-crevice (weight loss) samples. Overall, the crevice specimens do not systematically indicate higher general corrosion rates than the weight loss coupons, but there are some data sets where the average rate and range of rates from crevice specimens do appear higher. DOE is in the process of performing a more detailed analysis of the data sets to determine whether there is bias in the results and if so, what factors may be responsible.

When the 5 year corrosion data become available in February 2002, additional physical measurements will be performed and the difference between the corrosion rates for crevice and non-crevice samples will be reassessed.

Agreement Number TSPAI.3.01

Agreement The technical basis for sources of uncertainty will be established upon completion of existing agreement items CLST 1.4, 1.5, 1.6, and 1.7. DOE will then propagate significant sources of uncertainty into projections of waste package and drip shield

performance included in future performance assessments. This technical basis will be documented in a future revision of the General and Localized Corrosion of Waste Package Outer Barrier AMR, ANL-EBS-MD-000003, expected to be available consistent with the scope and schedules for the specified CLST agreements. The results of the AMR analyses will be propagated into future TSPA analyses for any potential license application.

Subissue #3 - Model abstraction ENG 1.3.2

Tracking # ENG 1.3.2

Comment DOE should explain why corrosion rates tend to decrease with test duration in the Long Term Corrosion Testing experiments.

It has been explained that decreasing corrosion rates are the result of a passive film that thickens with time (CRWMS M&O, 2000, p 3-42). Is there any evidence that the passive film on 2-year samples is thicker than the 0.5 and 1-year samples? The inner chromium-rich oxide film, which is responsible for passivity, is likely to achieve steady-state in a short time (few weeks), at which time the inner film may maintain a constant thickness. The outer layer(s) in the film are not necessarily responsible for passivity.

References CRWMS M&O. "Waste Package Degradation PMR." TDR-WIS-MD-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The observed decrease in corrosion rate with time for long term corrosion test samples exposed for 0.5, 1.0 and 2-2.3 years is attributed to a combination of factors as indicated below:

The actual Alloy 22 corrosion rates measured on the currently used small surface area specimens in the various Long Term Corrosion Test Facility environments at 60 and 90oC are too low to allow accurate measurement by descaled weight loss. Whereas the measured corrosion rates indicate a decrease with time (mean rate decreases from 0.05 microns/year at six month to 0.01 microns/years), the calculated weight loss uncertainty due to various measurement errors is equivalent to ~0.04 microns metal loss at one standard deviation (CRWMS M&O 2000be, p. 74). Thus, any corrosion rate trend at shorter test times is partially masked by the measurement uncertainty.

For the most passive materials, and the types of expected environments, the passive film thickness and resulting corrosion rate rapidly reach an essentially constant value. Thus, as the test time increases, the measured corrosion rate would be expected to approach the true value since the weight loss uncertainty becomes a smaller fraction of the actual weight loss.

The Container Life and Source Term agreement 1.6 indicates that DOE will resolve the corrosion rate uncertainty by using higher sensitivity corrosion rate measurement techniques and by directly measuring the passive film growth kinetics using techniques such as the Tunneling Atomic Force Microscope.

Reference: CRWMS M&O 2000be. General Corrosion and

Localized Corrosion of Waste Package Outer Barrier. ANL-EBS-MD-000003 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000202.0172.

Agreement Number TSPAI.3.01

Agreement The technical basis for sources of uncertainty will be established upon completion of existing agreement items CLST 1.4, 1.5, 1.6, and 1.7. DOE will then propagate significant sources of uncertainty into projections of waste package and drip shield performance included in future performance assessments. This technical basis will be documented in a future revision of the General and Localized Corrosion of Waste Package Outer Barrier AMR, ANL-EBS-MD-000003, expected to be available consistent with the scope and schedules for the specified CLST agreements. The results of the AMR analyses will be propagated into future TSPA analyses for any potential license application.

Subissue #3 - Model abstraction ENG 1.3.3

Tracking # ENG 1.3.3

Comment DOE should provide additional technical basis in support of the interpretation of the experimental data from the Long Term Corrosion Test Facility.

For example,
(A)
Deposition of corrosion products producing "weight gain" may compete with dissolution through the film causing "weight loss," thus weight loss measurements may underestimate corrosion rates. Precipitates have been observed on Alloy 22 under transpassive conditions (Dunn et al., 2001).

(B)
It has been explained that the observed weight gain is due to the formation of silica precipitates. Do silica precipitates form an insulating coating? Is it possible that the apparent decrease in the corrosion rate with time is due to a decrease in the extent of the reactive surface area? Note that longer term testing tended to yield more samples with weight gain (up to 40% of the total number of samples).

(C)
It has been estimated that correcting apparent corrosion rates by 63 nm/yr is sufficient to provide an estimate of intrinsic corrosion rates. Note the following computations:

Simulated Dilute Water conditions (SDW), Weight Loss Specimens - 6 month
Average corrosion rate = 27 nm/yr
Penetration of corrosion front = 27x0.5 = 13.5 nm SDW,
Weight Loss Specimens B 1 year
Average corrosion rate = -22 nm/yr
Penetration of corrosion front = -22x1 = -22 nm
Penetration of the corrosion front from 0.5 yr to 1 yr = -22 nm - 13.5 nm = -35.5 nm

If the "outward" motion of the surface is due to silica deposits, the rate of deposition would be 35.5/0.5 = 71 nm/yr. This number of 71 nm/yr is greater than the correction of 63 nm/yr used in the abstraction.

(D)
Caution must be taken when defining corrosion rates with PDFs having wide variances so as to avoid risk dilution.

References CRWMS M&O. "Waste Package Degradation PMR." TDR-WIS-

MD-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response (A, B & C)
The current DOE analysis includes a correction to the general corrosion rates from the weight loss measurements for potential incomplete de-scaling of silica deposit on the sample coupons. Observations of limited number of sample coupons with atomic force microscope showed varying degrees of coverage of the sample coupon surface by the silica scale. The maximum correction of 63 nm/yr is for the complete coverage of the coupon surface by silica scale. In the DOE analysis, the correction for potential incomplete de-scaling of the silica deposit from sample coupons is accomplished by sampling the correction factor from uniform distribution between 0 and 63 nm/yr and adding the sampled factor to the general corrosion rate distribution. The maximum corrosion rate adjustment of 63 nm/yr is consistent with current experimental data. If ongoing experiments show a higher corrosion rate adjustment is appropriate, then a higher rate adjustment will be incorporated into the corrosion models.

It should be noted that the presence of silica scale on the Alloy 22 coupons would provide a certain level of protection against corrosion attack. With silica scale forming on the waste package (and drip shield) surface, which is very likely under expected repository exposure conditions, the current analysis is a realistic measure for the general corrosion rate of the waste package.

The Container Life and Source Term agreement 1.6 identifies specific activities to resolve the ambiguity regarding silica deposition and calculation of a factor to account for its influence in the general corrosion rate of Alloy 22 specimens. Corrosion data for silica-free environment will provide additional valuable information to resolve the issues associated with potential effect of silica deposit on the general corrosion rate.

(D)
Sensitivity analyses were conducted for effect of varying number of waste packages and patches on a waste package (CRWMS M&O 2000az, Section 6.4.3), which provides good indications on the stability of the analysis results from the perspective of the sampling of the tails of the stochastic input parameters (e.g., general corrosion rate distribution). The analysis results show that a larger number of waste packages and patches per waste package than the current analysis (i.e., 400 waste packages per simulation and 1,000 patches per waste package) do not have impact on the waste package degradation results (CRWMS M&O 2000az, Section 6.4.3). This demonstrates that the tails of the current general corrosion rate distribution are represented appropriately in

the current analysis.

Reference: CRWMS M&O 2000az. WAPDEG Analysis of Waste Package and Drip Shield Degradation. ANL-EBS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001208.0063.

Agreement Number TSPAI.3.01

Agreement The technical basis for sources of uncertainty will be established upon completion of existing agreement items CLST 1.4, 1.5, 1.6, and 1.7. DOE will then propagate significant sources of uncertainty into projections of waste package and drip shield performance included in future performance assessments. This technical basis will be documented in a future revision of the General and Localized Corrosion of Waste Package Outer Barrier AMR, ANL-EBS-MD-000003, expected to be available consistent with the scope and schedules for the specified CLST agreements. The results of the AMR analyses will be propagated into future TSPA analyses for any potential license application.

