Summary Highlights of NRC/DOE Technical Exchange and Management Meeting on Repository Design and Thermal-Mechanical Effects

February 6-8, 2001
Las Vegas, Nevada

Introduction and Objectives

This Technical Exchange and Management Meeting on Repository Design and Thermal-Mechanical Effects (RDTME) is one in a series of meetings related to the U.S. Nuclear Regulatory Commission (NRC) key technical issue (KTI) and sufficiency review and the U.S. Department of Energy (DOE) site recommendation decision. Consistent with NRC regulations on prelicensing consultations and a 1992 agreement with the DOE, staff-level resolution can be achieved during prelicensing consultation. The purpose of issue resolution is to assure that sufficient information is available on an issue to enable the NRC to docket a proposed license application. 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. Issue resolution at the staff level, during prelicensing, is achieved when the staff has no further questions or comments at a point in time regarding how the DOE is addressing an issue. The discussions recorded here reflect NRC's current understanding of aspects of repository design and thermal-mechanical effects most important to repository performance. This understanding is based on all information available to date which includes limited, focused, risk-informed reviews of selected portions of recently provided DOE documents (e.g., Analysis and Model Reports (AMRs) and Process Model Reports (PMRs)). Pertinent additional information (e.g., changes in design parameters) could raise new questions or comments regarding a previously resolved issue.

Issues 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. Issues are "closed-pending" if the NRC staff has confidence that the DOE proposed approach, together with the DOE agreement to provide the NRC with additional information (through specified testing, analysis, etc.) acceptably addresses the NRC's questions such that no information beyond that provided, or agreed to, will likely be required at time of initial license application. Issues 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.

The objective of this meeting was to discuss and review the progress on resolving the RDTME KTI (see Attachment 1 for the description of the subissues). The quality assurance (QA) aspect of this KTI was determined to be outside the scope of the meeting and is being tracked in NRC's ongoing review of the DOE's QA program.

Summary of Meeting

At the close of the Technical Exchange and Management Meeting, the NRC staff stated that Subissues 1 and 4 are "closed," and Subissue 2 and 3 are "closed-pending." Specific NRC/DOE agreements made at the meeting are provided as Attachment 1. Information

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pertaining to Subissue #3, Agreement 4 is provided as Attachment 2. The agenda and the attendance list are provided as Attachments 3 and 4, respectively. Copies of the presenters slides are provided as Attachment 5. Highlights from the Technical Exchange and Management Meeting are listed below.

Highlights

1) Opening Comments

In its opening comments, the NRC stated that it had received valid comments about the terms used to document the status of technical issues during the prelicensing stage, specifically about the use of the term "closed-pending." The NRC stated that it is possible to infer from the use of "closed-pending" that more progress has been made in closing an open issue than is actually the case. In a letter dated January 22, 2001, the Chairman of the NRC addressed this issue and copies of the letter were made available at the meeting. In his letter, the Chairman discussed the terms used and indicated that to mark the status of a technical issue during the prelicensing stage, the NRC used "closed," "closed-pending," and "open" as "bookkeeping terms." The NRC then discussed the terms and the goal of issue resolution (this discussion is similar to what is discussed in the Introduction and Objectives section above and is not repeated here).

The DOE stated that the intent of the meeting was to reach agreement on the current status and path forward for each of the RDTME subissues (see "Repository Design and Thermal-Mechanical Effects" presentation given by Kirk Lachman) In the RDTME Issue Resolution Status Report (IRSR), Revision 3, the NRC stated that RDTME Subissues #1 and 4 are "closed," Subissue #2 is "closed-pending," and Subissue #3 is "open." During this meeting, the DOE stated that its presentation would focus on the open items identified by the NRC in the IRSR and subsequent discussions The DOE stated that it felt that the details provided during the current meeting would be the basis for NRC to continue to list Subissues #1 and 4 as "closed," and Subissues #2 and 3 as "closed-pending "

2) Technical Discussions - Subissue 1: Design Control Processes; Subissue 2: Seismic Design Methodology; Subissue 4: Repository Seals

A summary of the current status of resolution was presented (see "Subissue 1: Design Control Processes; Subissue 2: Seismic Design Methodology, Subissue 4· Repository Seals" presentation given by Dan McKenzie and Richard Quittmeyer).

Subissue 1· Design Control Processes

The DOE stated that it has developed a technical work control process consistent with the quality assurance program The DOE stated that the NRC has identified this subissue as "closed" in the RDTME IRSR, Rev. 3 and considers that this subissue remains "closed." The NRC noted that most of its review to date in this area was in response to design control concerns related to the Exploratory Studies Facility. The NRC further stated that, although the design control process was acceptable it would continue to monitor implementation of the design control process, especially in the pre-closure area, and would bring relevant issues to the DOE's attention as they arise. The DOE also clarified that the same requirements are

applicable for design and performance assessment. As a result of additional discussions, the NRC stated that Subissue #1 could continue to be listed as "closed."

Subissue 2: Seismic Design Methodology

The DOE discussed the seismic design methodology which is the subject of the second in a series of three topical reports. The DOE noted that the first two topical reports had been completed and that the NRC had no further questions related to them. The NRC stated that after receiving Topical Report 3, it would review all three topical reports in an integrated manner and may have questions related to the first two topical reports at that time. The NRC also asked whether the substantive technical content of Topical Report 3 could be provided prior to publication of the formal report which is currently scheduled for completion in 2002. The DOE stated that it would provide the preliminary seismic design input data sets used in site recommendation design analyses to the NRC by April 2001.

As a result of additional discussions, the NRC and DOE reached two agreements for Subissue #2 (see Attachment 1). With these two agreements, the NRC stated that Subissue #2 could be listed as "closed-pending."

Subissue 4: Repository Seals

The DOE stated that it does not take credit for the use of repository seals in the performance assessment. Based on this fact and that the NRC listed this subissue as "closed" in the RDTME IRSR, Rev. 3, the DOE stated that it considers this subissue "closed." The NRC noted that information pertaining to seal design, construction, and material selection was still required even though seals are not relied upon in meeting the performance objectives and proposed 10 CFR Part 63 does not include requirements specific to seals. The NRC also stated that any potential negative impacts of seal construction and seal materials must be evaluated by the DOE. The DOE stated that such an evaluation is part of its overall evaluation of repository performance.

Mr. Steve Frishman (State of Nevada) stated that this would be the first time the NRC would be basing its decision to list a subissue as "closed" based on proposed 10 CFR Part 63. He stated that either this issue should remain open with respect to 10 CFR Part 60, or if listed as "closed," it should be linked to proposed 10 CFR Part 63 The NRC stated that in its discussion of Subissue #4, closure is linked to proposed 10 CFR Part 63.

As a result of additional discussions, the NRC stated that Subissue #4, with respect to proposed 10 CFR Part 63, could continue to be listed as "closed."

3) Features, Events, and Processes Relevant to RDTME

The DOE summarized the total system performance assessment process, including the identification and screening of features, events, and processes (FEPs). The NRC questioned what was meant by the phrase "effect partially included" in the FEPs table. The DOE stated, that it took no credit for ground control systems in postclosure, and, even if a primary FEP were excluded, the associated secondary FEPs could still be included in the total system

performance assessment. The backup material on this presentation includes examples of included, excluded, and partially included FEPs

The NRC questioned the DOE about screening out rockfall The DOE stated that rockfall was screened out because the design of the waste package and the drip shield would take into account the design basis rock size. The NRC stated that it would address this issue again in the subsequent presentations, specifically in Subissue 3, Component 3, Acceptance Criterion 5.

4) Technical Discussions - Subissue #3, Thermal-Mechanical Effects on Underground Facility Design and Performance

Component 1, Thermal-Mechanical Effects on Design of Underground Facility

A summary of the current status of resolution was presented (see "Subissue 3, Thermal-Mechanical Effects on Underground Facility Design and Performance – Component 1, Thermal-Mechanical Effects on Design of Underground Facility" presentation given by Dan McKenzie, Barry Thom, Richard Quittmeyer, and Fei Duan). The DOE identified the NRC information needs from Revision 3 of the RDTME IRSR and subsequent discussions. The DOE stated that the presentation would provide the basis for going to "closed-pending." The DOE then presented the information related to the various acceptance criteria (AC).

Acceptance Criterion 1 addresses the design assumptions, codes, and standards used for the design of subsurface facility structures, systems, and components important to safety. The DOE stated that design control is described in Procedure AP-3.13Q, which requires the design to be developed in accordance with system description documents. The NRC questioned whether the DOE would update the requirements to correspond to the most current version of the ASME Boiler and Pressure Vessel Code. The DOE stated that, for now, the design will be based on the 1995 ASME Boiler and Pressure Vessel Code. Furthermore, the DOE stated that they would generally "freeze" the selected codes and standards and not continuously revise the design to keep up with evolving version of codes and standards, consistent with industry and NRC practice for reactors, and spent nuclear fuel dry cask storage licenses.

The NRC asked how the applicability/appropriateness of various design codes and standards are determined, particularly for situations for which standards do not exist. The DOE stated that they use engineering judgement, industry and NRC practices and precedents to choose the appropriate design code and standard and document the basis for the decision in Appendix A of the appropriate system description document

Acceptance Criterion 3 addresses the materials and material properties used for the subsurface facility design. The DOE stated that material standards are specified in the system description documents. The ultimate selection of committed materials is an iterative process involving the subsurface designers and performance assessment team The NRC questioned the technical basis of precluding corrosion of rock bolts and maintaining relative humidity less than 40%. The DOE stated that their position regarding corrosion is based on previous waste package overpack studies and their position regarding relative humidity is based on Yucca Mountain meteorology data and ventilation calculations

The NRC questioned why temperature dependent effects on engineered barrier system materials were not discussed. The DOE stated that this issue would be discussed in more detail in later presentations, specifically Subissue 3, Component 2, Acceptance Criterion 2.

Acceptance Criterion 4 addresses whether design analyses use appropriate load combinations for normal and Category 1 and 2 event sequence conditions. In its presentation, the DOE addressed three specific NRC concerns: (1) appropriateness of in-situ stress ratio, (2) incorporation of thermal load in ground support design, and (3) appropriateness of seismic design inputs for design analysis.

In its discussion of in-situ stress ratio (K_o), the DOE stated that both hydraulic fracturing data and Goodman Jack measurements indicate that K_o values of 0.3 and 1.0 are lower and upper bounds for the horizontal to vertical stress ratio, respectively, at the proposed repository host horizon.

In its discussion of thermal load in ground support design, the DOE stated that thermal loads for thermal-mechanical models are based on the heat output and ventilation rate from thermal management analyses and use them as input for the ground control analyses. The DOE further stated that the thermal load used is the upper bound. The NRC questioned how the upper bound was determined and how the DOE plans to maintain the temperature below the upper bound. The DOE stated that the project design goal for preclosure emplacement drift wall temperature is 96 °C (below boiling point) and that modeling was performed using peak preclosure drift wall temperatures of approximately 125°C. The DOE indicated that it would use the design to control peak temperature (e.g., adjust the spacing of waste packages, change ventilation rate, etc.)

In its discussion of seismic design inputs, the DOE stated that the Seismic Design Inputs AMR will contain the inputs to be used for design. The NRC requested that the critical combinations of in-situ, thermal, and seismic stresses for the period of interest, together with their technical bases, and their impact on ground support system be provided.

Acceptance Criterion 5 addresses whether the design analyses use appropriate models and site-specific properties of the host rock, and consider spatial and temporal variation and uncertainties in such properties. In its presentation, the DOE addressed four specific NRC issues: (1) justify mechanical properties for continuum rock mass modeling, (2) justify mechanical properties for discontinuum rock mass modeling, (3) provide basis for mechanical degradation of rock support materials, and (4) justify thermal-mechanical modeling.

In its discussion of mechanical properties for continuum rock mass modeling, the DOE stated that the models are appropriate and adequately justified, and that NRC concerns on mechanical properties will be examined through sensitivity studies. The NRC asked why the 1997 Yucca Mountain Geotechnical Characterization Report concluded that additional information was required, but that the DOE now considers the information to be acceptable. The NRC asked for details regarding any additional work that was conducted since March 1997 and where the results were documented. The DOE stated that the information was available in various sources in the Technical Document Management System and it will provide the additional information in a future document.

The DOE discussed two reports expected to be completed in fiscal year 2002, Design Parameter Analysis and Rock Mass Classification Analysis. The NRC indicated that additional information was needed in these two documents, as well as a third report documenting sensitivity analyses in fiscal year 2003 The DOE stated it would provide these three reports.

In its discussion of mechanical properties for discontinuum rock mass modeling, the DOE stated that its discontinuum rock mass models are appropriate and adequately justified, and that NRC concerns on mechanical properties for blocks between fractures, fracture patterns, and fracture friction angle will be examined through sensitivity studies.

In its discussion, the DOE indicated that both continuum and discontinuum modeling were used to conduct ground control analysis for emplacement drifts for site recommendation. The NRC noted that performance of ground support systems were not modeled using discontinuum modeling and the results from discontinuum modeling may drive the support design.

The DOE discussed the seismic analysis conducted in its ground control for emplacement drifts for site recommendation. The NRC questioned the use of sinusoidal time history with single frequency and short duration because a sinusoidal signal may not be able to bound the site-specific ground motion time history. The DOE responded that its study indicated that effects of frequency and time history on rock bolts were analyzed and no effects were found; however, no documentation is available for review. The DOE stated their position that the ground control design was sufficiently robust but would agree to additional discontinuum analysis to further enhance the understanding of ground support performance

In its discussion of mechanical degradation of rock support materials, the DOE stated that it has adequately documented the basis for mechanical degradation of rock support materials.

Acceptance Criterion 6 addresses whether the design of ground support systems is based on appropriate design methodologies and interpretations of modeling results. The DOE stated that numerical approaches are the primary means of analyzing ground support design. The selection of ground support systems is compared against the empirical approach. The NRC asked what empirical data is being used for comparison with the numerical ground support calculations. The DOE responded that they used the empirical design methodology for conventional underground excavation to check the numerical results.

Acceptance Criterion 7 addresses whether subsurface ventilation systems are adequately analyzed. The DOE stated that it has extensively evaluated and checked the ventilation model since its development in 1995 To enhance confidence that the model is adequate, the DOE stated that model results are compared with results from another model that performs similar calculations. In addition, an ongoing 1/4-scale test at the Atlas Facility will provide data that can be used to gauge the accuracy of the model The NRC raised questions regarding the discretization employed in the ANSYS ventilation model The DOE responded that based on their study of using more discretized segments, their discretization is adequate.

The NRC questioned whether radial heat flow is adequately represented in the Atlas ventilation testing. The DOE responded that they are continuing to evaluate this issue. The DOE also emphasized that the primary objective of the ventilation test is presently limited to verifying the ANSYS ventilation model

The NRC pointed out that the line load assumption used in the ANSYS ventilation model may not be applicable if the waste package spacing within the drift is significantly increased. The DOE responded that there would be some additional effects if the spacing were increased significantly. The spacings currently being considered do not appear to cause large temperature disparities, and that they may have to address this concern if, at a future time, it is determined that waste package spacing will in fact be increased. The DOE stated that one report would synthesize all the ventilation test results and would include comparison with numerical models.

Component 2 – Effects of Seismically Induced Rockfall in Engineered Barrier Performance

A summary of the current status of resolution was presented (see "Subissue 3, Thermal-Mechanical Effects on Underground Facility Design and Performance – Component 2, Effects of Seismically Induced Rockfall in Engineered Barrier Performance" presentation given by Dwayne Kicker and Scott Bennett). The DOE identified the NRC information needs from Revision 3 of the RDTME IRSR and subsequent discussions. The DOE stated that the presentation would provide the basis for going to "closed-pending." The DOE then presented the information in the appropriate acceptance criteria.

Acceptance Criterion 1 addresses the evaluation and abstraction of design features and processes. In its presentation, the DOE addressed nine specific NRC issues: (1) basis of assumption regarding modeling of joint plane radius, (2) representativeness of joint mapping data, (3) basis for exclusion of small joint trace lengths, (4) treatment of thermal and long-term degradation of joint strength, (5) joint sampling bias, (6) temperature dependency of titanium material properties, (7) design basis rock size, (8) use of 10^{-4} ground motion values for postclosure seismic ground motion analysis, and (9) verification of key block analysis approach.

The NRC raised questions regarding the location of the model boundaries being located too close to the drift. The DOE responded that they will reconsider the location of the model boundaries. The DOE stated that it used subcritical crack propagation theory to simulate thermally-induced degradation of joint cohesion. The basis of this methodology is the assumption that joints are either not persistent (joint bridge) or with filling material. The NRC expressed concerns about the approach and a lack of field data to justify the simulation. Furthermore, the DRKBA program does not simulate joint bridges. Consequently, assuming that joint cohesion is a result of joint bridge is not a reasonable assumption. The DOE said it plans to perform additional analysis to verify the approach.

The NRC asked if observations in the field justify the joint filling assumed in the key block analyses. The DOE responded that such joint filling ("locked patches") is common in Yucca Mountain.

The DOE briefly discussed its positions on the status of fracture data adequacy for input to rockfall analysis. The DOE believes that sufficient fracture mapping data have been obtained and are representative of the potential repository area. The DOE further believes that it has resolved the NRC's concern about fracture sampling-bias errors (in the Fracture Geometry Analysis AMR). The NRC stated that these issues will be addressed in future interactions with the Structural Deformation and Seismicity KTI staff who are reviewing the DOE's technical bases.

The NRC questioned the exclusion of small trace length joints as being conservative in terms of block size. The DOE responded that not including small trace length will result in relatively larger size rock blocks and, therefore, it is conservative. The NRC pointed out that while it may be the case for Topopah Spring crystal-poor middle non-lithophysal unit, it may not be the case for Topopah Spring crystal-poor lower lithophysal unit. The DOE indicated that field observations in the lower lithophysal do not suggest the occurrence of large blocks. The DOE indicated that it will examine the effect of small trace length joints on block number and size.

The NRC commented that the DOE determination of shape and size of rockfall blocks using UNWEDGE program did not include the effect of variation of joint dip angle. The DOE stated that the approach used was based on field observations in which strike variation was more prominent than dip variation The DOE stated that dip variation will be evaluated. The NRC questioned the representativeness of fracture data used to obtain potential rock block size. The DOE responded that the fracture data set for the site was one of the most extensive in the world. Specifically, the fracture data set for the lower lithophysal unit in the Repository Host Horizon was derived from approximately 1000 meters of continuous exposure in the enhanced characterization of the repository block and that it is considered sufficiently representative for the same lower lithophysal located in the emplacement drift area.

The NRC pointed out that the technical bases for the result that the drip shield can withstand a 10MT rock has yet to be provided Various agreements were made at the CLST Technical Exchange to address this issue however

The NRC questioned how seismic effects can be accounted for by friction angle. The DOE responded that the technical basis for the approach is documented in the Drift Degradation AMR. The NRC raised concerns regarding validity of the verification analyses presented by the DOE. The DOE stated that the seismic effects approach is adequate, based on the consistent prediction of blocks compared to an alternate numerical solution, and based on the comparison to natural analogues of seismic motion The DOE stated further that it plans to perform more analyses to verify the approach

The NRC questioned the frequency and duration of sinusoidal loading used in the verification analysis and the technical basis for the response measure used to compare the analysis cases The DOE responded that the objective of the verification analyses to confirm the adequacy of the quasi-static approach was fulfilled by the approach used.

Acceptance Criterion 2 addresses the sufficiency of data In its presentation, the DOE addressed three specific NRC issues: (1) temperature dependency of titanium material properties, (2) adequacy of drip shield stress analysis, and (3) adequacy of stress corrosion cracking analysis The DOE concluded that the data collected to date, analysis performed, and planned work captured in existing Container Life and Source Term (CLST) agreements with the NRC support closure of this criterion The NRC asked several clarifying questions regarding the boundary conditions for the finite element models used to assess the consequences of rockfall on the drip shield and waste package The DOE indicated that they are modeling the drip shield as a free standing structure and include the potential interaction with the gantry rail in the analyses The DOE also pointed out that they are accounting for the ground motion by including the effects of the invert floor moving vertically upward in their drip shield and waste package models

Acceptance Criterion 3 addresses the data uncertainty. The DOE concluded that data collected to date, analyses performed, and planned work captured in existing CLST agreements with the NRC support "closed-pending" of this criterion as it pertains to the presently proposed engineered barrier materials

Acceptance Criterion 4 addresses alternative conceptual models. The DOE stated that it considers this criterion to be "closed-pending" completion of additional rockfall verification and completion of additional waste package and drip shield analyses as agreed to during the CLST meeting. The NRC raised concerns on the applicability of the DRKBA code to determine rock block size and distribution under seismic and thermal conditions. The DOE stated that it believes DRKBA code gave reasonable results based on the verification activities described under Acceptance Criterion 1 and will conduct further verification studies to confirm the DRKBA results.

The NRC questioned how the DOE accounted for the multiple rock block scenario. The DOE responded that it may account for the multiple rock block scenario by using maximum available block size. The NRC stated that it will review the analysis when it becomes available. The DOE also stated that it will assess the effect of fall height associated with subsequent rock fall at the same location on waste package and drip shield performance.

Acceptance Criterion 5 addresses model abstraction. The DOE stated that because rockfall has been excluded from TSPA based on low consequence, this criterion is not applicable. However, the DOE stated that based on the information presented under AC #1, additional rockfall verification analyses are being considered.

Component 3 – Thermal Effects on Flow into Emplacement Drifts

A summary of the current status of resolution was presented (see "Subissue 3, Thermal-Mechanical Effects on Underground Facility Design and Performance – Component 3, Thermal Effects on Flow into Emplacement Drifts" presentation given by Bo Bodvarsson, Robert MacKinnon, Ernest Hardin, and Stephen Blair). The DOE identified the NRC information needs from Revision 3 of the RDTME IRSR and subsequent discussions. The DOE stated that the presentation would provide the basis for going to "closed-pending." The DOE then presented the information in various acceptance criteria (AC).

The DOE divided the Component 3 presentation into three parts with their associated AC: (1) Degradation of Engineered Barriers, (2) Quantity and Chemistry of Water Contacting Waste Packages and Waste Forms, and (3) Spatial and Temporal Distribution of Flow.

In the discussion of the degradation of engineered barriers, the DOE addressed two issues: (1) the adequacy of treatment of seismic and thermal loading in drift degradation analysis, and (2) assumption of thermal load initial conditions for thermal-hydrological effects on the engineered barrier environment.

The DOE stated that the effect of floor heave on engineered barrier system performance has been screened out because the predicted displacement is only about 10 millimeters. The NRC asked whether the DOE was counting on the drifts remaining stable for the entire 10,000 year

period The DOE stated that its analysis results showed that there will be only 40 cubic meters of fallen rock in one kilometer length of the drift The NRC asked what the effects of natural backfill on engineered barrier system component temperatures would be. The DOE stated that the thermal effects results would be similar to and generally bounded by the analysis which was done for the design option that included backfill

The DOE stated that as a basis for closure of the fracture permeability issue, it was considering additional modeling to evaluate spatial heterogeneity effects, which would include major faults and other permeable features. The DOE has identified spatial heterogeneity of fracture characteristics as a potentially important factor for seepage during the thermal period, as well as for post-thermal (ambient) seepage. The DOE has a three-dimensional study underway which incorporates fracture sets used in the Drift Degradation Analysis. This study will provide a basis for resolution by estimating the fracture permeability over time resulting from thermal-mechanical effects. Results will be documented in the Coupled Thermal-Hydrologic-Mechanical Effects on Permeability AMR

In the discussion of the quantity and chemistry of water contacting waste packages and waste forms, the DOE addressed six NRC issues: (1) evaluation of changes in drift geometry on water chemistry and quantity, (2) technical basis for parameters used to assess thermal-mechanical effects on hydrological properties, (3) technical basis for temperature distributions used in ventilation design, (4) alternative conceptual models to assess effects of changes in drift geometry, (5) alternative conceptual models to assess effects of changes in rock mass hydrological properties, and (6) alternative conceptual models to assess effects of changes in ventilation on water chemistry and quantity.

The DOE stated that thermal-hydrologic-mechanical effects on fracture permeabilities will vary for horizontal and vertical fractures that are in close proximity to drift openings. The NRC asked if water from the pillar will be diverted to the drifts. The DOE responded that its evaluation indicates that water diversion from pillar to drift is unlikely.

The NRC commented that the drift scale models are not adequate to capture thermal-mechanical effects on flow (a repository scale is required) The DOE described current models for evaluating the effects of changes in fracture properties, on flow fields in the host rock, and the potential for drift seepage These models indicated that changes in fracture permeability of up to two orders of magnitude (comparable to existing variability) would not significantly change the flow fields or the potential for lateral diversion Also the vertical permeability in the pillars will likely remain more than sufficient for vertical drainage, given the magnitude of permeability changes which are expected to occur

The NRC questioned whether drift collapse has been considered in drift seepage and accounted for in the TSPA code. The DOE stated that based on results from the Drift Degradation Analysis, the volume of rock expected to fall into a drift is small and has no significant impact on the seepage into the drift

The DOE presented a basis for resolution of fracture permeability that includes a Distinct Element Analysis which: incorporates discrete fractures, provides stress redistribution due to local shearing along fractures, includes shear effects on permeability, and uses the cubic law to relate fracture deformation to permeability change

The NRC asked why the model was set up to examine changes around the drift but not in the pillar. The DOE stated that the model will be modified in the future to include regions of the pillar that may affect seepage into the drift. The NRC asked for more information pertaining to the choice of fracture pattern. The DOE stated that the fracture pattern was selected to be consistent with hydrologic flow models.

The NRC questioned the primary sources of fracture data used in the three-dimensional discontinuum model. The DOE responded that the orientation data were taken from the Fracture Geometry Analysis AMR and the spacing data were taken from the Calibrated Rock Properties AMR. The NRC asked if the sensitivity analysis will include permeability changes in the pillar. The DOE stated it would.

The NRC asked how flux would be affected by changes in fracture aperture in the pillar. The DOE stated that experimental data does not indicate that changes in permeability in the pillars could lead to lateral diversion. The NRC noted that thermal loads are not accounted for in the pillars. The DOE acknowledged that repository thermal loading is not accounted for in the data. The NRC asked how major faults are being considered. The DOE stated that sensitivity analyses addressing this issue are planned and will consist of thermal hydrology modeling with spatially heterogeneous fractured properties. The NRC questioned how the DOE could consider its drift seepage analysis to be conservative though complete collapse of drifts was not accounted for in the analysis. The DOE stated that complete collapse is highly unlikely.

RDTME Subissue 3, Overall Status

As a result of additional discussions, the NRC and DOE reached 21 agreements for Subissue #3 (see Attachment 1). With these 21 agreements the NRC stated that Subissue #3 could be listed as "closed-pending."

5) Public Comments

Ms. Judy Treichel (Nevada Nuclear Waste Task Force) commented that (1) proposed 10 CFR Part 63 should not be used at this point since it is not final and that, 10 CFR Part 60 would be more appropriate, (2) the NRC should understand in more detail the DOE reliance on ventilation and ground support for the first 300 years, and (3) the NRC should not list subissues as "closed-pending" if the DOE states that it is still considering what course of action to take. Regarding the first issue, the NRC stated that the Commission directed that staff use a risk-informed, performance-based approach for Yucca Mountain. Proposed 10 CFR Part 63 was developed with this in mind and, for this reason, the NRC uses it as a reference in meetings with the DOE. When the final rule is published, the NRC will revisit each of the key technical issues to determine if additional information is needed from the DOE and whether the current status of the issue is appropriate. The NRC acknowledged the validity of Ms. Treichel's second comment. Regarding her third comment, the NRC stated that it had reviewed past agreements

and believed it was using the word 'consider' appropriately in its agreements with the DOE. The NRC requested that Ms. Treichel identify specific agreements with which she takes issue and the NRC would discuss them with her

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Summary of the Resolution of the Key Technical Issue on Repository Design and Thermal-Mechanical Effects

Subissue #	Subissue Title	Status	NRC/DOE Agreements
1	Implementation of an effective design control process within the overall quality assurance program	Closed	N/A
2	Design of the geologic repository operations area for the effects of seismic vents and direct fault disruption	Closed-Pending	1) Provide Topical Report 3, Preclosure Seismic Design Inputs for a Geologic Repository at Yucca Mountain. Consistent with SDS Subissue 2, Agreement 2, the DOE will provide Seismic Topical Report 3, *Preclosure Seismic Design Inputs for a Geologic Repository at Yucca Mountain*, expected to be available to the NRC in January 2002. 2) Provide the substantive technical content of Topical Report 3. The DOE will provide the preliminary seismic design input data sets used in Site Recommendation design analyses to the NRC by April 2001. The DOE will provide the draft final seismic design inputs for license application via an Appendix 7 meeting after calculations are complete prior to delivery of Seismic Topical Report 3.

3	Thermal-mechanical effects on underground facility design and performance	Closed-Pending	1) Provide the technical basis for the range of relative humidities, as well as the potential occurrence of localized liquid phase water, and resulting affects on ground support systems. The DOE will provide the technical basis for the range of relative humidity and temperature, and the potential effects of localized liquid phase water on ground support systems, during the forced ventilation preclosure period, in the *Longevity of Emplacement Drift Ground Support Materials*, ANL-EBS-GE-000003 Rev 01, and revision 1 of the *Ventilation Model*, ANL-EBS-MD-000030, analysis and model reports. These are expected to be available to NRC in September and March 2001, respectively 2) Provide the critical combinations of in-situ, thermal, and seismic stresses, together with their technical bases, and their impacts on ground support performance. The DOE will examine the critical combinations of in-situ, thermal, and seismic stresses, together with their technical bases and their impacts on preclosure ground support performance. These results will be documented in a revision to the *Ground Control for Emplacement Drifts for SR*, ANL-EBS-GE-000002 (or other document) supporting any potential license application This is expected to be available to NRC in FY 2003 3) Provide the Seismic Design Inputs AMR and the Preclosure Seismic Design Inputs for a Geologic Repository at Yucca Mountain, Seismic Topical Report 3. Consistent with SDS Subissue 2, Agreement 2, the DOE will provide the *Seismic Design Inputs* analysis and model report and *Preclosure Seismic Design Inputs for a Geologic Repository at Yucca Mountain*, Seismic Topical Report 3. These documents are expected to be available to NRC in January 2002.

3	Thermal-mechanical effects on underground facility design and performance - cont.		4) Provide in the Design Parameter Analysis Report (or some other document) site-specific properties of the host rock, as a minimum those included in the NRC handout, together with the spatial and temporal variations and uncertainties in such properties, as an update to the information contained in the March 1997 Yucca Mountain Site Geotechnical Report The DOE will: (1) evaluate the adequacy of the currently available measured and derived data to support the potential repository licensing case and identify areas where available data may warrant additional field measurements or testing to reduce uncertainty DOE will provide a design parameters analysis report (or other document) that will include the results of these evaluations, expected to be available to NRC in FY 2002, and (2) acquire data and/or perform additional analyses as necessary to respond to the needs identified in 1 above The DOE will provide these results prior to any potential license application. 5) Provide the Rock Mass Classification Analysis (or some other document) including the technical basis for accounting for the effects of lithophysae. The DOE will provide a rock mass classification analysis (or other document), including the technical basis for accounting for the effects of lithophysae, expected to be available to NRC in FY 2002 6) Provide the design sensitivity and uncertainty analyses of the rock support system. The DOE will prepare a scoping analysis to determine the significance of the input parameters for review by NRC staff by August 2002. Once an agreed set of significant parameters has been determined by the DOE and the NRC staff, the DOE will prepare an analysis of the sensitivity and uncertainty of the preclosure rock support system to design parameters in a revision to the *Ground Control for Emplacement Drifts for SR*, ANL-EBS-GE-000002 (or other document) supporting any potential license application. This is expected to be available to NRC in FY 2003.

3	Thermal-mechanical effects on underground facility design and performance - cont.		7) The DOE should account for the effect of sustained loading on intact rock strength or provide justification for not accounting for it The DOE will assess the effects of sustained loading on intact rock strength . The DOE will provide the results of this assessment in a design parameters analysis report (or other document), expected to be available to NRC in FY 2002. 8) Provide the design sensitivity and uncertainty analyses of the fracture pattern (with respect to Subissue 3, Component 1). The DOE will provide sensitivity and uncertainty analysis of fracture patterns (based on observed orientation, spacing, trace length, etc) on the preclosure ground control system design in a revision to the *Ground Control for Emplacement Drifts for SR*, ANL-EBS-GE-000002 (or other document) supporting any potential license application This is expected to be available to NRC in FY 2003 9) Provide appropriate analysis that shows that rock movements in the invert are either controlled or otherwise remain within the range acceptable to provide for retrieval and other necessary operations within the deposal drifts 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 SR*, ANL-EBS-GE-000002 (or other document) supporting any potential license application. This is expected to be available to NRC in FY 2003. 10) Provide technical basis for the assessment that two-dimensional modeling for emplacement drifts is considered to be adequate, considering the fact that neither the in-situ stress field nor the principle fracture orientation are parallel or perpendicular to emplacement drift orientation. The DOE will provide the technical bases for the modeling methods used in ground control analysis in a revision to the *Ground Control for Emplacement Drifts for SR*, ANL-EBS-GE-000002 (or other document) supporting any potential license application. This is expected to be available to NRC in FY 2003.

3	Thermal-mechanical effects on underground facility design and performance - cont.		11) Provide continuum and discontinuum analyses of ground support system performance that take into account long-term degradation of rockmass and joint strength properties. 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 SR*, ANL-EBS-GE-000002 (or other document) supporting any potential license application. This is expected to be available to NRC in FY 2003. 12) Provide dynamic analyses (discontinuum approach) of ground support system performance using site specific ground motion time history as input. The DOE will provide appropriate analyses to include dynamic analyses (discontinuum approach) of preclosure ground support systems, using site specific ground motion time histories as input, in a revision to the *Ground Control for Emplacement Drifts for SR*, ANL-EBS-GE-000002 (or other document) supporting any potential license application. This is expected to be available to NRC in FY 2003. 13) Provide technical justification for boundary conditions used for continuum and discontinuum modeling used for underground facility design The DOE will provide the technical justification for boundary conditions used in modeling for preclosure ground control analyses in a revision to the *Ground Control for Emplacement Drifts for SR*, ANL-EBS-GE-000002 (or other document) supporting any potential license application. This is expected to be available to NRC in FY 2003.

3	Thermal-mechanical effects on underground facility design and performance - cont.		14) Provide the results of the ventilation modeling being conducted at the University of Nevada-Reno (Multi-Flux code) and validation testing at the Atlas Facility (validation of the ventilation model based on the ANSYS code), including: 1) the technical bases for the adequacy of discretization used in these models and 2) the technical bases for the applicability of the modeling results to prediction of heat removal from the repository The DOE will provide the results of the ventilation tests in a update to the *Ventilation Model*, ANL-EBS-MD-000030, analysis and model report including 1) the technical bases for the adequacy of discretization used in these models and 2) the technical bases for the applicability of the modeling results to prediction of heat removal from the repository This is expected to be available to NRC in FY 2002. 15) Provide field data and analysis of rock bridges between rock joints that are treated as cohesion in DRKBA modeling together with a technical basis for how a reduction in cohesion adequately accounts for thermal effects. The DOE will provide clarification of the approach and technical basis for how reduction in cohesion adequately accounts for thermal effects, including any additional applicable supporting data and analyses. Additionally, the adequacy of the cohesion reduction approach will be verified according to the approach described in Subissue 3, Agreement 22, of the Repository Design and Thermal-Mechanical Effects Technical Exchange. This will be documented in a revision to the *Drift Degradation Analysis*, ANL-EBS-MD-000027, expected to be available to NRC in FY 2003. 16) Provide a technical basis for the DOE position that the method used to model joint planes as circular discs does not under-represent the smaller trace-length fractures. The DOE will analyze the available small trace-length fracture data from the Exploratory Studies Facility and Enhanced Characterization of the Repository Block, including their effect on block development. This will be documented in a revision to the *Drift Degradation Analysis*, ANL-EBS-MD-000027, expected to be available to NRC in FY 2003.

3	Thermal-mechanical effects on underground facility design and performance - cont.		17) Provide the technical basis for effective maximum rock size including consideration of the effect of variation of the joint dip angle The DOE will provide the technical basis for effective maximum rock size including consideration of the effect of variation of the joint dip angle This will be documented in revisions to the *Drift Degradation Analysis*, ANL-EBS-MD-000027, and the *Rockfall on Drip Shield*, CAL-EBS-ME-000001, expected to be available to NRC in FY 2003 18) Provide a technical basis for a stress measure that can be used as the equivalent uniaxial stress for assessing the susceptibility of the various engineered barrier system materials to stress corrosion cracking (SCC). The proposed stress measure must be consistent and compatible with the methods proposed by the DOE to assess SCC of the containers in WAPDEG and in accordance with the agreements reached at the CLST Technical Exchange The DOE will include a detailed discussion of the stress measure used to determine nucleation of stress corrosion cracks in the calculations performed to evaluate waste package barriers and the drip shield against stress corrosion cracking criterion DOE will include these descriptions in future revisions of the following: *Design Analysis for UCF Waste Packages*, ANL-UDC-MD-000001, *Design Analysis for the Defense High-Level Waste Disposal Container*, ANL-DDC-ME-000001, *Design Analysis for the Naval SNF Waste Package*, ANL-UDC-ME-000001, and *Design Analysis for the Ex-Container Components*, ANL-XCS-ME-000001. The stresses reported in these documents will be used in WAPDEG and will be consistent with the agreements and associated schedule made at the Container Life and Source Term Technical Exchange (Subissue 1, Agreement 14, Subissue 6, Agreement 1).
3	Thermal-mechanical effects on underground facility design and performance - cont.		19) The acceptability of the process models that determine whether rockfall can be screened out from performance assessment abstractions needs to be substantiated by the DOE by doing the following: (1) provide revised DRKBA analyses using appropriate range of strength properties for rock joints from the Design Analysis Parameters Report, 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 Report for the Stratigraphic Units of the Repository Host Horizon, including

			small joints trace lengths; (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 the Design Analysis Parameters Report; (d) long-term degradation of rock block and joint strength parameters; and (e) site-specific groundmotion time histories appropriate for post-closure period; provide a detailed documentation of the analyses results; and (4) in view of the uncertainties related to the rockfall analyses and the importance of the outcome of the analyses to the performance of the repository, evaluate the impacts of rockfall in performance assessment calculations. DOE believes 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 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*, ANL-EBS-GE-000006, 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*, ANL-EBS-MD-000027, expected to be available to NRC in FY 2003. 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.

3	Thermal-mechanical effects on underground facility design and performance - cont.		20) Provide the sensitivity analyses including the effects of boundary conditions, coefficient of thermal expansion, fracture distributions, rock mass and fracture properties, and drift degradation (from Subissue 3, Component 3, Slide 39). The DOE will provide sensitivity analyses of thermal-mechanical effects on fracture permeability, including the effects of boundary conditions, coefficient of thermal expansion, fracture distributions, rock mass and fracture properties, and drift degradation. This will be provided consistent with site data and integrated with appropriate models in a future revision to the *Coupled Thermal Hydrologic Mechanical Effects on Permeability*, ANL-NBS-HS-000037, and is expected to be available to NRC in FY 2003 21) Provide the results of additional validation analysis of field tests (from Subissue 3, Component 3, Slide 39) The DOE will provide the results of additional validation analysis of field tests related to the thermal-mechanical effects on fracture permeability in a future revision to the *Coupled Thermal Hydrologic Mechanical Effects on Permeability*, ANL-NBS-HS-000037, and is expected to be available to NRC in FY 2003.
4	Design and long-term contribution of repository seals in meeting post-closure performance objectives	Closed	N/A

MEETING SUMMARY OF THE JANUARY 31, 2001 U.S. NUCLEAR REGULATORY COMMISSION/U.S. DEPARTMENT OF ENERGY TECHNICAL EXCHANGE ON DATA VERIFICATION & DATA/SOFTWARE QUALIFICATION

On January 31, 2001, staff of the U.S. Nuclear Regulatory Commission (NRC) and U.S. Department of Energy (DOE) met at NRC headquarters in Rockville, Maryland with telephone conference with the DOE office in Las Vegas, Nevada and the Center for Nuclear Waste Regulatory Analyses in San Antonio, Texas. The purpose of the meeting was to provide DOE the opportunity to brief the staff on Yucca Mountain Project's (YMP's) progress on verification of data and qualification of data and software.

Attendees

Attachment 1 provides the name, affiliation and telephone number of the attendees.

Agenda

Attachment 2 provides the agenda.

Opening Remarks

Ted Carter welcomed the attendees and introduced the DOE representatives. Robert Latta stated that the purpose of the meeting was to have DOE present the background on the methodology to verify data and to qualify data and software for the YMP.

Presentations

Dr. Robert Wemheuer presented the YMP basis for establishing a process to assure that previously-qualified data meets all of the project requirements for traceability, technical quality, and documentation. This need was based on a series of Corrective Action Reports (CARs) generated by the YMP in 1998. Root Cause evaluations, remedial actions and actions to preclude recurrence have been completed. The verification process discussed is a project initiative that has been continued after closure of the CARs.

Dr. Wemheuer stated that his presentations focused on information and data, and not on analyses. He provided an overview of the data verification/qualification and software qualification process with view graphs (Attachment 3). He illustrated the traceability of the processes with samples of process documents and DOE's web site. He also discussed some documents for these processes. These include: Plan for Resolution of TBV/TBD Issues for Data Used as Direct Input to AMRs/PMRs, Checklist for Compiling TBV/TBD Removal Records Package, Data Qualification Documentation Checklist and Reports. He concluded that the processes, applied together with the documentation, addressed the issues of traceability and reproducibility to ensure regulatory compliance.

Summary Highlights of NRC/DOE Technical Exchange and Management Meeting on Evolution of the Near-Field Environment

January 9-11, 2001
Pleasanton, California

Introduction and Objectives

This Technical Exchange and Management Meeting on the Evolution of the Near-Field Environment (ENFE) is one in a series of meetings related to the U.S. Nuclear Regulatory Commission (NRC) key technical issue (KTI) and sufficiency review and the U.S. Department of Energy (DOE) site recommendation decision. Consistent with NRC regulations on prelicensing consultations and a 1992 agreement with DOE, staff-level resolution can be achieved during prelicensing consultation. The purpose of issue resolution is to assure that sufficient information is available on an issue to enable the NRC to docket a proposed license application. 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. Issue resolution at the staff level, during prelicensing, is achieved when the staff has no further questions or comments at a point in time regarding how the DOE is addressing an issue. The discussions recorded here reflect NRC's current understanding of aspects of the ENFE KTI most important to repository performance. This understanding is based on all information available to date which includes limited, focused, risk-informed reviews of selected portions of recently provided DOE documents (e.g., Analysis and Model Reports (AMRs) and Process Model Reports (PMRs)). Pertinent additional information (e.g., change in design parameters) could raise new questions or comments regarding a previously resolved issue.

Issues 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. Issues are "closed-pending" if the NRC staff has confidence that the DOE proposed approach, together with the DOE agreement to provide the NRC with additional information (through specified testing, analysis, etc.) acceptably addresses the NRC's questions such that no information beyond that provided, or agreed to, will likely be required at time of initial license application. Issues 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.

The objective of this meeting is to discuss and review the progress on resolving the ENFE KTI (see Attachment 1 for the description of Subissues #1, 2, 3, and 4). Subissue #5, "Effects of Coupled Thermal-Hydrologic-Chemical Processes on Potential Nuclear Criticality in the Near Field," was discussed during a Technical Exchange and Management Meeting on October 22-23, 2000, and was not discussed during this meeting. The quality assurance (QA) aspect of this KTI was determined to be outside the scope of the meeting and is being tracked in NRC's ongoing review of DOE's QA program.

technical basis supporting the DOE conclusion that interactions between water and engineered materials would have negligible impact on performance. The DOE referred to a general discussion in the corrosion AMR and mentioned modeling results on steel corrosion product effects. The NRC stated that this argument needed to be strengthened. In response to an NRC question on the range of gas fluxes modeled, the DOE referred to the EBS Physical Chemical Environment AMR. The NRC also asked why nitrate was not included among modeled species. The DOE answered that its corrosion modelers did not consider nitrate to play an important role. In response to another NRC question, the DOE stated that, currently, they did not believe propagation of uncertainty among coupled process models would significantly change the results. The NRC stated that the DOE needed to provide additional technical bases that this approach is adequate.

The DOE then addressed two comments from Revision 3 of the ENFE IRSR on in-drift colloid transport modeling. The in-drift water chemistry model treatment was argued to be conservative, as was the exclusion of alternative conceptual transport models. The NRC asked if the DOE considered colloid entrainment by vigorous water movement in the drift. The DOE answered that they had not considered this but would expect the effect on transport to be small due to (1) low flow rates in the drift and (2) the tendency of boiling-generated flow to be directed toward the source.

NRC Comments Related to TSPA for the Site Recommendation Results Related to Waste Form Degradation

This presentation focused on the TSPA-SR waste form degradation model. The in-package chemistry and colloid concentration components were addressed to answer the NRC comments under Subissue 3. The DOE stated that this presentation provided context for more detailed discussions to be presented in subsequent talks and provided the basis for resolution of five NRC Subissue 3 comments. The in-package chemistry component - new to TSPA - is directly coupled to model components covering waste degradation and radionuclide concentration. Included chemical parameters are pH, ionic strength, and chloride. Bulk chemistry calculations, at the package scale, are used so that localized effects such as radiolysis are not included, but have been evaluated. Next, the colloid release model component was described. The model includes reversible and irreversible attachment, assumes no filtration or sorption of colloids within the package, and incorporates pH and ionic strength effects. The DOE has concluded that colloids are minor contributors to dose. The DOE then addressed three comments from Revision 3 of the ENFE IRSR regarding colloid release. The first comment concerned the current exclusion of release of waste-form colloids from spent nuclear fuel. The DOE will continue to monitor drip corrosion tests for possible colloid production. The second NRC comment related to neglecting of chemical effects other than pH and ionic strength effects: The DOE indicated that they will in future reports strengthen arguments supporting the neglect of chemical effects. The third NRC comment related to the selection of radionuclides included in colloid modeling. The DOE made qualitative arguments for the selection of radionuclides included in colloid modeling. The NRC raised a number of questions concerning colloid modeling. The NRC stated that it was looking for a more quantitative basis for the radionuclide selection. In its response, the DOE reiterated the dose-effect basis it had presented. Two questions concerned the impact of the ionic strength stability effect on radionuclide mobility. The DOE stated that in its models, colloids were consistently at their maximum stability levels, so that the highest possible colloid concentrations are being modeled. The NRC pointed out

that it may be inappropriate to evaluate the proportional dose importance of colloids by comparison to aqueous release, which may be much less mobile than colloid releases. The NRC asked if model results on relative concentrations of aqueous and colloidal plutonium release have been compared directly to Argonne National Laboratory test results. The DOE said that they had not made this comparison. The NRC commented that it would be informative to show how the quantity of colloids produced compared to the in-package chemistry-limited-values, released from the waste package to the invert. The NRC asked whether it was possible that the dose-based radionuclide selection process could be circular. The DOE answered that their selection process, while qualitative, was initiated in the absence of any dose contribution information. The NRC suggested that this process is not well documented. Finally, Mr. Don Shettel (Nye County) asked why the DOE had not used vadose zone water equilibrated with tuff for corrosion tests. The DOE stated that the in-package concentration are not sensitive to the range of influent water compositions used.

The NRC inquired about the method used to solve for pH in the "in-package chemistry model." For example, pH is used in the calculation of the rate of high-level waste dissolution and the rate of high-level waste dissolution is a function of pH. The DOE stated that the pH is calculated in a step-wise (temporally) manner.

TSPA Representation of Effects of Coupled THC Processes on Radionuclide Transport

The DOE discussed the incorporation of THC effects in the EBS transport abstraction in TSPA. Currently, the DOE takes no credit for retardation within the EBS. The NRC had provided comments to the DOE on this topic under Subissue 4. These comments had been resolved prior to the meeting. This abstraction integrates information on seepage and flow, thermal evolution, waste package corrosion, and water compositions as affected by EBS materials. Diffusive transport is modeled to begin as soon as stress corrosion cracking affects the waste package, irrespective of drip shield failure. Advective release requires formation of waste package general corrosion patches. In response to the NRC questions, the DOE said that: (1) they may in the future include EBS radionuclide retardation in the invert and on corrosion products as part of efforts to reduce conservatism; and (2) they have done calculations showing that the waste package flow-through model approach is conservative.

The NRC questioned whether the flow-through model was most conservative with respect to peak mean dose. In particular the NRC submitted that a "draining bath-tub" would release mass more quickly. However, the NRC submitted that the risk significance of this alternative release model was not known. The DOE stated that their selection of the EBS release model was conservative with respect to earliest release.

3) Technical Discussions - Subissue #1, Effects of Coupled Thermal-Hydrologic-Chemical Processes on Seepage and Flow

NRC Comments on Coupled Thermal-Hydrological-Chemical Processes Affecting the Calico Hills Hydrogeological Unit Related to Subissue 1

A summary of the current status of resolution was presented (see "NRC Comments on Coupled Thermal-Hydrological-Chemical Processes Affecting the Calico Hills Hydrogeological Unit Related to Subissue 1" presentation given by Eric Sonnenthal). This presentation addressed

comments from Revision 3 of the ENFE IRSR that indicated that the DOE needs to evaluate the potential effects on performance (e.g., shorter travel time, diminished sorption) of alteration of the Calico Hills nonwelded unit (CHn) below the repository. The DOE has concluded that any changes to CHn resulting from the excursion up to approximately 75°C will have negligible impact. The key line of reasoning is that alteration of clinoptilolite to analcime will be kinetically and thermodynamically inhibited due to the abundance of silica. Furthermore, the DOE has concluded that any alteration of zeolite properties (in the absence of alteration to analcime) would be minor. These conclusions may be tested in the future by mountain-scale THC models. In response to an NRC question, the DOE stated that it has not yet decided whether this modeling will be performed. The NRC asked if the DOE had considered the alteration of glass to zeolite. The DOE said this minor effect had been discussed in the AMR on drift-scale coupled processes. This AMR is also the source of validation information requested in another NRC question. The NRC asked if there was a threshold temperature at which the mineral transformation will be important. The DOE answered that the temperature is dependent on particular conditions and that, in any case, it is above 70°C for CHn alteration. The NRC asked if advective removal of silica was considered because slow silica removal is central to their argument. The DOE considered the different flow regimes (in vitric and zeolitic minerals) present in the CHn. The DOE stated their model considered inter-fingering of vitric and zeolite minerals and should bound possible flow regimes. The NRC asked about uncertainty propagation in the handoff of drift-scale THC calculations to other abstractions. The DOE stated that it considered the use of the two mineral models (simple and complex) and the representation of infiltration uncertainty to bound uncertainties. The NRC acknowledges that the performance impact of CHn alteration is minor under the current DOE model approach in which only a portion of unsaturated zone flow from the repository traverses the CHn. Performance impact will need to be reassessed if that assumption changes.

Subissue 1: NRC Comments on Thermal Alteration of the Paintbrush Tuff Nonwelded Hydrogeological Unit

A summary of the current status of resolution was presented (see "Subissue 1: NRC Comments on Thermal Alteration of the Paintbrush Tuff Nonwelded Hydrogeological Unit" presentation given by Nicolas Spycher). In this presentation, the DOE addressed the NRC comments regarding the DOE neglect of repository-driven alteration of the Paintbrush Tuff Nonwelded (PTn) unit above the emplacement zone. The DOE has determined that effects of alteration of the PTn on performance would be negligible. The THC modeling indicates that permeability and porosity changes would be negligible. The PTn is modeled to be above 40°C for about 2000 years and predicted porosity decreases are less than 0.005 percent. Results of this modeling and sensitivity studies are to be documented in future DOE reports and work is still in progress.

Subissue 1: Comments on Effects of Cementitious Materials

A summary of the current status of resolution was presented (see "Subissue 1: Comments on Effects of Cementitious Materials" presentation given by Ernest Hardin). This presentation was focused on addressing a comment from Revision 3 of the ENFE IRSR on the need for the DOE to analyze and evaluate the potential for interaction between cementitious materials and host rock that may affect flow and transport. The DOE stated that analyses of the effects of cement grout for rockbolts are reported in the EBS Physical and Chemical Environment AMR Rev 01.

The DOE stated that these analyses concluded that effects on gas and water compositions will be minor. Grout leachates will comprise only a few percent of the total seepage into the drift. The DOE described proposed additional mountain-scale THC modeling expected to further support their exclusion of cement influence. Key mitigating processes include leachate dilution, leachate neutralization by gas-phase carbon dioxide, and permeability reduction by calcite precipitation. The DOE stated that information in planned updates to AMRs and PMRs will bolster their argument. The NRC asked whether the DOE believed they could further support the exclusion without new modeling. The DOE responded that mass balance considerations may be sufficient. In response to a question from Mr. Carl DiBella (Nuclear Waste Technical Review Board - NWTRB staff), the DOE said that discussion of a relevant anthropogenic analog is included in the EBS Physical and Chemical Environment AMR Rev 01.

Subissue 1: NRC Comments on Mineral Precipitation in Fractures or at the Fracture-Matrix Interface

A summary of the current status of resolution was presented (see "Subissue 1: NRC Comments on Mineral Precipitation in Fractures or at the Fracture-Matrix Interface" presentation given by Eric Sonnenthal). This presentation addressed the NRC comments on modeling approaches related to THC processes including fluid dynamics at the boiling front and the treatment of dry fracture blocks. The DOE has determined that effects of mineral precipitation on hydrologic properties can be neglected based on modeling which shows that fracture sealing will not occur. The DOE asserted that these conclusions are supported by Drift Scale Test results. The NRC asked, considering the three year duration of the drift scale test, how can one conclude that there is no bulk fracture sealing. An example was given that if the rate of deposition was one percent per year, only three percent of the fracture porosity will have sealed over the test duration which is likely to not be observable with current measurement techniques. The DOE stated that the observations to date provide constraints to some of the reaction rates. Model assumptions regarding the boiling front are justified by sensitivity studies and the modeled demonstration of conservation of mass. Results are stated to be in the Unsaturated Zone Flow and Transport milestones which the NRC requested the DOE to provide. Discussion of numerical modeling of the dry-out front and reactive surface areas prompted a request from NRC for information on the modeled quantity of unreacted solute trapped in a non-physical manner produced in the dry-out zone. The NRC also requested information on available physical evidence from the Drift Scale Test which would support the DOE's precipitation model predictions. The NRC inquired as to the validity of the active fracture model during the thermally-perturbed time period. The DOE responded that this point should be evaluated but that they believe water flow is appropriately represented during ambient and thermally perturbed conditions.

The NRC expressed the concern that the various sources of uncertainty, such as data uncertainty, conceptual model uncertainty, and model implementation result in very uncertain output. The NRC inquired whether the DOE's treatment of uncertainty in the drift-scale THC model appropriately represented and propagated uncertainty from the various sources. The DOE agreed that the uncertainties are large and felt that comparison to experimental results are the way to build confidence in the model results. The DOE stated that some sealing does occur in small fractures, based on laboratory experiments. The NRC questioned what implications to the seepage or radionuclide transport models may be if sealing of small

fractures occurred but bulk permeability was minimally reduced. The DOE stated it would most likely depend on how the final distribution ended up.

During the public comment section, Mr. Steve Frishman (State of Nevada) asked what is the fate of the mobilized silica and how is it treated in terms of conceptual models.

ENFE Subissue 1 Overall Status

As a result of additional discussions, the NRC and DOE reached seven agreements for Subissue #1 (see Attachment 1). With these seven agreements, the NRC stated that Subissue #1 could be listed as "closed-pending".

4) Technical Discussions - Subissue #4, Effects of Coupled Thermal-Hydrologic-Chemical Processes on Radionuclide Transport

Subissue 4: NRC Comments on Colloidal Transport in the Unsaturated Zone

A summary of the current status of resolution was presented (see "Subissue 4: NRC Comments on Colloidal Transport in the Unsaturated Zone" presentation given by Jim Houseworth). The DOE addressed a comment from Revision 3 of the ENFE IRSR that the DOE provide additional technical bases supporting models and data for simulating unsaturated zone colloidal transport. The DOE described the colloidal transport model, noting conservatisms such as neglect of colloid diffusion, confining most colloids to fracture transport, and neglect of colloid retardation. The presentation included a description of how the distribution for the colloidal radionuclide transport parameter K_c was determined using the maximum model colloid concentration determined using an empirical relationship to ionic strength, and the high K_d for Am on smectite. The NRC asked if the DOE had screened out THC effects on transport parameters such as sorption coefficient and aqueous speciation. The DOE responded that THC screening was in reference to effects on rock properties, and that chemical effects on transport-relevant properties (including colloids) had not been explicitly addressed. The DOE stated that the broad distribution range for K_c may encompass all possible effects. The NRC suggested that waters collected during the drift-scale test (none have yet been observed) may yield colloid information, and that ongoing studies at Rainier Mesa may also be pertinent. The DOE answered that they will look at such data, but that they are unlikely to add information because the DOE is assuming no colloid retardation. The NRC asked if the maximum colloid concentration used in calculating K_c is bounding with respect to perturbed conditions; the DOE answered that this value reflects ionic strength relationships under ambient conditions. Finally, the NRC asked whether the DOE had considered possible entrainment of colloids and particulates in convecting/advecting fluids during boiling. The DOE said that they had not, but that low fluid fluxes made it unlikely that this effect would be significant.

As a result of additional discussions, the NRC and DOE reached eight agreements for Subissue #4 (see Attachment 1). With these eight agreements, the NRC stated that Subissue #4 could be listed as "closed-pending".

5) Technical Discussion - Subissue #2, Effects of Coupled Thermal-Hydrologic-Chemical Processes on the Waste Package Environment

The NRC staff made available their concern on the technical basis for treatment of FEP 1.2.06.00 (Hydrothermal activity) they had presented verbally on January 8, 2001, during the Thermal Effects of Flow (TEF) Key Technical Issue Technical Exchange (see Attachment 4, Presenter's Slides).

Subissue 2: NRC Comments on In-drift Geochemical Environment

A summary of the current status of resolution was provided in the first DOE presentation (see "Subissue 2: NRC Comments on In-drift Geochemical Environment", presentation given by Ernest Hardin). The purpose of the presentation was to address the NRC concern that the incomplete description of the geochemical environment, including introduced materials and trace elements, does not allow the DOE to calculate or bound, using local reactions and reaction paths, the potential geochemical environments that may be important to the performance of the drip shield and waste package. Additionally, the presentation addressed the NRC's concern on the DOE's approach to complete a final design that accounts for: (a) impacts of in-drift materials on the geochemical environment and repository performance; and (b) definition of those materials that could be incorporated into the emplacement area.

The DOE's basis for resolution includes their technical judgement that the current models produce expected and bounding compositions based on the behavior of major and minor chemical species. The DOE's approach currently uses bulk chemical calculations. The NRC staff questioned the importance of local reactions on the variability and uncertainty of downstream performance assessment models. The DOE responded that heterogeneities are not important from a features, events, and processes screening approach. Responding to an NRC question, the DOE indicated that fluoride could be calculated in the process-level models, but it is not used in total system performance assessment models. The NRC staff expressed a concern that the current DOE approach does not bound the possible water chemistries, rather it provides boundary conditions to the exisiting models. For instance, the NRC indicated that the current two conceptual models used to calculate the composition at the drift wall are not necessarily bounding. The NRC also inquired as to how the waters could be considered bounding considering the impact of the degradation of introduced materials. The DOE presented, in tabular form, a comparison of various waters. In particular water predicted for seepage period 2 at a relative humidity of 95%, cement leachate, and equilibriated leachate were compared. The DOE stated that the compositions of these waters were similar. The NRC pointed out that aluminum was quite a bit (three orders of magnitude) higher in the cement-reacted waters than the other waters. In addition, the NRC commented that they expected the evaporation of the cement leachate waters may result in compositions that are significantly more concentrated in some species than the evaporated seepage water. As an additional basis, the DOE indicated that planned activities to evaluate alternative reactions and reaction paths would be documented in updates to the engineered barrier system geochemical models. The activities would focus on trace elements (lead, mercury, and arsenic, and expanded as necessary) that have been suggested to be important to the performance of the EBS. A further basis for resolution is additional work being performed on revising the Pitzer database, and work that is being considered to modify the EQ3/6 computer code. The DOE indicated that the current baseline control process (AP-3.4Q) is a basis to resolve the NRC's concern on the DOE's approach to a final design.

The NRC staff stated that the planned activities do not clearly address their concerns on the materials, their compositions and reactions, and their potential importance to repository performance. The DOE's response was two-fold. First, the DOE indicated that efforts to characterize trace elements in the natural environment, in rocks and fluids, can be completed and efforts are ongoing. Regarding the focus of the NRC's concern, the DOE indicated that they would evaluate trace elements in steel and concrete. Once the inventory activity was completed, they would model the environment focusing on lead, mercury, and arsenic.

Mr. Don Shettel (Nye County) asked DOE which trace elements were important to the drip shield performance. The DOE responded that the review process is still underway and the list has not been finalized. The NRC staff asked whether there are plans for additional uncertainty analyses for reaction pathways. The DOE responded that they had not yet closely looked at reaction pathway uncertainties.

Evolution of the Near-Field Environment Subissue 2: NRC Comments on Treatment of Coupled Process and Model Integration

The second DOE presentation (see "Evolution of the Near-Field Environment Subissue 2: NRC Comments on Treatment of Coupled Process and Model Integration" presentation given by Ernest Hardin) addressed two NRC concerns. The first NRC concern is that there is an inadequate technical basis to support DOE's approach that coupled THC processes can be decoupled, evaluated separately, and then re-coupled, without adversely affecting predictions of repository performance. The second NRC concern is that the DOE's Physical and Chemical Environment sub-models are insufficiently integrated and that the use of J-13 water composition as an initial condition is inappropriate. The DOE addressed these concerns using three discussions. The first discussion focused on coupling relationships and also addressed an alternative approach that is being considered. The second discussion on mass and energy fluxes addressed the technical basis for separating sub-models. The final discussion on model integration addressed the concerns on insufficient integration and the use of J-13 water composition.

In the first discussion the DOE indicated that the basis for resolution is that thermal-hydrological coupling effects are already included, thermal effects on chemistry have been addressed, and that small-scale coupling relationships are addressed empirically. The DOE indicated that another basis for resolution is that other in-drift thermal-hydrological-chemical processes are negligible. The NRC questioned whether these arguments had been documented and the DOE stated that specific in-drift coupling relationships have been and will be addressed in a variety of revised reports. The DOE added that the drift-scale test represents the coupled processes pertinent to Yucca Mountain. For example, electrical potential variations have been observed in the rock near the wing heaters. The NRC asked what was the magnitude of the electrical potential variation. The DOE responded it was several hundred millivolts. The NRC staff asked whether the potential for rockfall on the drip shield denting the shield and subsequent impacts of fluid collection in the dent had been evaluated. The DOE indicated that this has been addressed in the stress corrosion cracking analysis/model report. The NRC questioned what changes were documented concerning microbial processes and whether the model had been supported by data. The DOE indicated that production of carbon dioxide and the presence of a localized biofilm had been addressed and the validation information was included in the revised microbes report. The DOE outlined an alternative proposed approach that would include the in-

drift environment on the same thermal-hydrological-chemical simulations that are now used for the host rock. The NRC questioned at which locations the model would be applied. The DOE indicated that the main focus would be application in evaluating changes to the diffusivity properties of the drift invert. The NRC asked what the importance of the porosity of the deposited minerals/salts would be with respect to the deliquesence point. The DOE responded that observations from mechanical engineering, when determining the deliquesence point of salts, suggest the effect to be of minor importance.

The second discussion focused on mass and energy fluxes. The DOE asserted that processes can be separated, simulated, and re-coupled provided that important interactions are included. The NRC stated that this conclusion is conditional on the assumption that various sources of uncertainty from sub-models are propagated through the analysis. The DOE stated that the impact of various sub-models on the physical and chemical environment is documented in a variety of revised reports. The primary basis for DOE assertions that models can be simulated separately is that interactions between locations are unimportant if there is no solid or liquid mass transfer. Because gravity is the dominant physical process controlling liquid transfer, only those models directly tied via liquid flow pathways are coupled. All models that are dependent on oxygen and carbon dioxide concentrations are coupled to the processes affecting gas composition. The DOE indicated that they are investigating small-scale interactions in the materials testing program. The NRC questioned the technical basis for the DOE screening out the effects of fluids interacting with grouted rock bolts. The NRC asked whether the DOE has adequately addressed the chemistry of initial fluids formed upon re-wetting of evaporated salts. The DOE stated that separation of physical and chemical process submodels is justified by the separation of key locations within the EBS. Interactions between locations would be unimportant if there is no solid or liquid mass transfer. The NRC commented that it is difficult to determine when interactions between locations are unimportant because the chemical divide process in an evaporative system can result in small uncertainties being propagated into large effects.

The final discussion on model integration offered two bases for resolution. First, the DOE indicated that current models use abstracted water compositions from thermal-hydrological-chemical modeling of the host rock as the drift-wall boundary conditions. Second, the DOE indicated that the type of water represented by thermal-hydrological-chemical model results (chloride-sulfate type) has been incorporated in corrosion testing.

Subissue 2, NRC Comments on the Assumption of Chemical Equilibrium

The third DOE presentation (see "Subissue 2, NRC Comments on the Assumption of Chemical Equilibrium" presentation given by Ernest Hardin) addressed the assumption of equilibrium in chemical models in the salts/precipitates analyses in response to an NRC comment requesting a stronger technical basis for this assumption. The response focused on similarities between laboratory and model results. In addition, suppressed minerals in models were selected based on known paragenesis, and suppressions and alternate precipitates are tested in sensitivity studies. The NRC questioned the extent of the technical basis used in determining mineral suppressions. The DOE indicated that the current revision of the precipitates/salts report does not contain additional technical bases. The NRC questioned whether the current results were bounding, considering that experiments with introduced materials had not yet been completed. The DOE responded that the chemical divide effect is the biggest influence in determining final

compositions. The DOE noted plans to make comparisons to results of kinetic models. The NRC noted that mineral precipitates observed in evaporation tests were few compared to modeled precipitates. The DOE responded that precipitates may not be detectable and that solution composition variations may reveal precipitation. However, the DOE noted that some predicted precipitates should have been detectable. The NRC questioned the validity of equilibrium modeling for silica and the DOE acknowledged that silica is a difficult species to model at equilibrium. Mr. Don Shettel (Nye County) asked if thermal gradient tests were being conducted to test for coupled nonequilibrium phenomena. The DOE responded that thermal gradient tests were being examined for model validation purposes.

Subissue 2: Range of Water Chemistry and Trace Elements in the Waste Package Chemical Environment

The fourth DOE presentation (see "Subissue 2: Range of Water Chemistry and Trace Elements in the Waste Package Chemical Environment" presentation given by Gregory Gdowski) addressed two NRC concerns. The first NRC concern is that the DOE should provide information on the full water chemistry, including trace metals important to drip shield and waste package performance. The second NRC concern is that the DOE should provide additional laboratory and field data on the performance of the drip shield, especially in the presence of fluoride. The DOE identified the processes, in existing models, that control the chemistry of water contacting the waste packages. The type of brine characterization studies that the DOE has conducted and has planned to conduct was then described. The DOE presented information on the various sources for the water chemistry information, including thermal tests and laboratory aqueous solutions. The NRC asked whether the DOE had any plans to characterize dust that might settle on engineered materials. The DOE described that both air sampling and wipe tests would be conducted. Mr. Carl DiBella (NWTRB staff) asked whether the dust would be evaluated for organic components (e.g., pollen, spores) and the DOE stated that the sampled dust would be characterized by scanning electron microscopy. Plans to analyze laboratory solutions that have interacted with introduced materials were presented by the DOE. The types of information collected from the various field and laboratory experiments were identified. The NRC noted that it needs documentation of the rationale that the DOE used to select only a limited subset of water sample analyses in the Drift Scale Heater Test to calibrate or validate its model of coupled THC processes. The NRC asked whether and where the results from the Atlas facility crushed tuff experiments were documented. The DOE indicated that results were not yet documented.

Results from evaporative concentration tests that used a bicarbonate-type water and chloride-sulfate-type water were presented. The NRC staff questioned whether these results supported the assumption of chemical equilibrium. The relationship of the time scale of the experiments to the time steps used in performance assessment calculations was also questioned by the NRC. The NRC staff questioned whether the DOE understands the water chemistry at the time of initial re-wetting of the completely dry precipitates. The NRC also noted that two types of water tested could adversely impact different barriers and asked how the DOE would choose which type of water chemistry to use in performance assessment calculations. Finally, the NRC questioned whether the DOE will complete evaporative concentration experiments with solutions that had initially reacted with engineered materials. The DOE indicated that these tests are being considered.

Trace element concentrations were provided for J-13 and EJ-13 water samples. Mr. Don Shettle (Nye County) asked whether trace elements in the corrosion tests would be measured. Information on plans to characterize the trace element content of solutions used in the long-term corrosion testing program was provided by DOE. The NRC asked whether speciation of trace elements like lead was going to be measured in the trace element tests. The DOE replied that it was not currently in the scope of the planned work. Finally, the DOE described the type of testing being conducted for the Ti Grade 7 drip shield, including testing that will incorporate elevated levels of fluoride in dilute waters. The NRC questioned whether waters would have around 1000 ppm of fluoride and whether the DOE knows what the consequences would be for drip shield performance. The DOE indicated that the elevated range of fluoride would encompass 1000 ppm and that the consequences to drip shield performance have not yet been quantified.

Subissue 2: NRC Comments on Data Uncertainties and Sensitivity Studies

The fifth DOE presentation (see "Subissue 2: NRC Comments on Data Uncertainties and Sensitivity Studies" presentation given by Ernest Hardin) addressed three NRC concerns. The first NRC concern is that data uncertainties should be evaluated more rigorously in the DOE Physical and Chemical Environment model analysis/model reports. The DOE summarized the technical basis for resolution, described the technical basis for their current approach, and described planned actions to further support existing models. The DOE is relying on model improvements, more extensive use of natural and man-made analogs, and the corrosion testing process to address limitations associated with validating EBS models of the physical and chemical environment. The DOE is addressing data uncertainties by comparing predicted equilibrium conditions to test data in experiments that may not produce equilibrium conditions. The DOE asserted that data uncertainties are addressed by using a plausible boundary condition, however they also indicated ongoing work will evaluate alternatives. The NRC indicated that the compositions used may not be bounding.

The second NRC concern is that additional sensitivity studies should be performed by the DOE to identify the limitations of models used to predict coupled THC processes, and the evolution of water and gas compositions with time. The DOE presented four lines of evidence to support resolution of the sensitivity study concern. First, the DOE is comparing results obtained with the abstracted THC model to the J-13 and matrix pore water compositions that are also used for influent water. The NRC expressed a concern that unless the conditions under which the data have been collected are sufficiently described, it is unlikely that the range of uncertainty can be adequately assessed. In addition, the NRC indicated that the data that are currently being used for model calibration or model support have not been rigorously addressed in terms of its uncertainty (e.g., analytical, sampling). Second, steel corrosion rates are evaluated with different water compositions to estimate the possible range of corrosion rates. Third, the DOE asserted that effects of drift seepage on the in-drift thermodynamic environment (relative humidities and temperatures) are minor. Finally, mixing and disperison of gas-phase constituents produced and consumed in the drifts, associated with thermal-hydrologic circulation in the host rock are being evaluated.

The final concern addressed (also see "Addendum to Data Uncertainties and Sensitivity Studies Presentation for Subissue 2: Validation Approach for the Precipitates/Salts Model" presented by Ernest Hardin) was that the DOE has insufficiently validated the Physical and Chemical Environment models, including the critical evaluation of data used in model validation. The

DOE indicated that they are focusing on data and model issues with the greatest potential to affect repository performance. For instance, the DOE is considering developing additional laboratory test data to constrain the interpolative Low Relative Humidity Salts Model. The NRC stated that this model has not been adequately validated. The DOE also indicated additional sensitivity testing will be performed for planned report revisions. Comparison of the Precipitates/salts Model results using the PT4 database to calculations from the Harvie, Moeller, Weare database for a Canadian Shield Brine and a Dead Sea Brine at ambient temperatures were presented. The DOE presented a comparison of lab test data from the evaporative concentration experiments at elevated temperatures to the PT4 predictions. The NRC indicated that those tests had mass balance problems which calls into question the usefulness of the comparison. The DOE indicated that they planned to repeat the tests. Agreement between the models was good, except for nitrate salts. In addition the PT4 results were compared to handbook aqueous solubilities for sodium and potassium salts at 100°C. The DOE described the uncertainties of the elevated temperature data used in the comparisons. The NRC indicated that the DOE only needed to validate those activities that were used to address corrosion in the performance assessment calculations. However, the information that compared predicted solid phases to the observed solid phases suggests that the predictions are inaccurate. The DOE described the physical characterization, by use of X-ray diffraction techniques, of the evaporated salts. The DOE agreed with the NRC observation that solid phases that were not subject to dissolution from changes of relative humidity were not observed in the sample, even though detection limits should have allowed their observation. The DOE suggested that this type of question is being evaluated in ongoing and planned activities. The NRC asked whether both the reduced and extended mineral models used in the Drift-Scale THC model were going to be validated. The DOE indicated that efforts to validate both models would be documented in a revised report.

ENFE Subissue 2 Overall Status

As a result of additional discussions, the NRC and DOE reached 18 agreements for Subissue #2 (see Attachment 1). With these 18 agreements, the NRC stated that Subissue #2 could be listed as "closed-pending."

6) Technical Discussion - Subissue #3, Effects of Coupled Thermal-Hydrologic-Chemical Processes on the Chemical Environment for Radionuclide Release

Subissue 3: NRC Comments on Thermal-Hydrological-Chemical Effects on Radionuclide Release

A summary of the current status of resolution was presented (see "Subissue 3: NRC Comments on Thermal-Hydrological-Chemical Effects on Radionuclide Release" presentation given by Christine Stockman). This presentation addressed 14 NRC comments (comments regarding colloids were addressed earlier in the meeting in the presentation titled "Subissue 3: NRC Comments Related to Total System Performance Assessment for the Site Recommendation Results Related Waste Form Degradation.") The DOE answered the comments with references to analyses documented in a number of DOE reports and to planned activities. Comments concerning the DOE neglect of high-temperature effects such as evaporative concentration of chloride and fluoride were answered with the assertion that no seepage would enter the waste package during the thermal period. The DOE's analyses does not currently predict failures of the waste package within the 10,000 year regulatory time period. The NRC

believes the release models applicable for early waste package failure when chemical conditions may be perturbed may need to be considered in multiple barrier analyses; this topic is expected to be addressed in the TSPAI technical exchange. Also, the DOE argued that evaporative concentration of fluoride is unimportant because they assume that all fluoride entering the waste package is utilized in cladding corrosion. The NRC pointed out that this is not necessarily conservative with respect to peak mean dose. The NRC commented that not all DOE arguments concerning degradation rates for spent nuclear fuel were strong, but that the modeled rates were nonetheless sufficiently conservative. The NRC asked how uncertainties arising from temperature dependence of thermodynamic parameters were handled. The DOE responded that new sensitivity studies are under consideration. NRC concerns regarding the neglect of local chemical environments were raised. The NRC returned to comments on colloid release modeling first discussed in the presentation titled "Subissue 3: NRC Comments Related to Total System Performance Assessment for the Site Recommendation Results Related Waste Form Degradation." The DOE pointed to a report on radionuclide selection that contained information on those radionuclides for which colloidal release was modeled. Regarding the NRC question on the DOE neglect of commercial spent nuclear fuel (CSNF) colloid production, the DOE described how CSNF corrosion tests are being altered to promote the detection of any colloids. On the use of the lab corrosion test results in the colloidal release abstraction, the DOE indicated that additional discussion of some of the uncertainties, assumptions, and alternative models would be included in a future revision of the AMR titled "Waste Form Colloid-Associated Concentration Limits: Abstraction and Summary."

As a result of additional discussions, the NRC and DOE reached 5 agreements for Subissue #3 (see Attachment 1). With these 5 agreements, the NRC stated that Subissue #3 could be listed as "closed-pending."