TSPAI.3.04 - DOE will provide the technical basis that the representation of the variation of general corrosion rates results in reasonably conservative projected dose rates. The technical basis will be documented in an update to the WAPDEG Analysis of Waste Package and Drip Shield Degradation AMR, ANL-EBS-PA-000001. This AMR is expected to be available to NRC in FY 2003. These results will be incorporated into future TSPA documentation for any potential license application.

Subissue #3 - Model abstraction ENG 1.3.4

Tracking # ENG 1.3.4

Comment Corrosion rates and TSPA computations.

(A) Including a factor for MIC uniformly sampled in the range (1,2) and a factor for thermal aging and phase instability uniformly sampled in the range (1,2.5) empirical PDF for corrosion rates (including 0.5-yr, 1-yr, and 2-yr test data) may produce general corrosion failure times as early as 5,000 yr. Similar independent computations by the NRC with only 2-yr test data produce much later failure times. Thus, it is very important to provide appropriate technical basis to disregard the 0.5-yr and 1-yr test data in the model abstraction.

(B) The independent computations by the NRC followed a simple approach. Corrosion rates were sampled from empirical PDFs, enhanced by the MIC and thermal aging factors. Failure times were computed as 2 cm/r, where r is the corrosion rate in cm/yr. This approach disregards the delay in the onset of aqueous environments (<<1,000 yr); however, these simple computations are expected to yield results comparable to those derived from complex models.

In particular, Figure 3.4-20 in TSPA-SR is directly comparable to results of the independent NRC computations. DOE should explain why only at most 1% of the waste package surface is degraded by general corrosion at 100,000 yr, while simple computations indicate an expected value of ~30% at 100,000 yr.

References CRWMS M&O. "Total System Performance for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response A.

The Alloy 22 2-year exposure corrosion rates were used to develop the general corrosion rate distribution used in Performance Assessment. The corrosion rate distributions obtained from the Long Term Corrosion Test Facility show that as the exposure time increases, the median and variance of the corrosion rates decrease. This indicates that longer-term measurements would result in lower corrosion rate distributions. Furthermore, it has been shown that as exposure time increases the error in the Long Term Corrosion Test Facility measurements decreases (CRWMS M&O 2000ar, Table 16). These observations provide appropriate technical basis to disregard the 0.5-yr and 1-yr test data in the model abstraction.

Analyses of corrosion rates appropriate for use over long time periods are part of existing Container Life and Source Term

agreements (1.4, 1.7, 1.8).

B.
(CRWMS M&O 2000ar) shows the percentage of waste package patch breaches per failed waste package. In the DOE model, waste packages may breach by cracks or patches. In Figure 2, only general corrosion processes are considered (no cracks were considered). Therefore, Figure 2 is not directly comparable to Figure 3.4-20 in the TSPA-Site Recommendation. The results of the cases in Figure 2 were reproduced in Waste Package Degradation Model and the results are in general agreement with those shown in Figure 2. In a telecon (7/11/2001) between DOE and NRC, it was confirmed that with the discrepancies in the approach resolved, the NRC results are sufficiently close to the current DOE analysis results.

The basis for not excluding microbial induced corrosion from a microbial communities standpoint is documented in the In-Drift Microbial Communities Analysis/Model Report (CRWMS M&O 2000ac).

References: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

CRWMS M&O 2000ac. In-Drift Microbial Communities. ANL-EBS-MD-000038 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001213.0066.

Agreement Number TSPAI.3.01

Agreement The technical basis for sources of uncertainty will be established upon completion of existing agreement items CLST 1.4, 1.5, 1.6, and 1.7. DOE will then propagate significant sources of uncertainty into projections of waste package and drip shield performance included in future performance assessments. This technical basis will be documented in a future revision of the General and Localized Corrosion of Waste Package Outer Barrier AMR, ANL-EBS-MD-000003, expected to be available consistent with the scope and schedules for the specified CLST agreements. The results of the AMR analyses will be propagated into future TSPA analyses for any potential license application.

Subissue #3 - Model abstraction ENG 1.3.5

Tracking # ENG 1.3.5

Comment High corrosion rates, upper tails of PDFs.

(A) It is assumed that corrosion rates are normally distributed (CRWMS M&O, 2000, p 3-36, 3-113), an assumption that seems adequate for the 2-yr testing data. However, this assumption is not valid if all the testing data (0.5, 1, and 2 yr) is considered in the statistical population. Furthermore, for the extended population set (0.5, 1, and 2 yr), the normal distribution underestimates the high corrosion rates. Using the Gauss-Variance partitioning scheme is not enough to define confidence intervals for the high corrosion rates. Independent NRC computations indicate that much earlier failure times are predicted on the basis of an empirical PDF (i.e., defined using experimental corrosion rates) than those derived using normal PDFs of the Gauss-Variance Partitioning approach.

The intention of this comment is suggesting that if all data available is used to define normal PDFs, there is some risk of predicting larger than expected early failure times, because normal PDFs do not capture the high corrosion rates.

(B) High corrosion rates are most relevant to model abstraction. The size of the statistical population should be large enough to define the upper tail of the PDF for the corrosion rate with confidence.

References CRWMS M&O. "Waste Package Degradation PMR." TDR-WIS-MD-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The corrosion rates are not assumed to be normally distributed. They are given by an empirical Cumulative Distribution Function derived from the two-year experimental data and corrected for silica deposition. Gaussian-Variance Partitioning (GVP) preserves the span of the general corrosion rate distribution. The highest and lowest values are present in every GVP output. The Cumulative Distribution Function probabilities are mapped to normal probabilities; the variance is partitioned; and the probabilities are mapped back to real space. The net effect is that variance is partitioned between uncertainty and variability. The resulting distribution is not normally distributed.

The Alloy 22 2-year exposure corrosion rates were used to develop the general corrosion rate distribution used in Performance Assessment. The corrosion rate distributions obtained from the Long Term Corrosion Test Facility show that as the exposure time increases, the median and variance of the corrosion rates decrease. This indicates that longer-term measurements would

result in lower corrosion rate distributions. Furthermore, it has been shown that as exposure time increases the error in the Long Term Corrosion Test Facility measurements decreases (CRWMS M&O 2000be, Table 16). These observations provide appropriate technical basis to disregard the 0.5-yr and 1-yr test data in the model abstraction.

Analyses of corrosion rates appropriate for use over long time periods are part of existing Container Life and Source Term agreements (1.4, 1.7, 1.8).

(B)
TSPA simulations use 100 (sometimes 300) realizations with 400 waste package/drip shield pairs per realization. Each drip shield has 500 patches and each waste package has 1000 patches. In all some 40,000,000 patches are simulated to determine the mean annual DOSE.

Reference: CRWMS M&O 2000be. General Corrosion and Localized Corrosion of Waste Package Outer Barrier. ANL-EBS-MD-000003 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000202.0172.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction ENG 1.3.6

Tracking # ENG 1.3.6

Comment Staff believes that the interpretation of the corrosion-rate data could make a significant difference in the regulatory dose, and therefore disagrees with the DOE conclusion in section 5.2.3.3 of the TSPA results that there is little effect from Gaussian Variance Partitioning (GVP).

NRC staff has developed a highly abstracted model of the relationship between failed WP area and peak mean dose, and believes there are circumstances where assuming that the corrosion rate data represent mostly spatial variability will lead to a higher peak mean dose than if the same data represented mostly experimental uncertainty.

References CRWMS M&O. "Total-System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2001.

DOE Response Assuming enough samples are considered, one would expect little effect of a sampling scheme on the mean DOSE. This is shown in Section 5.2.3.3 of the TSPA in Figures 5.2-7 and 5.2-8.

In a given realization, increased spatial variability should lead to the potential for earlier failure and decrease the peak DOSEs. It is agreed that increased spatial variability could lead to higher peak DOSEs for the mean DOSE.

Review of the NRC analysis results provided to DOE and subsequent discussion of the results during a recent DOE and NRC telecon (7/11/2001 teleconference) confirmed that the NRC results of the relationship between failed waste package area and peak mean DOSE are driven mostly by the modeling assumptions made for the radionuclide transport from the failed waste packages and through the failed area. In the NRC analysis, the effect of the waste package failed area and its subsequent degradation (i.e., additional failed areas) with time on the peak mean DOSE that result from the two end-member cases assuming 100% variability and 100% uncertainty in the Alloy 22 general corrosion rate is secondary to the effect of the transport modeling assumptions. The discrepancies of the peak mean DOSE to the conceptual understanding for the two end-member cases (i.e., higher peak mean DOSEs with the 100% variability case) become greater when more conservative assumptions are employed for the transport modeling. In comparison, the DOE analysis results for the two end-member cases show no significant difference in the peak mean DOSEs.