7) Features, Events, and Processes

The DOE presented information on FEPs during the Thermal Effects on Flow KTI meeting held on January 8-9, 2001 (see "Features, Events, and Processes for Thermal Effects on Flow and Evolution of the Near Field Environment" presentation given by Nicholas Francis). The NRC questioned whether the FEPs AMR updates would address all the NRC comments in Revision 3 of the IRSRs, including whether traceable references for the documentation of low consequence calculations will be provided. The DOE stated that it believed many of the NRC comments were addressed and requested that the NRC review the updates and provide the DOE with any additional comments. The DOE also provided a summary of the TEF and ENFE FEPs.

8) Public Comments

In addition to the public questions and comments mentioned above, Ms. Judy Treichel (Nevada Nuclear Waste Task Force) addressed the uncertainties apparent from the discussions at the meeting concerning the interpretation of the results from the drift-scale heater test. She noted that visitors to the test facility are left with the impression that the test is a better simulation of the repository than it actually is. Declaring related subissues as "closed-pending" implies a level of comfort in interpreting drift-scale heater test results that is higher than is apparent from this meeting. Ms. Treichel also commented (1) that she was uncomfortable with the DOE reliance on a 10,000-year container lifetime for its safety case, and did not think members of the public would be convinced of its validity, and (2) that she disapproved of the use of the

"closed-pending" issue label. She feels that the label is artificial and has the psychological effect of suggesting that the DOE has proven its case, despite the fact that years of studies are yet to be conducted.

Mr. Don Shettel (Nye County) questioned the DOE's model results showing only minor mineral precipitation in host rocks during the thermal period, with resulting minor predicted changes in porosity and permeability. He pointed out that in natural refluxing zones, mineral precipitation in boiling zones and dissolution in condensate zones is common. The DOE responded that the experiments that show large effects are designed favorably for precipitation and so may not be applicable. Mr. Shettel responded that perhaps the drift-scale test design is not favorable for promoting precipitation. Mr. Shettel also stated that as a consultant to Nye County, his primary objective is protecting the health and safety of Nye County residents. He feels that only the best science should be applied in meeting that goal. He asked attendees to consider his earlier questions in that light.

1/12/01

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Summary of the Resolution of the Key Technical Issue on Evolution of the Near-Field Environment

Subissue #	Subissue Title	Status	NRC/DOE Agreements
1	Effects of coupled thermal-hydrologic-chemical processes on seepage and flow	Closed-Pending	1) Provide updated FEPs AMRs with additional technical bases for those FEPs previously identified by the NRC in Rev. 03 of the ENFE IRSR as inadequately screened. In Rev 03 of the ENFE IRSR, the NRC identified 17 FEPs associated with Subissue 1 for which no screening arguments were identified in the FEPs data base, screening arguments were inconsistent with other project documents, or inadequate exclusion arguments were provided. The lack of screening arguments has been addressed in Rev 00 of the FEPs data base and Rev 00 of the supporting AMRs. Current revisions (or ICNs) of the FEPs AMRs, scheduled for completion in January 2001, will partially address the remaining NRC comments. Consideration of the remaining NRC comments will be provided in subsequent FEPs AMR revisions, expected to be available as periodic revisions, the entirety of which will be available prior to license application. 2) Provide the FEPs database. The DOE will provide the FEPs data base to the NRC during March 2001.

1	Effects of coupled thermal-hydrologic-chemical processes on seepage and flow - cont.		3) Provide the Drift-Scale Coupled Processes (DST and THC Seepage) Models AMR, Rev. 01 and 02, including (1) 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 and (2) documentation of model validation consistent with the DOE QA requirements. The DOE will provide documentation of model validation, consistent with the DOE QA requirements, in the *Drift-Scale Coupled Processes (DST and THC Seepage) Models* AMR (MDL-NBS-HS-000001) Rev 01, expected to be available to the NRC in March 2001. The 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 (DST and THC Seepage) Models* AMR Rev 02, expected to be available to the NRC in FY 02. 4) Provide additional technical bases for the DOE's treatment of the effects of cementitious materials on hydrologic properties. The DOE will provide additional information on the effects of cementitious materials in an update to the *Unsaturated Zone Flow and Transport* PMR (TDR-NBS-HS-000002), available in FY 02. Information provided will include results of evaluation of the magnitude of potential effects on hydrologic properties and radionuclide transport characteristics of the unsaturated zone. 5) Address the various sources of uncertainty (e.g., model implementation, conceptual model, and data uncertainty (hydrologic, thermal, and geochemical)) in the THC model. The DOE will evaluate the various sources of uncertainty in the THC process model, including details as to how the propagation of various sources of uncertainty are calculated in a systematic uncertainty analysis. The DOE will document that uncertainty evaluation in the *Drift-Scale Coupled Processes (DST and THC Seepage) Models* AMR (MDL-NBS-HS-000001) Rev 02 (or in another future document), expected to be available in FY 02.

1	Effects of coupled thermal-hydrologic-chemical processes on seepage and flow - cont.		6) 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 and Transport* AMR (ANL-NBS-MD-000001), expected to be available in FY 02. 7) Provide physical evidence that supports the model of matrix fracture interaction precipitation effects (e.g., coring). The DOE will provide the following evidence that supports the model of matrix/fracture interaction precipitation effects: (1) Existing data from the Single Heater Test (SHT) of post-test overcoring Mineralogy-Petrology (Min-Pet) analysis (SHT final report [MOL.20000103.0634] and DTN LASL831151.AQ98.001) is expected to be provided to the NRC in March 2001. (2) Results of ongoing side-wall sampling Min-Pet analyses of DST samples are expected to be provided to the NRC in FY 02. (3) The DOE expects to provide the *Drift-Scale Coupled Processes (DST and THC Seepage) Models* AMR (MDL-NBS-HS-000001) Rev 01 to the NRC as evidence of matrix-fracture interaction in March 2001.
2	Effects of coupled thermal-hydrologic-chemical processes on waste package chemical environment	Closed-Pending	1) Provide updated FEPs AMRs with additional technical bases for those FEPs previously identified by the NRC in Rev. 03 of the ENFE IRSR as inadequately screened. In Rev 03 of the ENFE IRSR, the NRC identified 24 FEPs associated with Subissue 2 for which no screening arguments were identified in the FEPs data base, screening arguments were inconsistent with other project documents, or inadequate exclusion arguments were provided. The lack of screening arguments has been addressed in Rev 00 of the FEPs data base and Rev 00 of the supporting AMRs. Current revisions (or ICNs) of the FEPs AMRs, scheduled for completion in January 2001, will partially address the remaining NRC comments. Consideration of the remaining NRC comments will be provided in subsequent FEPs AMR revisions, expected to be available as periodic revisions, the entirety of which will be available prior to license application. 2) Provide the FEPs database. The DOE will provide the FEPs data base to the NRC during March 2001.

2	Effects of coupled thermal-hydrologic-chemical processes on waste package chemical environment - cont.		3) 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. 4) Provide the technical basis for bounding the trace elements and fluoride for the geochemical environment affecting the drip shield and waste package, including the impact of engineered materials. The DOE will document the concentrations of trace elements and fluoride in waters that could contact the drip shield and waste package in a revision to the *Environment on the Surfaces of the Drip Shield and Waste Package Outer Barrier* AMR (ANL-EBS-MD-000001), which will be available in FY02. In addition, trace elements and fluoride concentrations in introduced materials in the EBS (including cement grout, structural steels, and other materials as appropriate) will be addressed in a revision to the *Engineered Barrier System: Physical and Chemical Environment Model AMR* (ANL-EBS-MD-000033), expected to be available in FY 02. 5) Evaluate data and model uncertainties for specific in-drift geochemical environment submodels used in TSPA calculations and propagate those uncertainties following the approach described in Agreement #5, Subissue 1. The DOE will evaluate data and model uncertainties for specific in-drift geochemical environment submodels used in TSPA calculations and propagate those uncertainties following the approach described in Subissue 1, Agreement #5. The DOE will document the evaluation in an update to the *Engineered Barrier System: Physical and Chemical Environment Model* AMR (ANL-EBS-MD-000033) (or in another future document), expected to be available in FY 02.

2	Effects of coupled thermal-hydrologic-chemical processes on waste package chemical environment - cont.		6) Evaluate 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. This evaluation will be documented in a revision to the *Engineered Barrier System: Physical and Chemical Environment Model* AMR (ANL-EBS-MD-000033), expected to be available in FY 02. 7) Identify specific coupling relationships that are included and excluded from TSPA, including Onsager couples, and give technical bases for their inclusion or exclusion. The DOE will identify specific coupling relationships that are included and excluded from TSPA, including Onsager couples, and give the technical basis for inclusion and exclusion. This information will be documented in a revision to the *Engineered Barrier System Degradation, Flow, and Transport* PMR (TDR-EBS-MD-000006), expected to be available by September 2001. 8) Provide stronger technical basis for the suppression of individual minerals predicted by equilibrium models. The DOE will provide additional technical basis for suppression of individual minerals predicted by equilibrium models, in a revision to the *Engineered Barrier System: Physical and Chemical Environment Model* AMR (ANL-EBS-MD-000033), expected to be available in FY02.

2	Effects of coupled thermal-hydrologic-chemical processes on waste package chemical environment - cont.		9) Provide the In-Drift Precipitates/Salts Analysis AMR, Rev. 00, ICN 02, including (1) the major anionic (e.g., fluoride or chloride) and cationic species, and (2) additional technical basis for the low relative humidity model. The DOE will provide the *In-Drift Precipitates/Salts Analysis* AMR (ANL-EBS-MD-000045), Rev. 00, ICN 02, including the major anionic (e.g., fluoride or chloride) and cationic species, in January 2001. The DOE will provide to the NRC an update to the *In-Drift Precipitates/Salts Analysis* AMR (ANL-EBS-MD-000045) that will provide additional technical bases for the low relative humidity model, expected to be available in FY 02. 10) Provide additional information about the range of composition of waters that could contact the drip shield or waste package, including whether such waters are of the bicarbonate or chloride-sulfate type. The DOE will describe the range of bulk composition for waters that could affect corrosion of the drip shield or waste package outer barrier, in a revision to the *Environment on the Surfaces of the Drip Shield and Waste Package Outer Barrier* AMR (ANL-EBS-MD-000001), expected to be available in FY02. 11) Provide the technical basis for the current treatment of the kinetics of chemical processes in the in-drift geochemical models. This basis should address data in the figure on page 16 of the G.Gdowski Subissue 2 presentation with appropriate treatment of time as related to abstractions used in TSPA. 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* AMR (ANL-EBS-MD-000033), expected to be available in FY02. 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 TSPA.

2	Effects of coupled thermal-hydrologic-chemical processes on waste package chemical environment - cont		12) Provide the documentation and analysis of the column crush tuff experiments. The DOE will provide documentation of the results obtained from the crushed tuff hydrothermal column experiment, and of post-test analysis, in new reports specific to the column test, expected to be available by September 2001. 13) Provide documentation regarding the deposition of dust and its impact on the salt analysis. The DOE will provide documentation of dust sampling in the Exploratory Studies Facility, and analysis of the dust and evaluation of its impact on the chemical environment on the surface of the drip shield and waste package, in a revision to the *Engineered Barrier System: Physical and Chemical Environment Model* AMR (ANL-EBS-MD-000033), expected to be available in FY02. 14) Provide the analysis of laboratory solutions that have interacted with introduced materials. The DOE will provide additional information about laboratory solutions that have interacted with introduced materials, in a revision to the *Environment on the Surfaces of the Drip Shield and Waste Package Outer Barrier* AMR (ANL-EBS-MD-000001), expected to be available in FY02. 15) Provide the additional data to constrain the interpolative low relative humidity salts model. The data should provide the technical basis as to why the assumption of the presence of sodium nitrate is conservative, when modeling and experimental results indicate the presence of other mineral phases for which the deliquesence point is unknown. The DOE will provide additional information to constrain the low-relative humidity salts model. The information will include the deliquescence behavior of mineral assemblages derived from alternative starting water compositions (including bulk water compositions, and local variations associated with cement leaching or the presence of corrosion products) representing the range of potential water compositions in the emplacement drifts. This information will be documented in a revision to the *In-Drift Precipitates/Salts Analysis* AMR (ANL-EBS-MD-000045), expected to be available in FY02.
2	Effects of coupled		16) Provide the Drift-Scale Coupled Processes (DST and THC Seepage)

	thermal-hydrologic-chemical processes on waste package chemical environment - cont.		Models, Rev. 01, including information supporting both the limited suite mineral model and the more complete extended model. The DOE will provide the *Drift-Scale Coupled Processes (DST and THC Seepage) Models* AMR (MDL-NBS-HS-000001) Rev 01, including information supporting both the limited suite mineral model and the more complete extended model, in March 2001. 17) Provide documentation of data used to calibrate models and data to support model predictions, and an assessment of data uncertainty (e.g., sampling and analytical), that includes critical analyses of variables that affect the data measurements and their interpretations (e.g., drift-scale thermal test and evaporation tests). The DOE will provide documentation of data used to calibrate models and data to support model predictions, and an assessment of data uncertainty (e.g., sampling and analytical) in the area of water and gas chemistry from the drift-scale thermal tests and evaporation tests. This documentation will be provided in revisions to the following AMRs: *Environment on the Surfaces of the Drip Shield and Waste Package Outer Barrier* (ANL-EBS-MD-000001), *Engineered Barrier System: Physical and Chemical Environment Model* (ANL-EBS-MD-000033), and *Drift-Scale Coupled Processes (DST and THC Seepage) Models* (MDL-NBS-HS-000001), or other documents as appropriate. All documents or revisions are expected to be available in FY 02. 18) Provide the following documents: EBS: Physical and Chemical Environment Model, Rev. 01; Multiscale Thermohydrologic Model, Rev. 00, ICN 01; Abstraction of Drift-Scale Coupled Processes, Rev 01; Environments on the Surfaces of the Drip Shield and the Waste Package Outer Barrier, Rev. 00, ICN 01; Waste Package Degradation PMR, Rev. 00, ICN 01; EBS Degradation, Flow, and Transport PMR, Rev. 01; Near Field Environment PMR, Rev. 00, ICN 02 and Rev. 01; Hydrogen Induced Cracking of Drip Shield, Rev. 00, ICN 01; Drift Degradation Analysis, Rev. 01; Design Analysis for the Ex-Container Components, Rev. 00; Longevity of Emplacement Drift Ground Support Materials, Rev. 01; Stress Corrosion Cracking AMR, Rev. 00, ICN 01; In-Drift Microbial Communities, Rev. 00, ICN 01; Physical and Chemical Environment Abstraction Model, Rev. 00, ICN 01; UZ Flow and Transport Model PMR, Rev. 01; General Corrosion and Localized Corrosion

			of the Drip Shield, Rev. 00; Water Distribution and Removal Model, Rev. 01. The DOE will provide the documents requested by the dates indicated: *Engineered Barrier System: Physical and Chemical Environment Model* (ANL-EBS-MD-000033) Rev. 01: FY 02; *Multiscale Thermohydrologic Model* (ANL-EBS-MD-000049) Rev. 00, ICN 01: January 2001; *Abstraction of Drift-Scale Coupled Processes* (ANL-NBS-HS-000029) Rev 01: September 2001; *Environment on the Surfaces of the Drip Shield and the Waste Package Outer Barrier* (ANL-EBS-MD-000001) Rev. 00, ICN 01: January 2001; *Waste Package Degradation* PMR (TDR-WIS-MD-000002) Rev. 00, ICN 01: January 2001; *Engineered Barrier System Degradation, Flow, and Transport* PMR (TDR-EBS-MD-000006) Rev. 01: September 2001; *Near Field Environment* PMR (TDR-NBS-MD-000001) Rev. 00, ICN 02: January 2001 and Rev. 01: September 2001; *Hydrogen Induced Cracking of Drip Shield* (ANL-EBS-MD-000006) Rev. 00, ICN 01: January 2001; *Drift Degradation Analysis* (ANL-EBS-MD-000027) Rev. 01: January 2001; *Design Analysis for the Ex-Container Components*, ANL-XCS-ME-000001 Rev. 00: January 2001; *Longevity of Emplacement Drift Ground Support Materials* (ANL-EBS-GE-000003) Rev. 01: January 2001; *Stress Corrosion Cracking* of the Drip Shield, the Waste Package Outer Barrier, and the Stainless Steel Structural Material AMR (ANL-EBS-MD-000005) Rev. 00, ICN 01: January 2001; *In-Drift Microbial Communities* (ANL-EBS-MD-000038) Rev. 00, ICN 01: January 2001; *Physical and Chemical Environmental Abstraction Model* (ANL-EBS-MD-000046) Rev. 00, ICN 01: January 2001; *Unsaturated Zone Flow and Transport Model* PMR (TDR-NBS-HS-000002) Rev. 01: September 2001; *General Corrosion and Localized Corrosion of the Drip Shield* (ANL-EBS-MD-000004) Rev. 00: January 2001; *Water Distribution and Removal Model* (ANL-EBS-MD-000032) Rev. 01: January 2001.

3	Effects of coupled thermal-hydrologic-chemical processes on chemical environment for radionuclide release	Closed-Pending	1) Provide the following documents: WAPDEG Analysis of Waste Package and Drip Shield Degradation AMR, Rev. 00, ICN 01; Near-Field Environment PMR, Rev. 00, ICN 03; In-Package Chemistry AMR, Rev. 01; CAL-EBS-PA-000002, Rev. 01; ANL-EBS-PA-000005, Rev. 00; In-Package Chemistry Abstraction AMR, Rev. 01; TSPA-SR, Rev. 00; Waste Form Colloid-Associated Concentration Limits: Abstraction and Summary AMR. The DOE will provide the following documents to the NRC by February 2001: *WAPDEG Analysis of Waste Package and Drip Shield Degradation* AMR (ANL-EBS-PA-000001) Rev 00 ICN 01; *Near Field Environment* PMR (TDR-NBS-MD-000001) Rev 00 ICN 03; *Summary of In-Package Chemistry for Waste Forms* AMR (ANL-EBS-MD-000050) Rev 01; *Calculation of General Corrosion Rate of Drip Shield and Waste Package Outer Barrier to Support WAPDEG Analysis* (CAL-EBS-PA-000002) Rev 01; *Abstraction of Models for Stainless Steel Structural Material Degradation* (ANL-EBS-PA-000005) Rev 00; *In-Package Chemistry Abstraction* AMR (ANL-EBS-MD-000037) Rev 01; *Total System Performance Assessment for the Site Recommendation* (TDR-WIS-PA-000001) Rev 00; *Waste Form Colloid-Associated Concentrations Limits: Abstraction and Summary* AMR (ANL-WIS-MD-000012) Rev 00 ICN 01 2) Provide the thermodynamic database and the report associated with the database. The DOE will provide the thermodynamic data base [Input Transmittal for Thermodynamic Data Input Files for Geochemical Calculations (MO0009THRMODYN.001)] and *Data Qualification Report for the Thermodynamic Data File, DATA0.ympR0 for Geochemical Code EQ 3/6* (TDR-EBS-MD-000012) to the NRC in February 2001. 3) Provide analyses to verify that bulk-scale chemical processes dominate the in-package chemical environment. The DOE will provide analyses justifying the use of bulk chemistry as opposed to local chemistry for solubility and waste form degradation models. These analyses will be documented in an update to the *Miscellaneous Waste-Form FEPs* AMR (ANL-WIS-MD-000009) or in an update to the *Summary of In-Package Chemistry for Waste Forms* AMR (ANL-EBS-MD-000050), expected to be available in FY 02.

3	Effects of coupled thermal-hydrologic-chemical processes on chemical environment for radionuclide release - cont.		4) Complete validation of in-package chemistry models. Agreement #5 for CLST subissue 3 addresses testing plans. Model validation based on this testing and further analysis will be documented in an update to the *Summary of In-Package Chemistry for Waste Forms* AMR (ANL-EBS-MD-000050), expected to be available in FY 02. 5) Provide the technical basis for selection of radionuclides that are released via reversible and irreversible attachment to colloids for different waste forms in the TSPA. The technical bases for the selection of radionuclides released via reversible and irreversible attachments to colloids for different waste forms is provided in section 3.5.6.1 of the *Total System Performance Assessment (TSPA) Model for Site Recommendation* (MDL-WIS-PA-000002) Rev 00. This document will be provided to the NRC in January 2001.
4	Effects of coupled thermal-hydrologic-chemical processes on radionuclide transport through engineered and natural barriers	Closed-Pending	1) Provide the executable version of the most recently qualified version of TOUGHREACT. The DOE will provide the executable TOUGHREACT Rev 2.2 to the NRC by February 2001, subject to the NRC obtaining any applicable agreement for usage of the software. 2) Provide the Drift-Scale Coupled Processes (DST and THC Seepage) Models AMR, Rev. 01 and 02. The DOE will provide the *Drift-Scale Coupled Processes (DST and THC Seepage) Models* AMR (MDL-NBS-HS-000001) Rev 01 to the NRC in March 2001. The DOE will provide the *Drift-Scale Coupled Processes (DST and THC Seepage) Models* AMR Rev 02 to the NRC in FY 02. 3) Provide the technical bases for screening out coupled THC effects on radionuclide transport properties and colloids. The DOE will provide the technical bases for screening out coupled THC effects on radionuclide transport properties and colloids in a new AMR or in a revision to an existing AMR, expected to be available in FY 02.

4	Effects of coupled thermal-hydrologic-chemical processes on radionuclide transport through engineered and natural barriers - cont		4) 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 and Transport* AMR (ANL-NBS-MD-000001), expected to be available in FY 02. 5) Provide the screening criteria for the radionuclides selected for PA. Provide the technical basis for selection of radionuclides that are transported via colloids in the TSPA. The screening criteria for radionuclides selected for TSPA are contained in the AMR *Inventory Abstraction* (ANL-WIS-MD-000006) Rev 00, ICN 01. The DOE is documenting identification of radionuclides transported via colloids for TSPA in the AMR *Colloid-Associated Concentration Limits: Abstraction and Summary* (ANL-WIS-MD-000012) Rev 0, in the Total System Performance Assessment for the Site Recommendation (TDR-WIS-PA-000001) Rev 00 ICN 01, and in the *Total System Performance Assessment (TSPA) Model for Site Recommendation* (MDL-WIS-PA-000002) Rev 00. These documents will be available to the NRC in January 2001. 6) Provide documentation to demonstrate suitability of the bounding values used for colloid transport through the perturbed near-field environment. For example, consider sensitivity analyses to investigate the effects of varying colloid sorption parameters (K_c) on repository performance. The DOE will evaluate the suitability of the colloid transport model under perturbed conditions as discussed in agreement #3 for this subissue. As part of this work, the DOE will consider sensitivity analyses to investigate the effects of varying colloid sorption parameters (K_c) on repository performance. The DOE will also provide the TSPA-SR (TDR-WIS-PA-000001) Rev 00 ICN 01 in January 2001. The TSPA-SR includes sensitivity studies in the form of barrier degradation and parameter sensitivity analyses that investigate the effect of sorption and colloid parameters on repository performance.

4	Effects of coupled thermal-hydrologic-chemical processes on radionuclide transport through engineered and natural barriers - cont.		7) Provide updated FEPs AMRs with additional technical bases for those FEPs previously identified by the NRC in Rev. 03 of the ENFE IRSR as inadequately screened. In Rev 03 of the ENFE IRSR, the NRC identified 17 FEPs associated with Subissue 1 for which no screening arguments were identified in the FEPs data base, screening arguments were inconsistent with other project documents, or inadequate exclusion arguments were provided. The lack of screening arguments has been addressed in Rev 00 of the FEPs data base and Rev 00 of the supporting AMRs. Current revisions (or ICNs) of the FEPs AMRs, scheduled for completion in January 2001, will partially address the remaining NRC comments. Consideration of the remaining NRC comments will be provided in subsequent FEPs AMR revisions, expected to be available as periodic revisions, the entirety of which will be available prior to license application. 8) Provide the FEPs database. The DOE will provide the FEPs data base to the NRC during March 2001.

DOE-NRC TECHNICAL EXCHANGE AGENDA THERMAL EFFECTS ON FLOW AND EVOLUTION OF THE NEAR-FIELD ENVIRONMENT KEY TECHNICAL ISSUES January 8-12, 2001 Pleasanton, California			
Monday, January 8, 2001			
Schedule	TEF Presentation	Time (Minutes)	
		Duration	Discussion
8:00 – 8:20 AM	Introduction/Objectives (DOE-NRC)	20	
8:20 – 8:40 AM	TEF Summary (Barr)	10	10
8:40 – 9:10 AM	Uncertainties (Coppersmith)	20	10
9:10 – 9:45 AM	TSPA for TEF (Francis)	20	15
9:45 – 10:00 AM	BREAK	15	
10:00 – 10:30 AM	TEF and ENFE FEPs (Francis)	15	15
10:30 – 11:15 AM	Caucus Subissue 1		45
11:15 – 11:45 AM	DOE-NRC Discussion of Resolution Status		30
11:45 AM – 12:45 PM	LUNCH	60	
12:45 – 4:15 PM with 15-minute break	Subissue 2 Open Item Presentations		
	Open Item 1: Repository Design (Hardin)	15	10
	Open Item 2: Cold Traps (Hardin)	15	10
	Open Item 6: Ventilation Model (Hardin)	15	10
	Open Item 5: Cross Drift Thermal Testing (Peters)	20	10
	Open Item 7: Data Uncertainty (Bodvarsson)	30	15
	Open Item 8: Model Uncertainty (Bodvarsson)	30	15
4:15 – 5:15 PM	Caucus Subissue 2	60	
5:15 – 5:45 PM	DOE-NRC Discussion of Resolution Status		30
5:45 – 6:00 PM	Closing Remarks	15	
6:00 PM	Adjourn Day 1		

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5:15 – 5:45 PM	DOE-NRC Discussion of Resolution Status		30
5:45 – 6:00 PM	Closing Remarks	15	
6:00 PM	Adjourn Day 1		

Summary Highlights of NRC/DOE Technical Exchange and Management Meeting on Thermal Effects on Flow

January 8-9, 2001
Pleasanton, California

Introduction and Objectives

This Technical Exchange and Management Meeting on Thermal Effects on Flow (TEF) is one in a series of meetings related to the U.S. Nuclear Regulatory Commission (NRC) key technical issue (KTI) and sufficiency review and the U.S. Department of Energy (DOE) site recommendation decision. Consistent with NRC regulations on prelicensing consultations and a 1992 agreement with the DOE, staff-level resolution can be achieved during prelicensing consultation. The purpose of issue resolution is to assure that sufficient information is available on an issue to enable the NRC to docket a proposed license application. 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. Issue resolution at the staff level, during prelicensing, is achieved when the staff has no further questions or comments at a point in time regarding how the DOE is addressing an issue. The discussions recorded here reflect NRC's current understanding of aspects of thermal effects on flow most important to repository performance. This understanding is based on all information available to date which includes limited, focused, risk-informed reviews of selected portions of recently provided DOE documents (e.g., Analysis and Model Reports (AMRs) and Process Model Reports (PMRs)). Pertinent additional information (e.g., changes in design parameters) could raise new questions or comments regarding a previously resolved issue.

Issues 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. Issues are "closed-pending" if the NRC staff has confidence that the DOE proposed approach, together with the DOE agreement to provide the NRC with additional information (through specified testing, analysis, etc.) acceptably addresses the NRC's questions such that no information beyond that provided, or agreed to, will likely be required at time of initial license application. Issues 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.

The objective of this meeting is to discuss and review the progress on resolving the TEF KTI (see Attachment 1 for the description of Subissues #1 and 2). The quality assurance (QA) aspect of this KTI was determined to be outside the scope of the meeting and is being tracked in NRC's ongoing review of the DOE's QA program.

Summary of Meeting

At the close of the Technical Exchange and Management Meeting, the NRC staff stated that Subissues 1 and 2 were "closed-pending." Specific NRC/DOE agreements made at the meeting are provided as Attachment 1. The agenda and the attendance list are provided as

Attachments 2 and 3, respectively. Copies of the presenters' slides are provided as Attachment 4. Highlights from the Technical Exchange and Management Meeting are listed below.

Highlights

1) Opening Comments

The DOE stated that the intent of the meeting is to reach agreement on the current status and path forward for each of the TEF subissues (see "Thermal Effects on Flow" presentation given by Deborah Barr). In the TEF Issue Resolution Status Report (IRSR), Revision 3, the NRC stated that TEF Subissues #1 and 2 are "open." During this meeting, the DOE stated that its presentation would focus on the open items identified by the NRC in the IRSR and subsequent discussions. The DOE stated that it felt that the details provided during the current meeting would be the basis for NRC to list Subissues 1 and 2 as "closed-pending."

The DOE stated that for Subissue #2, Open Items 3, 4, and 9 would not be discussed and that documents addressing these open items would be submitted to the NRC. The NRC has identified the documents needed to resolve the open items, including the relevant concerns, in the agreements pertaining to Subissue #2.

2) Uncertainties in Total System Performance Assessment for the Site Recommendation

The DOE provided an overview of ongoing activities to identify the treatment of uncertainties in Total System Performance Assessment (TSPA) for the Site Recommendation (see "Uncertainties in Total System Performance Assessment for the Site Recommendation" presentation given by Kevin Coppersmith). The DOE discussed three ongoing activities to evaluate uncertainties: uncertainty review, conservatism assessment, and unquantified uncertainties.

Regarding the uncertainty review, the DOE stated that it would perform a bottom-up review of uncertainty treatment in process models and abstractions. The DOE stated that guidance to PMR and AMR authors was as follows: (1) if there is sufficient data, it would use a probability distribution function, and (2) if there is large uncertainty or complexity, it would provide a conservative estimate that is technically defensible. The DOE stated that the TSPA-SR is a mix of distributions and conservative estimates. The DOE asserted that, because these are conservative inputs, the TSPA-SR results are conservative, but the magnitude of the conservatism has not been assessed. The NRC replied that conservative inputs do not necessarily translate to conservative outputs in nonlinear coupled systems. The DOE agreed and stated that the intent of the ongoing uncertainties activities is to evaluate the degree of nonlinearity between conservatism in inputs and conservatism in dose estimates.

Regarding the conservatism assessment, the DOE stated the purpose was to complete a qualitative evaluation of the representativeness/conservatism of features, events, and processes (FEPs) in process models. The DOE stated that the conservatism assessment was a starting point for the unquantified uncertainties activity. The DOE further stated that the conservatism review includes all conservatisms in TSPA-SR. However, the evaluation of importance of these conservatisms to dose estimates is qualitative in the conservatism activity. The NRC noted that the conservatism report and AMRs do not evaluate all the uncertainties

and their importance to dose. Thus the determination of importance to dose is subjective. The DOE agreed and stated that the unquantified uncertainties activity is intended to quantitatively evaluate the importance to dose estimates.

Regarding unquantified uncertainties, the DOE identified the key uncertainties and stated that it would evaluate the significance of these uncertainties to dose estimates. The DOE stated that currently the uncertainty review is non-Q and would be used for guidance to DOE staff/contractors for license application development. Subsequent revisions to the AMRs would be developed in accordance with guidance that is developed. The DOE stated that the evaluation complements, but does not replace, TSPA for the Site Recommendation. The NRC raised an issue regarding the QA status of the uncertainty analyses in light of the fact that these analyses are providing important guidance for license application development. The DOE responded that the present uncertainties activities will only be used to provide insight to develop guidance for treatment of uncertainties to support license application.

3) Total System Performance Assessment

The DOE provided an overview of how TEF is being incorporated into the TSPA (see "Thermal Effects on Flow - Representation in the Total System Performance Assessment" presentation given by Nicholas Francis).

The DOE stated that thermally-enhanced percolation flux above the drift crown and the in-drift thermodynamic environment are the two TSPA process level models pertinent to TEF. The NRC commented that the thermohydrologic abstractions do not include the mountain-scale coupled processes model results and large features such as faults. The DOE agreed that multi-scale model calculations used as input to TSPA do not consider effects from mountain-scale hydrologic processes or flow in faults.

Regarding the thermally enhanced percolation flux above the drift crown, the DOE stated that percolation flux at five meters above the drift crown was selected as input for the abstracted seepage model. The DOE stated that the thermal effects die out before the first climate stage, which is in approximately six hundred years. The DOE stated that thermodynamic variables are calculated for 610 locations representing waste package groups. The NRC questioned how the temperature and relative humidity responses calculated at 610 locations are reduced to the 400 waste package groups used in the corrosion models. The DOE stated the staff to answer that question were not present but that they would determine the answer. The NRC questioned whether the utilization of uncertainty in climate states represents or bounds all sources of uncertainty. The NRC asked whether the representation of variability and uncertainty in thermodynamic variables calculated from TEF models at the 610 locations needed to be propagated to other models (such as chemistry) or whether the current representation was appropriate. The DOE stated they believed the current abstraction appropriately represents variability and uncertainty.

The DOE stated that the variability and uncertainty in TEF do not have a large impact on TSPA-SR corrosion models as currently implemented. The NRC asked what the impact on the corrosion models would be with an increase in variability and uncertainty from TEF thermodynamic variables. The DOE responded that uncertainty resulting from heterogeneity can't be greater than uncertainty resulting from the no-backfill versus backfill example.

4) Technical Discussions - Subissue #1, Features, events, and processes related to thermal effects on flow

A summary of the current status of resolution was presented (see "Features, Events, and Processes for Thermal Effects on Flow and Evolution of the Near Field Environment" presentation given by Nicholas Francis). The DOE identified the NRC information needs from Revision 3 of the TEF IRSR. The DOE stated that the presentation would provide the basis for going to "closed-pending."

In its presentation, the DOE stated that the five open items would be addressed in the FEPs AMR revisions/changes and the update to the FEPs database. The NRC questioned whether the FEPs AMR updates would address all the NRC comments in Revision 3 of the IRSRs, including whether traceable references for the documentation of low-consequence calculations will be provided. The DOE stated that, in general, it believed the NRC comments were addressed, and it requested that the NRC review the updates and provide the DOE any additional comments. The DOE also addressed an NRC comment on regional hydrothermal activity. The DOE also provided a summary of the TEF and Evolution of the Near-Field Environment (ENFE) FEPs.

As a result of additional discussions, the NRC and DOE reached two agreements for Subissue #1 (see Attachment 1). With these two agreements, the NRC stated that Subissue #1 could be listed as "closed-pending".

5) Technical Discussions - Subissue #2, Thermal effects on temperature, humidity, saturation, and flux

The DOE addressed the nine open items listed in Revision 3 of the TEF IRSR (with the exception of Open Items 3, 4, and 9 as previously discussed).

TEF Subissue 2, Open Item 1: Thermohydrologic Modeling for the Current Repository Design:

The DOE discussed the basis for resolving Open Item #1 (see "Thermal Effects on Flow Subissue 2, Open Item 1: Thermohydrologic Modeling for the Current Repository Design" presentation given by Ernest Hardin and Tom Buscheck). The DOE stated that the presentation would provide the basis for closing the open item.

The DOE stated that multi-scale thermohydrologic model calculations have been conducted for the Enhanced Design Alternative II design with no backfill. The NRC inquired whether the design included ventilation. The DOE stated that the design included ventilation for the 50-year pre-closure period. The NRC further inquired whether the model included water removal resulting from ventilation and the DOE responded that it did not.

The DOE concluded that the thermohydrologic models incorporate relevant Enhanced Design Alternative II design features and, therefore, this open item can be closed.

TEF Subissue 2, Open Item 2: Cold Trap Effects in the Multi-scale Thermohydrologic Model:

The DOE discussed the basis for resolving Open Item #2 (see "Thermal Effects on Flow Subissue 2, Open Item 2: Cold Trap Effects in the Multi-scale Thermohydrologic Model" presentation given by Ernest Hardin and Tom Buscheck). The DOE stated that the presentation would provide the basis for going to "closed-pending" for this open item.

The DOE stated that it has identified the technical issues in modeling cold traps, key assumptions for cold traps for the Multi-scale Thermohydrologic Model, and is considering additional models, as appropriate, to represent cold trap effects in the Multi-scale Thermohydrologic Model. The DOE stated that the cold trap effects occur in emplacement drifts with water and latent heat transfer from warmer to cooler locations. The DOE stated that previous analyses indicated that drift-scale cold traps could produce condensate flux on cooler waste packages. The DOE stated: (1) it is developing a mountain-scale model to represent the repository-scale cold trap effect; (2) it is considering development of a detailed drift-scale thermohydrologic model to estimate the magnitude of the drift-scale cold trap effect; and (3) it may not incorporate the cold trap effect into TSPA unless it significantly changes the predicted dose. The NRC inquired what the DOE's standard is for a "significant" change in calculated dose. The DOE replied they would provide the NRC a response to the question.

TEF Subissue 2, Open Item 6: Data Support for the Ventilation Model:

The DOE discussed the basis for resolving Open Item #6 (see "Thermal Effects on Flow Subissue 2, Open Item 6: Data Support for the Ventilation Model" presentation given by Ernest Hardin). The DOE stated that the presentation would provide the basis for going to "closed-pending" for this open item.

The DOE presented an overview of the ventilation test. The DOE stated that the testing will be used to calibrate ventilation models based on ANSYS and Multiflux codes. During Phase 3 of the test, the DOE will simulate moisture removal by ventilation air using water injection and evaluate the effect on heat removal efficiency. The NRC questioned how the DOE would determine how much water needed to be added to adequately represent thermohydrologic coupling with the repository drift wall. The DOE stated that the ventilation test is designed to represent heat removal by ventilation air and is not designed to represent thermal-hydrologic coupling with the host rock at the drift wall.

Mr. Shettel (Nye County) questioned the evaporation and precipitation at the drift wall. The DOE responded that the precipitation occurs inside the rock and not at the drift wall. In addition, the DOE stated that calculations could be done to calculate the quantity of minerals precipitated. Mr. Shettel stated that Nye County has already done the calculations and they are presented on the Nye County webpage.

TEF Subissue 2, Open Item 5: Potential Heat Losses in Cross Drift Thermal Test:

The DOE discussed the basis for resolving Open Item #5 (see "Thermal Effects on Flow Subissue 2, Open Item 1: Potential Heat Losses in Cross Drift Thermal Test" presentation given by Mark Peters). The DOE stated that the presentation would provide the basis for closing the open item.

At the start of the presentation, the NRC asked about the status of monitoring mass and energy losses through the bulkhead of the drift-scale test. The DOE replied that a contractor proposal for monitoring losses through the bulkhead had been received and the DOE determined the proposal to not be feasible.

With respect to the cross-drift thermal test, the DOE stated that the potential for unmonitored mass and energy flow through the cross drift thermal test boundaries has been taken into account as identified in the Cross Drift Thermal Test Planning Report, Section 4.0. The DOE indicated that simulations to support test design showed that minimal mass or energy losses would occur through the boundaries of the cross drift thermal test. The NRC questioned whether these simulations were done using a stochastic representation of heterogeneity. The DOE said they were not. The NRC noted that incorporating heterogeneity into the simulations may provide different results related to potential losses through the test boundaries. The NRC stated that it would review the Cross-Drift Thermal Test Planning Report and provide the DOE comments, if any.

The DOE discussed the test design configuration. The DOE stated that the objectives of the cross drift thermal test include testing water shedding between drifts. The NRC questioned whether the water collection holes would be effective in collecting water and stated that capillary diversion needs to be taken into account. The DOE noted the NRC comment. The DOE stated that there might not be sufficient water for collection in the collection holes. The DOE acknowledged that conclusions on whether thermal seepage into emplacement drifts occurs could not be drawn solely on the basis of no water accumulating in the collection holes. Similarly, the DOE acknowledged that chemical analyses of liquid water cannot be undertaken if no water accumulates in the collection holes. The DOE stated that the Cross Drift Thermal Test Final Report is scheduled for December 2004 in the present baseline schedule.

Later in the meeting, Mr. Frishman (State of Nevada) raised three concerns about the cross drift thermal test. First, he noted that the current schedule for the test would not allow information to be used in the license application. Second, he stated that current repository design is based upon hypotheses that need to be tested. Finally, he indicated that the test would provide data to test three key hypotheses: (1) mobilized water would be shed between emplacement pillars; (2) there would be no penetration of the boiling isotherm by liquid; and (3) mobilized waters would have a benign chemistry with respect to engineered barrier performance. During the NRC review of the Cross-Drift Thermal Test Planning Report, the NRC will consider the State of Nevada's comments.

TEF Subissue 2, Open Item 7: Data Uncertainty:

The DOE discussed the basis for resolving Open Item #7 (see "Thermal Effects on Flow Subissue 2, Open Item 7: Data Uncertainty" presentation given by Bo Bodvarsson). The DOE stated that the presentation would provide the basis for going to "closed-pending" for this open item.

The NRC questioned how data uncertainty is propagated into TSPA because data uncertainty in calibrated properties used for current modeling represents only uncertainty in the boundary condition flux. The DOE responded by discussing ongoing efforts to account for other uncertainties in the calibrated properties model wherein the resulting calibrated properties

would properly include a measure of uncertainty along with the sets for high, mean, and low flux boundary conditions. The NRC responded that this would provide the needed measure of uncertainty but questioned whether this would be propagated further into TSPA. The DOE asked if the NRC has a suggestion for an efficient method to do so. The NRC suggested additional runs of the Multi-Scale Thermohydrologic Model, using important parameters at their 95% confidence (including parameters, such as thermal conductivity, not determined in the calibrated properties AMR), and binning these results into the abstraction along with results for the high, mean, and low boundary fluxes. Both the DOE and NRC acknowledge that a full analysis of parameter uncertainty would require an impossibly large number of model runs and that efforts need to focus on those parameters that have the largest effect on thermohydrologic model results and ultimately performance.

The DOE stated that to address this area, it would discuss: (1) uncertainty from spatially heterogeneous properties; (2) uncertainty in measured data; (3) propagation of uncertainty in inverse modeling; and (4) upscaling.

Regarding uncertainty from spatially heterogeneous properties, the DOE stated that it is most important for site-scale flow and transport. The DOE further stated that heterogeneity within individual layers is incorporated for specific problems (e.g., seepage into drift, perched water bodies).

Regarding uncertainty in measured data, the DOE stated that measured data are upscaled to the unsaturated zone model gridblock scale common to both mountain scale simulations and inverse modeling calibration studies. The DOE further stated that upscaling is only necessary for certain parameters. The NRC suggested the methods used for upscaling be summarized and documented.

The DOE stated that measurement errors are taken into account in iTOUGH. The NRC commented that the AMR currently available to the NRC does not take into account heat dissipation probe information. The DOE stated that the future AMR will incorporate it.

Regarding propagation of uncertainty in inverse modeling, the DOE stated that iTOUGH2 utilizes a statistical minimization routine and automatic optimization algorhythm to yield best matches to the observed data. The analysis yields a statistical evaluation of the goodness of fit and the relative importance of all relevant input parameters (including the ten most sensitive ones). The DOE stated that it was going to start submitting the iTOUGH2 output on sensitivity and uncertainties of parameters to the technical database. The NRC commented that this would be a good idea.

The NRC noted that the various property sets used for thermohydrologic modeling were determined by the DOE to be equally valid based on comparisons to temperature data from the drift scale test, although saturations and fluxes obtained using these various property sets were significantly different. The NRC questioned whether additional comparisons of modeled versus measured saturations were to be done and if these comparisons would take into account uncertainties such as losses through the thermal bulkhead and in saturation measurements using ERT, GPR, and neutron probes. The DOE responded that these comparisons were being made.

TEF Subissue 2, Open Item 8: Model Uncertainty.

The DOE discussed the basis for resolving Open Item #8 (see "Thermal Effects on Flow Subissue 2, Open Item 8: Model Uncertainty" presentation given by Bo Bodvarsson). The DOE stated that the presentation would provide the basis for going to "closed-pending" for this open item.

The DOE stated that three types of uncertainties are considered in the thermohydrologic models (1) property/parameter, (2) conceptual model, and (3) numerical model uncertainty. The DOE then discussed flow conceptualization under ambient and thermal conditions. The DOE indicated there is uncertainty in conceptual models and said this uncertainty is being evaluated using alternative conceptual models such as discrete fracture models. The DOE stated that this evaluation would be discussed in the Unsaturated Zone Flow and Transport PMR, Rev. 00, ICN 02.

TEF Subissue 2, Overall Status

As a result of additional discussions, the NRC and DOE reached 13 agreements for Subissue #2 (see Attachment 1). With these 13 agreements, the NRC stated that Subissue #2 could be listed as "closed-pending."

6) Public Comments

There were no general public comments other than those discussed above.

1/11/01 1/11/2001

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Summary of the Resolution of the Key Technical Issue on Thermal Effects on Flow

Subissue #	Subissue Title	Status	NRC/DOE Agreements
1	Features, events, and processes related to thermal effects on flow	Closed-Pending	1) Provide the FEPs AMRs relating to TEF. The DOE will provide the following updated FEPs AMRs related to thermal effects on flow to the NRC: *Disruptive Events FEPs* (ANL-NBS-MD-000005) Rev 00 ICN 01; *Features, Events, and Processes: System Level* (ANL-WIS-MD-000019) Rev 00; *Features, Events, and Processes in UZ Flow and Transport* (ANL-NBS-MD-000001) Rev 01; *Features, Events, and Processes in SZ Flow and Transport* (ANL-NBS-MD-000002) Rev 01; *Features, Events, and Processes in Thermal Hydrology and Coupled Processes* (ANL-NBS-MD-000004) Rev 00 ICN 01; *Miscellaneous Waste Form FEPs* (ANL-WIS-MD-000009) Rev 00 ICN 01; and *Engineered Barrier System Features, Events, and Processes* (ANL-WIS-PA-000002) Rev 01. Expected availability: January 2001. 2) Provide the FEPs database. The DOE will provide the FEPs data base to the NRC during March 2001.

2	Thermal effects on temperature, humidity, saturation, and flux	Closed-Pending	1) Consider measuring losses of mass and energy through the bulkhead of the drift-scale test (DST) and provide the technical basis for any decision or method decided upon (include the intended use of the results of the DST such as verifying assumptions in FEP exclusion arguments or providing support for TSPA models: The DOE should analyze uncertainty in the fate of thermally mobilized water in the DST and evaluate the effect this uncertainty has on conclusions drawn from the DST results. The DOE's position is that measuring mass and energy losses through the bulkhead of the DST is not necessary for the intended use of the DST results. The DST results are intended for validation of models of thermally-driven coupled processes in the rock, and measurements are not directly incorporated into TSPA models. Results of the last two years of data support the validation of DST coupled-process models and the current treatment of mass and energy loss through the bulkhead. The DOE will provide the NRC a white paper on the technical basis for the DOE's understanding of heat and mass losses through the bulkhead and their effects on the results by April 2001. This white paper will include the DOE's technical basis for its decision regarding measurements of heat and mass losses through the DST bulkhead. This white paper will address uncertainty in the fate of thermally mobilized water in the DST and also the effect this uncertainty has on conclusions drawn from the DST results. The NRC will provide comments on this white paper. The DOE will provide analyses of the effects of this uncertainty on the uses of the DST in response to NRC comments. 2) Provide the location and access to the Multi-Scale Thermohydrologic Model input and output files. The output files are in the Technical Data Management System. The DTNs are LL000509112312.003, LL000509012312.002, and LL000509212312.004. The input files are located in the Project records system. The document identification number is MOL.20000706.0396. The DOE will provide the requested information to the NRC in January 2001.

2	Thermal effects on temperature, humidity, saturation, and flux - cont.		3) Provide the following references: Multi-Scale Thermohydrologic Model AMR, ICN 01; Abstraction of Near Field Environment Drift Thermodynamic and Percolation Flux AMR, ICN 01; Engineered Barrier System Degradation Flow and Transport PMR, Rev. 01; and Near Field Environment PMR, ICN 03. DOE will provide to the NRC the following documents: • *Multi-Scale Thermohydrologic Model* AMR (ANL-EBS-MD-00049) Rev 00 ICN 01 (January 2001) • *Abstraction of Near-Field Environment Drift Thermodynamic and Percolation Flux* AMR (ANL-EBS-HS-000003) Rev 00 ICN 01 (January 2001) • *Engineered Barrier System Degradation, Flow and Transport* PMR (TDR-EBS-MD-000006) Rev 01 (September 2001) • *Near-Field Environment* PMR (TDR-NBS-MD-000001) Rev 00 ICN 03 (January 2001) 4) Provide the Multi-Scale Thermohydrologic Model AMR, Rev. 01. The DOE will provide the *Multi-Scale Thermohydrologic Model* AMR (ANL-EBS-MD-00049) Rev 01 to the NRC. Expected availability is FY 02. 5) Represent the cold-trap effect in the appropriate models or provide the technical basis for exclusion of it in the various scale models (mountain, drift, etc.) considering effects on TEF and other abstraction/models (chemistry). See page 11 of the Open Item (OI) 2 presentation. The DOE will represent the "cold-trap" effect in the *Multi-Scale Thermohydrologic Model* AMR (ANL-EBS-MD-00049) Rev 01, expected to be available in FY 02. This report will provide technical support for inclusion or exclusion of the cold-trap effect in the various scale models. The analysis will consider thermal effects on flow and the in-drift geochemical environment abstraction. 6) Provide the detailed test plan for Phase III of the ventilation test, and consider NRC comments, if any. The DOE will provide a detailed test plan for the Phase III ventilation test in March 2001. The NRC comments will be provided no later than two weeks after receipt of the test plan, and will be considered by the DOE prior to test initiation.

2	Thermal effects on temperature, humidity, saturation, and flux - cont.		7) Provide the Ventilation Model AMR, Rev. 01 and the Pre-Test Predictions for Ventilation Test Calculation, Rev. 00. The DOE will provide the *Ventilation Model* AMR (ANL-EBS-MD-000030) Rev 01 to the NRC in March 2001. Note that ventilation test data will not be incorporated in the AMR until FY02. The DOE will provide the Pre-test Predictions for Ventilation Tests (CAL-EBS-MD-000013) Rev 00 to the NRC in February 2001. Test results will be provided in an update to the *Ventilation Model* AMR (ANL-EBS-MD-000030) in FY 02. 8) Provide the Mountain Scale Coupled Processes AMR, or an other appropriate AMR, documenting the results of the outlined items on page 20 of the OI 7 presentation (considering the NRC suggestion to compare model results to the O.M. Phillips analytical solution documented in Water Resources Research, 1996). The DOE will provide the updated *Mountain-Scale Coupled Processes Model* AMR (MDL-NBS-HS-000007) Rev 01 to the NRC in FY 02, documenting the results of the outlined items on page 20 of DOE's Open Item 7 presentation at this meeting. The DOE will consider the NRC suggestion of comparing the numerical model results to the O M Phillips analytical solution documented in WRR (1996). 9) Provide the Multi-Scale Thermohydrologic Model AMR, ICN 03. The DOE will provide the *Multi-Scale Thermohydrologic Model* AMR (ANL-EBS-MD-00049) Rev 00 ICN 03 to the NRC. Expected availability July 2001. 10) Represent the full variability/uncertainty in the results of the TEF simulations in the abstraction of thermodynamic variables to other models, or provide technical basis that a reduced representation is appropriate (considering risk significance). The DOE will discuss this issue during the TSPAI technical exchange tentatively scheduled for April 2001. 11) Provide the Calibrated Properties AMR, incorporating uncertainty from all significant sources. The DOE will provide an updated *Calibrated Properties Model* AMR (MDL-NBS-HS-000003) Rev 01 that incorporates uncertainty from significant sources to the NRC in FY 02.

2	Thermal effects on temperature, humidity, saturation, and flux - cont.		12) Provide the Unsaturated Zone Flow and Transport PMR, Rev. 00, ICN 02, documenting the resolution of issues on page 5 of the OI 8 presentation. The DOE will provide the *Unsaturated Zone Flow and Transport* PMR (TDR-NBS-HS-000002) Rev 00 ICN 02 to the NRC in February 2001. It should be noted, however, that not all of the items listed on page 5 of the DOE's Open Item 8 presentation at this meeting are included in that revision. The DOE will include all the items listed on page 5 of the DOE's Open Item 8 presentation in Revision 02 of the *Unsaturated Zone Flow and Transport* PMR, scheduled to be available in FY 02. 13) Provide the Conceptual and Numerical Models for Unsaturated Zone Flow and Transport AMR, Rev. 01 and the Analysis of Hydrologic Properties Data AMR, Rev. 01. The DOE will provide updates to the *Conceptual and Numerical Models for UZ Flow and Transport* (MDL-NBS-HS-000005) Rev 01 and the *Analysis of Hydrologic Properties Data* (ANL-NBS-HS-000002) Rev 01 AMRs to the NRC. Scheduled availability is FY 02.

Summary Highlights of NRC/DOE Technical Exchange and Management Meeting on Radionuclide Transport

December 5-7, 2000
Berkeley, California

Introduction and Objectives

This Technical Exchange and Management Meeting on Radionuclide Transport (RT) is one in a series of meetings related to the U.S. Nuclear Regulatory Commission (NRC) key technical issue (KTI) and sufficiency review and the U.S. Department of Energy (DOE) site recommendation decision. Consistent with NRC regulations on prelicensing consultations and a 1992 agreement with DOE, staff-level resolution can be achieved during prelicensing consultation. The purpose of issue resolution is to assure that sufficient information is available on an issue to enable the NRC to docket a proposed license application. 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. Issue resolution at the staff level, during prelicensing, is achieved when the staff has no further questions or comments at a point in time regarding how the DOE is addressing an issue. The discussions recorded here reflect NRC's current understanding of aspects of radionuclide transport most important to repository performance. This understanding is based on all information available to date which includes limited, focused, risk-informed reviews of selected portions of recently provided DOE documents (e.g., Analysis and Model Reports (AMRs) and Process Model Reports (PMRs)). Pertinent additional information could raise new questions or comments regarding a previously resolved issue.

Issues 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. Issues are "closed-pending" if the NRC staff has confidence that the DOE proposed approach, together with the DOE agreement to provide the NRC with additional information (through specified testing, analysis, etc.) acceptably addresses the NRC's questions such that no information beyond that provided, or agreed to, will likely be required at time of initial license application. Issues 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.

The objective of this meeting is to discuss and review the progress on resolving the RT KTI (see Attachment 1 for the description of Subissues #1, 2, and 3). Subissue #4, "Nuclear Criticality in the Far Field," was discussed during a Technical Exchange on October 22-23, 2000, and was not discussed during this meeting. The quality assurance (QA) aspect of this KTI was determined to be outside the scope of the meeting and is being tracked in NRC's ongoing review of DOE's QA program.

Enclosure

Summary of Meeting

At the close of the Technical Exchange and Management Meeting, the NRC staff stated that Subissues 1, 2, and 3 were "closed-pending." Specific NRC/DOE agreements made at the meeting are provided as Attachment 1. The agenda and the attendance list are provided as Attachments 2 and 3, respectively. Copies of the presenters' slides are provided as Attachment 4. Highlights from the Technical Exchange and Management Meeting are listed below.

Highlights

1) Opening Comments

DOE stated that the intent of the meeting is to reach agreement on the current status and path forward for each of the RT subissues (see "Radionuclide Transport" presentation given by Eric Smistad). In the RT Issue Resolution Status Report (IRSR), the NRC stated that RT Subissues 1, 2, and 3 are "open." During this meeting, DOE stated that its presentation would focus on confirmatory and additional information, data, and analyses identified by the NRC in the IRSR and subsequent discussions. DOE stated that it felt that the details provided during the current meeting would be the basis for NRC to list Subissues 1, 2, and 3 as "closed-pending."

2) Total System Performance Assessment

DOE provided an overview of how radionuclide transport is being incorporated into the Total System Performance Assessment (TSPA) for both the unsaturated zone (UZ) from the repository to the top of the water table and for the saturated zone (SZ) from the top of the water table beneath the repository to the 20 kilometer boundary.

Radionuclide transport processes parameters were implemented into the TSPA code using a particle tracking technique. Three-dimensional dual-continuum (fracture and matrix) flow fields (steady state flux) from the unsaturated and saturate zone process-level flow models were imported into TSPA code. The TSPA transport model incorporates probabilistically defined transport parameters in the unsaturated and saturated zone. In addition to these transport parameters, the TSPA code also varies the effective porosity of the alluvial material and the location of the alluvial boundary. The DOE provided clarifying information on the use of retardation and filtration expressions for modeling colloid transport. The DOE stated that colloid transport parameters were not as well constrained as other types of parameters.

3) Technical Discussions - Subissue #1, Radionuclide Transport Through Porous Rock

A summary of the current status of resolution was presented (see "Radionuclide Transport Key Technical Issue, Subissue 1, Radionuclide Transport in Porous Rock" presentation given by Jim Houseworth and Arend Meijer). The DOE identified the NRC information needs from Revision 2 of the RT IRSR and subsequent NRC/DOE discussions. The DOE stated that the presentations would provide the basis for going to "closed" or "closed-pending" for each of the acceptance criteria and, therefore, that it believed Subissue #1 should be listed as "closed-pending." For transport in porous rock, the DOE considers various transport processes

including hydrodynamic dispersion, matrix diffusion, sorption (solutes), filtration (colloids), and radioactive decay important to performance.

The DOE stated that all the acceptance criteria are considered "closed" with the exception of criteria 2b, 2c, and 5. The DOE stated that it believed these criteria are "closed-pending." Additional testing is needed for Criterion 2b titled "Demonstrate evaluation of R_f" and for Criterion 2c titled "Demonstrate assumptions for K_d approach are valid." For Criterion 2b additional sensitivity studies and review of available data need to be done to evaluate the adequacy of sorption parameters derived from laboratory experiments. Experiments for plutonium have shown kinetic effects that make the high flow rates used for the column tests non-representative. Additional sensitivity studies and a review of available data will be used to evaluate the adequacy of the data. The sensitivity of performance assessment results to protactinium sorption will be investigated to evaluate if additional tests are needed. If protactinium is important to performance and the existing data are inadequate, additional batch sorption tests using site-specific materials will be considered. The criterion to confirm the K_d for plutonium determined in static tests that are appropriate for calculating retardation in dynamic systems has not been met. To evaluate the adequacy of the data, the DOE stated that the effect of plutonium sorption on performance will be investigated in sensitivity studies and external information on plutonium sorption will be reviewed.

For Criterion 2c, NRC staff had previously commented that batch and column experiments with plutonium indicate that retardation reactions are not instantaneous in the time scale of the experiments. The DOE plans to consider the effects of plutonium sorption on performance in sensitivity studies and will also review external information concerning plutonium sorption. These experiments will be used to evaluate the need for additional experiments with plutonium.

The NRC stated that additional documentation for Criterion 4, titled "Expert judgement/elicitation," is needed to enable a thorough evaluation of the use of expert judgement to obtain ranges and probabilities for transport parameters used in the TSPA code. The NRC staff expressed the concern that retardation (K_d) distributions were obtained from inadequately documented expert judgments. For transport parameters derived from expert judgements, the judgements should be conducted and documented in accordance with the guidance in NUREG-1563, as applicable. For those species for which K_ds were measured or referenced, the selected ranges of K_ds used to model transport of chemical species either through porous rock or fractures should be technically supported. The DOE plans to provide additional documentation to explain how transport parameters obtained from expert judgments and used for performance assessment were derived.

As a result of additional discussions, the NRC and DOE reached five agreements for Subissue #1 (see Attachment 1). With these five agreements, the NRC stated that Subissue #1 could be listed as "closed-pending".

4) Technical Discussions - Subissue #3, Radionuclide Transport Through Fractured Rock

A summary of the current status of resolution was presented (see "Radionuclide Transport Key Technical Issue, Subissue 3. Radionuclide Transport in Fractured Rock" presentation given by Al Aziz Eddebbarh, Bo Bodvarsson, George Moridis, Paul Reimus, and Edward Kwicklis). DOE

identified the NRC information needs from Revision 2 of the RT IRSR and subsequent NRC/DOE discussions. The DOE stated that the presentations would provide the basis for going to "closed" or "closed-pending" for each of the acceptance criteria and, therefore, that it believed Subissue #3 should be listed as "closed-pending."

The DOE stated that for the unsaturated zone, the path lengths through the various units are generally the shortest distance between the potential repository and the water table. The only case where this is not true is where there is lateral diversion when downward flowing water encounters lower permeability rock such as bedded zeolitized tuff units or basal vitrophyres. The DOE stated that transport behavior in the unsaturated zone is not highly sensitive to alternative transport pathways, consistent with the data and known flow processes. Fractures are the main pathways of radionuclide transport in most units of the unsaturated zone. Diffusion from the fractures into the matrix and sorption in the matrix are the main retardation processes in radionuclide transport.

Sorption onto the matrix retards the migration of sorbing radionuclides. Flow and transport in the Calico Hills nonwelded hydrogeologic unit are strongly dependent on the spatial variability of the distribution of the vitric and zeolitic layers.

Recent unsaturated zone modeling at Yucca Mountain indicates that Topopah Spring welded units appear to be the most important for early arrival at the water table, while bedded tuff zeolitic units are more important for later arrival. In terms of relative importance to arrival times at the water table, the Topopah Spring is more important than bedded tuff zeolitic units, which in turn are more important than bedded vitric tuff units.

As discussed above, the DOE believes that all acceptance criteria for this subissue are considered "closed" or not applicable, with the exception of criteria 2a and 2b. These criteria are considered to be "closed-pending." Criterion 1c is considered to be closed by the DOE, because for the saturated zone, the uncertainty related to the lengths of flow paths in the tuff and in the alluvium was discussed at the October 31-November 2, 2000, Saturated Zone Technical Exchange. However, the DOE agreed at that technical exchange to provide additional information, including Nye County data, to further justify the uncertainty distribution of the flow path in alluvium in updates to the Uncertainty Distribution Stochastic Parameters AMR. Additional information was presented at this meeting to show how water chemistry and isotopic data are being used by the DOE to better define groundwater flow paths in the saturated zone.

Criterion 2a is titled "Demonstrate ability to predict breakthrough curves". Breakthrough curves of reactive, non-reactive, and colloidal tracers have been developed from field tests. These breakthrough curves are documented in the Saturated Zone Process Model Report, the planned C-well testing report, and the Unsaturated Zone Process Model Report. The DOE has developed breakthrough curves for nonsorbing tracer transport in fractured, welded tuff based on Alcove 1 data. Additional tests are being conducted in Alcove8/Niche 3 ,which will include nonsorbing and moderately sorbing tracers. The DOE is developing predictive models for the Alcove 8/Niche 3 tests as was discussed at the October 11-13, 2000, Structural Deformation and Seismicity Technical Exchange. This was the subject of an agreement made at that exchange. DOE considers this criterion "closed-pending" pending results from Alcove 8/Niche 3 testing and predictive modeling.

The NRC previously commented on the test plans for Alcove 8/Niche 3 and recommended that slots be cut into the walls of Niche 3. The NRC stated that this would allow the capture of most of the water percolating down from infiltration beds in Alcove 8. The DOE showed simulations that suggest percolation could occur well beyond where slots can be cut, making it unlikely to achieve a full water balance. The DOE also indicated that full recovery of percolation is not necessary to interpret the Alcove 8/Niche 3 tests. As an alternative, the DOE proposed to cut slots in Niche 5 to capture the bypass flow from seepage experiments. The injection of fluid will occur only a few meters above Niche 5, making it possible to capture all flow diverted around the niche.

Criterion 2b, titled "Demonstrate tracers are appropriate homologues for radionuclides," states that if credit is to be taken for radionuclide attenuation in fractured rock, then the DOE should have demonstrated nonradioactive tracers used in field tests are appropriate homologues for radioelements. The DOE expects to show that non-radioactive tracers used in field tests are appropriate homologues for radioelements. Ongoing testing at Alcove 8/Niche 3 will provide transport data using a suite of tracers representative of conservative and weakly sorbing radionuclides. The DOE has completed tests at the C-well complex using pentafluorobenzoic acid, bromide, lithium, and microspheres . The DOE considers these tests to be representative of transport of conservative radionuclides, sorbing radionuclides, and colloids. For dissolved radionuclides, the DOE is using these results as a means of demonstrating the appropriateness of conceptual models rather than as a source of transport parameters for TSPA. The DOE considers this criterion "closed-pending" pending documentation of Busted Butte and C-wells data.

As a result of additional discussions, the NRC and DOE reached 10 agreements for Subissue #3 (see Attachment 1). With these 10 agreements, the NRC stated that Subissue #3 could be listed as "closed-pending".

5) Technical Discussion - Subissue #2, Radionuclide Transport Through Alluvium

A summary of the current status of resolution was presented (see "Radionuclide Transport Key Technical Issue, Subissue 2, Radionuclide Transport Through Alluvium" presentation given by Al'Aziz Eddebbarh, Paul Reimus, and Arend Meijer). The DOE identified the NRC information needs from Revision 2 of the RT IRSR and subsequent NRC/DOE discussions. The DOE stated that the presentations would provide the bases for going to "closed" or "closed-pending" for Subissue #2 acceptance criteria and, therefore, that it believed Subissue #2 should be listed as "closed-pending."

Through performance assessment the DOE has determined that for the alluvium, transport processes such as sorption, radioactive decay, and colloidal filtration are important to repository performance. On-going and planned testing at the Alluvium Testing Complex will help confirm the applicability of laboratory determined transport parameters. Testing at the Alluvium Testing Complex will also confirm whether the alluvial aquifer can be considered a single continuum porous medium. Future TSPA analyses will be revised to better incorporate the effects of heterogeneity in the alluvium. Heterogeneity in the alluvial aquifer will be incorporated into TSPA analyses by the use of effective porosity distributions. The DOE indicated that

gravimeter logs will be run in addition to Nye County wells to obtain further estimates of average formation porosity.

The DOE believes that all acceptance criteria are considered "closed" with the exception of criteria 2a, 2b, 2c, and 4. These criteria are considered to be "closed-pending."

Criterion 2a stated that for the valid application of the constant K_d approach, the DOE should demonstrate that the flow path acts as a single continuum porous medium. If the flow cannot be shown to be a single continuum porous medium, then the acceptance criteria for radionuclide transport in fractured rock apply. Evidence that the alluvium can be modeled as a single continuum porous medium will be obtained by testing at the Alluvium Testing Complex. The DOE considers this criterion "closed-pending" completion of these tests.

Criterion 2b states that for the valid application of the constant K_d approach, the DOE should demonstrate that appropriate sorption values have been adequately considered (e.g., experimentally determined or measured). The DOE is using preliminary transport parameter values derived from lab measurements in performance assessment analyses. The DOE will refine and confirm these parameter values after multiple well tracer testing of radionuclide surrogates at the Alluvium Testing Complex and after laboratory batch and column radionuclide transport studies. The DOE considers this criterion "closed-pending" the completion of the testing at the Alluvium Testing Complex to obtain hydraulic and transport parameters for the alluvium.

The DOE considers Criterion 2c "closed-pending." The DOE cited as a basis for "closed-pending" that the following tests of alluvial aquifer samples are planned: (1) batch and column testing of alluvial aquifer material for technetium and neptunium under reducing conditions; (2) column testing to address the assumption of fast desorption kinetics; and (3) laboratory testing under reducing conditions to address the assumption of bulk chemistry.

For Criterion 4, "Expert Elicitation," the DOE stated that it did not use expert elicitation for development of K_ds for the alluvium. Additional documentation will be provided to explain how sorption coefficient distributions used for performance assessment were derived. The DOE considers this criterion "closed-pending" additional documentation of expert judgement.

As a result of additional discussions, the NRC and DOE reached 11 agreements for Subissue #2 (see Attachment 1). With these 11 agreements, the NRC stated that Subissue #2 could be listed as "closed-pending".

6) Features, Events, and Processes

The DOE presented Features, Events, and Processes (FEPs) for unsaturated zone and saturated zone transport (see "Features, Events, and Processes for Unsaturated Zone and Saturated Zone Transport" presentation given by Jim Houseworth). The objective of the presentation was to describe the upcoming revision to the FEPs AMRs.

Out of 128 features, events, and processes important to performance in the unsaturated and saturated zone, the DOE stated that 35 are related to unperturbed radionuclide transport. Of

these, 28 are included and 7 are excluded. Included FEPs are those that are modeled in the TSPA either directly or indirectly. Excluded FEPs are not included in the TSPA. The seven excluded features, events, and processes were excluded based on low consequence.

The DOE stated that it was updating the unsaturated and saturated zone flow and transport FEPs AMRs, and that the AMRs will be provided in NRC upon completion.

7) Public Comments

The State of Nevada (Ms. Linda Lehman) provided written comments at the meeting which were read at the end of the meeting. The comments were as follows:

1) There may be a disconnect between unsaturated zone and saturated zone structures important to transport. For example, the Ghost Dance Fault Splay seems to be important in the unsaturated zone, but may not be explicitly gridded in the saturated zone.

2) Distribution of recharge in the unsaturated zone is still problematic, for example on the western slope and especially where Paintbrush Tuff non-welded is absent. (This may also be relevant to the unsaturated zone FEP AMR - infiltration and recharge).

3) Flow paths in the saturated zone are still of concern.

4) Much more work must go into defining paths and chemistry thru alluvium.

5) There is concern about correlated variables and their use in Monte Carlo methods for performance assessment.

6) The State of Nevada has a problem with the boundary conditions used for diffusion, especially in Topapah Springs.

7) The State of Nevada has a problem with boundary conditions with respect to saturated zone dispersion stratigraphically and laterally.

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Deputy Director	Deputy Assistant Manager
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Summary of the Resolution of the Key Technical Issue on Radionuclide Transport

Subissue #	Subissue Title	Status	NRC/DOE Agreements
1	Radionuclide Transport Through Porous Rock	Closed-Pending	1) Provide the basis for the proportion of fracture flow through the Calico Hills non-welded vitric. DOE will revise the AMR *UZ Flow Models and Submodels* and the AMR *Calibrated Properties Model* to provide the technical basis for the proportion of fracture flow through the Calico Hills Nonwelded Vitric. These reports will be available to the NRC in FY 2002. In addition, the field data description will be documented in the AMR *In Situ Field Testing of Processes* in FY 2002. 2) Provide analog radionuclide data from the tracer tests for Calico Hills at Busted Butte and from similar analog and radionuclide data (if available) from test blocks from Busted Butte. DOE will provide data from tracers used at Busted Butte and data from (AECL) test blocks from Busted Butte in an update to the AMR *In Situ Field Testing of Processes* in FY 2002. 3) Provide the screening criteria for the radionuclides selected for PA. Provide the technical basis for selection of the radionuclides that are transported via colloids in the TSPA. The screening criteria for radionuclides selected for TSPA are contained in the AMR *Inventory Abstraction*. DOE is documenting identification of radionuclides transported via colloids for TSPA in the AMR *Waste Form Colloid-Associated Concentration Limits: Abstraction and Summary*, in the TSPA-SR Technical Report, and in the TSPA-SR Model Document. These documents will be available to the NRC in January 2001.

1	Radionuclide Transport Through Porous Rock - Cont		4) Provide sensitivity studies on K_d for plutonium, uranium, and protactinium to evaluate the adequacy of the data. DOE will analyze column test data to determine whether, under the flow rates pertinent to the Yucca Mountain flow system, plutonium sorption kinetics are important to performance. If they are found to be important, DOE will also perform sensitivity analyses for uranium, protactinium, and plutonium to evaluate the adequacy of K_D data. The results of this work will be documented in an update to the AMR *Unsaturated Zone and Saturated Zone Transport Properties* available to the NRC in FY 2002. 5) Provide additional documentation to explain how transport parameters used for performance assessment were derived in a manner consistent with NUREG-1563, as applicable. Consistent with the less structured approach for informal expert judgment acknowledged in NUREG-1563 guidance and consistent with DOE procedure AP-3.10Q, DOE will document how it derived the transport parameter distributions for performance assessment, in a report expected to be available in FY 2002.
2	Radionuclide Transport Through Alluvium	Closed-Pending	1) Provide further justification for the range of effective porosity in alluvium, considering possible effects of contrasts in hydrologic properties of layers observed in wells along potential flow paths. DOE will use data obtained from the Nye County Drilling Program, available geophysical data, aeromagnetic data, and results from the Alluvium Testing Complex testing to justify the range of effective porosity in alluvium, considering possible effects of contrasts in hydrologic properties of layers observed in wells along potential flowpaths. The justification will be provided in the *Alluvial Testing Complex* AMR due in FY 2003. 2) The DOE should demonstrate that TSPA captures the spatial variability of parameters affecting radionuclide transport in alluvium. DOE will demonstrate that TSPA captures the variability of parameters affecting radionuclide transport in alluvium. This information will be provided in the TSPA-LA document due in FY 2003.

2	Radionuclide Transport Through Alluvium - Cont.		3) Provide a detailed testing plan for alluvial testing (the ATC and Nye County Drilling Program) to reduce uncertainty (for example, the plan should give details about hydraulic and tracer tests at the well 19 complex and it should also identify locations for alluvium complex testing wells and tests and logging to be performed). NRC will review the plan and provide comments, if any, for DOE's consideration. In support and preparation for the October/November 2000 Saturated Zone meeting, DOE provided work plans for the Alluvium Testing Complex and the Nye County Drilling Program (FWP-SBD-99-002, Alluvial Tracer Testing Field Work Package, and FWP-SBD-99-001, Nye County Early Warning Drilling Program, Phase II and Alluvial Testing Complex Drilling). DOE will provide test plans of the style of the Alcove 8 plan as they become available. The plan will be amended to include laboratory testing. In addition, the NRC On Site Representative attends DOE/Nye County planning meetings and is made aware of all plans and updates to plans as they are made. 4) The NRC needs DOE to document the pre-test predictions for the ATC. DOE will document pretest predictions for the Alluvial Testing Complex in the *SZ In Situ Testing* AMR available in October 2001. 5) Provide the laboratory testing plan for laboratory radionuclide transport studies. NRC will review the plan and provide comments, if any, for DOE's consideration. In support and preparation for the October/November 2000 Saturated Zone meeting, DOE provided work plans for the Alluvium Testing Complex and the Nye County Drilling Program (FWP-SBD-99-002, Alluvial Tracer Testing Field Work Package, and FWP-SBD-99-001, Nye County Early Warning Drilling Program, Phase II and Alluvial Testing Complex Drilling). DOE will provide test plans of the style of the Alcove 8 plan as they become available. The plan will be amended to include laboratory testing. In addition, the NRC On Site Representative attends DOE/Nye County planning meetings and is made aware of all plans and updates to plans as they are made.

2	Radionuclide Transport Through Alluvium - Cont.		6) If credit is taken for retardation in alluvium, the DOE should conduct K_d testing for radionuclides important to performance using alluvium samples and water compositions that are representative of the full range of lithologies and water chemistries present within the expected flow paths (or consider alternatives such as testing with less disturbed samples, use of samples from more accessible analog sites (e.g., 40-mile Wash), detailed process level modeling, or other means). DOE will conduct K_d experiments on alluvium using samples from the suite of samples obtained from the existing drilling program; or, DOE will consider supplementing the samples available for testing from the alternatives presented by the NRC. This information will be documented in an update to the *SZ In Situ Testing* AMR, available in FY 2003. K_d parameter distributions for TSPA will consider the uncertainties that arise from the experimental methods and measurements. 7) Provide the testing results for the alluvial and laboratory testing. DOE will provide testing results for the alluvial field and laboratory testing in an update to the *SZ In Situ Testing* AMR available in FY 2003. 8) Provide additional information to further justify the uncertainty distribution of flow path lengths in the alluvium. This information currently resides in the *Uncertainty Distribution for Stochastic Parameters* AMR. DOE will provide additional information, to include Nye County data as available, to further justify the uncertainty distribution of flowpath lengths in alluvium in updates to the *Uncertainty Distribution for Stochastic Parameters* AMR and to the *Saturated Zone Flow and Transport* PMR, both expected to be available in FY 2002. 9) Provide the hydro-stratigraphic cross-sections that include the Nye County data. DOE will provide the hydrostratigraphic cross sections in an update to the *Hydrogeologic Framework Model for The Saturated Zone Site-Scale Flow and Transport Model* AMR expected to be available during FY 2002, subject to availability of Nye County data.