Reference: CRWMS M&O 2000ar. Total System Performance

Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

Agreement Number TSPAI.3.05

Agreement DOE will provide the technical basis for the representation of uncertainty/variability in the general corrosion rates. This technical basis will include the results of 100% uncertainty, 100% variability, and selected intermediate representations used in the DOE model. These results will be documented in an update to the WAPDEG Analysis of Waste Package and Drip Shield Degradation AMR, ANL-EBS-PA-000001, or other document. This AMR is expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction ENG 1.4.1

Tracking # ENG 1.4.1

Comment The DOE model abstraction assumes diffusive transport of radionuclides through stagnant water that fills stress corrosion cracks in the waste packages and lack of water transport through cracks in the drip shield. This assumption has a direct effect on dose because it is assumed that advective transport of radionuclides by flowing water through stress corrosion cracks in the waste package does not occur. In addition, the DOE model assumes that the quantity of water that is transported through cracks in the titanium alloy drip shield is limited by diffusion. Stress corrosion cracking of the drip shield has been excluded as a FEP on the basis of low consequence because water transport through cracks in the drip shield will not significantly increase the quantity of water contacting the waste packages and waste forms.

The assumption of diffusive transport of radionuclides with the exclusion of advective transport relies on stress corrosion crack geometries that will remain tight for thousands of years. The tight geometry of stress corrosion cracks are in turn based on unsupported assumptions. For the waste packages, it is assumed that the stress corrosion cracks will cease to propagate when the lid is penetrated. Secondary cracks and crack branching, which may contribute to crack opening displacement and subsequently allow advective transport of radionuclides by slow flowing water, are not considered in the DOE model.

References CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." MDL-WIS-PA-000002. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.
CRWMS M&O. "WAPDEG Analysis of Waste Package and Drip Shield Degradation." ANL-EBS-PA-000001. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The previous analyses using the fundamental relation of fracture mechanics have shown that the stress corrosion crack openings in drip shield and waste package are very "tight" (CRWMS M&O 2000ao, Section 6.5.5). The cracks in the drip shield due to rockfall (CRWMS M&O 2000am, Section 6; CRWMS M&O 2000ao, Section 6.5.5) and hydrogen induced cracking (CRWMS M&O 2000x, Section 6.3.4) are self-limited and remain tight. These tight cracks will be plugged by corrosion products and mineral precipitates. Recent analyses have shown that stress corrosion cracks are expected to be plugged by calcite within a few decades (BSC 2001d, Tables 6-3 and 6-5). Very limited water flow is expected through the plugged stress corrosion cracks. Because such plugged stress corrosion cracks would not affect the intended function of the drip shield (i.e., diversion of dripping water), the drip shield stress corrosion cracking was screened out and not modeled

in the waste package degradation analysis and TSPA-Site Recommendation.

Secondary cracks and crack branching are not modeled explicitly in the TSPA-Site Recommendation waste package degradation analysis. Because, when a crack propagates through the wall thickness, the tensile stress that has driven the crack propagation is relieved, no additional crack growth is assumed in the "immediate" vicinity of the through-wall crack. In the TSPA-Site Recommendation waste package degradation analysis, multiple cracks are allowed to grow in a single patch, and when that patch is breached by a stress corrosion crack, all remaining cracks in that patch cease to grow because of the stress relief in the immediate vicinity of the through-wall crack.

The waste package closure-lid weld region is represented with a total of 32 patches. Because one through-wall stress corrosion crack per patch is assumed in the waste package degradation analysis, the modeled maximum number of through-wall stress corrosion cracks per waste package is 32. In the TSPA-Site Recommendation analysis, the number of through-wall stress corrosion cracks estimated from the waste package degradation analysis is increased conservatively by a factor of 10 for the actual number of through-wall stress corrosion cracks used for transport calculations. The factor of 10 increase in the number of through-wall stress corrosion cracks is based on the "2T" rule, where T is the thickness of material subject to stress corrosion. The area represented by the "2T" rule is referred to a unit area in this discussion. The rule indicates that within an area that is represented by approximately two times the thickness of the material, a stress corrosion crack can grow without interfering with the neighboring stress corrosion cracks. For the weld region of the outer closure-lid (25-mm thick) of the waste package outer barrier, the "unit" area represented by the 2T rule is approximately 25 cm2 [(2x2.5 cm) x (2x2.5 cm)]. The unit area for the weld region of the inner closure-lid (10-mm thick) of the outer barrier is approximately 4 cm2 [(2x1.0 cm) - (2x1.0 cm)]. With the area of a single patch of approximately 234 cm2 (CRWMS M&O 2000az, Section 5.1), there are approximately 9.4 unit areas for the outer closure-lid weld region. This is the technical basis to increase conservatively the number of through-wall stress corrosion cracks from the waste package degradation analysis by a factor of 10 for the TSPA analysis. This is a highly conservative approach because it assumes that when a patch is breached by a through-wall stress corrosion crack, there are nine additional through-wall stress corrosion cracks penetrating that patch at the same time.

For the inner closure-lid weld region, the number of the unit areas per patch is much higher (approximately 59 unit areas) than the outer closure-lid weld region. However, the same number of the unit areas per patch as the outer closure-lid weld region is assumed for the inner closure-lid weld region. Because the approach used for the outer closure-lid weld region is already highly conservative, use of the same number of the unit areas per patch for the inner closure-lid weld region is considered reasonably conservative. Accordingly, the maximum possible number of through-wall stress corrosion cracks per waste package used in the TSPA-Site Recommendation analysis is 320. Details of the technical basis and accompanying assumptions will be documented in a future revision of the Waste Package Analysis/Model Report (CRWMS M&O 2000az).

As discussed above, the through-wall crack and secondary cracks (although not modeled explicitly) would be plugged by corrosion products and mineral precipitates in a relatively short time period (BSC 2001d, Tables 6-3 and 6-5), and exclusion of explicit representation of secondary cracks should not underestimate the transport rates of radionuclides through the plugged stress corrosion cracks. In a more realistic scenario, secondary cracks would increase tortuosity of the transport pathway, and non-inclusion of secondary cracks may be more conservative for the transport rate of radionuclides.

However, potential effects of static loads and/or rockfall on degraded drip shield and waste package by stress corrosion cracking and general corrosion have not been considered. This issue will be addressed under the Container Life and Source Term Agreement Item 2.8 prior to any potential License Application.

References: BSC 2001d. Plugging of Stress Corrosion Cracks by Precipitates. CAL-EBS-MD-000017 REV 00A. Las Vegas, Nevada: Bechtel SAIC Company. Submit to RPC.

CRWMS M&O 2000ao. Stress Corrosion Cracking of the Drip Shield, the Waste Package Outer Barrier, and the Stainless Steel Structural Material. ANL-EBS-MD-000005 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001102.0340.

CRWMS M&O 2000am. Rock Fall on Drip Shield. CAL-EDS-ME-000001 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000509.0276.

CRWMS M&O 2000x. Hydrogen Induced Cracking of Drip Shield. ANL-EBS-MD-000006 REV 00 ICN 01. Las Vegas, Nevada:

CRWMS M&O. ACC: MOL.20001025.0100.

CRWMS M&O 2000az. WAPDEG Analysis of Waste Package and Drip Shield Degradation. ANL-EBS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001208.0063.

Agreement Number TSPAI.3.03

Agreement DOE will provide the technical basis for crack arrest and plugging of crack openings (including the impact of oxide wedging and stress redistribution) in assessing the stress corrosion cracking of the drip shield and waste package in an update to the Stress Corrosion Cracking of the Drip Shield, Waste Package Outer Barrier, and the Stainless Steel Structural Material AMR, ANL-EBS-MD-000005, in accordance with the scope and schedule for existing agreement item CLST 1.12.

Subissue #3 - Model Abstraction ENG 1.5.1

Tracking # ENG 1.5.1

Comment Validation of WAPDEG is still pending by DOE's own account, particularly validation of the Gauss Variance Partitioning methodology.