2	Radionuclide Transport Through Alluvium - Cont.		10) Provide additional documentation to explain how transport parameters used for PA were derived in a manner consistent with NUREG-1563, as applicable. Consistent with the less structured approach for informal expert judgment acknowledged in NUREG-1563 guidance and consistent with AP-3.10Q, DOE will document how it derived the transport distributions for performance assessment, in a report expected to be available in FY 2002. 11) Provide the updated UZ Flow and Transport and the SZ Flow and Transport FEPs AMRs. DOE will provide updates to the AMRs *Features, Events, and Processes in UZ Flow and Transport* and *Features, Events, and Processes in SZ Flow and Transport*, both available in January 2001.
3	Radionuclide Transport Through Fractured Rock	Closed-Pending	1) For transport through fault zones below the repository, provide the technical basis for parameters/distributions (consider obtaining additional information, for example, the sampling of wells WT-1 and WT-2), or show the parameters are not important to performance. DOE will provide a technical basis for the importance to performance of transport through fault zones below the repository. This information will be provided in an update to the AMR *Radionuclide Transport Models Under Ambient Conditions* available to the NRC in FY 2002. If such transport is found to be important to performance, DOE will provide the technical basis for the parameters/distributions used in FY 2002. DOE will consider obtaining additional information. 2) Provide the analysis of geochemical data used for support of the flow field below the repository. DOE will provide the analysis of geochemical data used for support of the fluid flow patterns in the AMR *UZ Flow Models and Submodels*, available to the NRC in FY 2002.

3	Radionuclide Transport Through Fractured Rock - Cont.		3) Provide additional information to further justify the uncertainty distribution of flow path lengths in the tuff. This information currently resides in the *Uncertainty Distribution for Stochastic Parameters* AMR. DOE will provide additional information, to include Nye County data as available, to further justify the uncertainty distribution of flowpath lengths from the tuff at the water table through the alluvium at the compliance boundary in updates to the *Uncertainty Distribution for Stochastic Parameters* AMR and to the *Saturated Zone Flow and Transport* Process Model Report, both expected to be available in FY 2002. 4) Provide sensitivity studies for the relative importance of the hydrogeological units beneath the repository for transport of radionuclides important to performance. DOE will provide a sensitivity study to fully evaluate the relative importance of the different units below the repository that could be used to prioritize data collection, testing, and analysis. This study will be documented in an update to the AMR *Radionuclide Transport Models Under Ambient Conditions* available to the NRC in FY 2002. 5) Provide the documentation for the Alcove 8/Niche 3 testing and predictive modeling for the unsaturated zone. DOE will provide documentation for the Alcove 8 / Niche 3 testing and predictive modeling for the unsaturated zone in updates to the AMRs *In Situ Field Testing of Processes* and *Radionuclide Transport Models Under Ambient Conditions*, both available to the NRC in FY 2002. 6) The NRC needs DOE to document the pre-test predictions for the Alcove 8/Niche 3 work. DOE responded that pre-test predictions for Alcove 8 Niche 3 work will be provided to NRC via letter report (Brocoum to Greeves) by mid-January 2001.

3	Radionuclide Transport Through Fractured Rock - Cont.		7) Provide sensitivity studies to test the importance of colloid transport parameters and models to performance for UZ and SZ. Consider techniques to test colloid transport in the Alcove 8/Niche 3 test (for example, microspheres). DOE will perform sensitivity studies as the basis for consideration of the importance of colloid transport parameters and models to performance for the unsaturated and saturated zones and will document the results in updates to appropriate AMRs, and in the TSPA-LA document, all to be available in FY 2003. DOE will evaluate techniques to test colloidal transport in Alcove 8 / Niche 3 and provide a response to the NRC in February 2001. 8) Provide justification that microspheres can be used as analogs for colloids (for example, equivalent ranges in size, charge, etc.). DOE will provide documentation in the C-Wells AMR to provide additional justification that microspheres can be used as analogs for colloids. The C-Wells AMR will be available to the NRC in October 2001. 9) Provide the documentation for the C-wells testing. Use the field test data or provide justification that the data from the laboratory tests is consistent with the data from the field tests. DOE will provide the C-Wells test documentation and will either use the test data or provide a justified reconciliation of the lab and field test data in the C-Wells AMR available in October 2001. 10) Provide analog radionuclide data from the tracer tests for Calico Hills at Busted Butte and from similar analog and radionuclide data (if available) from test blocks from Busted Butte. DOE will provide data from analog tracers used at Busted Butte and data from (AECL) test blocks from Busted Butte in an update to the AMR *In Situ Field Testing of Processes* in FY 2002.

Summary Highlights of NRC/DOE Technical Exchange and Management Meeting on Unsaturated and Saturated Flow Under Isothermal Conditions

October 31-November 2, 2000
Albuquerque, New Mexico

Introduction and Objectives

This Technical Exchange and Management Meeting on Unsaturated and Saturated Flow Under Isothermal Conditions (USFIC) is one in a series of meetings related to the U.S. Nuclear Regulatory Commission (NRC) key technical issue (KTI) and sufficiency review and the U.S. Department of Energy (DOE) site recommendation decision. Consistent with NRC regulations on prelicensing consultations and a 1992 agreement with DOE, staff-level resolution can be achieved during prelicensing consultation. The purpose of issue resolution is to assure that sufficient information is available on an issue to enable the NRC to docket a proposed license application. 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. Issue resolution at the staff level, during prelicensing, is achieved when the staff has no further questions or comments at a point in time regarding how the DOE is addressing an issue. The discussions recorded here reflect NRC's current understanding of aspects of saturated zone (SZ) flow most important to repository performance. This understanding is based on all information available to date which includes limited, focused risk-informed reviews of selected portions of recently provided DOE documents (e.g., Analysis and Model Reports (AMRs) and Process Model Reports (PMRs)). Pertinent additional information could raise new questions or comments regarding a previously resolved issue.

Issues 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. Issues are "closed-pending" if the NRC staff has confidence that the DOE proposed approach, together with the DOE agreement to provide the NRC with additional information (through specified testing, analysis, etc.) acceptably addresses the NRC's questions such that no information beyond that provided, or agreed to, will likely be required at time of initial license application. Issues 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.

The objective of this meeting is to discuss and review the progress on resolving the remaining subissues within the USFIC KTI (see Attachment 1 for list of subissues covered). Several USFIC subissues relating to the unsaturated zone (UZ) were discussed during a meeting conducted in August 2000. The quality assurance (QA) aspect of this KTI was determined to be outside the scope of the meeting and is being tracked in NRC's ongoing review of DOE's QA program.

Summary of Meeting

At the close of the Technical Exchange and Management Meeting, the NRC staff stated that Subissue 3, 5, and 6 were "closed-pending." Specific NRC/DOE agreements made at the meeting are provided as Attachment 1. The agenda and the attendance list are provided as Attachments 2 and 3, respectively. Copies of the presenters' slides are provided as Attachment 4. Highlights from the Technical Exchange and Management Meeting are listed below.

Highlights

1) Opening Comments

DOE stated that the intent of the meeting is to reach agreement on the current status and path forward for each of the USFIC subissues (see "Saturated Zone Flow Under Isothermal Conditions" presentation given by Claudia Newbury). Following the August 2000 meeting on the UZ issues (Subissue 1, 2, 3, 4, and part of 6), the NRC stated that Subissues 1 and 2 are closed, Subissue 3 is open, Subissue 4 and part of 6 (that relate to UZ) is "closed-pending." During this meeting, DOE stated that its presentation would focus on confirmatory and additional information, data, and analyses identified by the NRC during the April 2000 Technical Exchange, the August Technical Exchange, and subsequent discussions. DOE stated that it felt that the details provided during the current meeting would be the basis for NRC to list Subissues 3, 5, and the SZ portion of 6 as "closed-pending."

2) Technical Discussions - USFIC Subissue #3, Present-Day Shallow Groundwater Infiltration

A summary of the current status of resolution was presented (see "Present-Day Shallow Infiltration" presentation given by James Houseworth). Subissue #3, Acceptance Criterion (AC) #3, was reopened by the NRC at the August 2000 Technical Exchange because the DOE estimates of shallow infiltration were revised downward since the Total System Performance Assessment - Viability Assessment (TSPA-VA) and NRC believes sufficient justification was not provided.

DOE provided the basis to resolve the present-day shallow infiltration subissue, AC #3. A draft plan to address NRC concerns included three elements: (1) developing an upper-bound infiltration case based on the Monte-Carlo analysis for the glacial-transition climate. The upper-bound will be based on the 90th percentile case from the Monte Carlo analysis and new weighting factors for the lower bound, mean, and upper bound cases will be based on the documented methodology (Analysis of Infiltration Uncertainty Analysis and Model Report: ANL-NBS-HS-000027); (2) developing upper-bound infiltration cases for the monsoon and modern climates by proportional scaling based on the average infiltration ratio between the upper bound and mean cases for the glacial-transition climate; and (3) incorporating the new infiltration maps and weighting factors into the models that support Total System Performance Assessment - License Application.

The NRC expressed concern that revised weighting factors for upper bound infiltration may be too low. DOE responded that the recalculated weighting factors only changed about 30 percent

for upper bound infiltration. The DOE stated that the modern day infiltration was not affected using the scaling from the glacial-transition climate. DOE stated, based on its recollection, that the recalculated infiltration rates are approximately 53 mm/yr for glacial-transition and 30 mm/yr for the monsoon climate. The DOE was asked by the NRC how well the infiltration model represents modern climate, considering the neutron data, temperature data, chloride mass balance, and the calcite data. The DOE believes the current climate is reasonably well covered with the model. There are some minor issues with the site data that could change the current infiltration rate a few millimeters per year, but that is within the uncertainty ranges. DOE stated the spatial distribution covered in the model matches the conceptual model implemented in the mathematical model. NRC questioned if the model values are reasonable for the repository block area. DOE stated the model is best represented for the repository block area. NRC staff asked for an explanation why there was apparently a large change (i.e. reduction) in the infiltration since the TSPA-VA was issued. DOE provided three reasons for the changes: (1) the temperature representation was inadequate in the VA infiltration model and has since been fixed; (2) improvements were made to the evaporation-transpiration parameters along with calibration improvements; and (3) the bedrock geology was updated which caused a change in the spatial distribution of the permeability parameters. The NRC raised some issues with the consistency of the Alcove 1 permeability measurements with the model parameters and the lack of justifications for the Analysis of Infiltration Uncertainty AMR Table 4-1 distributions. A representative from the USGS stated the majority of the new Yucca Mountain infiltration data is or will be published outside of the project and committed to provide the NRC with the references. The NRC emphasized the need to provide the technical basis for the Table 4-1 distributions, and specifically noted that bedrock permeability estimates need to be reconciled with observations from the Alcove 1 and Pagany Wash experiments.

The NRC agreed with the approach of the Monte-Carlo analysis and the use of the 90th percentile. The NRC and DOE reached two agreements in this area (see Attachment 1). The NRC stated that these agreements supercede the three agreements reached during the August 2000 meetings. With these two new agreements, the NRC stated that Subissue #3 could be listed as "closed-pending."

3) Technical Discussions - USFIC Subissue #6, Matrix Diffusion (Saturated Zone Aspects)

A summary of the current status of resolution was presented (see "Subissue 6, Acceptance Criterion 2: Matrix Diffusion, Saturated Zone Aspects" presentation given by Al Aziz Eddebbarh). DOE identified the NRC information needs from Revision 2 of the USFIC Issue Resolution Status Report (IRSR), the April 2000 KTI technical exchange, and subsequent NRC/DOE discussions. DOE stated that it would provide the basis for resolving matrix diffusion in the saturated zone.

A summary of the current status of resolution was presented and DOE stated that: (1) the C-wells conservative and reactive tracer tests demonstrated that models that incorporate matrix diffusion provide more reasonable fits to the tracer-experiment data than those that assume a single continuum; and (2) the matrix sorption coefficients that fit the data for the lithium tracer in the C-wells reactive tracer experiment agreed well with the values in laboratory sorption tests.

The NRC asked what the recovery was for the tests. The DOE stated it was 50% for the conservative tracers, 15-16% for lithium, and 1% for the microspheres. The NRC expressed concern that the loss of tracers from these field tests could be used as an indication of uncertainty associated with the modeling of transport in fractured rock. DOE responded that tracers may have entered the matrix but were not recovered in the wells. Also, more of the tracers would have been recovered had the test been run longer. The NRC questioned the ability to scale a laboratory test and 30 meter field test to the site scale model using 500 meter grid spacing. DOE believes the scale effects are captured with treatment of matrix diffusion properties in TSPA. The NRC asked why the field tests were not used for the model diffusivity coefficients, instead of the laboratory data. The DOE stated the field tests served to constrain matrix diffusion parameters and the field tests agree with the laboratory data. The DOE is confident in the results of the tracer tests because several tracers were used in two stratigraphic horizons in the saturated zone which captured several hydraulic regimes. The NRC questioned why there was a gap in the observed and simulated data and notes that the slope of the tails on a log-log plot should be -1.5 (based on work by Mathew Becker, State University of New York - Buffalo, presented to the Spring 2000 American Geophysical Union meeting). DOE stated that was an issue with partial recirculation creating a weak dipole field. There are three parameters used in the TSPA as input to the matrix diffusion abstraction. They are effective diffusion coefficients, spacing of flowing intervals, and fracture porosity. The DOE stated that for each simulation run, all radionuclides were assigned the same effective diffusion coefficients. There is currently no matrix diffusion modeled in the alluvium portion of the saturated zone flow path, because the alluvium is considered for modeling purposes as a continuous porous medium.

The NRC agreed that the tests demonstrate that matrix diffusion exists in the SZ tuffs. The NRC noted that matrix diffusion is a proposed mechanism that affects radionuclide transport and additional questions may be raised on this subject in the Radionuclide Transport Technical Exchange. The DOE agreed to provide documentation for the C-well testing and to use field testing data or provide justification that data from the laboratory test is consistent with data from field tests.

As a result of the additional discussions, the NRC stated that of the three agreements made during the August 2000 meeting, the first agreement needed to be modified to include SZ , the second one could be closed, and the third remained the same. In addition, the NRC and DOE reached an additional agreement concerning the C-well testing (see Attachment 1 for list of open and closed agreements). With the remaining three agreements, the NRC stated that Subissue #6 could be listed as "closed-pending."

4) Technical Discussion - USFIC Subissue #5, Saturated Zone Ambient Flow Conditions and Dilution Processes

In the opening summary (see "Saturated Zone Flow Under Isothermal Conditions" presentation given by Claudia Newbury), DOE stated that there are 10 acceptance criteria (excluding QA), all of which are considered to be either closed or closed-pending by the DOE. DOE then identified the NRC information needs from Revision 2 of the USFIC IRSR, the April 2000 KTI technical exchange, and subsequent NRC/DOE discussions. DOE then addressed these needs during discussions of each acceptance criteria.

Presentations and Discussion Pertaining to AC #1

In its discussion of AC #1, Conceptual Flow and Data Uncertainties, DOE described its approach to treat horizontal anisotropy in volcanic units, how SZ specific discharge is discretized for incorporation in TSPA, and how other uncertain parameters are incorporated in TSPA based on Monte Carlo simulations. DOE concluded that documentation needed for AC #1 is provided in the SZ PMR and supporting AMRs and that conceptual model and data uncertainty will be refined as additional site data becomes available.

The discussion following this presentation focused on the appropriate degree of anisotropy for the site-scale saturated zone model, on proper calibration of the model, and on the use of alternative conceptual models. DOE stated that the isotropic case is really anisotropic given the discrete features, such as faults, included in the site-scale model. NRC asked if the calibration was based on the isotropic or anisotropic case. DOE replied that calibration was performed with the isotropic case and noted that only a small, on average 1 meter head change was observed when using the anisotropic model. DOE stated that bulk permeability was preserved between isotropic and anisotropic models. NRC asked whether an anisotropy ratio greater than 5:1 was possible. DOE stated that it is possible, and that more analysis is needed. NRC noted that the uncertainty is very large, with a range that could spread from an isotropic model to a highly anisotropic model. DOE stated it would consider a wider range of horizontal anisotropy. NRC stated that it expects to see documentation of relevant C-well test analysis. NRC observed that a 10:1 vertical anisotropy is used in the DOE model. DOE stated that the model lacked the resolution to capture all vertical structural features.

NRC inquired about the use of alternative conceptual models. DOE stated that isotropic and anisotropic models are considered different conceptual models. NRC raised the question whether flow to the carbonate aquifer should be considered. DOE stated that hydraulic head and water chemistry data suggest there is a potential for upward flow from the carbonate aquifer to the tuffs, and that south of Yucca Mountain, flow is from tuff to alluvium. DOE stated that the process of model calibration successively eliminated alternative conceptual models. NRC stated that head data alone is not sufficient to establish a flow path. Linda Lehman (Consultant for the State of Nevada) suggested that temperature data should be considered when calibrating the model. DOE stated that geochemical and temperature data are important. Geochemical data are consistent with the model. NRC stated that model calibration includes the use of the regional model, which has been criticized. DOE replied that the regional model is only used to obtain boundary conditions for the site-scale model. NRC asked for an agreement to revise the site-scale SZ model when the updated regional model is finalized.

Presentations and Discussion Pertaining to AC #5

In its discussion of AC #5, Estimates of Key Hydrologic Parameters, DOE stated that it planned to address four issues: (1) the hydraulic conductivity and effective porosity for saturated valley fill at 20-km and in the data gaps to the south of Yucca Mountain, (2) the plan to fill the data gap north of the Washburn well and 19D complex, (3) the plans to obtain porosity data in the valley fill, using geophysical methods, and (4) the plans for tracer tests at the Alluvium Testing Complex, along with detailed stratigraphy and results of aquifer tests in the complex. Following the DOE presentation, the NRC questioned how DOE was going to extrapolate the testing data

to 500 meters (the size of the grid blocks in the model) given that the test covered distances less than 100 meters. DOE stated that the transport model is grid independent, therefore, no numerical dispersion would occur.

The NRC stated that it was pleased to see predictions for the single-well tests and questioned how the tracer recovery would affect the usability of these tests. DOE stated that by using multi-tracer tests, the results are good and not as sensitive to recovery, even for the low amount of recovery in the C-wells. DOE suggested the need for obtaining core from Nye County bore holes to use in laboratory flow and transport experiments that will help better define field testing parameters for the alluvial tracer tests. After further discussions, the NRC stated that it needed additional information on the DOE testing plans for the alluvium studies.

Presentations and Discussion Pertaining to AC #2

Nye County, Nuclear Waste Repository Office, presented the Nye County Early Warning Drilling Program. Topics included delineation of flow paths, Phase II progress, Preliminary Findings, and Phase III plans. Nye County cautioned that the material in the presentation was preliminary. More than a dozen wells are completed and four are in progress. Nye County reported that "water levels are looking up" because several of the wells have upward gradients and that the depth to groundwater was shallower than expected at the paleodischarge site. Details were presented for well NC-EWDP-2DB, temperature profiles, conceptual compartments in Amargosa Desert, spinner survey, gravity data, and structural complexities. Nye County was concerned the DOE is using the regional model for input into the site-scale model. The DOE stated there is consistency in fluxes. Nye County discussed its plans to acquire water rights. They have applied for 33,000 acre feet of water rights which is under evaluation by the State Engineer. Nye County discussed the upcoming sequence of drilling and testing.

Linda Lehman, a consultant for the State of Nevada, presented an interpretation of the saturated zone with regards to temperature and structural interpretation. Ms. Lehman stated the flow fields near Yucca Mountain may not be connected. The DOE stated they are currently running a flow model which incorporates thermal effects.

DOE then provided the basis for closure of this subissue. DOE stated the subissue should be closed because (1) DOE has appropriately delineated saturated zone flow paths and is further refining the flow path delineation through additional Fiscal Year 2001 work; and (2) the DOE, in cooperation with Nye County, is conducting an extensive investigation of the stratigraphy of the saturated zone to define the transition of the water table from tuff to valley fill. Existing uncertainty is incorporated in the performance assessment.

Discussion followed DOE's presentation. The NRC suggested other methods to evaluate interpretations of the bore hole stratigraphy, such as age dating of cuttings, or palynology. The DOE agreed the methods could be used, but has no plan to use them because the model is not sensitive to the information. The NRC asked the DOE to justify the statistical model of uncertainty for the length of the saturated zone flow path in alluvium. The DOE stated that there is no evidence for a specific stochastic distribution other than a uniform distribution, which is the least biased.

Presentations and Discussion Pertaining to AC #3

In its presentation of AC #3, Moderate and Large Hydraulic Gradient, DOE reported on the drilling and testing of wells WT-24 and SD-6. DOE acknowledged NRC's earlier request, that related data should be provided and analyzed, and stated that information from this testing would be incorporated in the Technical Data Management System and considered in preparing updated AMRs and PMRs. DOE also stated that individual borehole reports would no longer be developed. DOE reported on water bearing features and water depths measured in these wells. DOE stated that AC#3 should be closed, mainly based on the fact that the hydraulic gradients are represented in the SZ flow and transport model.

NRC asked whether the 840 meter water elevation in WT-24 represents the regional water table. NRC also asked if there was a plan to deepen well SD-6 to test the moderate hydraulic gradient. DOE stated that 100% of the well test objective for SD-6 was not achieved, but that the tests provided a good source of information, and allowed testing of alternative conceptual models that have a significant impact. NRC asked which models were tested. DOE replied that, for example, large hydraulic gradient models were also considered. NRC asked whether tests yielded average transmissivity estimates. DOE replied that tests were not analyzable due to the rapid drawdown, and that they had faced difficulties drilling well SD-6. NRC recommended testing other wells. NRC asked when detailed test reports will be available. DOE replied that information is distributed among pertinent AMRs. NRC stated that some of this information is not yet published. NRC will continue to evaluate data such as water chemistry, mineralogy, stratigraphy, and hydraulic testing as it becomes available.

Presentations and Discussion Pertaining to AC #4

In its presentation of AC #4, Potentiometric Maps, DOE described an updated potentiometric map of the regional uppermost aquifer, and stated that infiltration, evapotranspiration, spring discharges, and pumping estimates are included in the regional model.

NRC commented that the head data is applied to a single, uppermost aquifer, and that the large head gradients may suggest that the aquifer is not well connected, which could require the fitting of several maps. The NRC also stated that its published interpretations of the SZ are found in Revision 2 of the USFIC IRSR. DOE replied that they have tried to develop potentiometric surface maps of lower aquifers, but given the limited data, were unsuccessful. The Nye County data may help in future analysis. NRC asked whether constant head values were used as model input. A Nye County representative questioned whether water levels are really composite heads, rather than representing discrete intervals. DOE stated that water level data are not always useful for contouring, but are used directly in model calibration at the depth of measurement. NRC suggested that the analysis start with the description of a flow net, development of potentiometric maps for each aquifer, and then calibration of corresponding models. However, the NRC also commented that the current approach may be appropriate. DOE replied that they needed to address all parts of this AC.

Presentations and Discussion Pertaining to AC #6

In its discussion of AC #6, Mathematical Groundwater Models, DOE stated that it has used mathematical groundwater models: (1) that incorporate site-specific climatic and subsurface information; (2) that are reasonably calibrated and reasonably represent the physical system; (3) whose fitted aquifer parameters compare reasonably well with observed site data; (4) whose implicitly or explicitly simulated fracturing and faulting are consistent with the data in the 3D geologic framework model (GFM); (5) whose abstractions are based on initial and boundary conditions consistent with site-scale modeling and the regional model of the Death Valley groundwater flow system. DOE has used mathematical groundwater models whose abstractions of the groundwater models for use in PA simulations use the appropriate spatial and temporal averaging techniques.

The DOE's presentation included a discussion of the hydrogeologic framework model (HFM) which provides the fundamental geometric framework for development of a site-scale three-dimensional groundwater flow and transport model. The DOE stated the framework provides a basis for the mathematical model which incorporates site-specific subsurface information and will continue to be updated. The regional model is also being revised.

The DOE presented the basis of resolution for the numerical flow model. The basis for resolution stated that DOE has developed a numerical flow model that adequately incorporates site data, that is reasonably calibrated, and reasonably represents the physical system. The DOE suggested the flow model has a lower upward gradient than observed at well P-1 but is consistent with the flow direction. The DOE stated the models will be updated with new information to further reduce uncertainty. The NRC asked if more work will be done on the HFM. The DOE stated the framework model will be updated to include available Nye County data. The NRC asked several questions regarding the analysis of alternative conceptual models and the propagation of such models through performance assessment. NRC requested that the alternative conceptual models be discussed in the PMR. The DOE stated they incorporate alternative conceptual models in TSPA only if they impact flow pathlines and flux changes that are important to performance. NRC expressed concerns in the HFM AMR regarding the boundary between the GFM and areas to the south which presented problems in correlating geologic units in faults and maintaining unit thickness. DOE stated that the HFM is being updated to include new data. The NRC questioned the model permeabilities which fall outside of field or lab data. The DOE agreed that some fall outside the data ranges but they focused on the permeabilities that affect TSPA runs. The NRC asked the DOE if permeabilities along the Solitario Canyon Fault could be revised to permit additional flow from Crater Flat into the regional deep aquifer beneath Yucca Mountain. The NRC indicated that in this way, the model can be used to evaluate alternate conceptual flow models. The DOE indicated this alternative model could be evaluated. The DOE stated the model has good resolution and allows for short run times. Priority was given in the model to those features with the greatest impacts to performance assessment. In response to the DOE's presentation, the NRC stated that the removal of the east-west barrier (corresponding to the large hydraulic gradient) would not likely cause major changes in the SZ site-scale model output since this parameter was assigned a low composite scaled sensitivity of 0.2. The DOE agreed.

The DOE stated that the averaged calibrated water level error of 16 meters is small in comparison to the entire thickness of the model. The NRC stated that the comparison should only include the thickness of the aquifer in which the measured vs. simulated hydraulic heads are compared, not the entire thickness of the model. The NRC stated that the PMR referred to the recharge as a candidate for use as a calibration parameter. The DOE clarified that the recharge rate is redistributed as it is applied from the regional model onto the site-scale model, but is not a calibrated parameter. The NRC pointed out that the difference between the SZ site-scale model inflow and outflow, which represents recharge, varied substantially from the regional model recharge rate. In response to an NRC question concerning the southern boundary condition, the DOE stated that no actual pumping occurs within the model boundaries. The NRC stated that two of the three criteria used for model validation justification were data used to develop or calibrate the model. The DOE agreed. The NRC further stated that, at present, the site-scale model can not be considered fully validated. The NRC and DOE discussed using NUREG-1636, "Regulatory Perspectives on Model Validation in High-Level Radioactive Waste Management Programs: A Joint NRC/SKI White Paper," as guidelines. DOE noted that the site-scale AMR acknowledged that the model was only partially validated and that confidence building activities would continue as the model matures.

Presentations and Discussion Pertaining to AC #8

In its discussion of AC #8, Dilution, DOE stated that it would address this AC using the particle tracking based transport methodology. DOE's discussion included the key features of the particle tracking model, code verification simulations, the treatment of dilution, and ongoing model development. NRC questioned the dispersivity values. DOE stated the values assumed in each specific realization are constant, but vary by realization. DOE and NRC discussed fracture spacing, both for the no-sorption and with-sorption cases. The NRC stated that the issue of dilution and the particle tracking based transport methodology will be discussed again during the Radionuclide Transport Technical Exchange, but at this point, it did not need any NRC/DOE agreements.

With regarding to AC #7, Wellbore Dilution, DOE stated that no additional credit for any wellbore dilution specifically due to well pumping is taken in the TSPA. Therefore, DOE stated this AC should be closed.

Presentations and Discussion Pertaining to AC #9

In its discussion of AC #9, Potential Effects on the Saturated Zone Flow System, DOE stated that its basis for closure was the investigation of secondary mineral deposits that have been interpreted by others as providing evidence that potential geothermal processes and seismicity modified the ambient flow system and the alternative models resulting from this interpretation. The DOE expects the fluid inclusion study to confirm the validity of their conclusions that there has not been geothermal upwelling in the repository horizon. The DOE acknowledged the ongoing University of Nevada - Las Vegas (UNLV) studies of fluid inclusions as a test of the geothermal hypothesis. The DOE said they will evaluate results of the UNLV fluid inclusion study when they are available. DOE feels that based on interim reports these results are not expected to change conclusions previously drawn regarding geothermal and seismic effects on the water table.

Discussion followed DOE's presentation. The NRC asked about possible alternative thermal sources at the site that could explain the fluid inclusion results. The DOE stated possible other sources include the residual heat from the Timber Mountain volcanism or detachment faulting. The USGS representative stated that the greatest abundance in calcite/opal minerals occurs beneath the Drill Hole Wash. NRC asked the significance of this observation. USGS responded that this suggests significant deep infiltration at this location and questioned the assumptions used in the UZ flow models. The NRC also asked about sources of calcite in fault zones. The DOE position is that the fault zone calcite came from surface infiltration because there is no plausible mechanism for seismic pumping to raise the water table 2000 feet. The NRC asked about the status of carbon-14 dating of organic carbon in groundwater. The DOE said the results from samples collected in Amargosa may be available in the next three months.

As a result of additional discussions, NRC and DOE reached 14 agreements for Subissue #5 (see Attachment 1). With these 14 agreements, the NRC stated that Subissue #5 could be listed as "closed-pending".

5) Total System Performance Assessment

DOE offered a brief discussion following a question on sensitivity analysis in TSPA. NRC asked how, given the long life of the engineered barrier, can the contributions of the natural barriers be properly estimated. DOE answered that, if waste packages are not expected to fail before 10,000 years, then performance studies of longer duration should be carried out. DOE stated that, although not a realistic scenario, neutralization of the engineered barrier has been simulated. In addition, analysis of "degraded" and "enhanced" barriers in TSPA simulate realistic behavior of the system. DOE stated that this would allow a better estimate of the performance of natural barriers. DOE stated that failure of the engineered barrier system is also included in the human intrusion scenario, as well as in the disruptive igneous case. NRC asked if related results could be presented at the Radionuclide Transport Technical Exchange. DOE answered that this was possible, but needed to be planned for.

6) Features, Events, and Processes

The DOE presented Features, Events, and Processes (FEPs) in Saturated Zone Flow and Transport. The objective of the presentation was to describe the upcoming revision to the Saturated Zone Features, Events, and Processes Analysis and Model Report. Two new secondary FEPs will be added and additional documentation of the secondary FEPs will be included in the revised AMR.

Discussion followed the presentation. NRC asked whether any screening results were changed since Rev. 00. DOE answered that a few previously excluded FEPs are now included. The DOE explained the process of excluding low consequence FEPs using either qualitative or quantitative arguments based on TSPA runs. The NRC asked the DOE for the definition and screening process of several specific FEPs, including microbial activity, wells, and water table rise. Each of these FEPs was explained by the DOE and will be defined in the upcoming AMR. The DOE explained to Nye County that the water management FEP does not include potential changes to future groundwater appropriations due to the regulatory requirements. The State of

Nevada asked how the water conducting features FEP was included in the DOE models. The DOE stated that they captured these features with the flowing interval spacing parameter and the horizontal anisotropy. NRC commented that the provided table of FEPs screening results was very useful, and asked to get a similar presentation at future technical exchanges. The DOE agreed to provide the revised Saturated Zone Features, Events, and Processes Analysis and Model Report.

7) Public Comments

None

11/2/2000 11/2/2000

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Summary of the Resolution of the Key Technical Issue on Unsaturated and Saturated Flow Under Isothermal Conditions

Subissue #	Subissue Title	Status	NRC/DOE Agreements
3	Present-Day Shallow Groundwater Infiltration	Closed-Pending	1) Provide the documentation sources and schedule for the Monte Carlo method for analyzing infiltration. DOE will provide the schedule and identify documents expected to contain the results of the Monte Carlo analyses in February 2002. 2) Provide justification for the parameters in Table 4-1 of the Analysis of Infiltration Uncertainty AMR (for example, bedrock permeability in the infiltration model needs to be reconciled with the Alcove 1 results/observations. Also, provide documentation (source, locations, tests, test results) for the Alcove 1 and Pagany Wash tests. DOE will provide justification and documentation in a Monte Carlo analyses document. The information will be available in February 2002.

5	Saturated Zone Ambient Flow Conditions and Dilution Processes	Closed-Pending	1) The NRC believes that the incorporation of horizontal anisotropy in the site scale model should be reevaluated to ensure that a reasonable range for uncertainty is captured. The data from the C-wells testing should provide a technical basis for an improved range. As part of the C-wells report, DOE should include an analysis of horizontal anisotropy for wells that responded to the long-term tests. Results should be included for the tuffs in the calibrated site scale model. DOE will provide the results of the requested analyses in C-wells report(s) in October 2001, and will carry the results forward to the site-scale model, as appropriate. 2) Provide the update to the SZ PMR, considering the updated regional flow model. A revision to the Saturated Zone Flow and Transport PMR is expected to be available and will reflect the updated United States Geological Survey (USGS) Regional Groundwater Flow Model in FY 2002, subject to receipt of the model report from the USGS (reference item 9).

5	Saturated Zone Ambient Flow Conditions and Dilution Processes (Cont.)		3) DOE's outline for collecting data in the alluvium appears reasonable but lacks detail. Provide a detailed testing plan for alluvial testing to reduce uncertainty (for example, the plan should give details about hydraulic and tracer tests at the well 19 complex and it should also identify locations for alluvium complex testing wells and tests and logging to be performed). NRC will review the plan and provide comments, if any, for DOE's consideration. In support and preparation for this meeting, DOE provided work plans for the Alluvium Testing Complex and the Nye County Drilling Program (FWP-SBD-99-002, Alluvial Tracer Testing Field Work Package, and FWP-SBD-99-001, Nye County Early Warning Drilling Program, Phase II and Alluvial Testing Complex Drilling). DOE will provide test plans of the style of the Alcove 8 plan as they become available. In addition, the NRC On Site Representative attends DOE/Nye County planning meetings and is made aware of all plans and updates to plans as they are made. 4) Provide additional information to further justify the uncertainty distribution of flow path lengths in the alluvium. This information currently resides in the Uncertainty Distribution for Stochastic Parameters AMR. DOE will provide additional information, to include Nye County data as available, to further justify the uncertainty distribution of flowpath lengths in alluvium in updates to the Uncertainty Distribution for Stochastic Parameters AMR and to the Saturated Zone Flow and Transport PMR, both expected to be available in FY 2002.

5	Saturated Zone Ambient Flow Conditions and Dilution Processes (Cont)		5) Provide the hydro-stratigraphic cross-sections that include the Nye County data. DOE will provide the hydrostratigraphic cross sections in an update to the Hydrogeologic Framework Model for the Saturated Zone Site-Scale Flow and Transport Model AMR expected to be available during FY 2002, subject to availability of the Nye County data. 6) Provide a technical basis for residence time (for example, using C-14 dating on organic carbon in groundwater from both the tuffs and alluvium). DOE will provide technical basis for residence time in an update to the Geochemical and Isotopic Constraints on Groundwater Flow Directions, Mixing, and Recharge at Yucca Mountain, Nevada AMR during FY 2002. 7) Provide all the data from SD-6 and WT-24. Some of this data currently resides in the Technical Data Management System, which is available to the NRC and CNWRA staff. DOE will include any additional data from SD-6 and WT-24 in the Technical Data Management System in February 2001.

5	Saturated Zone Ambient Flow Conditions and Dilution Processes (Cont.)		8) Taking into account the Nye County information, provide the updated potentiometric data and map for the regional aquifer, and an analysis of vertical hydraulic gradients within the site scale model. DOE will provide an updated potentiometric map and supporting data for the uppermost aquifer in an update to the Water-Level Data Analysis for the Saturated Zone Site-Scale Flow and Transport Model AMR expected to be available in October 2001, subject to receipt of data from the Nye County program. Analysis of vertical hydraulic gradients will be addressed in the site-scale model and will be provided in the Calibration of the Site-Scale Saturated Zone Flow Model AMR expected to be available during FY 2002. 9) Provide additional information in an updated AMR or other document for both the regional and site scale model (for example, grid construction, horizontal and vertical view of the model grid, boundary conditions, input data sets, model output, and the process of model calibration). The updated USGS Regional Groundwater Flow Model is a USGS Product, not a Yucca Mountain Site Characterization Project product. It is anticipated that this document will be available in September 2001. DOE believes that the requested information is now available in the current version of the Calibration of the Site-Scale Saturated Zone Flow Model AMR and will be carried forward in future AMR revisions.

5	Saturated Zone Ambient Flow Conditions and Dilution Processes (Cont.)		10) Provide in updated documentation of the HFM that the noted discontinuity at the interface between the GFM and the HFM does not impact the evaluation of repository performance. DOE will evaluate the impact of the discontinuity between the Geologic Framework Model and the Hydrogeologic Framework Model on the assessment of repository performance and will provide the results in an update to the Hydrogeologic Framework Model for the Saturated-Zone Site-Scale Flow and Transport Model AMR during FY 2002. 11) In order to test an alternative conceptual flow model for Yucca Mountain, run the SZ flow and transport code assuming a north-south barrier along the Solitario Canyon fault whose effect diminishes with depth or provide justification not to. DOE will run the saturated zone flow and transport model assuming the specified barrier and will provide the results in an update to the Calibration of the Site-Scale Saturated Zone Flow Model AMR expected to be available during FY 2002. 12) Provide additional supporting arguments for the Site-Scale Saturated Zone Flow model validation or use a calibrated model that has gone through confidence building measures. The model has been calibrated and partially validated in accordance with AP 3.10Q, which is consistent with NUREG-1636. Additional confidence-building activities will be reported in a subsequent update to the Calibration of the Site-Scale Saturated Zone Flow Model AMR, expected to be available during FY 2002.

5	Saturated Zone Ambient Flow Conditions and Dilution Processes (Cont.)		13) Provide the evaluation of the ongoing fluid inclusion studies (for example, UNLV, State of Nevada, and USGS). DOE's consideration of the fluid inclusion studies will be documented in an update to the Saturated Zone Flow and Transport PMR expected to be available in FY 2002, subject to availability of the studies. 14) Provide the updated SZ FEPs AMR. DOE will provide the updated Features, Events, and Processes in Saturated Zone Flow and Transport AMR in February 2001.