References CRWMS M&O. "Waste Package Degradation PMR." TDR-WIS-MD-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The Waste Package Degradation software was unqualified and has since been qualified. The qualification efforts included execution of approximately 100 test cases (CRWMS M&O 2000ax) verifying the operation of various segments of the Waste Package Degradation code. The Waste Package Degradation Model has also been validated in accordance with applicable DOE procedures. The WAPDEG Analysis of Waste Package and Drip Shield Degradation (CRWMS M&O 2000az) was reviewed in accordance with applicable DOE procedures. The review included reviewers from quality assurance, waste package materials, and regulatory and licensing organizations. An International/National Waste Package Materials Peer Review is underway to review and improve corrosion testing and modeling approaches. Also, studies are underway of relevant natural analogues.

References: CRWMS M&O 2000ax. Validation Test Report (VTR) for WAPDEG V4.0. STN: 1000-4.0-00, SDN: 10000-VTR-4.0-00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001205.0014.

CRWMS M&O 2000az. WAPDEG Analysis of Waste Package and Drip Shield Degradation. ANL-EBS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001208.0063.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction ENG 1.5.2

Tracking # ENG 1.5.2

Comment Model validation is argued to be done implicitly through sub-model validation. It is unclear that this approach satisfies DOE QA requirements for model validation.

The above comment was accurate for Rev 00 of the referenced document. In ICN 01, all references to "conceptual model" have been removed and replaced with "conceptualization" in most cases. First and foremost it is unclear what the difference is between a "conceptual model" and a "conceptualization". Second, this document discusses appropriate connections and integration of in-drift models. These connections and integration are developed via analysts determining what an appropriate framework may be. It is unclear why this part of performance assessment model development would not be subject to the same degree of model support required of individual process models.

References CRWMS M&O. "Physical and Chemical Environmental Abstraction Model AMR." ANL-EBS-MD-000046. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response REV 01 of the Physical and Chemical Environmental Abstraction Model AMR (CRWMS M&O 2001l) describes more clearly the nature and purpose of the document. It presents an overall conceptualization of the physical and chemical environment in the emplacement drift, as stated in Sections 1 and 6 of REV 01. Use of this conceptualization is limited to assistance for the Performance Assessment Department in modeling the physical and chemical environment within a repository drift and in answering key technical issues, as stated in Section 7.5 of ICN 01 (CRWMS M&O 2000bf).

However, the Physical and Chemical Environmental Abstraction Model Analysis/Model Report, along with the remainder of the project Analysis/Model Reports that support TSPA-Site Recommendation are being re-evaluated as part of Corrective Action Report-BSC-01-C-001. The scope of the Corrective Action Report includes identifying deficiencies in model validation and identifying the subset of the TSPA-Site Recommendation Analysis/Model Reports that need to be carried forward to any potential License Application.

References: CRWMS M&O 2000bf. Physical and Chemical Environmental Abstraction Model. ANL-EBS-MD-000046 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001204.0023.

CRWMS M&O 2001l. Physical and Chemical Environmental Abstraction Model. ANL-EBS-MD-000046 REV 01. Las Vegas,

Nevada: CRWMS M&O. Submit to RPC.

Letter from S.J. Brocoum to W. Reamer, Total System Performance Assessment Quality Issues, dated July 6, 2001

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction ENG 1.TT.1

Tracking # ENG 1.TT.1

Comment The abstraction for degradation of engineered barriers does not use consistent and appropriate assumptions throughout the abstraction process. The stated assumption that the drip shield is not subject to SCC is inconsistent with the discussions for FEP 2.1.03.02.00 (stress corrosion cracking of waste containers and drip shield), which indicate the potential for SCC of the drip shield and the expected attributes of the cracks that would develop (i.e small crack opening that will fill with corrosion products and carbonate minerals).

The discussion of the abstraction in the TSPA should be consistent with the discussions in the supporting Analysis and Model Reports.

References CRWMS M&O. "FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation." ANL-EBS-PA-000002. Revision 01. Las Vegas, Nevada: CRWMS M&O. 2001.
CRWMS M&O. "Total-System Performance Assessment for the Site Recommendation." TDR-WIS-PA-000001. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000a.
CRWMS M&O. "Total System Performance Assessment Model for Site Recommendation." MDL-WIS-PA-000002. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000b.

DOE Response The assumption that the drip shield is not subject to stress corrosion cracking in the absence of rockfall is valid. However, the potential for rockfall induced stress corrosion cracking is acknowledged in the Waste Package FEP Analysis/Model Report (CRWMS M&O 2001e). It was concluded that the consequences of the cracking were very low because the cracks are expected to be plugged by corrosion products and deposits.

DOE will update the FEPs Analysis/Model Report to clarify the FEPs screening argument and to make it consistent with TSPA-Site Recommendation (CRWMS M&O 2000ar, p. 3-91).

References: CRWMS M&O 2001e. FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation. ANL-EBS-PA-000002 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010216.0004.

CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

Agreement Number

Agreement DOE response during Technical Exchange was considered

adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction ENG 2.1.1

Tracking # ENG 2.1.1

Comment The DOE has implemented seismic effects on cladding via random sampling for the occurrence of a seismic event of sufficient magnitude (1.1E-6/yr). Unless thousands of realizations are completed, it is unlikely that the approach adopted results in a stable dose estimate. It is also unclear that risks are not underestimated utilizing this method of abstraction. The DOE should consider alternative methods for abstracting seismic cladding failure events.

References NRC. "Issue Resolution Status Report. Key Technical Issue: Total System Performance Assessment and Integration." Revision 3. Page 197. Washington, DC: NRC. 2000.

DOE Response Emphasis in the TSPA-Site Recommendation was on the first 10,000 years of performance, with simulations extended to 100,000 years to evaluate the behavior of the system after the containment of the engineered barriers is significantly degraded and to show that doses remain below the proposed limits well past 10,000 years (CRWMS M&O 2000ar, Section 4.1.1). Because of the robust waste package performance in TSPA-Site Recommendation, seismic cladding failures occurring prior to 10,000 years would not have an affect on releases from the Engineered Barrier System, and therefore do not affect the stability of the expected annual dose during the regulatory period.

As discussed at the Structural Deformation & Seismicity technical exchange in October 2000 (P. Swift presentation), the DOE recognizes that the approach taken for including seismic cladding failure in the TSPA-Site Recommendation does not provide full statistical coverage of the uncertainty associated with consequences of low-probability seismic events. However, the approach is considered appropriate for the TSPA-Site Recommendation for the following reasons:

1)
There is no impact on the expected annual dose from nominal performance during the first 10,000 years. (Cladding damage is already included in the dose calculated for igneous scenario analyses).

2)
During the first 100,000 years, consequences of seismic cladding failure were effectively bounded by the cladding neutralization analysis published in Repository Safety Strategy Rev. 4 (CRWMS M&O 2001i, Figure 3-29) and presented by Swift at the October 2000 Structural Deformation & Seismicity technical exchange. This analysis showed an increase in mean annual dose of

approximately a factor of ten.

3)
The approach provides insight into possible effects of seismic cladding damage on peak dose occurring after 10,000 years, because approximately 60% of million-year simulations include a seismic cladding failure event.

As discussed at the Structural Deformation & Seismicity technical exchange in October 2000, if future analyses show the potential for a significant impact of seismic cladding failure on expected annual dose during the regulatory period (such as might occur if ground motion were also to breach waste packages), DOE will revise the approach to ensure that risks are not underestimated.

References: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

CRWMS M&O 2001i. Repository Safety Strategy: Plan to Prepare the Safety Case to Support Yucca Mountain Site Recommendation and Licensing Considerations. TDR-WIS-RL-000001 REV 04 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010329.0825

Agreement Number TSPAI.3.06

Agreement DOE will provide the technical basis for the methodology used to implement the effects of seismic effects on cladding in revised documentation. DOE will demonstrate that the methodology used to represent the seismic effects of cladding does not result in an underestimation of risk in the regulatory timeframe in TSPA-LA. The documentation is expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction ENG 2.1.2

Tracking # ENG 2.1.2

Comment Insufficient information is available to evaluate the extent of damage to proposed waste packages during potential intrusive igneous events. The analyses for limited waste-package damage in Zone 2 do not consider physical conditions representative of likely igneous events and do not evaluate the range of physical processes likely to affect waste package response during potential igneous events.

References CRWMS M&O. "Igneous Consequence Modeling for the TSPA-SR." ANL-WIS-MD-000017. Revision 00. Las Vegas, Nevada: U.S. Department of Energy, Yucca Mountain Site Characterization Office. 2000a.
CRWMS M&O, "Waste Package Behavior in Magma." CAL-EBS-ME-000002. Revision 00. Las Vegas, Nevada: U.S. Department of Energy, Yucca Mountain Site Characterization Office. 2000b.

DOE Response Addressed during the Igneous Activity KTI Technical Exchange meeting June 21-22, 2001.

Agreement Number

Agreement Igneous Activity KTI Technical Exchange, June 21-22, 2001.
DOE response to this comment is unsatisfactory and will require further discussion.

Subissue #3 - Model Abstraction ENG 2.2.1

Tracking # ENG 2.2.1

Comment Juvenile and Early Failure of Waste Containers uses the software program entitled RR-PRODIGAL (NRC, 1998) to estimate waste package closure lid weld flaws and defects. RR-PRODIGAL is not an appropriate method for estimating nickel alloy or titanium welding flaws or defects because it was developed for ferretic steel nuclear reactor pressure vessels only.

References NRC. "RR-PRODIGAL - A Model for Estimating the Probabilities of Defects in Reactor Pressure Vessel Welds." NUREG/CR-5505, PNNL-11898. Rockville, Maryland: NRC. 1998.

DOE Response In the TSPA-Site Recommendation waste package degradation analysis, the probability, frequency and size of manufacturing flaws in the waste package outer barrier closure-lid welds are used as input to the stress corrosion cracking analysis of the closure-lid weld region (CRWMS M&O 2000az, Sections 4.1.7 and 5.5). The analyses for the parameters were based on the published Rolls Royce -PRODIGAL simulation results for the welds of stainless steel piping of nuclear power reactor (Khaleel et al. 1999). It is acknowledged that the results used in the waste package stress corrosion cracking analysis are not for the candidate material (Alloy 22) for the waste package outer barrier and the fabrication techniques proposed for the outer barrier closure-lids. However these are the most relevant information that was available for the TSPA-Site Recommendation. The weld flaw data specific to the waste package design and fabrication techniques will be developed from the on-going testing and measurement with a set of simulated mockups and a planned full-scale mockup. The current weld flaw model will be validated against the waste package design specific data and improved as necessary. The use of Rolls Royce - PRODIGAL will be phased out as applicable data become available.

References: CRWMS M&O 2000az. WAPDEG Analysis of Waste Package and Drip Shield Degradation. ANL-EBS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001208.0063.

Khaleel, M.A.; Chapman, O.J.V.; Harris, D.O.; and Simonen, F.A. 1999. "Flaw Size Distribution and Flaw Existence Frequencies in Nuclear Piping." Probabilistic and Environmental Aspects of Fracture and Fatigue: The 1999 ASME Pressure Vessels and Piping Conference. PVP-386, 127-144. New York, New York: American Society of Mechanical Engineers. TIC: 245621.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and

Integration Technical Exchange, August 6-10, 2001. Also see Preclosure technical exchange, July 24-26, 2001.

Subissue #3 - Model Abstraction ENG 2.2.2

Tracking # ENG 2.2.2

Comment Insufficient data are available to evaluate the extent of damage to proposed waste packages during potential igneous events.

References CRWMS M&O. "Igneous Consequence Modeling for the TSPA-SR." ANL-WIS-MD-000017. Revision 00. Las Vegas, Nevada: U.S. Department of Energy, Yucca Mountain Site Characterization Office. 2000a.
CRWMS M&O. "Waste Package Behavior in Magma." CAL-EBS-ME-000002. Revision 00. Las Vegas, Nevada: U.S. Department of Energy, Yucca Mountain Site Characterization Office. 2000b.

DOE Response Addressed during the Igneous Activity KTI Technical Exchange meeting in June 21-22, 2001.

Agreement Number

Agreement Igneous Activity KTI Technical Exchange, June 21-22, 2001.
DOE response to this comment is unsatisfactory, and will require further discussion.

Subissue #3 - Model Abstraction ENG 3.1.1

Tracking # ENG 3.1.1

Comment Dripping has been observed (e.g., fist- to plate-sized puddles, wet drip cloth, corroded metal) in the sealed portion of the ECRB. This dripping may result from vapor-phase mobilization of water and condensation on surfaces such as rock bolts, ventilation ducts, and utility conduits under small thermal gradients. In an unventilated near-field environment where waste-canister heat causes spatial temperature variability, this process could result in significant dripping. Condensate could react with metal and grout at elevated but below-boiling temperatures. Dripping in the ECRB may also have resulted from seepage into the drift. Data at present are insufficient to distinguish what processes are primarily responsible for the observed dripping.

These comments were generated based on observations made in the sealed portion of the ECRB.

References

DOE Response DOE is investigating the dripping from condensation within the Enhanced Characterization of the Repository Block. New instrumentation will be installed in late fall 2001. The results of the new measurements could be used to refine the Unsaturated Zone drift-scale seepage model and the Engineered Barrier System Thermal Hydrology Model prior to the any potential License Application.

Agreement Number TSPAI.3.07

Agreement DOE will provide technical basis for determination of future sources of water in the ECRB, will evaluate the possibility of preferential dripping from engineered materials, and will give appropriate consideration to the uncertainties of the water sources, as well as their potential impact on other models. The work done to date as well as the additional work will be documented in the AMR on In-Situ Field Testing Processes (ANL-NBS-HS-000005) or other documents. This AMR will be available to NRC in FY 2003. DOE will evaluate the role of condensation as a source of water and any impacts of this on hydrologic and chemical conditions in the drift, and DOE will document this work. The effects of condensation will be included in TSPA if found to be potentially important to performance.

Subissue #3 - Model Abstraction ENG 3.1.2

Tracking # ENG 3.1.2

Comment "Flux splitting" is performed for the waste package but not for the drip shield (see page 214). No technical basis is provided for the perceived inconsistency.

References CRWMS M&O. "Total-System Performance Assessment Model for the Site Recommendation." TDR-WIS-PA-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Parts of the wording on p. 214 (CRWMS M&O 2000aq) implies that the flux splitting at the drip shield is based on patch area whereas the flux splitting at the waste package is based on axial length of patches. The Engineered Barrier System-Transport Analysis/Model Report (CRWMS M&O 2000bg) indicates that both should be based on axial length. DOE will correct the discrepancy between the TSPA-Site Recommendation and the Analysis/Model Report.

References: CRWMS M&O 2000aq. Total System Performance Assessment (TSPA) Model for Site Recommendation. MDL-WIS-PA-000002 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001226.0003.

CRWMS M&O 2000bg. EBS Radionuclide Transport Abstraction. ANL-WIS-PA-000001 REV 00 ICN 02. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001204.0029.

Agreement Number TSPAI.3.40

Agreement DOE will implement program improvements to ensure that the abstractions defined in the AMRs are consistently propagated into the TSPA, or ensure that the TSPA documentation describes any differences. Program improvements may include, for example, upgrades to work plans, procedural upgrades, preparation of desktop guides, worker training, increased review and oversight. The program improvements will be implemented and be made available to the NRC during FY 2002.

Subissue #3 - Model Abstraction ENG 3.1.3

Tracking # ENG 3.1.3

Comment The method used to abstract the in-package environments appears to be inappropriate and likely results in an underestimation of risk. For a given thermohydrological bin, a certain number of packages are assigned. An average package failure time is calculated for the packages in that bin. If the average package failure time is less than 1000 years, then "early" chemistry conditions are applied. Because waste package failure is distributed in time in the DOE model, only the first few packages that fail in a bin experience the "early" chemistry. All waste packages that fail should experience 1000 years of early chemistry if the process model was abstracted properly into the TSPA.

References CRWMS M&O. "Total-System Performance Assessment Model for the Site Recommendation." TDR-WIS-PA-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response As noted on pages 259-260 of the TSPA model for SR (CRWMS M&O 2000aq), a weighted-moving-average of in-package chemistry was selected to assure the in-package chemistry for the different waste package types modeled (co-disposal waste package and commercial spent nuclear fuel), different hydrologic environments (always drip, intermittent drip, never drip), and different infiltration rate bins was representative and reasonable. DOE believes this approximation is appropriate at times when a small number of waste packages have been degraded and the rate of waste package failure is increasing. DOE believes these chemistries are most appropriate during the 10,000-year regulatory period.