Summary Highlights of NRC/DOE Technical Exchange and Management Meeting on Subissues Related to Criticality

October 23-24, 2000
Las Vegas, Nevada

Introduction and Objectives

This Technical Exchange and Management Meeting on subissues related to criticality (Container Life and Source Term (CLST Subissue 5), Radionuclide Transport (RT Subissue 4), and Evolution of the Near-Field Environment (ENFE Subissue 5)) is one in a series of meetings related to the U.S. Nuclear Regulatory Commission (NRC) key technical issue (KTI) and sufficiency review and the U.S. Department of Energy (DOE) site recommendation decision. Consistent with NRC regulations on prelicensing consultations and a 1992 agreement with DOE, staff-level resolution can be achieved during prelicensing consultation. The purpose of issue resolution is to assure that sufficient information is available on an issue to enable the NRC to docket a proposed license application. 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. Issue resolution at the staff level, during prelicensing, is achieved when the staff has no further questions or comments at a point in time regarding how the DOE is addressing an issue. Pertinent additional information could raise new questions or comments regarding a previously resolved issue.

Issues 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. Issues are "closed-pending" if the NRC staff has confidence that the DOE proposed approach, together with the DOE agreement to provide the NRC with additional information (through specified testing, analysis, etc.) acceptably addresses the NRC's questions such that no information beyond that provided, or agreed to, will likely be required at time of initial license application. Issues 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.

The objective of this meeting is to discuss and review the progress on resolving the subissues related to criticality (see Attachment 1 for list of subissues).

Summary of Meeting

At the close of the Technical Exchange and Management Meeting, the NRC staff stated that CLST Subissue 5, RT Subissue 4, and ENFE Subissue 5 were "closed-pending." Specific NRC/DOE agreements made at the meeting are provided as Attachment 1. The agenda and the attendance list are provided as Attachments 2 and 3, respectively. Copies of the presenters' slides are provided as Attachment 4. Highlights from the Technical Exchange and Management Meeting are listed below.

Highlights

1) Opening Comments

DOE stated that the intent of the meeting is to reach agreement on the current status and path forward for each of the criticality subissues (see "Criticality - Summary of Status from a DOE Perspective" presentation given by Paige Russell). DOE stated that in the CLST Issue Resolution Status Report (IRSR), Rev. 02, RT IRSR, Rev. 02, and ENFE IRSR, Rev. 3, the NRC listed CLST Subissue 5 as "open" and RT Subissue 4 and ENFE Subissue 5 as "closed-pending." During this meeting, DOE stated that its presentation would focus on confirmatory and additional information, data, and analyses identified by the NRC in its Safety Evaluation Report (SER), the previously mentioned IRSRs, and subsequent discussions. DOE stated that it felt the presentations would identify future documents which can be used as the basis to go to "closed-pending."

DOE stated that it has two documents that will contain the methodology for evaluating criticality: (1) the Disposal Criticality Analysis Methodology Topical Report (Topical Report) and (2) the Preclosure Criticality Analysis Process Report (Preclosure Report). DOE stated that the Preclosure Report would not be issued until Fiscal Year 2002 due to work prioritization. DOE stated that it plans to validate the models in a series of validation reports which will provide justification for the range over which the models are to be used. The NRC questioned when the validation reports will be issued and whether they will cover all the specific waste forms. DOE stated that the validation reports will be issued during the next two fiscal years and that it is in the process of gathering information on all the waste types. DOE noted that as information became available, it would provide it to the NRC. DOE also stated that it did not believe the current waste package design would be negatively impacted by the other waste types.

2) Discussion of Criticality Topical Report

DOE presented an overview of the update to the criticality topical report (see "Disposal Criticality Topical Report Update" presentation given by Daniel Thomas). DOE stated that the objective of this presentation was to give a general description of Revision 1 to the Topical Report, briefly summarize the changes in Revision 1, and provide a cross-reference to the NRC SER open items, Revision 1 of the Topical Report, and the presentations for this technical exchange. DOE stated that the Topical Report was reorganized to be consistent with the NRC SER. DOE provided an overview of the methodology used in the Topical Report and the changes since Revision 0 to the Topical Report.

DOE stated that of the 28 SER open items, all except one are addressed in the CLST Subissue 5 presentations. The exception related to Open Item 1, the verification of the spent fuel burnup. DOE stated that this open item was unique in that it did not correspond to a KTI subissue and that it would be more appropriate to address it as part of the Topical Report/SER process. DOE stated that it was developing an approach for burnup verification and that it would be formally documented in the Preclosure Report. The NRC stated that, since this was a preclosure issue, that it would be more fully discussed during a future technical exchange addressing preclosure issues.

3) Technical Discussions - CLST Subissue #5, Effect of In-Package Criticality on Waste Package and Engineered Barrier System Performance

A summary of the current status of resolution was presented in a number of presentations (see Container Life and Source Term Subissue 5, Acceptance Criterion presentations). There are a total of seven acceptance criteria for this subissue, all of which are considered to be "closed-pending" by the DOE. DOE then discussed each acceptance criterion (AC) and the information items identified in the CLST IRSR, Rev. 2 and in the NRC SER.

Under AC #1, DOE discussed the design criteria for components to mitigate potential effects of in-package criticality on repository performance. DOE addressed the actions or information needs identified by the NRC and stated that the consequence criterion has been removed from the Topical Report and that all probability/consequence pairs will be evaluated for inclusion in at least one Total System Performance Assessment (TSPA) sensitivity analysis. DOE further stated that only probability defined in the proposed 10 CFR 63.114(d) will be used for screening criticality events from TSPA. The NRC had questions related to the analysis done for TSPA. DOE stated that the sensitivity analysis related to criticality would be further discussed under AC #7.

Under AC #2, DOE discussed the features, events, and processes (FEPs) that may increase the reactivity of the system inside the waste package. DOE addressed the actions or information needs identified by the NRC and stated that the description of the methodology and modeling for igneous events is provided in the revision to the Topical Report and that an application of this methodology will be available in November 2000 (Probability of Criticality Before 10,000 years, CAL-EBS-NU-000014, Rev. 0). DOE also discussed the inclusion of seismicity and faulting in the in-package criticality scenario development. DOE stated that the description for seismicity has already been accepted by the NRC in the SER. DOE stated that faulting has been screened out based on low probability for damage. The NRC stated that providing the revision to the Disruptive Events FEPs AMR was an agreement reached in the Structural Deformation and Seismicity (SDS) KTI technical exchange and still needed to be reviewed prior to accepting DOE's conclusions. The NRC also stated that it needed to review the revision to the FEPs database.

The NRC questioned whether low-frequency, high-volume infiltration events were factored into the DOE analysis. The NRC questioned whether some FEPs conducive to criticality may be screened out since they may not affect the performance assessment. DOE stated that a wide range of seepage distributions were factored in and covered the full range of possible drip rates and that DOE does consider the potential differences in conservative approaches with respect to criticality and radionuclide release. DOE stated that the full range of credible parameters will be considered for criticality.

The NRC questioned whether DOE's approach in CAL-EBS-NU-000014, Rev. 0 was consistent with the NRC/DOE agreements made during the igneous activity technical exchange (e.g., discussions related to the probability of igneous activity at 10^{-8}). DOE stated that its approach was consistent. The NRC also questioned whether DOE's approach considered the potential for criticality within a tephra deposit following an extrusive volcanic

event. DOE stated that processes equivalent to this scenario were considered in CAL-EBS-NU-000014, Rev. 0.

Under AC #3, DOE discussed the configuration classes that have potential for criticality. DOE addressed the actions or information needs identified by the NRC and stated that the acceptance of the methodology for identifying the configuration classes was discussed in the NRC SER. The NRC stated that the SER just discusses the configuration classes and not specific configurations. The NRC stated that it needed examples of parameter values within specific configurations. DOE stated that it has issued a number of calculations which discuss the range of parameters which could be considered as examples in this area. The NRC stated that it would review these documents and provide DOE with any comments, if applicable.

The NRC and DOE also discussed tables listing the primary and secondary criticality FEPs. The NRC stated that it would review the tables and also the revised FEPs database when it becomes available.

The NRC raised a question regarding fuel misloads. DOE stated that fuel misloads are covered as a change in waste package inventory and not as a FEP or configuration class. DOE stated it considers all possible loadings of a particular waste form and that it is treated as a preclosure issue (verification of waste package loading).

Ms. Treichel (Nevada Nuclear Waste Task Force) asked whether it was safe to use the proposed 10 CFR Part 63 criteria (rather than Part 60). The NRC stated that the Commission has adopted a risk-informed, performance based approach for licensing and that this was more consistent with proposed Part 63 criteria. Therefore, the proposed Part 63 was more appropriate for discussions focused toward a potential license application. Mr. Frishman (State of Nevada) questioned how future changes to the proposed Part 63 would affect the agreements made at these KTI technical exchanges and the NRC's sufficiency review. The NRC stated that a change back to Part 60 would potentially change the agreements already made and sufficiency review comments.

Regarding AC #4, DOE discussed the method for assigning probability values. DOE addressed the actions or information needs identified by the NRC and stated that this AC should be closed pending confirmation by NRC review of cited examples. NRC questioned how the Monte Carlo calculations are implemented. DOE discussed the methodology and stated that the example calculations indicate the Monte Carlo technique can be applied with a moderately large number of simultaneous lookup and interpolation parameters without experiencing an unacceptably large running time. The NRC stated that it would review the calculations and provide DOE with any comments, if applicable.

Regarding AC #5, DOE discussed the computer models for calculating k_{eff}. DOE addressed the actions or information needs identified by the NRC (Open Items 4 through 19 of the NRC SER) and stated that the revision to the Topical Report addresses all of the SER open items related to this AC. DOE further stated that the details would be provided in specific validation reports. DOE stated that Open Items 4, 12, and 21 relating to pinhole effects would be discussed under AC #6.

In the discussions related to Open Item #5, DOE discussed criticality margin for regression analyses. DOE questioned the use of subcritical margin. DOE stated that using subcritical margin is inconsistent with proposed 10 CFR Part 63 and a risk-informed approach. DOE stated that ANSI/ANS 8.17 is intended for deterministic uses, not risk-informed approaches. DOE stated that it has accounted for all uncertainties and biases and, therefore, does not need to use an arbitrary margin.

In the discussions related to Open Item #7, DOE stated that the isotopic depletion model will account for multi-dimensional neutron spectral effects through comparisons to multi-dimensional codes. DOE further stated that the Isotopic Model Validation Reports will address the adequacy of the modeling used. In the discussions related to Open Item #8, DOE stated that it would demonstrate that the cross-section data at temperature used is conservative. In the discussions related to Open Item #10, DOE stated that no reactivity credit will be taken for neutron absorber in solution. In the discussions related to Open Item #13, DOE stated that it is following ANSI/ANS 8.17 guidelines for establishing biases and uncertainties. In the discussions related to Open Item #14, DOE stated that, if a single predictor is adequate to define a trend conservatively, it will not use multi-parameters.

The NRC and DOE then discussed the range of data needed. DOE stated that it was reviewing additional data from Three Mile Island and Quad Cities reactors. This additional data will extend the enrichment database and provide a valid basis for evaluation. DOE further stated that for DOE spent nuclear fuel, fresh-fuel assumptions would be used.

In the discussions related to Open Item #17, DOE stated that it will be using the procedures defined in ANSI/ANS 8.1 for extending trends. DOE concluded for AC #5 that all the issues relative to the SER open items have been addressed in the revision to the Topical Report and the validation report plans are presented therein.

Regarding AC #6, DOE discussed the computer models for criticality consequences. DOE addressed the actions or information needs identified by the NRC (Open Items 20 through 27 of the NRC SER) and stated that the revision to the Topical Report addresses all of the SER open items related to this AC.

In the discussions related to Open Item #20, DOE stated that the revision to the Topical Report will address other moderators (other than water), in particular silica. In the discussions related to Open Item #21, DOE stated that the revision to the Topical Report shows a comprehensive approach to evaluating the probability of neutron absorber loss through cladding defects. The NRC and DOE discussed the likelihood for pinholes to affect consequences since pinholes occur in a very small percentage of commercial spent nuclear fuel cladding. Mr. Frishman (State of Nevada) stated that older fuel may have a much higher percentage of pinholes and questioned its effect on the consequences if DOE does not blend the fuel. DOE stated that it would account for the probability of such an occurrence. NRC noted that discussions under this open item must be consistent with CLST Subissue #3.

In the discussions related to Open Item #22, DOE stated that it believed that the revision to the Topical Report shows a comprehensive approach to evaluating the enhanced corrosion rate of the waste package barriers from the prolonged elevated temperature resulting from a steady-

state criticality. The NRC raised a question regarding how the increase in the radiation fields due to the criticality event affects the consequence evaluation because of the possibility of increased radiolysis inside the waste package and at the surfaces of nearby waste packages. DOE stated that they will conduct the appropriate calculations and include such coupled processes.

In the discussions related to Open Item #23, DOE stated that the modeling for external steady-state criticality consequences is sufficiently similar to those for internal steady-state criticality that it should be accepted on the same basis. DOE further stated that as an additional validation of the external model, that it would check for consistency with the most authoritative analyses of the Oklo natural reactor. DOE stated that it is currently identifying external configurations and that it will soon do new calculations using Topical Report approach, applied to high-enriched DOE spent nuclear fuel.

In the discussions related to Open Item #25, DOE stated that spent nuclear fuel inside the waste package is sufficiently similar to in-reactor configurations that RELAP5/MOD3.2 code is applicable. In the discussions related to Open Item #27, DOE stated that the revision to the Topical Report adequately describes the validation approach for the transient criticality consequence model. In particular, eight candidate comparison experiments have been identified and evaluated as having parameters similar to those that could occur in the repository. DOE concluded for AC #6 that all the issues relative to the SER open items will be addressed in the revision to the Topical Report and the model validation reports.

Regarding AC #7, DOE discussed the risk contribution from the in-package criticality to the total repository system performance. DOE addressed the actions or information needs identified by the NRC and stated that the process for evaluating criticality results is addressed in the revision to the Topical Report. DOE stated that in-package criticality has been screened out of the TSPA-SR on the basis of low probability during the regulatory period. NRC asked whether criticality was considered in the human intrusion analysis required in both the proposed NRC and Environmental Protection Agency (EPA) rules. DOE stated that criticality was not included in the human intrusion analysis because unlikely disruptive events are not required in the human intrusion analysis in the proposed EPA standard. DOE stated that all probability/consequence pairs will be evaluated for inclusion in at least one TSPA sensitivity analysis. DOE stated that the TSPA-SR document does not include a post 10,000 year criticality, but these would be considered in a post 10,000 year TSPA, called sensitivity analysis. NRC questioned the scope and screening processes for these sensitivity analyses. DOE stated that the scope of these sensitivity analyses had not been determined to date. DOE also discussed a "what-if" analysis to evaluate the impact of criticality assuming an early waste package failure. The scope and assumptions used for this "what-if" analyses were discussed and DOE stated that the assumptions used would be consistent with other early-failure sensitivity studies.

NRC stated that DOE had provided it with a large amount of documents and calculations which the NRC has not had a chance to review. Therefore, based on these additional reviews, the agreements listed in Attachment 1 may not be a complete list. However, based on the information provided during this technical exchange, NRC and DOE reached seven

agreements (see Attachment 1). With these agreements, the NRC stated that Subissue #5 could be listed as "closed-pending."

4) Technical Discussion - RT Subissue #4, "Nuclear Criticality in the Far Field" and ENFE Subissue #5, "Effects of Coupled Thermal-Hydrologic-Chemical Processes on Potential Nuclear Criticality in the Near Field

A summary of the current status of resolution was presented (see "Evolution of the Near Field Environment Subissue 5 and Radionuclide Transport Subissue 4" presentation given by Daniel Thomas). DOE provided a general overview of the near and far field issues. DOE stated that much of the discussion on external criticality took place under the CLST subissue and that DOE would address the five issues pertaining to external criticality in Revision 1 to the Topical Report. NRC questioned where the actual analysis and data for external criticality would be documented. DOE stated that it would be documented in a similar fashion as in-package criticality. DOE stated that the validation reports would contain some of the information and that there are two documents that have previously been issued that would provide an example of the type of data and analysis that would be provided in a license application.

NRC stated that DOE had provided it with a large amount of documents and calculations which the NRC has not had a chance to review. Therefore, based on these additional reviews, the agreements listed in Attachment 1 may not be a complete list. However, based on the information provided during this technical exchange, NRC and DOE reached 3 agreements (see Attachment 1) for both the ENFE and RT subissues. With these agreements, the NRC stated that both RT Subissue #4 and ENFE Subissue #5 could be listed as "closed-pending."

7) Public Comments

Mr. Frishman (State of Nevada) stated that if the NRC is considering "closed-pending" based on the revision of the Topical Report it was entering "new territory." He further stated that this would be the first time the NRC based "closed-pending" on it taking actions rather than DOE taking actions. The NRC noted his comments and stated that it too was discussing whether the information DOE discussed was adequate to list CLST Subissue #5 as "closed-pending."

Mr. Bullen (Nuclear Waste Technical Review Board) requested that (1) DOE discuss moderator exclusion, and (2) NRC discuss what kind of data does the NRC need to take credit for cladding. Regarding (1), DOE stated that it has looked at the issue and addressed it in several design process documents (which are available on the internet). Although moderator exclusion did show some advantages with respect to criticality, several system level issues, including high heat generation and cladding damage, precluded it from further consideration. Regarding (2), the NRC stated that it was looking at this issue under CLST Subissue #3.

Kevin Stablein for 10/24/00

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10/24/2000

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Summary of the Resolution of the Key Technical Issue on Subissues Related to Criticality

Subissue #	Subissue Title	Status	NRC/DOE Agreements
CLST Subissue 5	Effect of In-Package Criticality on Waste Package and Engineered Barrier System Performance	Closed-Pending	1) Provide Revision 1 to the Topical Report. DOE stated that it will provide the Disposal Criticality Analysis Methodology Topical Report, Revision 01, to NRC during January 2001. 2) Provide the Disruptive Events FEPs AMR, the FEPs database, and the Analyses to Support Screening of System-Level Features, Events, and Processes for the Yucca Mountain Total System Performance Assessment-Site Recommendation. DOE stated that it will provide the FEPs AMRs, the Analyses to Support Screening of System-Level Features, Events, and Processes for the Yucca Mountain Total System Performance Assessment-Site Recommendation AMR, and the FEPs database to NRC during January 2001. 3) Provide the "Probability of Criticality Before 10,000 years" calculation. DOE stated that it will provide the calculation to NRC by November 1, 2000.

CLST Subissue 5	Effect of In-Package Criticality on Waste Package and Engineered Barrier System Performance (Cont.)		4) Provide the list of validation reports and their schedules. DOE stated that the geochemical model validation reports for "Geochemistry Model Validation Report: Degradation and Release" and "Geochemistry Model Validation Report: Material Accumulation" are expected to be available during 2001. The remainder of the reports are expected to be available during FY2002 subject to the results of detailed planning and scheduling. DOE understands that these reports are required to be provided prior to LA. A list of model validation reports was provided during the technical exchange and is included as an attachment to the meeting summary. 5) Provide information on how the increase in the radiation fields due to the criticality event affects the consequence evaluation because of increased radiolysis inside the waste package and at the surfaces of nearby waste packages or demonstrate that the current corrosion and dissolution models encompass the range of chemical conditions and corrosion potentials that would result from this increase in radiolysis. DOE stated that the preliminary assessment (calculation) of radiolysis effects from a criticality event will be available to NRC during February 2001. The final assessment of these conditions will be available to NRC prior to LA. 6) Provide a "what-if" analysis to evaluate the impact of an early criticality assuming a waste package failure. DOE stated that it would provide the requested analyses prior to LA. Actual schedule to be provided pending DOE planning process.

CLST Subissue 5	Effect of In-Package Criticality on Waste Package and Engineered Barrier System Performance (Cont.)		7) Provide sensitivity analyses that will include the most significant probability/consequence criticality scenarios. DOE stated that it would provide the requested analyses prior to LA. Actual schedule to be provided pending DOE planning process.
RT Subissue 4	Nuclear Criticality in the Far Field	Closed-Pending	1) Provide Revision 1 to the Topical Report. DOE will provide the Disposal Criticality Analysis Methodology Topical Report, Revision 01, to NRC during January 2001. 2) Provide the updated FEPs database. DOE stated that it would provide the FEPs AMRs and the FEPs database to NRC during January 2001. 3) Provide the applicable list of validation reports and their schedules for external criticality. DOE stated that the geochemical model validation reports for "Geochemistry Model Validation Report: Degradation and Release" and "Geochemistry Model Validation Report: Material Accumulation" are expected to be available during 2001. The remainder of the reports are expected to be available during FY2002 subject to the results of detailed planning and scheduling. DOE understands that these reports are required to be provided prior to LA. A list of model validation reports was provided during the technical exchange and is included as an attachment to the meeting summary.

ENFE Subissue 5	Effects of Coupled Thermal-Hydrologic-Chemical Processes on Potential Nuclear Criticality in the Near Field	Closed-Pending	1) Provide Revision 1 to the Topical Report. DOE will provide the Disposal Criticality Analysis Methodology Topical Report, Revision 01, to NRC during January 2001. 2) Provide the updated FEPs database. DOE stated that it would provide the FEPs AMRs and the FEPs database to NRC during January 2001. 3) Provide the applicable list of validation reports and their schedules for external criticality. DOE stated that the geochemical model validation reports for "Geochemistry Model Validation Report: Degradation and Release" and "Geochemistry Model Validation Report: Material Accumulation" are expected to be available during 2001. The remainder of the reports are expected to be available during FY2002 subject to the results of detailed planning and scheduling. DOE understands that these reports are required to be provided prior to LA. A list of model validation reports was provided during the technical exchange and is included as an attachment to the meeting summary.

Summary Highlights of NRC/DOE Technical Exchange and Management Meeting on Structural Deformation and Seismicity

October 11-12, 2000
Las Vegas, Nevada

Introduction and Objectives

This Technical Exchange and Management Meeting on Structural Deformation and Seismicity (SDS) is one in a series of meetings related to the U.S. Nuclear Regulatory Commission (NRC) key technical issue (KTI) and sufficiency review and the U.S. Department of Energy (DOE) site recommendation decision. Consistent with NRC regulations on prelicensing consultations and a 1992 agreement with DOE, staff-level resolution can be achieved during prelicensing consultation. The purpose of issue resolution is to assure that sufficient information is available on an issue to enable the NRC to docket a proposed license application. 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. Issue resolution at the staff level, during prelicensing, is achieved when the staff has no further questions or comments at a point in time regarding how the DOE is addressing an issue. Pertinent additional information could raise new questions or comments regarding a previously resolved issue.

Issues 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. Issues are "closed-pending" if the NRC staff has confidence that the DOE proposed approach, together with the DOE agreement to provide the NRC with additional information (through specified testing, analysis, etc.) acceptably addresses the NRC's questions such that no information beyond that provided, or agreed to, will likely be required at time of initial license application. Issues 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.

The objective of this meeting is to discuss and review the progress on resolving the SDS KTI (see Attachment 1 for list of subissues). The quality assurance (QA) aspect of this KTI was determined to be outside the scope of the meeting and is being tracked in NRC's ongoing review of DOE's QA program.

Summary of Meeting

At the close of the Technical Exchange and Management Meeting, the NRC staff stated that Subissues 1 through 3 were closed-pending and Subissue 4 was closed. Specific NRC/DOE agreements made at the meeting are provided as Attachment 1. The agenda and the attendance list are provided as Attachments 2 and 3, respectively. Copies of the presenters' slides are provided as Attachment 4. Highlights from the Technical Exchange and Management Meeting are listed below.

Highlights

1) Opening Comments

DOE stated that the intent of the meeting is to reach agreement on the current status and path forward for each of the SDS subissues (see "Overview - Structural Deformation and Seismicity: Key Technical Issue" presentation given by Tim Sullivan). During the April 25-26, 2000, KTI Technical Exchange, the NRC listed Subissues 1 and 2 as "closed-pending" and Subissues 3 and 4 as "open." During this meeting, DOE stated that its presentation would focus on confirmatory and additional information, data, and analyses identified by the NRC during the April 2000 Technical Exchange and subsequent discussions. DOE stated that it felt that the details provided during the meeting would be the basis for NRC to list Subissues 1, 2, and 4 as closed-pending and Subissue 3 as "closed."

2) Discussion of SDS Subissue in the Total System Performance Assessment - Site Recommendation (TSPA-SR)

DOE presented an overview of the TSPA-SR process (see "Structural Deformation and Seismicity Subissues in the Total System Performance Assessment - Site Recommendation" presentation given by Peter Swift). DOE stated that the TSPA-SR process begins with the identification of features, events, and processes (FEPs). Each of the FEPs is then evaluated outside of TSPA by the appropriate subject matter experts. The evaluation of the individual FEPs are documented in the analysis and model reports (AMRs) and those that are not screened out are included in the TSPA-SR models. DOE stated that it is currently strengthening and clarifying the technical bases for excluding FEPs and will update all the FEPs AMRs by January 2001.

DOE then discussed the FEPs related to the SDS subissues. DOE stated that the TSPA-SR would not contain a separate scenario for new faulting or new fault displacement on existing faults, but would consider the effects of existing faults on unsaturated zone and saturated zone flow for the nominal (base case) scenario. DOE stated, with regard to seismicity, that the evaluation of cladding failure (commercial spent nuclear fuel cladding fragility only), due to seismic ground motion, is included in the nominal scenario. DOE stated that it is not taking performance credit for DOE spent nuclear fuel cladding. DOE stated that the only explicit effect of seismicity included in the TSPA-SR model is the potential failure of spent nuclear fuel cladding. A justification was given by DOE for the method utilized to abstract cladding failure. While it was acknowledged by DOE that the abstraction could be done similar to the representation of igneous effects on the repository, DOE presented performance assessment results to suggest that performance of the repository is not very sensitive to cladding performance. NRC expressed concerns that the calculated insensitivity of repository performance to cladding may change as other parts of the system model change. DOE responded that they have process controls in place to evaluate the impact of changes to the system model or supporting data.

DOE stated, with regard to the fracture framework, that the effects of existing fractures on unsaturated zone and saturated zone flow models are included in the nominal scenario. DOE stated that tectonic models were considered in the probabilistic volcanic hazards analysis

(PVHA) and probabilistic seismic hazards analysis (PSHA) by experts in the respective expert elicitations. DOE further stated that the tectonic framework enters the TSPA indirectly through the geologic model.

The NRC requested clarification regarding the technical basis for screening FEPs from further consideration on low probability versus insignificant consequence to dose. DOE stated that this issue would be clarified in the update to the Features, Events, and Processes: Disruptive Events (ANL-WIS-MD-000005), ICN1 AMR (FEPs AMR).

The NRC then discussed the scope of the four SDS subissues and the relationship to other key technical issues (KTIs). The NRC stated that questions involving the use of fracture data in specific process models is beyond the scope of this technical exchange and should be deferred to other KTI technical exchanges as appropriate.

3) Technical Discussions - Subissue #1, Faulting

A summary of the current status of resolution was presented (see "Subissue #1: Structural Deformation and Seismicity - Faulting" presentation given by Kathy Gaither). There are six acceptance criteria (excluding QA), all of which are considered to be either closed or closed-pending by the DOE. DOE then identified the NRC information needs from Revision 2 of the SDS Issue Resolution Status Report (IRSR), the April 2000 KTI technical exchange, and subsequent NRC/DOE discussions for each acceptance criteria. DOE then addressed these needs during discussions of each acceptance criterion.

To address faulting parameters for low probabilities derived from the PSHA, the DOE proposed using median rather than mean values. The rationale given was that the median better reflected the central tendencies of the faulting data in the 10^{-6} to 10^{-8} range. In this range, the mean values are skewed beyond the 85th percentile. Regarding the acceptance criteria, the NRC raised questions regarding the use of median fault displacement as the appropriate measure for screening. The NRC stated that using the mean statistic is more appropriate, and consistent with its proposed 10 CFR Part 63 regulations. DOE stated that it is using the mean hazard for the pre-closure period and would use the median for the post-closure period. DOE stated that the approach of using median is consistent with NRC practice, specifically described in Regulatory Guide 1.165, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion." As a result of further discussion, the NRC identified and discussed five possible approaches for DOE to consider to address its concerns: (1) use mean fault displacement for probability based screening; (2) use a consequence analysis as a screening tool; (3) use maximum fault displacement as a deterministic screening criterion; (4) reconvene the expert elicitation panel to reconsider uncertainty in fault displacement of low probabilities; or (5) supply additional technical justification for the use of the median. Following additional discussions, the NRC stated that in a risk-informed regulatory environment, DOE could choose to use any statistical measure, but the DOE must provide technical basis to support their approach.

The NRC raised questions regarding the rationale for faults/faulting that are included and excluded from consideration in performance assessments. DOE stated that the basis for inclusion or exclusion of fault displacement is established in the update to the FEPs AMR. The

NRC also had questions regarding the setback distance. DOE stated that the current setback distance of 60 meters from block-bounding faults is based on engineering judgment, and is measured from the trace of the fault. In addition, DOE stated that the setback was measured from the center of the fault and not from the surrounding deformed (shear) zone along the fault. (In a subsequent follow-up question, DOE noted that the setback distance is denoted as "to be verified" in the forthcoming subsurface facility system description document.)

Following additional discussions, the NRC asked for clarification on two issues: (1) when screening FEPs, is the screening process done event by event, or is the screening process done by classes of events; and (2) does DOE consider the time period beyond 10,000 years when screening FEPs? Although NRC's proposed 10 CFR Part 63 time period of regulatory interest does not extend beyond 10,000 years, the NRC did note that it would conduct its analyses beyond 10,000 years so as to better inform its reasonable assurance decision. DOE stated that it is attempting to develop consequence arguments to aid in the screening process and carry them through to total system performance. DOE stated that the screening process looks at FEPs one by one for 10,000 years. The TSPA nominal scenario is run for time periods beyond 10,000 years. DOE stated that it has no plan at this time to extend all the FEPs analyses past 10,000 years. Both NRC and DOE agreed that these two issues would be discussed again in the forthcoming TSPA KTI technical exchange. Following additional discussions, the NRC clarified that proposed 10 CFR Part 63 does not have a requirement for performance analyses for the period beyond 10,000 years.

As a result of the additional discussions, NRC and DOE reached two agreements (see Attachment 1). With these agreements, the NRC stated that Subissue #1 could be listed as closed-pending.

4) Technical Discussion - Subissue #4, Tectonic Framework

A summary of the current status of resolutions was presented (see "Subissue #4: Structural Deformation and Seismicity - Tectonic Framework" presentation given by Carl Stepp). There are six acceptance criteria (excluding QA), all of which are considered to be either closed or closed-pending by the DOE. DOE then identified the NRC information needs from Revision 2 of the SDS IRSR, the April 2000 KTI technical exchange, and subsequent NRC/DOE discussions for each acceptance criteria. DOE then addressed these needs during discussions of each acceptance criteria. The matter of "consistency of treatment of tectonic models in PSHA and PVHA" was discussed by DOE in the Igneous Activity (IA) technical exchange (see IA summary highlights dated August 31, 2000). DOE re-emphasized the technical basis for resolution by reiterating that the so-called "hinge line" is not a structural barrier that delineates the volcanic source zone; and volcanic source zones do not represent seismogenic sources as used in the PSHA.

As a result of these discussions, the NRC stated that DOE had provided the necessary information and needed clarifications. Therefore, the NRC stated that Subissue #4 is closed.

5) Technical Discussion - Subissue #2, Seismicity

A summary of the current status of resolutions was presented (see "Subissue #2: Structural Deformation and Seismicity - Seismicity" presentation given by Richard Quittmeyer). There are six acceptance criteria (excluding QA), all of which are considered to be either closed or closed-pending by the DOE. DOE then identified the NRC information needs from Revision 2 of the SDS IRSR, the April 2000 KTI technical exchange, and subsequent NRC/DOE discussions for each acceptance criteria. DOE then addressed these needs during discussions of each acceptance criteria.

DOE stated that all of the additional information needed by the NRC will be included in the update to the FEPs AMR, the seismic design input report, and the seismic topical report 3. The NRC had questions regarding the seismic design input report, the DOE stated that the seismic design input report would be part of the basis for data inputs to the seismic topical report 3.

The NRC raised additional questions related to the use of the median versus the mean for probabilistic ground motions at low probabilities. DOE offered the same argument as in the faulting subissue, that the median more accurately reflects the central tendency of the probability distribution (see discussion in the faulting subissue).

The NRC had questions regarding the approach applied to evaluate seismic risk, including the assessment of seismic fragility and evaluation of event sequences. The NRC commented that no documentation has been provided that describes the approach to be used to evaluate the seismic fragility of components and a systems analysis that identifies the set of event sequences (including multiple hazards) that can occur. It was requested that DOE provide information in this area that describes their seismic probabilistic risk assessment methodology, its application to screening issues, and other topics.

Regarding ground motion, the NRC had questions about the PSHA expert elicitation process, specifically the issue of feedback to the subject matter experts following the elicitation of their respective judgements. DOE stated that they would provide the information requested.

The NRC also questioned the multiple definitions of the term "event." DOE stated that in the update to the FEPs AMR, the term "events" would be defined, and used in a manner that is consistent with other documents.

Following additional discussions, the NRC asked for clarification regarding the six metric ton rock fall design basis event. DOE stated that the design basis for exclusion of rockfall in the drip shield design is that this is the bounding rock size for impact loads on the engineered barrier system (EBS). DOE noted that their design criteria were such that the EBS would be constructed to withstand rockfall from the largest impact loads possible from blocks falling on the emplacement drifts. Therefore, consideration of rockfall is excluded from the post-closure performance assessment.

As a result of the additional discussions, NRC and DOE reached four agreements (see Attachment 1). With these agreements, the NRC stated that Subissue #2 could be listed as closed-pending.

6) Technical Discussion - Subissue #3, Fracturing

A summary of the current status of resolutions was presented (see "Subissue #3: Structural Deformation and Seismicity - Fracturing and Structural Framework" presentation given by Steve Beason, Jennifer Hinds, and Dwayne Kicker). There are six acceptance criteria (excluding QA), all of which are considered to be closed by the DOE. DOE then identified the NRC information needs from Revision 2 of the SDS IRSR, the April 2000 KTI technical exchange, and subsequent NRC/DOE discussions for each acceptance criterion. DOE then addressed these needs during discussions of each acceptance criteria.

NRC staff were concerned that some of DOE's justifications of fracture-related issue closures were based on assertions of conservatism. The bases for these assertions are beyond the scope of this technical exchange and will be addressed under Unsaturated and Saturated Flow Under Isothermal Conditions (USFIC), Repository Design and Thermal-Mechanical Effects (RDTME), Thermal Effects of Flow (TEF), Radionuclide Transport (RT), and Evolution of the Near-Field Environment (ENFE) KTI's as appropriate.

NRC agreed with DOE that fracture aperture data are not critical to rockfall analysis. NRC pointed out the apparent disparity between the apertures of measured fractures ($\geq$ 0.2 mm) and the fractures considered important to flow modeling <0.2 mm (200 microns). DOE responded by asserting that there are no field methods to measure apertures <0.2mm. Also, the unsaturated zone models are mostly based on air permeability and moisture content data and do not depend on fracture geometry data.

NRC suggested that hydraulic apertures determined from air permeability tests would be controlled by constrictions of the flow path. Consequently average aperture over the flow pathway may be underestimated. Using the active fracture model assumptions in which mobile water exists in connected, locally saturated aperture segments which could overestimate fracture/matrix interface area. DOE responded that aperture is not important in the active fracture model.

NRC expressed concern that fracture porosity (and aperture) measurements through pneumatic and gas tracer testing inherently measure dry, well-connected, and largest-aperture fractures. Small-aperture and water-filled fractures, which are those that are expected to transport water in the unsaturated zone under ambient conditions and considered to be important to unsaturated zone flow modeling, may not be captured by air permeability testing. DOE responded that the pneumatic tests are sensitive to fracture networks at varying scales, including small aperture fractures.

NRC expressed concern that there is an apparent inconsistency between assumption of 100% fracture connectivity and observations of localization of Cl-36 anomalies at repository depths. The DOE indicated that 100% fracture connectivity was realistic and did not contradict Cl-36 anomalies. The 100% connectivity refers to the extensive interconnected network of smaller-

scale fractures that pervade the welded tuffs. Large-scale pneumatic tests clearly show the interconnectivity of these units. DOE noted that the Cl-36 data show that fast paths may exist through the nonwelded Paintbrush Tuff via major faults as the elevated Cl-36 is associated with these major faults.

NRC expressed concern that fracture connectivity has not been investigated systematically. In response, DOE described two stratigraphic boundaries in the Topopah Spring Tuff where abrupt and consistent terminations of fractures occur. In further response to NRC questions, the DOE said that fracture data for Calico Hills Formation comes from three wells, and one air permeability test (UZ-16). Wells SD-12 and UZ-16 penetrated the entire Calico Hills Formation and NRG7 penetrated only the upper Calico Hills Formation. DOE confirmed that data from Calico Hills Formation (and lower units) is limited and stated that they have used conservative assumptions in the unsaturated zone flow model to account for the sparse data.

NRC questioned the technical basis for the active fracture model. For example, are the mineralized (calcite, opal) fractures those that carry the water, or are the mineralized fractures those where flow rate is low and significant evaporation occurs? The role of mineralized fractures with respect to unsaturated zone flow has been addressed for USFIC by DOE's agreement to perform the Alcove 8-Niche 3 test. DOE recently provided plans for this test and the NRC staff has provided review comments. This topic will be further addressed by RT as needed.

NRC commented that the assumption of lateral flow in the Calico Hills seems inconsistent with the assumption of no lateral flow in the Paintbrush Tuff-nonwelded unit. Furthermore, Cl-36 which is focused in zones up to 200 m wide (perpendicular to faults) in ESF is indicative of lateral diversion beneath PTn. This may be particularly important for the question of infiltration along the west flank of Yucca Mountain, and lateral flow towards the proposed repository emplacement area. DOE stated that they have no data to evaluate recharge from Solitario Canyon, but acknowledged that they had not yet investigated this in the flow model, and while not in FY2001 budget, it may be studied in the future. The NRC staff noted this issue will be addressed by the long-term passive test in the cross drift if the test tunnel is allowed to return to ambient conditions. The western-most part of the isolated cross drift should show whether percolation is enhanced by lateral flow from recharge along the western slope of Yucca Mountain.