At times approaching 100,000 years, the calculated weighted-moving average pH will be affected by the average chemistry of all packages that would have degraded prior to that time. Although it is possible that the unzipping rate of the cladding may be increased with a different conceptual representation, this is not expected to have a significant effect on the peak mean dose.

The extent of potential non conservatism is expected to be insignificant for the following reasons which relate to the solubility of key radionuclides and the dissolution rate of the commercial spent nuclear fuel and unzipping rate of the Zircaloy cladding on the commercial spent nuclear fuel. While the lower pH of the packages that fail at any particular time would increase the Np (and other actinide) solubilities in the waste package, the invert pH would remain essentially unchanged. The invert would then be the controlling chemistry as far as actinide releases are concerned. In addition, at lower pH, the dissolution rate may be about a factor of 10 greater, which would have a corresponding change on the rate

of unzipping of the cladding (CRWMS M&O 2000aq, Table 6-49). Such changes in dissolution rate and cladding degradation are insignificant to peak dose, because the peak is dominated by solubility-limited releases rather than the dissolution rate limited release radionuclides.

The conceptual model for in-package chemistry will be reviewed and revised for TSPA-License Application, at which time this issue will be revisited.

Reference: CRWMS M&O 2000aq. Total System Performance Assessment (TSPA) Model for Site Recommendation. MDL-WIS-PA-000002 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001226.0003.

Agreement Number TSPAI.3.08

Agreement DOE will provide the technical basis (quantification) for the abstraction of in-package chemistry and its implementation into the TSPA, which will demonstrate that the implementation methodology will not result in an underestimation of risk. The technical basis will be documented in TSPA-LA and is expected to be available in FY 2003.

Subissue #3 - Model Abstraction ENG 3.1.4

Tracking # ENG 3.1.4

Comment Near-field geochemical variables are discussed as being abstracted to "representative constant values". (Page 3-70) More information/technical basis is needed for the simplifications used in the near-field environment abstraction process.

References CRWMS M&O. "Total-System Performance Assessment Model for the Site Recommendation." TDR-WIS-PA-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The current abstraction is found in the Abstraction of Drift-Scale Coupled Processes Analysis/Model Report (CRWMS M&O 2000b). The abstraction is being updated to reflect updates to the process model. The values selected for use in the abstraction will be tied to direct results from the process model; thus the validation of the abstraction will hang on the validation of the process model. The location (i.e., the specific Analysis/Model Report) of the documentation has not been determined yet.

Reference: CRWMS M&O 2000b. Abstraction of Drift-Scale Coupled Processes. ANL-NBS-HS-000029 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000525.0371.

Agreement Number TSPAI.3.09

Agreement DOE will present the representation of uncertainty and variability in water and gas chemistry entering the drift in the near-field environment abstractions for the TSPA. This will be documented in the Abstraction of Drift-Scale Coupled Processes, ANL-NBS-HS-000029, or other document expected to be available in FY 2003.

Subissue #3 - Model Abstraction ENG 3.1.5

Tracking # ENG 3.1.5

Comment The referenced AMR provides a global framework defining connections and interactions of other models. The framework presented appears to be consistent with the expected physical processes that may occur. Other AMRs appear to have followed a different framework for water pathways and related water chemistry calculations, even though their general inputs and outputs were to be defined by the Physical and Chemical Environmental Abstraction Model AMR.

In particular, water to the invert is discussed as potentially resulting from flow around the dripshield, flow around the waste package, and flow through the waste package. In the TSPA-SR model it appears that only flow through the waste package is represented.

References CRWMS M&O. "Physical and Chemical Environmental Abstraction Model AMR." ANL-EBS-MD-000046. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The Physical and Chemical Environmental Abstraction Model Analysis/Model Report describes several processes, chemical, physical, and transport, that potentially affect the in-drift environment that is relevant to performance assessment, although results from related Analysis/Model Reports and other documents may show that some of them can be neglected (CRWMS M&O 2000bf, Section 6.3).

Reference: CRWMS M&O 2000bf. Physical and Chemical Environmental Abstraction Model. ANL-EBS-MD-000046 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001204.0023.

Agreement Number TSPAI.3.10

Agreement DOE will provide the documentation of the integrated analyses and comprehensive uncertainty analyses related to the EBS physical and chemical environment in documentation associated with TSPA for any potential license application. The documentation is expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction ENG 3.1.6

Tracking # ENG 3.1.6

Comment During the integration of UZ percolation above the repository horizon with the seepage abstraction, DOE combines abstracted statistical distributions (the "seepage bins" from the TH model) with data of positional relevance (the output of the UZ model). This results in a spatial disconnect in the abstractions of the involved process models.

References CRWMS M&O. "Total-System Performance Assessment Model for the Site Recommendation." TDR-WIS-PA-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response As stated in the TSPA-Site Recommendation model Analysis/Model Report (CRWMS M&O 2000aq) and the TSPA-Site Recommendation technical report (CRWMS M&O 2000ar), the percolation flux is taken from the Multiscale Thermo-Hydrologic model (CRWMS M&O 2000ag), not the Unsaturated Zone flow model.

The binning in the TSPA model is based on infiltration rather than spatial location because infiltration is a more important indicator of performance than spatial location. That is, seepage and transport velocity would both be expected to be higher where infiltration is higher.

References: CRWMS M&O 2000aq. Total System Performance Assessment (TSPA) Model for Site Recommendation. MDL-WIS-PA-000002 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001226.0003.

CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

CRWMS M&O 2000ag. Multiscale Thermohydrologic Model. ANL-EBS-MD-000049 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001208.0062.

Agreement Number TSPAI.3.11

Agreement DOE will compare the infiltration flux used for the infiltration bins with the 3D Unsaturated Zone flow model and the multi-scale thermohydrologic (MSTH) model results. The technical basis for any approximations in the spatial distribution of flow rates involved in this abstraction will be provided in Abstraction of NFE Drift Thermodynamic Environment and Percolation Flow AMR, ANL-EBS-HS-000003, or other suitable document. In particular, DOE will ensure that the MSTH model output to the seepage abstraction (or any other model that may provide percolation flux to the

seepage abstraction) does not lead to underestimation of seepage. This AMR is expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction ENG 3.1.7

Tracking # ENG 3.1.7

Comment During the TEF technical exchange, there was a discussion pertaining to the abstraction of temperature and RH and the representation of those thermodynamic variables in the waste package corrosion models. It was presented that temperature and drift RH were propagated from 610 calculations. A response was not given as to how 610 results are assigned to 400 waste package groups.

References NRC. "Summary Highlights of NRC/DOE Technical Exchange and Management Meeting on Thermal Effects on Flow, January 8-9, 2001." Letter from C.W. Reamer (NRC) to S.Brocoum (DOE) dated January 26, 2001. Washington, DC: NRC. 2001.

DOE Response In the TSPA-Site Recommendation REV 00 Waste Package Degradation Model, the primary effect of the thermal hydrologic files is in determining the corrosion initiation time (the critical relative humidity for corrosion initiation is a function of exposure temperature). The Waste Package Degradation Model used only one of the thermal hydrology files (WDHLW_nbf_high_bin2.ou) which contains information for the 14 High Level Waste, bin2, high infiltration scenario spatial locations. Approximately 28 waste packages were simulated using the information from each spatial location.

References: CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

CRWMS M&O 2000az. WAPDEG Analysis of Waste Package and Drip Shield Degradation. ANL-EBS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001208.0063.

Agreement Number TSPAI.3.40

Agreement DOE will implement program improvements to ensure that the abstractions defined in the AMRs are consistently propagated into the TSPA, or ensure that the TSPA documentation describes any differences. Program improvements may include, for example, upgrades to work plans, procedural upgrades, preparation of desktop guides, worker training, increased review and oversight. The program improvements will be implemented and be made available to the NRC during FY 2002.

Subissue #3 - Model Abstraction ENG 3.1.8

Tracking # ENG 3.1.8

Comment DOE has made an agreement to develop the expected chemical environments considering various sources of uncertainty. An agreement does not exist for DOE to complete testing of corrosion rates in environments similar to those predicted by the modeling. Either this task should be completed to ensure consistency and develop adequate model support for the general and localized corrosion models or a strong argument should be made as to why it is not necessary.

References CRWMS M&O. "Total-System Performance Assessment Model for the Site Recommendation." TDR-WIS-PA-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Earlier work on the possible ranges of environment focused on carbonate dominated types of Yucca Mountain waters. Results of these studies were used to identify test environments. Container Life and Source Term agreements 1.1 and 1.10 will address other credible ranges of environment on the surfaces of the drip shield and the waste package. This includes introduced materials and other trace elements that could potentially affect the corrosion rates. As was done in the past, corrosion testing environments will be extended to the results of these studies as appropriate. Also, agreement 6.1 includes corrosion testing over the ranges of credible environments as applicable.

Agreement Number TSPAI.3.12

Agreement DOE will conduct testing of corrosion in the credible range of chemical environments predicted by the model in accordance with the scope and schedule for existing agreements CLST 1.4 and 1.6 or provide a technical basis why it is not needed.

Subissue #3 - Model Abstraction ENG 3.1.9

Tracking # ENG 3.1.9

Comment This is a new comment to clarify and complement ENG3.1.8. The model for engineered barrier system failure (WAPDEG) is stated as using environmental information to determine the corrosion rates. In particular, pH is assessed to determine whether localized corrosion would occur. An explanation is needed as to how this is accomplished in the TSPA model. WAPDEG is apparently executed at the beginning of a simulation. How is the pH available for both the external surfaces of the package and from the in-package chemistry calculations for the engineered barrier system failure calculations when WAPDEG is executed first? This comment is also directed at ionic species like chloride and flouride.

References CRWMS M&O. "Total-System Performance Assessment Model for the Site Recommendation." TDR-WIS-PA-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Seepage chemistry in-drift is characterized in the In-Drift Precipitates/Salts Analysis Analysis/Model Report (CRWMS M&O 2001f). In-package chemistry is characterized in the In-Package Chemistry Abstraction Analysis/Model Report (BSC2001c). These abstraction Analysis/Model Reports provide look-up tables for environmental chemical conditions (e.g., pH and Cl- concentration) as a function of exposure temperature and relative humidity. Because pH is the dominant parameter, among the environmental condition parameters considered, for corrosion potentials and threshold corrosion potentials for localized corrosion initiation, the localized corrosion initiation of waste package and drip shield is expressed as a function of pH only. A thermal hydrology pre-processor is run to provide WAPDEG with time histories of environmental chemical conditions corresponding to the exposure temperature and relative humidity files used.

References: BSC 2001c. In-Package Chemistry Abstraction. ANL-EBS-MD-000037 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010315.0053.

CRWMS M&O 2001f. In-Drift Precipitates/Salts Analysis. ANL-EBS-MD-000045 REV 00 ICN 02. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010220.0008.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction   ENG 3.2.1

Tracking # ENG 3.2.1

Comment A comparison is needed between the environments (in particular ionic strength) predicted by the low ionic strength model to the environments utilized in the corrosion tests. The comparison between the testing environments and the modeled environments will determine the amount of support needed for the low ionic strength model (CRWMS M&O, 2000; p 3-70).

References CRWMS M&O. "Total-System Performance Assessment Model for the Site Recommendation." TDR-WIS-PA-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response On-going corrosion tests in the long- term corrosion test facility include a range of environments based on carbonate dominated Yucca Mountain waters, including dilute waters (10X J-13 type). However, focus of the corrosion tests has been to use highly concentrated environments to bound the environmental issues so that the bounding corrosion rates can be established for performance assessment.

The range of chemical environments that could interact with the drip shield and waste package is currently being assessed as part of the Evolution of Near Field Environment agreements 2.6 and 2.10. The results will be compared to the corrosion tests chemistries and modified, if necessary.

Agreement Number TSPAI.3.13

Agreement DOE will provide a comparison of the environments for corrosion predicted in the models, to the testing environments utilized to define empirical corrosion rates in revised documentation consistent with the scope and schedule for existing agreement item CLST 1.1.

Subissue #3 - Model Abstraction ENG 3.2.2

Tracking # ENG 3.2.2

Comment Table 3.3-7 (Page 3-71) for geochemical environments shows that when RH is increasing, Cl(molal) is increasing. Support for this modeled result is needed. I would expect that Cl(molal) should decrease as RH increased, due to more dilution.

References CRWMS M&O. "Total-System Performance Assessment Model for the Site Recommendation." TDR-WIS-PA-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Less than 50% relative humidity, 100% evaporation is assumed and thus left with salts. As the relative humidity increases, the Cl concentration increases due to the dissolution of salts. The technical basis is documented in the In-drift precipitates and salts Analysis/Model Report (CRWMS M&O 2001f).

Reference: CRWMS M&O 2001f. In-Drift Precipitates/Salts Analysis. ANL-EBS-MD-000045 REV 00 ICN 02. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010220.0008.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction ENG 3.3.1

Tracking # ENG 3.3.1

Comment Page 3-35. An assessment is needed of the potential error involved with using calibrated property sets derived for the niches and used for seepage modeling. The different state of the system here is the ventilation processes.

References CRWMS M&O. "Total-System Performance Assessment Model for the Site Recommendation." TDR-WIS-PA-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The current assumption in Section 5.6 in the Seepage Calibration Model (CRWMS M&O 2001j) is that the effects of evaporation are small. This assumption carries a TBV (4951). DOE will investigate the impact of the ventilation process on calibrated properties.

Reference: CRWMS M&O 2001j. Seepage Calibration Model and Seepage Testing Data. MDL-NBS-HS-000004 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010122.0093.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction ENG 3.3.2

Tracking # ENG 3.3.2

Comment Triangular distributions are utilized for parameters in the modeling and abstraction of seepage processes (page 124). Are the ranges of the data and most likely value known well enough that the use of a triangular distribution is appropriate?

References CRWMS M&O. "Total-System Performance Assessment Model for the Site Recommendation." TDR-WIS-PA-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Data supporting the parameter distributions are included in the seepage model. The distributions are representative of the expected ranges and peak at the best estimate. The data ranges and distributions are discussed in the seepage-abstraction Analysis/Model Report (CRWMS M&O 2001o).

References: CRWMS M&O 2001o. Abstraction of Drift Seepage. ANL-NBS-MD-000005 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010309.0019.

Agreement Number TSPAI.3.41

Agreement DOE will provide the technical basis for the data distributions utilized in the TSPA to provide support for the mathematical representation of data uncertainty in the TSPA. The documentation of the technical basis will be incorporated in documentation associated with TSPA for any potential license application. The documentation is expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction ENG 3.TT.1

Tracking # ENG 3.TT.1

Comment How is the spatial variability of the UZ percolation flux above the repository horizon (see e.g. Fig. 3.2-8 on p. F3-16 of TSPA-SR) carried into the seepage abstraction? What input of percolation flux is used in Fig. 3.2-15 on p. F3-23 of TSPA-SR) to determine seepage properties?

References CRWMS M&O. "Total-System Performance Assessment Model for the Site Recommendation." TDR-WIS-PA-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response 1) Spatial variability of the percolation flux comes from the Multi-scale Thermo-Hydrologic Model (CRWMS M&O 2000ag). The way that spatial variability of percolation and other quantities is incorporated in the Multi-scale Thermo-Hydrologic Model is discussed briefly in Section 3.3.3.2.2 of the TSPA-Site Recommendation technical report (CRWMS M&O 2000ar) and in detail in the Multi-scale Thermo-Hydrologic Model Analysis/Model Report.

2) As stated in Sections 3.2.4.1, 3.2.4.3, and 3.3.3.2.3 of the TSPA-Site Recommendation technical report and Section 6.3.1.2 of the TSPA- Site Recommendation model Analysis/Model Report (CRWMS M&O 2000aq), the percolation flux 5 m above the drift from the Multi-scale Thermo-Hydrologic Model is used as input to the seepage abstraction. (The percolation flux is also modified by the flow-focusing factor as discussed briefly in Section 3.2.4.3 of the TSPA-Site Recommendation technical report and 6.3.1.2 of the TSPA-Site Recommendation model Analysis/Model Report and discussed in more detail in the seepage-abstraction Analysis/Model Report [CRWMS M&O 2001o].)

References: CRWMS M&O 2000ag. Multiscale Thermohydrologic Model. ANL-EBS-MD-000049 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001208.0062.