In response to a query from the NRC, DOE noted that the unsaturated zone flow model for TSPA-VA did not include the hydrology of the Abandoned Wash fault. DOE indicated that the Unsaturated Zone Flow Model, Revision 1, does evaluate the Abandoned Wash fault.

The DOE indicated that the fracture hydraulic properties (e.g., alpha parameter) active fracture model parameter was not sensitive to small changes in fracture frequency that would be derived from sampling bias correction (e.g., a 10% increase in the number of fractures).

NRC agreed that fracture origin is not directly linked to performance.

NRC suggested, in the absence of direct measurements of fracture characteristics, DOE should provide a technical basis for fracture-related parameters used in process models. This

topic will be further pursued in the USFIC, RDTME, TEF, ENFE, and RT KTI's. USFIC has emphasized the need for DOE to complete the Alcove 8 - Niche 3 test and the long-term passive test in the cross drift. These tests should be used to calibrate unsaturated zone models of seepage.

NRC staff commented that they are concerned that length bias for largest fractures from tunnel data has not been corrected by the analysis of the full periphery geometric mapping data. This concern will be addressed by review of the Fracture Geometry in Key Stratigraphic Units in the Repository Host Horizon (ANL-EBS-GE-000006) AMR.

NRC staff raised the concern that isotropic permeability is still being used in one of two models for modeling flow and radionuclide transport in the saturated zone. The anisotropic model has an established technical basis and is supported by C-well data. DOE pointed out that the NRC analysis of C-well data is poorly constrained and could be interpreted to cover a wide range of anisotropy. DOE's approach is to use alternate conceptual models that are treated as being equally probable - one with laterally anisotropic permeability and the other treated as anisotropic. This issue is to be pursued further in the Saturated Zone technical exchange of the USFIC KTI.

NRC staff's concerns regarding seismic and thermal effects on rockfall will be pursued under the RDTME KTI.

The NRC noted that the DOE assumptions that fracture diameters are 4X the trace length of all fractures measured in detailed line surveys (DLS) including those abutting other fractures may result in underestimation of block size. DOE reiterated that this approach is conservative. This issue will be addressed in the RDTME technical exchange.

NRC questioned modeling of a 1-m thick excavation induced disturbed zone with increased permeability around drifts which is discussed in the Seepage Calibration Model and Seepage Testing Data (MDL-NBS-HS-00004) AMR. DOE said that the model was based on measurements of air permeability enhancement, which it assumes to be the effect of unloading-induced dilation of existing fractures, rather than the formation of new fractures. DOE addressed this by agreeing to provide a writeup about excavation-induced fractures.

The NRC stated that in pre-technical exchange conference calls, a consolidated report on fractures was discussed. Although it is not a necessity, the NRC stated that it would enhance the review of numerous process models for consistency with site conditions and transparency of the review.

As a result of additional discussions, NRC and DOE reached four agreements (see Attachment 1). With these agreements, the NRC stated that Subissue #3 could be listed as closed-pending.

7) Public Comments

Ms. Treichel (Nevada Nuclear Water Task Force) had questions/comments regarding (1) the inconsistency in informaton presented at previous KTI meetings associated with rockfall; (2)

the use of proposed 10 CFR Part 63; and (3) whether rockfall will be addressed in pre-closure discussions. Specifically, Ms. Treichel (1) stated that a 13 ton rock was discussed in the Container Life and Source Term technical exchange and a 6 ton rock was discussed in the SDS discussions; (2) stated that references to 10 CFR Part 63 should not be made during these meetings since Part 63 has not been approved, instead reference should be made to Part 60; (3) questioned whether rockfall is just a post-closure issue or if it will be addressed in pre-closure discussions.

Regarding (1), DOE noted that there had been an evolution in decision-making regarding the design-basis rockfall to be considered in repository design. The original 13-ton design basis was based on older DOE design documents. Subsequent drift degradation analysis yielded smaller block-size distributions on the order of 6 tons - the current design basis as a result of drift reorientation. The NRC noted that it had additional questions regarding the rockfall issue, but that the questions would be raised in the Repository Design and Thermal-Mechanical Effects technical exchange. Regarding (2), this comment was noted without response. Regarding (3), the NRC stated that rockfall will be addressed in pre-closure discussions, specifically within the RDTME KTI technical exchange. DOE stated that ground supports should ensure safety during the pre-closure period.

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Summary of the Resolution of the Key Technical Issue on Structural Deformation and Seismicity

Subissue #	Subissue Title	Status	NRC/DOE Agreements
1	Faulting	Closed-Pending	1) Provide the updated FEPs: Disruptive Events AMR. DOE will provide the updated FEPs AMR to the NRC. Expected availability is January 2001. 2) Consistent with proposed 10 CFR Part 63, the NRC believes the use of the mean is appropriate, however, DOE may use any statistic as long as it is consistent with site data and technically defensible. DOE will either provide technical justification for use of median values or another statistical measure, such as the mean, or will evaluate and implement an alternative approach. The DOE-proposed approach and its basis will be provided to NRC prior to September 2001. The approach will be implemented prior to any potential LA.
2	Seismicity	Closed-Pending	1) Regarding ground motion, provide documentation, or point the NRC to the documentation on the expert elicitation process, regarding the feedback to the subject matter experts following the elicitation of their respective judgements. DOE will provide documentation demonstrating the adequacy of the elicitation feedback process by December 2000.

2	Seismicity (Cont.)		2) Provide the updated FEPs: Disruptive Events AMR, the Seismic Design Input Report, and the update to the Seismic Topical Report. DOE will provide the updated FEPs AMR to NRC. Expected availability is January 2001. DOE will provide STR 3 to the NRC for their review. Expected availability is January 2002. The Seismic Design Inputs Report is expected to be available to the NRC by September 2001. 3) Consistent with proposed 10 CFR Part 63, the NRC believes the use of the mean is appropriate, however, DOE may use any statistic as long as it is consistent with site data and technically defensible. DOE will either provide technical justification for use of median values or another statistical measure, such as the mean, or will evaluate and implement an alternative approach. The DOE-proposed approach and its basis will be provided to NRC prior to September 2001. The approach will be implemented prior to any potential LA. 4) The approach to evaluate seismic risk, including the assessment of seismic fragility and evaluation of event sequences is not clear to the NRC, provide additional information. DOE believes the approach contained in the FEPs AMR will be sufficient to support the Site Recommendation. The updated FEPs AMR is expected to be available in January 2001.

3	Fracturing	Closed-Pending	1) The ECRB long-term test and the Alcove 8 Niche 3 test need to be "fractured-informed" (i.e., observation of seepage needs to be related to observed fracture patterns). Provide documentation which discusses this aspect. DOE responded that for the passive test, any observed seepage will be related to full periphery maps and other fracture data in testing documentation. The documentation will be available by any potential LA. For Niche 3, fracture characterization is complete and a 3-D representation will be included in testing documentation. The documentation will be available August 2001. 2) The NRC needs DOE to document the pre-test predictions for the Alcove 8 Niche 3 work. DOE responded that pre-test predictions for Alcove 8 Niche 3 work will be provided to NRC via letter report (Brocoum to Greeves) by mid-January 2001. 3) The NRC needs to review the Fracture Geometry Analysis for the Stratigraphic Units of the Repository Host Horizon AMR. The NRC will provide feedback and proposed agreements to DOE, if needed, by December 2000. 4) The NRC needs DOE to document the discussion of excavation-induced fractures. DOE responded that observations of excavation-induced fractures will be documented in a report or AMR revision by June 2001.
4	Tectonic Framework	Closed	None

Summary Highlights of NRC/DOE Technical Exchange and Management Meeting on Container Life and Source Term

September 12-13, 2000
Las Vegas, Nevada

Introduction and Objectives

This Technical Exchange and Management Meeting on Container Life and Source Term (CLST) is one in a series of meetings related to the U.S. Nuclear Regulatory Commission (NRC) key technical issue (KTI) and sufficiency review and the U.S. Department of Energy (DOE) site recommendation decision. Consistent with NRC regulations on prelicensing consultations and a 1992 agreement with DOE, staff-level resolution can be achieved during prelicensing consultation. The purpose of issue resolution is to assure that sufficient information is available on an issue to enable the NRC to docket the license application. 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. Issue resolution at the staff level during prelicensing is achieved when the staff has no further questions or comments at a point in time regarding how the DOE is addressing an issue. Pertinent additional information could raise new questions or comments regarding a previously resolved issue.

Issues 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 initial license application. Issues are "closed-pending" if the NRC staff has confidence that the DOE proposed approach, together with the DOE agreement to provide the NRC with additional information (through specified testing, analysis, etc.) acceptably addresses the NRC's questions such that no information beyond that provided, or agreed to, will likely be required at time of initial license application. Issues 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 the license application.

The objective of this meeting is to discuss and review the progress on resolving the CLST KTI (see Attachment 1 for list of subissues). The quality assurance (QA) aspect of this KTI was determined to be outside the scope of the meeting and is being tracked in NRC's ongoing review of DOE's QA program.

Summary of Meeting

At the close of the Technical Exchange and Management Meeting, the NRC staff stated that Subissues 1 through 4 and 6 were closed-pending. Subissue 5, "The effects of in-package criticality on waste package and engineered barrier subsystem performance" was not addressed at this meeting and will be addressed in a future meeting. Specific NRC/DOE agreements made at the meeting are provided as Attachment 1. The agenda and the attendance list are provided as Attachments 2 and 3, respectively. Copies of the presenters'

slides are provided as Attachment 4. Highlights from the Technical Exchange and Management Meeting are listed below.

Highlights

1) Opening Comments

DOE stated that the intent of the meeting is to reach agreement on the current status and path forward for each of the CLST subissues (see "Container Life and Source Term (CLST)" presentation given by Paige Russell). During the April 25-26, 2000, KTI Technical Exchange, the NRC listed Subissues 1 and 5 as open and Subissues 2, 3, 4, and 6 as closed-pending. During this meeting, DOE stated that its presentation would focus on confirmatory and additional information, data, and analyses identified by the NRC during the April 2000 Technical Exchange. DOE stated that it felt that the details provided during the meeting would be the basis for NRC to list Subissues 1, 2, 3, 4, and 6 as closed-pending.

2) Technical Discussions - Subissue #3, Rate at Which Radionuclides in Spent Nuclear Fuel are Released from the Engineered Barrier Subsystem Through the Oxidation and Dissolution of Spent Fuel and Subissue #4, Rate at Which Radionuclides in High-Level Waste Glass are Released from the Engineered Barrier Subsystem.

A summary of the current status of resolution was presented (see "Subissue 3 and 4: The Rate at Which Radionuclides in Spent fuel or High Level Waste Glass are Released from the Engineered Barrier System" presentation given by Christine Stockman). There are nine acceptance criteria, all of which are considered closed-pending by the DOE. There is substantial overlap in the topics relevant to both Subissues on Spent Nuclear Fuel and Glass Degradation. As a result of the overlap, DOE first discussed two topics common to both subissues. DOE addressed Total System Performance Assessment (TSPA) models and results to provide a risk-informed framework for subsequent discussions (Slides 4 - 19). TSPA information was provided on preliminary overall dose calculations, preliminary waste package results, and influences on waste form model results due to radionuclide inventory, in-package chemistry, high-level waste degradation, cladding perforation and unzipping, and Neptunium (Np) solubility. A staff question on the conclusion that there are no initial failures of the waste package for the first 10,000 years was addressed by stating the basis is addressed in detail in the slides for Subissue 2. The relative importance of dose contributions from commercial spent nuclear fuel versus the co-disposal packages was presented. Information provided indicated that the dose from spent nuclear fuel was much higher than that from high-level waste glass. Staff had questions on the degraded cladding analysis and sensitivity to dripping conditions. For the first topic, DOE indicated that the basis for their analysis is documented in later slides on cladding. For the second question, the DOE indicated that the quantity of water during intermittent dripping conditions was higher than under the always drip conditions, and therefore was more detrimental to cladding performance.

The next topic discussed that is common to both Subissue 3 and 4 is the in-package chemistry (Slides 20 - 22). This chemistry would affect radionuclide release from both spent nuclear fuel and the high-level waste glass. The effects of radiolysis on in-package chemistry were reviewed and DOE indicated that in the revised Summary of In-Package Chemistry for Waste

Forms Analysis and Model Report (AMR) the discussion would be documented. Potentially mutually exclusive conditions were offered as a basis for neglecting the effects of radiolysis. The Center for Nuclear Waste Regulatory Analyses (CNWRA) staff had questions on the sufficiency of the technical basis for excluding radiolysis effects that will be provided in the revised AMR. Sensitivity of in-package pH to different parameters such as incoming fluid chemistry and drip rates was discussed. CNWRA staff questioned whether uncertainties associated with differing degradation rates for waste package components and different corrosion products had been considered. NRC staff questioned whether initial transient chemistry effects in the first water contacting the cladding was captured in the analysis. DOE indicated that the results for differing incoming water chemistry (Slide 22) and results from waste package breach due to localized corrosion would be documented in the revised AMR. NRC staff also questioned whether the time steps used in the in-package chemistry abstraction are sufficiently small to capture the expected behavior and processes such as evaporation that would be needed to be propagated in the case for initial failures. Three potential incoming water compositions have been used to assess effects on in-package pH (J-13, evaporated J-13, and post-thermal water). Questions on the assumption of high bicarbonate solutions by Mr. DiBella (NWTRB) were addressed by DOE. They indicated that reactions of waste glass, assuming fluids are in equilibrium with carbon dioxide in the gas phase at 4 times atmospheric concentrations, leads to high bicarbonate solutions. Several additional questions were posed by Mr. Morganstein (Nye County) on the impact of other engineered materials such as grouting and rock bolts on the incoming water chemistry. DOE stressed the importance of the waste package components dominating in-package chemistry. NRC staff inquired about any plans for confirmatory testing of the expected in-package chemistry. DOE responded that there is budget for limited work in that area.

Finally specific points pertinent to degradation of spent nuclear fuel cladding were addressed (Slides 23 -28). DOE's information to address concerns on hydride reorientation in cladding will be documented in two revised AMRs. Temperatures of less than about 200 °C were argued to be too low for significant hydride reorientation. NRC staff questioned whether the temperatures presented were mean temperatures and what was the distribution of temperatures for the cladding. Staff also questioned what was the distribution of stresses for the cladding. DOE indicated that hydride reorientation would be excluded in the feature, events, and processes (FEPs) analysis. NRC staff wanted to know whether the FEP will be screened out based on probability or consequence. The determination from the AMR was that the FEP was screened out based on probability. Stress corrosion cracking (SCC) was presented next by DOE and they indicated their approach will be documented in a revised AMR. A failure criterion of 180 MPa is currently used. CNWRA staff questioned whether the failure criterion is appropriate and relevant for the in-package chemical environment, in particular that associated with external surface of the cladding. DOE's approach for localized corrosion was presented next and is documented in three AMRs. DOE has concluded that for model predictions of in-package chemistry localized corrosion is not expected. CNWRA staff questioned how localized failure can be related to bulk in-package chemistry. NRC staff indicated a need for confirmatory testing for the model predicted environment to affirm that localized corrosion does not occur. DOE presented their approach for abstracting failure rates due to localized corrosion. Questions by CNWRA focused on the relationship between assumed failure rates and in-package chemistry and processes such as localized corrosion. Finally DOE indicated that they are evaluating failure modes for cladding including reactor

operation, dry storage, and seismic events. CNWRA staff inquired about where analysis of seismic effects on cladding is documented.

As a result of additional discussions, NRC and DOE reached 10 agreements (see Attachment 1) for Subissues 3 and 4. In addition there was a separate agreement specific to Subissue #4. With these agreements, the NRC stated that Subissue 3 could be listed as closed-pending. DOE then discussed several issues specific to Subissue #4.

There are nine acceptance criteria; all of which are considered closed pending by the DOE. See above discussion of subissue 3 for description of TSPA models and results, and in-package chemistry pertinent to this subissue. Specific issues associated with high-level waste glass degradation were also presented (Slides 29 - 30). DOE addressed the pH range over which glass degradation is assessed and indicated that NRC has some concerns on the model in the acid pH region. They indicated that the concern would be addressed in the revised AMR on glass degradation. NRC staff questioned whether an analysis of the consequences on radionuclide release from assuming silicon bounds the release, rather than boron, had been completed. DOE indicated that this concern would also be documented in the revised AMR.

As a result of additional discussions, NRC and DOE reached 1 agreement (see Attachment 1). With this agreement, and the agreements listed above, the NRC stated that subissue 4 could be listed as closed-pending.

3) Technical Discussion on Subissue #2, Effects of phase instability and initial defects on the mechanical failure and lifetime of the containers

A discussion of acceptance criterion for Subissue #2 was presented by the DOE (see "Subissue 2: Effects of Phase Instability of Materials and Initial Defects on the Mechanical Failure and Lifetime of the Containers" presentation given by Joon Lee and Scott Bennett). DOE stated that it would address the effects of aging and phase instability of Alloy 22, the effects of initial defects in closure welds, and the effects of rockfall and seismic-induced ground motion.

Mr. von Tiesenhausen (Clark County) raised an issue regarding radiation-induced phase segregation at elevated temperatures under neutron and gamma flux. DOE stated that the radiation field is low enough (only 1000 R/hour at emplacement) to exclude this possibility in the FEP analysis.

Aging tests for base and welded Alloy 22 are ongoing and the results will be fed to mechanical failure and SCC analysis. Theoretical modeling will be employed to enhance confidence in the results. DOE stated that it would provide the revised AMR, taking into account the items listed on slides 5 and 6, including documentation of path forward items.

To assess initial defects in closure welds, DOE reviewed literature, identified the types of defects and the subset of defect types relevant to the waste package, and determined probability of occurrence per waste package for each type of defect. Questions were raised whether assessments based on data from generic engineering practices for other materials are relevant to Alloy 22 fabrication and welding. For this validation, DOE is conducting mock-up

tests. Alloy 22 is considered as inspectable as other metals, as documented in the mock-up reports. Currently a maximum of 40 defects and average of 20 flaws are expected per container; no initial thru-wall failures are expected.

NRC staff raised the question about inspection technique to detect flaw size in the final waste package closure weld since DOE has based their flaw size distribution on techniques not directly applicable to the waste package. These techniques are liquid dye penetrant and radiographic inspections of stainless steel welds which are impossible to perform on a loaded waste package. DOE indicated the waste package closure weld will be inspected using the alternative technology of ultrasonic testing (UT) technique.

DOE is studying induction annealing and laser peening of outer and inner closure welds respectively. DOE plans to follow the fabrication processes at vendor shops and the quality of each heat is screened for acceptable corrosion response using cyclic polarization. DOE will provide information on effect of entire fabrication sequence on phase instability of Alloy 22 including, the effects of welding, multiple passes, thick sections, and the proposed induction annealing process. DOE will also provide documentation on fabrication processes and controls.

DOE stated that rockfall calculations include temperature dependent material properties; rock impact on closure weld; effect of seismic ground motion; and integrity of emplacement pallet. The design of the waste package and drip shield prelude contact between waste package and drip shield during rock impact. The boundary conditions include drip shield fixed at base and free standing to allow drip shield to move horizontally. In the analysis, the rock size is given because the design basis rockfall size is still an open question being discussed in the Repository Design Thermal-Mechanical Effect KTI. The technical basis for the criteria to be applied to assess mechanical failure was provided. The Tresca failure criterion was argued to be reasonable.

However, DOE needs to either provide technical justification for not using solid element formulations in the finite element analysis or provide documentation using solid element formulations for drip shield rock fall analysis; NRC wants documentation of the point loading of rock fall analysis; DOE needs to demonstrate that the Tresca failure criterion bounds a fracture mechanics approach to calculating mechanical failure; and DOE needs to demonstrate drip shield and waste package mechanical analysis addressing seismic excitation is consistent with the design basis earthquake covered by Structural Deformation and Seismicity (SDS) KTI.

In addition to the above subjects discussed, the path forward presented covers other NRC general concerns in phase stability/aging, initial defects, welding, and rockfall. These path forward plans need to be implemented.

As a result of additional discussions, NRC and DOE reached 9 agreements (see Attachment 1). With these agreements, the NRC stated that Subissue #2 could be listed as closed-pending.

4) Technical Discussion on Subissue #6, Effects of alternate engineered barrier subsystem design features on container lifetime and radionuclide release from the engineered barrier subsystem

A discussion of acceptance criterion for Subissue #6 was presented by the DOE (see "Subissue #6: Alternate EBS Design Features - Effect on Container Lifetime" presentation given by Gerald Gordon). DOE stated that it would specifically address the effects of design changes and titanium drip shield corrosion.

Regarding the current design, DOE stated that the current waste package and drip shield degradation models do not include the effects of backfill and that ceramic coatings are not part of the current design. DOE then stated that this subissue now focuses on drip shield performance. The failure modes of drip shields, such as corrosion, were then discussed. DOE stated that the detailed analysis of corrosion will be discussed in presentation for Subissue 1. DOE then presented the path forward activities which covered most of the NRC concerns. As a result of additional discussions, NRC and DOE reached 4 agreements (see Attachment 1). With these agreements and the path forward presented, the NRC stated that Subissue #6 could be listed as closed-pending.

5) Technical Discussion on Subissue #1, Effects of corrosion processes on the lifetime of the containers

A summary of the current status of resolution was presented (see attachment on "Subissue 1: The Effects of Corrosion Processes on the Lifetime of Containers" by Gerald Gordon). There are seven acceptance criteria; the subissue was considered closed-pending by the DOE. There were seven topics addressed by the DOE: environment around waste package and drip shield; microbial influenced corrosion (MIC) of Alloy 22 welds; general corrosion rates of alloy 22 and Ti-7 over long periods of time; long-term passive film stability of alloy 22 and Ti-7 ; localized corrosion of alloy 22 and Ti-7; stress corrosion cracking (SCC) testing of alloy 22 and Ti-7; and fabrication and welding of Alloy 22.

First, DOE addressed the environment around the waste package and drip shield (Slides 5 - 9). They indicated that solutions used for laboratory corrosion testing include bounding cases. DOE indicated that they will establish credible range for brine chemistry; evaluate the effect of introduced materials on water chemistry; determine likely concentrations and chemical form of minor constituents; types of brine which would evolve; and evaluate periodic water drip evaporation. CNWRA staff indicated that the adequacy of the treatment of environments on drip shield and waste package will also be addressed in the technical exchange and management meeting on the Evolution of the Near-Field Environment (ENFE). The importance of refluxing water was stressed by Mr. Shettel (Nye County). DOE responded that data from thermal tests would be considered and some tests would be conducted using crushed tuff.

Second, DOE addressed MIC of Alloy 22 welds (Slides 10 - 12). DOE indicated microbial activity can alter the chemical environment and enhance corrosion attack. The effects of MIC are accounted for in the general corrosion model by including an enhancement factor of 2.0 for the rate of corrosion. This enhancement factor was determined from linear polarization

measurements using both inoculated and sterile conditions. CNWRA staff questioned the resolution and appropriateness of the technique and whether the sterile solution had nutrients that can enhance the corrosion rate. DOE stated that the technique sensitivity is sufficient based on values cited in literature, and that sterile solution did not contain aggressive nutrients. DOE also indicated that corroborative testing from batch tests would be used to support existing tests. DOE responded to a question by Mr. Shettel (Nye county) on the significance of potential of mutation of microbes by radiation, stating that they had investigated the possibility and documented the analysis. The potential for de-alloying from MIC was also presented by DOE. They indicated that surface elemental analysis of base metal and welded specimens will be conducted after testing to determine whether selective dissolution is operative. DOE also indicated that they would address the different enhancement factors derived using solution composition and linear polarization techniques. CNWRA staff also asked whether potential deleterious species formed in a biofilm would be considered. DOE indicated that their treatment of microbial effects would be documented in a revised AMR.

Third, DOE addressed general corrosion rates over long time periods (Slides 13 - 14). General corrosion is modeled for both the titanium drip shield and the Alloy 22 waste package. Container lifetime is predicted to be greater than 10,000 years. Examination of silica surface deposits has been conducted and evaluated by DOE using atomic force microscopy. A testing program to evaluate passive film stability has been established. DOE indicated that they would continue their testing in the long term corrosion test facility and would be adding two new "bounding water" compositions (basic saturated water and simulated saturated water). Additional actions DOE will take include using thinner specimens and larger surface area to volume samples, installation of high sensitivity probes in some test vessels, and continuing materials testing during performance confirmation period. DOE indicated that the testing program is not strictly subdivided between regulatory time periods such as performance confirmation, but is a program of continuous, long-term testing. Extrapolation of corrosion rate data collected at 60 and 90 °C to 120 °C was questioned by Mr. DiBella (NWTRB). DOE responded that there was no measurable effect due to temperature. CNWRA staff questioned the sensitivity and measurement technique used for the high sensitivity probes. CNWRA staff questioned whether other standard methods to measure the corrosion rates, such as ASTM standard G-102, have been used by DOE. Finally, NRC and CNWRA staff questioned the sensitivity of DOE's existing methods to capture the variability and uncertainty in the silica deposition correction and its impact on general corrosion rate measurements. The importance of minor elements in the water that may affect the measured general corrosion rates was raised (Mr. Morgenstein, Nye county). DOE replied that minor constituents would be added to J-13 type water and evaporated to prepare solutions for corrosion testing.

The fourth item addressed by DOE was long-term passive film stability (Slides 16 -17). To address NRC concerns on passive film stability, DOE indicated that they will calculate potential-pH diagrams for multi-component Alloy 22. DOE will grow oxide films at higher temperatures to accelerate film growth, allowing compositional and structural studies to be conducted. DOE will address the kinetics of film growth and determine whether the film becomes mechanically brittle. The investigation of passive film thickness will include chemical, structural, and mechanical properties. NRC questioned whether intergranular dry air oxidation would be investigated and DOE indicated that they would address this in the testing program. CNWRA asked if differing cation mobility leading to vacancy movement and void formation,

would be addressed in the testing program. DOE stated this effect would also be studied in the testing program. Additional items DOE will complete include: (1) correlating changes in the corrosion potential with compositional changes in the passive film over time, (2) analyzing cold-worked materials to determine changes in film structural properties, (3) examination of films on samples of the natural analog mineral Josephinite that have been exposed in stream beds, and (4) comparing films on Alloy 22 to films on similar passive alloys from longer industrial experience. CNWRA staff indicated that besides the industrial database there is additional information from natural analogs, including geothermal systems, that should be considered by DOE. CNWRA staff also questioned the techniques and measurement used by DOE for investigating passive films, suggesting that meta-stable breakdown of the film may not be addressed using current techniques. Finally, CNWRA asked whether passive film composition in welded and thermally aged samples, including across grain boundaries, will be evaluated in DOE's testing program.

Fifth, DOE addressed localized corrosion (Slides 18 -22). Both pitting and crevice corrosion are considered in DOE's treatment of localized corrosion. Cyclic polarization studies have been performed in a range of environments and temperatures and indicate that localized corrosion is not expected. DOE indicated that this conclusion needs to be validated for welded material. Results from polarization studies and crevice studies for both Alloy 22 and stainless steel were presented. These results indicated that even though there is margin of 100 mV for stainless steel, no credit for stainless steel is assumed. CNWRA staff requested clarification regarding the use of the terms of corrosion current in some AMRs. DOE indicated that they would measure corrosion potentials in their testing program to determine any shift of potential with time toward the critical potential for localized corrosion. Critical potentials on welded and welded and aged coupons of Alloy 22 versus those for base metals will be evaluated by DOE. Separate effects of ionic mixtures of damaging species (chloride, fluoride, and possibly sulfate) and beneficial species in Yucca Mountain water on critical potentials will be investigated by DOE. DOE also indicated that critical potentials in environments containing heavy metal concentrations (e.g., Pb, As, and Hg) would also be conducted. NRC staff asked whether ionic ratios observed in the thermal testing will be addressed in the testing program. DOE replied these types of waters would be evaluated in the testing program. CNWRA staff questioned the existing confidence for the lower bound of the critical potential obtained in short-term tests, including microbial effects. DOE indicated that the uncertainty in the range of the parameter is being partially addressed by including four standard deviations of the parameter in the TSPA calculations and will be confirmed by additional testing.

Sixth, DOE addressed stress corrosion cracking (SCC) in Slides 23 - 37. DOE described their approach for SCC which focuses on initiation and subsequent propagation of the crack. DOE is using 300 series stainless steel data for the SCC initiation threshold. DOE is evaluating propagation by measuring crack growth rates of Alloy 22 under high stress intensities. High residual stresses associated with the final closure weld will require stress mitigation treatment. DOE has proposed using two post-weld stress mitigation treatments (laser peening and induction annealing). Constant load stress corrosion cracking test results in 20% basic saturated water, using stepped-up stresses, were described. These results indicate that Alloy 22 is resistant to SCC initiation up to 1.8 times the yield strength. Updated results of the cyclic loading tests for Alloy 22 on stress corrosion crack growth will be provided in a revised AMR. In addition results for 20% cold-worked Alloy 22 crack growth, Ti- grade 7 crack growth for

cold-worked samples will also be provided in an updated AMR. NRC staff asked if value of stress intensity provided in the plots is K maximum, and DOE confirmed that it is the maximum value. CNWRA staff asked about some details concerning the tests (i.e., air over-pressure), and whether future testing included testing for range of potentials. DOE replied that there is a plan to test over a range of potentials. Next DOE addressed the stress mitigation with laser peening concept. They indicated that stress relief up to 3 mm may be possible. CNWRA staff asked several questions on the thickness of the compressive layer, its variability, and its uncertainty. Because the SCC initiation is the critical step in the potential degradation of the waste package within the first 10,000 years, the CNWRA staff indicated the critical importance of well characterizing this information on the compressive layer. In the discussion of the DOE approach to induction annealing, Mr. von Tiesenhausen (Clark County) asked whether residual stress will be measured across the weld. DOE indicated that this parameter would be mapped. CNWRA asked about the availability of details of the time and temperature of the annealing process. DOE indicated that information is available and will be provided in the fabrication report. Ms. Treichel (Nevada Nuclear Waste Task Force) requested details on the cooling procedures used in the annealing process and DOE replied both air or sprayed water could be used to cool the annealed areas. DOE indicated that they would qualify and optimize the mitigation process, generate SCC data for mitigated materials over a range of metallurgical conditions, and would continue slow strain rate testing in same environments previously described. CNWRA staff requested details on how DOE would reduce the uncertainty in the exponential parameter used in the SCC model. DOE indicated that additional testing would constrain the value. NRC staff asked whether testing would include low pH conditions and DOE agreed that they would include that environment. DOE also indicated that they would evaluate the SCC resistance of welded and laser peened material, the resistance of induction annealed material, and the resistance of full thickness material from the prototype cylinder of Alloy 22. NRC staff asked whether the effects of stresses arising from rockfall on SCC of the waste package and drip shield has been considered. DOE indicated that this analysis for the waste package would be addressed after the revised analysis of the drip shield was completed.

Finally, DOE addressed concerns on fabrication and welding of Alloy 22 (Slides 38 - 39). CNWRA staff asked whether the fabrication mock-up was only the Viability Assessment design or whether the mock-ups included the Site Recommendation design. DOE stated that the mock-ups included the new design. Thin welded specimens are included in the long term testing program. DOE stated that no defects were observed in the two full diameter mockups of Alloy 22 waste packages. Finally, DOE stated that one inch thick laser peened mockups samples have been fabricated and the residual stress gradients have been verified. DOE indicated that they would use samples from welds in the mockups in their SCC testing program, once a specimen geometry can be defined. In addition, representative weld test samples will be used for MIC work, thermal aging, and localized corrosion evaluations. NRC staff requested more information on the potential importance of compositional variation associated with the welding and its effect on corrosion. DOE was asked whether structural effects after annealing would be examined (Mr. von Tiesenhausen), and they replied affirmatively.

As a result of additional discussions, NRC and DOE reached 17 agreements (see Attachment 1). With these agreements, the NRC stated that Subissue #1 could be listed as closed-pending.

6) Update on Features, Events and Processes (FEP)

The DOE stated that it was revising all the FEPs AMR, incorporating NRC comments, and would have them completed by January 2001. The DOE further stated that it would revise the FEPs database after completion of the FEPs AMR revisions.

7) Public Comments

None

King Stablein 9/13/00
for
C. William Reamer
Deputy Director
Division of Waste Management
Nuclear Regulatory Commission

9/13/2000
Dennis R. Williams
Deputy Assistant Manager
Office of Licensing & Regulatory Compliance
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Summary of the Resolution of the Key Technical Issue on Container Life and Source Term

Subissue #	Subissue Title	Status	NRC/DOE Agreements
1	The effects of corrosion processes on the lifetime of the containers	Closed-Pending	1) Provide the documentation for Alloy 22 and titanium for the path forward items listed on slide 8. DOE will provide the documentation in a revision to AMR "Environment on the Surfaces of the Drip Shield and Waste Package Outer Barrier" by LA. 2) Provide the documentation for the path forward items listed on slide 12. DOE will provide the documentation in a revision to AMR "General and Localized Corrosion of Waste Package Outer Barrier" by LA. 3) Provide documentation that confirms the linear polarization resistance measurements with corrosion rate measurements using other techniques. DOE will provide the documentation in a revision to AMR "General and Localized Corrosion of Waste Package Outer Barrier" by LA. 4) Provide the documentation for Alloy 22 and titanium for the path forward items listed on slide 14. DOE will provide the documentation in a revision to AMR "ANL-EBS-MD-000003 and ANL-EBS-MD-000004" by LA.

			5) Provide additional details on sensitivities, resolution of measurements, limitations, and deposition of silica for the high sensitivity probes. DOE will document the results of the sensitivity probes including limitation and resolution of measurements as affected by silica deposition in the Alloy 22 AMR and Ti Corrosion AMR (ANL-EBS-MD-000003 and ANL-EBS-MD-000004) prior to LA. 6) Provide the documentation on testing showing corrosion rates in the absence of silica deposition. DOE will document the results of testing in the absence of silica deposits in the revision of Alloy 22 AMR (ANL-EBS-MD-000003) prior to LA. 7) Provide the documentation for the alternative methods to measure the corrosion rate of the waste package material (e.g., ASTM G-102 testing) or provide justification for the current approach. DOE will document the alternative methods of corrosion measurement in the revision of Alloy 22 AMR (ANL-EBS-MD-000003), prior to LA. 8) Provide the documentation for Alloy 22 and titanium for the path forward items listed on slide 16 and 17. DOE will provide the documentation in the revision to AMRs (ANL-EBS-MD-000003 and ANL-EBS-MD-000004) prior to LA. 9) Provide the data that characterizes the passive film stability, including the welded and thermally aged specimens. DOE will provide the documentation in a revision to AMRs (ANL-EBS-MD-000003 and ANL-EBS-MD-000004) prior to LA.

			10) Provide the documentation for Alloy 22 and titanium for the path forward items listed on slide 21 and 22. DOE will provide the documentation in a revision to AMRs (ANL-EBS-MD-000003 and ANL-EBS-MD-000004) prior to LA. 11) Provide the technical basis for the selection of the critical potentials as bounding parameters for localized corrosion, taking into account MIC. DOE will provide the documentation in a revision to AMRs (ANL-EBS-MD-000003 and ANL-EBS-MD-000004) prior to LA. 12) Provide the documentation for Alloy 22 and titanium for the path forward items listed on slides 34 and 35. DOE will provide the documentation in a revision to AMRs (ANL-EBS-MD-000005 and ANL-EBS-MD-000006) prior to LA. 13) Provide the data that characterizes the distribution of stresses due to laser peening and induction annealing of Alloy 22. DOE will provide the documentation in a revision to AMR (ANL-EBS-MD-000005) prior to LA.

			14) Provide the justification for not including the rockfall effect and deadload from drift collapse on SCC of the waste package and drip shield. DOE will provide the documentation for the rockfall and dead-weight effects in the next revision of the SCC AMR (ANL-EBS-MD-000005) prior to LA. 15) Provide the documentation for Alloy 22 and titanium for the path forward items listed on slide 39. DOE will provide documentation for Alloy 22 and Ti path forward items on slide 39 in a revision to the SCC and general and localized corrosion AMRs (ANL-EBS-MD-000003, ANL-EBS-MD-000004, ANL-EBS-MD-000005) by LA. 16) Provide the documentation on the measured thermal profile of the waste package material due to induction annealing. DOE stated that the thermal profiles will be measured during induction annealing, and the results will be reported in the next SCC AMR (ANL-EBS-MD-000005) prior to LA. 17) Provide additional detail on quality assurance acceptance testing. DOE stated that it would provide guidance and criteria in the next revision of the Technical Guidance Document (TGD) for LA. The development of the LA sections and associated programs and process controls for the procurement and fabrication of waste package materials and components will be included. This will include consideration of the controls for compositional variations in Alloy 22. The TGD revision will be issued by June 2001, contingent upon NRC publication of the final 10 CFR 63 and the Yucca Mountain Review Plan.

2	The effects of phase instability and initial defects on the mechanical failure and lifetime of the containers	Closed-Pending	1) Either provide documentation using solid element formulation, or provide justification for not using it, for the drip shield - rockfall analysis. DOE stated that shell elements include normal stresses and transverse stresses in the calculations and provide more accurate results for thin plates and use far fewer elements. Therefore, shell elements will be used instead of solid elements. This justification will be documented in the next revision of AMR ANL-XCS-ME-000001, Design Analysis for the Ex-Container Components, prior to LA. 2) Provide the documentation for the point loading rockfall analysis. DOE stated that point loading rock fall calculations will be documented in the next revisions of AMRs ANL-XCS-ME-000001, Design Analysis for the Ex-Container Components, and ANL-UDC-MD-000001, Design Analysis for UCF Waste Packages, both to be completed prior to LA. 3) Demonstrate how the Tresca failure criterion bounds a fracture mechanics approach to calculating the mechanical failure of the drip shield. DOE stated that it believes its current approach of using ASME Code is appropriate for this application. Additional justification for this conclusion will be included in the next revision of AMR ANL-XCS-ME-000001, Design Analysis for the Ex-Container Components, to be completed prior to LA.