CRWMS M&O 2000ar. Total System Performance Assessment for the Site Recommendation. TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

CRWMS M&O 2000aq. Total System Performance Assessment (TSPA) Model for Site Recommendation. MDL-WIS-PA-000002 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001226.0003.

CRWMS M&O 2001o. Abstraction of Drift Seepage. ANL-NBS-MD-000005 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010309.0019.

Subissue #3 - Model Abstraction ENG 3.TT.1

Agreement Number TSPAI.3.11

Agreement DOE will compare the infiltration flux used for the infiltration bins with the 3D Unsaturated Zone flow model and the multi-scale thermohydrologic (MSTH) model results. The technical basis for any approximations in the spatial distribution of flow rates involved in this abstraction will be provided in Abstraction of NFE Drift Thermodynamic Environment and Percolation Flow AMR, ANL-EBS-HS-000003, or other suitable document. In particular, DOE will ensure that the MSTH model output to the seepage abstraction (or any other model that may provide percolation flux to the seepage abstraction) does not lead to underestimation of seepage. This AMR is expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction ENG 4.1.1

Tracking # ENG 4.1.1

Comment The integration and implementation efforts are insufficient since the use of pdfs requires that consistent environmental conditions and assumptions are applied to all of the chemical components. The full range of environmental conditions was not reasonably accounted for in the abstraction of radionuclide concentration limits inside breached WPs.

References CRWMS M&O. "Summary of Dissolved Concentration Limits." ANL-WIS-MD-000010. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The full range of environmental conditions will be emphasized in the next revision of the Analysis/Model Report.

Reference: CRWMS M&O 2001p. Summary of Dissolved Concentration Limits. ANL-WIS-MD-000010 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010223.0061.

Agreement Number TSPAI.3.14

Agreement DOE will update the in-package chemistry model to account for scenarios and their associated uncertainties required by TSPA. This will be documented in the In-Package Chemistry AMR (ANL-EBS-MD-000056) expected to be available to NRC in FY 2003.

Subissue #3 - Model Abstraction ENG 4.1.2

Tracking # ENG 4.1.2

Comment The EQ3/6 thermodynamic database was not used consistently for geochemical modeling throughout the Yucca Mountain Project.

References CRWMS M&O. "Summary of Dissolved Concentration Limits." ANL-WIS-MD-000010. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Data to be used in EQ3/6 will be checked and coordinated between all the affected groups.

Agreement Number TSPAI.3.15

Agreement DOE will define a reference EQ3/6 database for the Yucca Mountain Project. DOE will provide documentation of all the deviations from the reference database and justification for those deviations used by different geochemical modeling activities. The database will be available in FY 2003.

Subissue #3 - Model Abstraction ENG 4.1.3

Tracking # ENG 4.1.3

Comment DOE has completed modeling of solubility limits. Some of the simulations would not converge. This is in contradiction of a statement made for quality assurance purposes, that the model has not been utilized outside of the range for which it was validated. It is also not clear how values taken from non-convergent simulations will not lead to underestimation of risk.

References CRWMS M&O. "Summary of Dissolved Concentration Limits." ANL-WIS-MD-000010. Revision 00. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Non-convergent EQ3NR simulations occurs at extreme conditions (e.g., either high or low pH) and when it occurs, no solubility values are produced. As a result, the valid environmental condition ranges for the solubility model become narrower than desired. However, this drawback can be remedied by ensuring that the response surface is upwardly concave with respect to the environmental conditions (c.f. p.38 of the Analysis/Model Report on Am solubility response surface.) This upward concave property assures that the response surface will generate higher solubility values when it is applied out of the range from which it is derived. More effort will be devoted to assure this property for solubility models in the next revision of this Analysis/Model Report.

Reference: CRWMS M&O 2001p. Summary of Dissolved Concentration Limits. ANL-WIS-MD-000010 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010223.0061.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction ENG 4.1.4

Tracking # ENG 4.1.4

Comment More information is needed on how the abstraction methodology captures the situation where flow into the waste packages is close to the evaporation rate (page 252).

References CRWMS M&O. "Total-System Performance Assessment Model for the Site Recommendation." TDR-WIS-PA-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response DOE used 10X J-13 for sensitivity study. The sensitivity effect of turning off anhydrous products used up a lot of water similar to evaporation.

10 X J-13 is considered representative of the expected brines during the current modeling scenarios for a breached waste package:

Early failures with an intact drip shield

Waste package performance > 10,000 years.

If additional scenarios are developed that result in more aggressive chemistries during the regulatory period, use of 10 X J-13 within the models will be re-assessed.

Reference: BSC 2001g. In-Package Chemistry for Waste Forms. ANL-EBS-MD-000056 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010322.0490.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction ENG 4.1.5

Tracking # ENG 4.1.5

Comment The approach of using a random pH over the calculated range is possibly an appropriate way to represent uncertainty in the early time in-package chemistry. However, correlations may be needed in order for the model output to be consistent with the system-state that would be determined by the model input (See page 257).

References CRWMS M&O. "Total-System Performance Assessment Model for the Site Recommendation." TDR-WIS-PA-000002. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response The in-package chemistry component sets the hydronium ion concentration (pH), total carbonate concentration ([CO3]T), ionic concentration [i], carbon dioxide partial pressure (fCO2), and oxygen partial pressure (fO2), that is used by other model components of the waste form model in order to maintain consistency. Hence, there is no need to develop correlations between other distributions to maintain consistency. The terse sentence on p. 257 is referring to the fact that the pH inside the waste package is sampled randomly between pHhigh and pHlow. At each time step, pHhigh and pHlow are calculated as a function of the three regression parameters for each environment ("bins and drip conditions"): the average fraction of intact cladding (fclad), the average seepage (qseep), and rate of High Level Waste degradation (rHLW). The pH range represents the uncertainty not accounted for by these three parameters. Other parameters that influence pH (yet are not important enough to be regression variables) are the degradation rates of various steels and aluminum inside the package. To maximize the differences, these degradation rates were all set at either "high" or "low" values to develop the regression equations for pHhigh and pHlow. In REV 01 of the In-Package Chemistry Abstraction Analysis/Model Report (BSC 2001c), the regression equations have been changed; however, the same approach is used. Rather than discretize the in-package chemistry into two time periods (greater or less than 1000 yr) , four time periods are now used. Also, in REV 01 the degradation rates of various steels and aluminum used to establish pHhigh and pHlow have been decreased.

Reference: BSC 2001c. In-Package Chemistry Abstraction. ANL-EBS-MD-000037 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010315.0053.

Agreement Number

Agreement DOE response during Technical Exchange was considered adequate by the NRC. Total System Performance Assessment and Integration Technical Exchange, August 6-10, 2001.

Subissue #3 - Model Abstraction ENG 4.1.6

Tracking # ENG 4.1.6

Comment FEP 2.1.08.07.00 (Pathways for unsaturated flow and transport in the waste and engineered barrier system) evaluates unsaturated flow and radionuclide transport that may occur along preferential pathways in the waste and EBS. The DOE indicates that preferential pathways are already "included" via "a series of linked one dimensional flowpaths and mixing cells through the EBS, drip shield, waste package and into the invert (CRWMS M&O, 2000)." Staff are concerned that preferred pathways in the EBS are not being evaluated at the appropriate scale. Water has been observed to drip preferentially along grouted rock bolts in the ECRB, for example, demonstrating that the introduced materials themselves can influence the location of preferred flow pathways. Moreover, interactions with engineered materials, such as cementitious and metallic components, can have a significant effect on evolved water and gas compositions. Variations along water and gas chemistry that occur along preferential flow pathways in the EBS cannot be adequately measured by considering their volumetric contribution to the bulk EBS water and gas composition.

References CRWMS M&O. "Miscellaneous Waste Form FEPs." ANL-WIS-MD-000009. Revision 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. 2000.

DOE Response Analyses and modeling that takes into account the spatial heterogeneity are included in the Evolution of Near Field Environment agreements 2.4 and 2.6; which address trace elements and rock bolt grout, respectively.

Agreement Number TSPAI.3.16

Agreement DOE will evaluate the effect of localized flow pathways on water and gas chemistry in the engineered barrier system as input to TSPA calculations, including the influence of introduced materials on these preferential flow pathways consistent with existing agreements ENFE 2.4, 2.5, and 2.6. This will be documented in an update to the Physical and Chemical Environment Model AMR (ANL-EBS-MD-000033) or other suitable document. This AMR is expected to be available to NRC in FY 2003.