			4) Provide information on the effect of the entire fabrication sequence on phase instability of Alloy 22, including the effect of welding thick sections using multiple weld passes and the proposed induction annealing process. DOE stated that the aging studies will be expanded to include solution annealed and induction annealed Alloy 22 weld and base metal samples from the mock-ups as well as laser peened thick, multi-pass welds. This information will be included in revisions of the AMR "Aging and Phase Stability of the Waste Package Outer Barrier," ANL-EBS-MD-000002, before LA. 5) Provide the "Aging and Phase Stability of Waste Package Outer Barrier," AMR, including the documentation of the path forward items listed in the "Subissue 2: Effects of Phase Instability of Materials and Initial Defects on the Mechanical Failure and Lifetime of the Containers" presentation, slides 5 & 6. DOE stated that the "Aging and Phase Stability of the Waste Package Outer Barrier" AMR, ANL-EBS-MD-000002, Rev. 00 was issued 3/20/00. This AMR will be revised to include the results of the path forward items before LA. 6) Provide the technical basis for the mechanical integrity of the inner overpack closure weld. DOE will provide the documentation in AMR, ANL-UDC-MD-000001, Rev. 00, Design Analysis for UFC Waste Packages in the next revision, prior to LA.

			7) Provide documentation for the fabrication process, controls, and implementation of the phases which affect the TSPA model assumptions for the waste package (e.g., filler metal, composition range). DOE stated that updates of the documentation on the fabrication processes and controls (TDR-EBS-ND-000003, Waste Package Operations Fabrication Process Report and TDP-EBS-ND-000005, Waste Package Operations FY-00 Closure Weld Technical Guidelines Document) will be available to the NRC in January 2001. 8) Provide documentation of the path forward items in the "Subissue 2: Effects of Phase Instability of Materials and Initial Defects on the Mechanical Failure and Lifetime of the Containers" presentation, slide 16. DOE stated that the rockfall calculations addressing potential embrittlement of the waste package closure weld and rock falls of multiple rock blocks will be included in the next revision of the AMR ANL-UDC-MD-000001, Design Analysis for UCF Waste Packages, to be completed prior to LA. Rock fall calculations addressing drip shield wall thinning due to corrosion, hydrogen embrittlement of titanium, and rock falls of multiple rock blocks will be included in the next revision of the AMR ANL-XCS-ME-000001, Design Analysis for the Ex-Container Components, to be completed prior to LA. Seismic calculations addressing the load of fallen rock on the drip shield will be included in the next revision of the AMR ANL-XCS-ME-000001, Design Analysis for the Ex-Container Components, to be completed prior to LA.

			9) Demonstrate the drip shield and waste package mechanical analysis addressing seismic excitation is consistent with the design basis earthquake covered in the SDS KTI. DOE stated that the same seismic evaluations of waste packages and drip shield (revision of AMRs ANL-UDC-MD-000001 and ANL-XCS-ME-000001) will support both the SDS KTI and the CLST KTI, therefore consistency is ensured. These revisions will be completed prior to LA.
3	The rate at which radionuclides in spent nuclear fuel are released from the engineered barrier subsystem through the oxidation and dissolution of spent nuclear fuel	Closed-Pending	The agreements below address both subissues 3 & 4 1) In the revision to the "Summary of In-Package Chemistry for Waste Forms," AMR, the NRC needs to know whether and how initial failures are included in the in-package chemistry modeling, taking into account the multiple barrier analysis. DOE stated that the Summary of In-Package Chemistry for Waste Forms ANL-EBS-MD-000050 deals with time since waste package breach, instead of time of waste package failures. The model is appropriate for the current implementation in the TSPA scenarios because breaches do not occur until after aqueous films may be sustained. Multiple barrier analyses are discussed in the TSPAI IRSR, and therefore will be discussed in the TSPA KTI Technical Exchange.

			2) In the revision to the "Summary of In-Package Chemistry for Waste Forms," AMR, address specific NRC questions regarding radiolysis, incoming water, localized corrosion, corrosion products, transient effects, and a sensitivity study on differing dissolution rates of components. DOE stated that these specific questions are currently being addressed in the revision of the Summary of In-Package Chemistry for Waste Forms AMR, ANL-EBS-MD-000050 and related AMRs and calculations. To be available in January 2001. 3) Provide a more detailed calculation on the in-package chemistry effects of radiolysis. DOE stated that the calculations recently performed as discussed at the 9/12/00 Technical Exchange and preceeding teleconferences are being documented. These calculations will be referenced and justified in the revision of the Summary of In-Package Chemistry for Waste Forms AMR, ANL-EBS-MD-000050 and will be available in January 2001. 4) Need consistency between abstractions for incoming water and sensitivity studies conducted for in-package calculations, in particular, taking into account the interaction of engineered materials on the chemistry of water used for input to in-package abstractions. DOE stated that the revision of the Summary of In-Package Chemistry for Waste Forms AMR, ANL-EBS-MD-000050 will discuss the applicability of abstractions for incoming water, taking into account the revised Environment on the Surfaces of the Drip Shield and Waste Package Outer Barrier AMR. The revision will be available in January 2001.

			5) Provide the plan for experiments demonstrating in-package chemistry, and take into account subsequent NRC comments, if any. DOE stated that the current planning provides for the analysis of additional in-package chemistry model support. This analysis will determine which parts of the model are amenable to additional support by testing, and which parts are more amenable to sensitivity analysis, or use of analogues. Based on these results, longer range testing will be considered. If testing is determined to be appropriate, test plans will be written in FY01 and made available to the NRC. 6) Provide additional technical basis for the failure rate and how the rate is affected by localized corrosion. DOE stated that the technical basis for local corrosion conditions will be added to by additional discussion of local chemistry in the Summary of In-package Chemistry for Waste Forms revision ANL-EBS-MD-000050 which will be available in January 2001. Current Clad Degradation Summary Abstraction AMR Section 6.3, ANL-WIS-MD-000007 and Clad Degradation - Local Corrosion of Zirconium and its Alloys Under Repository Conditions AMR, ANL-EBS-MD-000012 contain the overall technical basis. 7) Provide data to address chloride induced localized corrosion and SCC under the environment predicted by in-package chemistry modeling. DOE stated that the technical basis for the models used for localized corrosion and SCC will be expanded in future revisions of the Clad Degradation Summary Abstraction AMR, ANL-WIS-MD-000007, available

			8) Provide the documentation on the distribution for cladding temperature and stress used for hydride embrittlement. DOE stated that the stresses are documented in the Initial Cladding Conditions AMR, ANL-EBS-MD-000048. CAL-UDC-ME-000001 contains the waste package internal temperatures. Waste package surface temperatures were provided within the TSPA model (ANL-EBS-HS-000003, Rev 00, ICN 01 and ANL-EBS-MD-000049). The updated versions of these documents will be available in January 2001. 9) Provide a technical basis for critical stress that is relevant for the environment in which external SCC takes place. DOE stated that critical stress from SCC experiments under more aggressive conditions will be cited in the Revision of the Cladding Degradation Summary Abstraction AMR, ANL-WIS-MD-000007, which will be available in January 2001. 10) Provide analysis of the rockfall and vibratory loading effects on the mechanical failure of cladding, as appropriate. DOE stated that the vibratory effects are documented in Sanders et. al. 1992 SAND90-2406, A Method For Determining The Spent-Fuel Contribution To Transport Cask Containment Requirements. This will be discussed in the SDS KTI meeting. The analysis of the rockfall effects on the mechanical failure of cladding will be addressed if the agreed to updated rockfall analysis in Subissue #2, Item 8 and Subissue #1, Item 14 demonstrate that the rock will penetrate the drip shield and damage the waste package.

4	The rate at which radionuclides in high-level waste glass are released from the engineered barrier subsystem	Closed-Pending	See agreements above, in addition: 1) In the revision to the "Defense High Level Waste Glass Degradation," AMR, address specific NRC questions regarding (a) the inconsistency of the rates in acid leg for glasses, (b) the technical basis for use of boron versus silica in the radionuclide release from glass, and (c) clarification of the definition of long term rates of glass dissolution. DOE stated that these questions will be addressed in the Defense High Level Waste AMR revision and will be available in January 2001.
5	The effects of in-package criticality on waste package and engineered barrier subsystem performance	Open - See Note 1	TBD - See Note 1
6	The effects of alternate engineered barrier subsystem design features on container lifetime and radionuclide release from the engineered barrier subsystem	Closed-Pending	1) Provide documentation for the path forward items in the "Subissue 6: Alternate EBS Design Features - Effect on Container Lifetime" presentation, slides 7 & 8. DOE stated that the documentation of the path forward items will be completed and as results become available, they will documented in the revisions of AMRs (ANL-EBS-MD-000005, Stress Corrosion Cracking of the Drip Shield, the Waste Package Outer Barrier and the Stainless Structural Material, and ANL-EBS-MD-000004, General Corrosion and Localized Corrosion of the Drip Shield), to be completed by LA.

			2) Provide additional justification for the use of a 400 ppm hydrogen criterion or perform a sensitivity analysis using a lower value. DOE stated that additional justification will be found in the report "Review of Expected Behaviour of Alpha Titanium Alloys under Yucca Mountain Condition" TDR-EBS-MD-000015, which is in preparation and will be available in January 2001. 3) Provide the technical basis for the assumed fraction of hydrogen absorbed into titanium as a result of corrosion. DOE stated that additional justification will be found in the report "Review of Expected Behaviour of Alpha Titanium Alloys under Yucca Mountain Condition" TDR-EBS-MD-000015, which is in preparation and will be available in January 2001. 4) Provide temperature distribution (CCDF) of the drip shield as a function of time under the current EBS design. DOE stated that the temperature distribution will be provided in the next revision of the AMR, ANL-EBS-MD-000049, Rev 00, ICN 01, which will be available in January 2001.

Note 1 - Subissue #5, "The effects of in-package criticality on waste package and engineered barrier subsystem performance" were not addressed at this meeting and will be addressed in a future meeting.

Summary Highlights of NRC/DOE Technical Exchange and Management Meeting on Igneous Activity

August 29-31, 2000
Las Vegas, Nevada

Introduction and Objectives

This Technical Exchange and Management Meeting on Igneous Activity (IA) is one in a series of meetings related to the U.S. Nuclear Regulatory Commission (NRC) key technical issue (KTI) and sufficiency review and the U.S. Department of Energy (DOE) site recommendation decision. Consistent with NRC regulations on prelicensing consultations and a 1992 agreement with DOE, staff-level resolution can be achieved during prelicensing consultation. The purpose of issue resolution is to assure that sufficient information is available on an issue to enable the NRC to docket the license application. 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. Issue resolution at the staff level during prelicensing is achieved when the staff has no further questions or comments at a point in time regarding how the DOE is addressing an issue. Pertinent additional information could raise new questions or comments regarding a previously resolved issue.

Issues 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 initial license application. Issues are "closed-pending" if the NRC staff has confidence that the DOE proposed approach, together with the DOE agreement to provide the NRC with additional information (through specified testing, analysis, etc.) acceptably addresses the NRC's questions such that no information beyond that provided, or agreed to, will likely be required at time of initial license application. Issues 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 the license application.

The objective of this meeting is to discuss and review the progress on resolving the IA KTI (see Attachment 1 for list of subissues). The quality assurance (QA) aspect of this KTI was determined to be outside the scope of the meeting and is being tracked in NRC's ongoing review of DOE's QA program.

Summary of Meeting

At the close of the Technical Exchange and Management Meeting, the NRC staff stated that subissue 1 (probability of igneous activity) is closed and subissue 2 (consequence of igneous activity) is open. Specific NRC/DOE agreements made at the meeting are provided as Attachment 1. The agenda and the attendance list are provided as Attachments 2 and 3, respectively. Copies of the presenters' slides are provided as Attachment 4. A copy of the draft meeting summary and draft matrix, which were handed out at the meeting, are included as Attachment 5. Highlights from the Technical Exchange and Management Meeting are listed below.

Enclosure

Highlights

1) Opening Comments

DOE stated that the intent of the meeting is to reach agreement on the current status and path forward for each of the IA subissues (see "Igneous Activity Key Technical Issue" presentation given by Eric Smistad). During the April 25-26, 2000, KTI Technical Exchange, the NRC listed the two subissues as being open. During this meeting, DOE stated that it would provide additional details about how acceptance criterion and NRC concerns have been addressed and provide references to relevant information. DOE stated that it felt that the details provided during the meeting would be the basis for NRC to list both subissues as closed-pending.

The NRC stated that the acceptance criterion presented in Revision 1 of the IA Issue Resolution Status Report (IRSR) will be changing in Revision 2 of the IRSR (see "NRC Introductory Comments" presentation given by John Trapp). The change will provide uniformity with other KTIs and are being developed in parallel with Revision 1 of the Yucca Mountain Review Plan. The NRC stressed, however, that the technical concerns the staff has will not change with the new acceptance criterion. The NRC also discussed the relationship of the subissues to NRC abstractions. The probability subissue will be covered under scenario analysis. The consequence subissue will be covered under the following integrated subissues: (1) volcanic disruption of waste package, (2) airborne transport of radionuclides, (3) mechanical disruption of engineered barriers, (4) redistribution of radionuclides in soil, and (5) lifestyle of the critical group. The DOE requested that they be provided with a matrix correlation between the current acceptance criterion and the revised acceptance criterion, once the revision has completed.

Neither the State of Nevada nor the Affected Units of Local Government (AULG) had opening remarks.

2) Igneous Activity in the Total Performance Assessment

DOE presented the general outline and status of the Total System Performance Assessment - Site Recommendation (TSPA-SR) (see "Igneous Activity in the Total System Performance Assessment - Site Recommendation: A Summary" presentation given by Peter Swift). The DOE stated that all TSPA-SR igneous disruption analyses (base case and sensitivity analyses) are based on a no backfill design. The results of the TSPA-SR will be summarized in the Site Recommendation Consideration Report, Revision 0. DOE then discussed the igneous intrusion groundwater transport and volcanic eruption ash fall pathways and the dose histories associated with each. The overall expected annual dose is the sum of the nominal dose history and the two igneous process dose histories, weighted by the annual probability of each event.

DOE's dose history showed that estimated dose from eruptive processes dominates for the first few thousand years and then the intrusive dose dominates out to 100,000 years. The NRC stated that it's calculations, however, shows the eruptive dose dominates to 10,000 years. For eruptive events, DOE stated that the probability weighted mean annual dose rate peaks at 0.006 mrem/yr, and for the intrusive-dominated period, the mean annual peak dose rate in the first 10,000 years is between 10^{-1} and 10^{-2} mrem/yr. DOE stated that it took no credit for either cladding or the waste packages intersected by an eruption or in close proximity to an intrusion in the IA calculations. DOE then discussed the TSPA-SR dose sensitivity analysis event for probability, showing the 10E-7 intrusive event probability which raised the dose rates by about a

factor of 6 over the base case probability to approximately 0.15 mrem/yr at 10,000 years. Using an approximately 10^{-8} probability for extrusive event, peak probability-weighted mean annual dose increased to 0.03 mrem/year with the DOE consequence model.

DOE concluded that the preliminary results show that the igneous disruption is the main contributor to dose in first 10,000 years and that the peak mean probability-weighted igneous doses are well below the EPA-proposed standard. The NRC pointed out that needs to see the results of a 10E-7 extrusive event as agreed to by DOE.

3) Technical Discussion of the Consequence of Igneous Activity

Acceptance Criterion 1 through 4 - Eruptive Scenario Modeling

A discussion of acceptance criterion for the IA consequence subissue - eruptive scenario modeling was presented by the DOE (see "Igneous Activity Consequences Subissue: Eruptive Scenario Modeling - Acceptance Criterion 1, 2, 3, 4, and 5" presentation given by Michael Sauer).

Under Acceptance Criterion #1, DOE stated that each extrusive igneous event is assumed to have a violent Strombolian phase that is modeled in the TSPA-SR using ASHPLUME v1.4LV. Strombolian and effusive eruption phases have been screened out due to low consequences and have not been incorporated into the TSPA-SR. DOE stated that high level waste entrainment is estimated via an incorporation ratio defined in ASHPLUME and is described in the igneous consequences Analysis and Model Report (AMR). DOE then presented the parameter inputs used in ASHPLUME (including ash particle size, event power, conduit diameter, violent eruptive phase volume, and waste particle diameter).

The NRC and Center for Nuclear Waste Regulatory Analyses (CNWRA) had a number of questions in this area: (1) how DOE accounted for the combined density of particles comprised of ash and waste in the eruption modeling, (2) the sensitivity of the grain size of waste, and (3) the technical basis for how the volumes from analog volcanos represent the likely range of volumes from Yucca Mountain volcanos. Mike Sheridan (Electric Power Research Institute representative) questioned why DOE selected violent Strombolian, given that it appears to be extremely conservative. DOE discussed evidence from southern Nevada. NRC discussed the Tolbachik analog as being useful for understanding the Crater Flat eruptive process.

As a result of additional discussions, NRC and DOE reached 3 agreements (see Attachment 1). With these agreements, the NRC stated that this Acceptance Criterion could be listed as closed-pending.

Under Acceptance Criterion #2, DOE stated that it is using ASHPLUME v1.4LV for the TSPA-SR and that it has compared ASHPLUME v1.4LV and v2.0 to the 1995 Cerro Negro eruption measured ashfall thickness (Hill et al. 1998). DOE concluded that both v1.4LV and v2.0 provide good agreement with the observed 1995 Cerro Negro ash layers and with each other. As a result of additional discussions, NRC and DOE reached one agreement (see Attachment 1). With this agreement, the NRC stated that this Acceptance Criterion could be listed as closed-pending.

Under Acceptance Criterion #3, DOE stated that no credit was being taken for potential rotation of least principal stress to vertical during the thermal period and that this would be documented

in the Igneous Consequence Modeling AMR. The NRC and the CNWRA expressed a concern that the current repository design, as shown in Sauer, 2000 (Igneous Activity Consequences Subissue: Intrusive Scenario presentation, slide 6), could result in an increased number of waste canisters being included in the conduit. This could result from the orientation of the repository drifts sub-perpendicular to the minimum in situ horizontal stress axis, resulting in conduit elongation or dike formation sub-parallel to the drifts. As a result of additional discussions, NRC and DOE reached one agreement (see Attachment 1). With this agreement, the NRC stated that this Acceptance Criterion could be listed as closed-pending.

Under Acceptance Criterion #4, DOE stated that the waste packages in the path of the eruptive conduit are assumed to be sufficiently damaged to provide no further protection and that this was documented in the Igneous Consequence Modeling for the TSPA-SR AMR (ANL-WIS PA000017). The NRC stated that it had no further questions in this area and that this Acceptance Criterion could be closed.

Acceptance Criterion 5 - Biosphere Modeling

Under Acceptance Criterion #5, the DOE stated that by conservatively fixing wind direction to the south and using transition phase Biosphere Dose Conversion Factors (BDCFs) for the full 10,000 years, that it bounds the expected range of doses and thus Acceptance Criterion #5 is addressed. The NRC requested a discussion of what DOE meant by "remobilization in Amargosa" and stated that DOE may not have adequately addressed uniform soil removal rates in the analyses. The NRC questioned whether DOE considers mechanical breakdown of particles (e.g., plowing). NRC discussed the process of soil removal and how it relates to agricultural or tilled land. William Melson (Nuclear Waste Technical Review Board (NWTRB) consultant) suggested that most ash gets slurried by overland water, getting into washes and in surface fractures/faults. DOE emphasized that by assigning the wind direction always to the south, uncertainties such as those associated with remobilization on variable slopes with variable thicknesses of ash are captured. NRC suggested that ash is continually being eroded and replenished by deposition of material eroded from locations nearer Yucca Mountain. John Stuckless (representing the USGS) disagreed, citing general observations, including the Jake Ridge area. The DOE stated that its present approach reasonably captures uncertainty associated with ash redistribution. The DOE stated that its analysis is sufficiently robust as to allow certain processes to be discounted. The NRC commented that DOE is not considering that through time incoming material would add to radionuclide inventory in the soils. As a result of additional discussions, NRC and DOE reached one agreement (see Attachment 1).

Under the Biosphere Modeling Eruptive Scenario, the DOE discussed the issues of (see "Igneous Activity Consequences Subissue: Biosphere Modeling - Eruptive Scenario" presentation given by Michael Sauer) mass loading, inhalation dose, soil removal and particle change, and self evacuation.

Under mass loading, the DOE provided information on the mass loading parameters and indicated that they were appropriate for the critical group. The NRC had no additional questions in this area and requested that DOE document the information. As a result of additional discussions, NRC and DOE reached one agreement (see Attachment 1).

Under inhalation dose, the DOE stated that it treats the inhalation of particles in the 10-100 micron range as additional soil ingestion. The NRC and CNWRA questioned this assumption and suggested that DOE might be underestimating the dose. The NRC stated that it needed

additional justification regarding this assumption. As a result of additional discussions, NRC and DOE reached one agreement (see Attachment 1).
Under soil removal and particle change, the NRC noted that it discussed this issue previously (see above paragraph) and that it had no additional comments.

Under self evacuation, the DOE stated that it no longer assumes that the critical group self-evacuates during extrusive eruption and that this is documented in a calculation recently provided to the NRC (Scoping Calculation for Volcanic Eruption Biosphere Dose Conversion Factors). The NRC stated it had no further questions in this area.

The DOE then provided a brief discussion on wind characteristics and how they are being handled in TSPA-SR. The NRC expressed a concern that DOE's wind speed data is truncated at an altitude below the top of the possible tephra column. The NRC suggested that DOE evaluate new wind data and use the appropriate wind speeds with the height of the eruption column being modeled. The DOE stated it is looking into the speed-altitude relationships. As a result of additional discussions, NRC and DOE reached one agreement (see Attachment 1). With this agreement and the other agreements noted above, the NRC stated that this Acceptance Criterion could be listed as closed-pending.

Acceptance Criterion 1 through 4 - Intrusive Scenario Modeling

Under Acceptance Criterion #1, the DOE stated that the conceptual model of the intrusive event is consistent with the geologic record of basaltic igneous activity in Yucca Mountain region. The NRC had no further questions in this area (see Attachment 1 for overall status and agreements for Acceptance Criterion 1 through 4).

Under Acceptance Criterion #2, the DOE stated the models are verified against analog igneous system and therefore acceptance criterion 2 is addressed. The NRC had no further questions in this area (see Attachment 1 for overall status and agreements for Acceptance Criterion 1 through 4).

Under Acceptance Criterion #3, the DOE stated that it has addressed acceptance criterion 3 by incorporating the conceptual model for dike drift interaction in the TSPA intrusive model. The NRC requested that DOE provide instructions for accessing the database in this area. The DOE agreed to this request. The NRC had no further questions in this area (see Attachment 1 for overall status and agreements for Acceptance Criterion 1 through 4).

Under Acceptance Criterion #4, the DOE stated that it had addressed acceptance criterion 4 by conservatively neutralizing all engineered barriers near the dike and assuming damaged lid welds on all remaining packages in intersected drifts. The DOE stated that packages intersected by the dike plus three packages on either side of the dike are assumed to be sufficiently damaged to provide no further protection (Zone 1) from influx of water and release of radionuclides. The waste in this zone is assumed to be instantly reduced in grain size and is available to be transported from the repository. The DOE stated that all additional packages in intersected drifts undergo lid weld failure (Zone 2). In this zone the drip shield, ground support, lid welds, and cladding of the waste will fail, but not the waste packages. All waste in Zone 1 is exposed to water flux in the drift as per the nominal case; in Zone 2 the waste packages need to be exposed to seepage to get water into the package. The DOE stated that there will be diffusional releases in Zone 2.

As a result of additional discussions, NRC and DOE reached one agreement (see Attachment 1). With this agreement the NRC stated that this was an acceptable path forward, but it did not have sufficient information to go to closed-pending. Therefore, this acceptance criterion is open.

4) Technical Discussion of Probability of Igneous Activity

The NRC began the discussions of the probability of igneous activity by discussing the overall status of the issue. The NRC understands that DOE plans on using a probability distribution derived from the Probabilistic Volcanic Hazard Assessment (PVHA) analysis having a mean value of approximately 1.6 x 10E-8 for its licensing case. The NRC disagrees with the use of that probability distribution and is more comfortable with a probability range of between 10E-8 and 10E-7. Therefore, the NRC has requested, and DOE has agreed that, in addition to its licensing case for SR and LA, DOE will provide, for informational purposes, the results of a single point sensitivity analysis for extrusive and intrusive igneous processes at 10E-7. Based on this agreement, the NRC stated that this subissue is closed-pending. The NRC noted that the upcoming revision to the IRSR will reflect this agreement and also contain the staff's evaluation of DOE's analyses. The DOE stated that it agrees with the NRC approach. Both the NRC and DOE agreed that it would review and incorporate any new information, if applicable, into its calculations. NRC stated that when DOE establishes parameter values by applying weighting factors (probabilities) to alternative conceptual models, DOE needs to provide a technical basis for the probabilities.

The DOE then provided its approach to meeting Acceptance Criterion 1 through 4 and 6 through 8 (see the Igneous Activity Probability Subissue: Acceptance Criterion 1, 3, 4, 6, and 7 presentation given by Frank Perry, the Igneous Activity Probability Subissue: Acceptance Criterion #2 - Definition of Igneous Event presentation given by Robert Young, the Igneous Activity Probability Subissue: Acceptance Criterion #8 - Expert Elicitation Process presentation given by Kevin Coppersmith). As a result of additional discussions, NRC and DOE reached two agreements (see Attachment 1). With these agreements, the NRC stated that the probability subissue could be listed as closed-pending.

The CNWRA then provided a discussion on tectonic models (see the Vertical Axis Rotations and Normal Faults: Paleomagnetic and Geologic Evidence for the Development of Crater Flat, Nevada presentation given by John Stamatakos). The CNWRA summary is listed on page 2 of the presentation.

The DOE then provided its approach to Acceptance Criterion #5 (see Igneous Activity Probability Subissue: Acceptance Criterion #5: Tectonic Models). DOE stated that its models are consistent with tectonic models proposed for the Yucca Mountain region. Carl Stepp indicated that source zone boundaries were drawn primarily from volcano locations. The NRC had no further questions in this area and considers Acceptance Criteria #5 as closed-pending.

Although not directly related to this Igneous Activity KTI Technical Exchange, the Structural Deformation and Seismicity KTI item on tectonic models was discussed. Based on the discussions at this meeting, the SDS KTI item on tectonic models is closed regarding an apparent inconsistency in the application of tectonic models to the Probabilistic Seismic Hazard Assessment (PSHA) and the PVHA. DOE has indicated that the hinge line, as shown by Fredrich and others, is not a structural barrier that delimits a volcanic source zone. The PVHA volcanic source zone thus does not represent seismogenic sources as used in PSHA. However, the tectonic framework subissue is closed-pending, awaiting revisions to the DOE's Disruptive

Events Features Events and Processes (FEPs) AMR. Resolution of this subissue will be formalized at the upcoming SDS Technical Exchange.

The CNWRA then provided an overview of NRC/CNWRA volcanism probability models (see Geologic Setting presentation given by Charles Connor). The presentation concluded that a uniform distribution between 10E-7 to 10E-8 annual probability of occurrence captures the range of uncertainty by considering relationships between tectonics, structural geology, geophysical information, and volcanism at Yucca Mountain. The conclusion concerning the concept of probability of "volcanic crisis" (2.5 x 10-4/year) drew comment from DOE to the effect of being unnecessarily provocative because of its being an unfamiliar term and potentially misleading the public. CNWRA staff provided a definition and NRC indicated sensitivity to DOE's concern.

5) Update on Features, Events and Processes (FEPs).

The NRC stated, in general, that the justification for screening out biosphere FEPs were not based on present knowledge of current conditions, and that screening of critical group should be based on current conditions without regard for future changes in behavior (see Issue in the Biosphere presentation given by Christopher McKinley). The DOE stated that it was revising all the FEPs AMR and would have them completed by January 2001. The DOE further stated that it would revise the FEPs database after completion of the FEPs AMR revisions.

The NRC staff stated that two specific FEPs may need to be added to the list of FEPs considered by DOE. Specifically:

(1) The re-entry of radionuclides that leach out of the soil back into the groundwater. This process is definitely negligible for the base case due to the low concentration of radionuclides in the soil and the large dilution volume due to pumping. However, for the volcanism scenario, there will be an ash deposit covering about 10s to 100s of square kilometers of land that are closer to Yucca Mountain than the critical group and could leach into the groundwater that flows to the critical group. This would not affect the peak dose from the volcanic event, but it may make a difference in the calculation of the expected annual dose.

(2) FEP 2.4.07.00.00 (Dwellings) should include an evaluation of the effects of evaporative coolers on the dose to the critical group.

6) Public Comments

Judy Treichel (Nevada Nuclear Waste Task Force) commented on the term 'closed.' She stated that it is a significant perception problem for concerned citizens. She stated that doing "tricky math" to get around the fact that there will be big doses when a volcanic eruption occurs is not perceived well. She cited the hearings associated with the proposed Private Fuel Storage Facility as relevant to the Yucca Mountain process.

Steve Frishman (Nevada Nuclear Waste Project Office) commented that no one can figure out how to calculate the redistribution factor. Everything deposited up gradient will pass through the critical group, but at an unknown rate. The rate needs to be determined (he suggested using the Lathrop Wells cone as an example). He stated that redistribution should not be dismissed by saying the analysis is conservative, unless the process is better understood.

William Melson (NWTRB) commented that issues related to Yucca Mountain and finding a repository is a societal issue which the NRC and DOE are trying to deal with.

Don Shettle (Nye County) commented on why volcanogenic thermal water has not been considered by DOE. A representative from USGS stated that the concept has been considered, but was not found to be significant for the Yucca Mountain site. The DOE stated that this was discussed in the Disruptive Events FEPs AMR and was exclude by low probability of occurrence and low magnitude of effect.

Sandra Wastler for 8/31/2000

C. William Reamer
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8/31/2000

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Summary of the Resolution of the Key Technical Issue on Igneous Activity

Subissue #	Subissue Title	Status	NRC/DOE Agreements
1	Probability of igneous activity at or near the proposed repository site. AC-1 through AC-7: Closed-Pending AC-8: Closed	Closed-Pending	1) In addition to DOE's licensing case, include for Site Recommendation and License Application, for information purposes, the results of a single point sensitivity analysis for extrusive and intrusive igneous processes at 10E-7. DOE agreed that the analysis will be included in TSPA-SR Rev. 0 and will be available to the NRC in November 2000. 2) Examine new aeromagnetic data for potential buried igneous features (see U.S. Geological Survey, Open-File Report 00-188, Online Version 1.0), and evaluate the effect on the probability estimate. If the data survey specifications are not adequate for this use, this action is not required. DOE agreed and its initial evaluation of the report with proposed actions resulting from the review will be available to the NRC by October 11, 2000.

2	Consequences of igneous activity within the repository setting. <u>Eruptive Scenario Modeling</u> AC-1: Closed-Pending AC-2: Closed-Pending AC-3: Closed-Pending AC-4: Closed AC-5: Closed-Pending AC-6: Closed <u>Intrusive Scenario Modeling</u> AC-1: Closed-Pending AC-2: Closed-Pending AC-3: Closed-Pending AC-4: Open	Open	1) Re-examine the ASHPLUME Code to confirm that particle density is appropriately changed when waste particles are incorporated into the ash. (Eruptive AC-1) DOE agreed and will correct the description in the ICN to AMR, Igneous Consequences Modeling for TSPA-SR [ANL-WIS-MD-000017] as needed to address the concern. This will be available to the NRC in January 2001. 2) Document results of sensitivity studies for particle size, consistent with (1) above. (Eruptive AC-1) DOE agreed and will document the waste particle size sensitivity study in TSPA-SR, Rev. 1. This will be available to the NRC in June 2001. 3) Document how the tephra volumes from analog volcanos represent the likely range of tephra volumes from Yucca Mountain Region (YMR) volcanos. (Eruptive AC-1) DOE agreed and will document the basis for determining the range of tephra volumes that is likely from possible future volcanoes in the YMR in TSPA-SR, Rev. 1 or demonstrate that TSPA-SR results are insensitive to uncertainties in the reasonably expected volumes of tephra in the YMR. This will be available to the NRC in June 2001.

2 (Cont.)	Consequences of igneous activity within the repository setting.		4) Document that the ASHPLUME model, as used in the DOE performance assessment, has been compared with an analog igneous system. (Eruptive AC-2) DOE agreed and will complete calculation CAL-WIS-MD-000011 that will document a comparison of the ASHPLUME code results to observed data from the 1995 Cerro Negro eruption. This will be available to the NRC in January 2001. DOE will consider Cerro Negro as an analog and document that in TSPA-SR Rev. 1. This will be available to the NRC in June 2001. 5) Document how the current approach to calculating the number of waste packages intersected by conduits addresses potential effects of conduit elongation along a drift. (Eruptive AC-3) DOE agreed and will document the way in which the change in geometry of the repository drifts affects the number of waste packages incorporated into the volcanic conduit. Possible consequences of conduit elongation parallel to drifts will be documented in TSPA-SR Rev. 1, available to the NRC in June 2001.

2 (Cont.)	Consequences of igneous activity within the repository setting.		6) Develop a linkage between soil removal rate used in TSPA and surface remobilization processes characteristics of the Yucca Mountain region (which includes additions and deletions to the system). (Eruptive AC-5) DOE agreed and will document its approach to include uncertainty related to surface-redistribution processes in TSPA-SR, Rev. 0. DOE will revisit the approach in TSPA-SR, Rev. 1. This documentation will be available to the NRC in June 2001. 7) Document the basis for airborne particle concentrations used in TSPA in Rev. 1 to the Input Values for External and Inhalation Radiation Exposure AMR. (Eruptive AC-5) DOE agreed and will provide documentation for the input values in the Input Parameter Values for External and Inhalation Radiation Exposure Analysis AMR [ANL-MGR-MD-000001] Rev. 1. This will be available to NRC in January 2001. 8) Provide additional justification on the reasonableness of the assumption that the inhalation of particles in the 10-100 micron range is treated as additional soil ingestion, or change the BDCFs to reflect ICRP-30. (Eruptive AC-5) DOE agreed and will review how 10-100 micron particles are considered in the model for the eruptive scenario. The results will be documented in Input Parameter Values for External and Inhalation Radiation Exposure Analysis AMR [ANL-MGR-MD-000001] Rev. 1. This will be available to the NRC in January 2001.

2 (Cont.)	Consequences of igneous activity within the repository setting.		9) Use the appropriate wind speeds for the various heights of eruption columns being modeled. (Eruptive AC-5) DOE agreed and will evaluate the wind speed data appropriate for the height of the eruptive columns being modeled. This will be documented in TSPA-SR, Rev. 1. This will be available to the NRC in June 2001.

2 (Cont.)	Consequences of igneous activity within the repository setting.		10) Document the ICNs to the Igneous Consequences AMR and the Dike Propagation AMR regarding the calculation of the number of waste packages hit by the intrusion. Include in these or other documents (1) the intermediate results of the releases from Zone 1 and 2, separately, and (2) the evaluation of thermal and mechanical effects, as well as shock, in assessing the degree of waste package damage in Zone 1 and 2. (Intrusive AC-1 to 4) DOE agreed and will provide ICN 1 of the following AMRs: Igneous Consequences Modeling for TSPA-SR AMR [ANL-WIS-MD-000017], the Dike Propagation Near Drifts AMR [ANL-WIS-MD-000015], the Characterize Framework for Igneous Activity at Yucca Mountain, Nevada AMR [ANL-MGR-GS-000001], and the Calculation Number of Waste Packages Hit by Igneous Intrusion [CAL-WIS-PA-000001]. This will be available to the NRC in January 2001. DOE will provide the results showing the relative contributions of releases from Zones 1 and 2 in TSPA-SR, Rev. 1. This will be available to the NRC in June 2001. DOE will provide the evaluation of thermal mechanical effects on waste package damage in Zones 1 and 2 in ICN 1 of the Dike Propagation Near Drifts AMR [ANL-WIS-MD-000015]. This will be available to the NRC in January 2001.

Summary Highlights of NRC/DOE Technical Exchange and Management Meeting on Unsaturated and Saturated Flow Under Isothermal Conditions

August 16-17, 2000
Berkeley, California

Introduction and Objectives

This Technical Exchange and Management meeting on Unsaturated and Saturated Flow Under Isothermal Conditions (USFIC) is one in a series of meetings related to the U.S. Nuclear Regulatory Commission (NRC) key technical issue (KTI) and sufficiency review and the U.S. Department of Energy (DOE) site recommendation decision. Consistent with NRC regulations on prelicensing consultations and a 1992 agreement with DOE, staff-level resolution can be achieved during prelicensing consultation. The purpose of issue resolution is to assure that sufficient information is available on an issue to enable the NRC to docket the license application. 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. Issue resolution at the staff level during prelicensing is achieved when the staff has no further questions or comments at a point in time regarding how the DOE is addressing an issue. Pertinent additional information could raise new questions or comments regarding a previously resolved issue.

Issues 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 initial license application. Issues are "closed-pending" if the NRC staff has confidence that the DOE proposed approach, together with the DOE agreement to provide the NRC with additional information (through specified testing, analysis, etc.) acceptably addresses the NRC's questions such that no information beyond that provided, or agreed to, will likely be required at time of initial license application. Issues 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 the license application.

The objective of this meeting is to discuss and review the progress on resolving unsaturated zone issues under the USFIC KTI (see Attachment 1 for list of subissues). The quality assurance (QA) aspect of this KTI was determined to be outside the scope of the meeting and will be tracked in NRC's ongoing review of DOE's QA program.

Summary of Meeting

At the close of the Technical Exchange and Management Meeting, the NRC staff agreed with DOE that subissue 1 and 2 are still closed. Subissue 3 is open. Subissues 4 and 6 (UZ portion) are closed-pending. Subissue 5, which relates to the saturated zone (SZ) and Subissue 6 (SZ portion) will be discussed in an upcoming KTI technical exchange and management meeting.

Specific NRC/DOE agreements made at the meeting are provided as Attachment 1. The DOE Action Plan for Net Infiltration Issues is included as Attachment 2. The DOE ongoing and planned testing synopsis (Testing and Modeling Activity Description) is provided as Attachment 3. The agenda and the attendance list are provided as Attachments 4 and 5, respectively.

Enclosure

downward since TSPA-VA, thus prompting NRC to reexamine the status of resolution. In addition to discussing the acceptance criteria DOE indicated that NRC still had questions. DOE presented its current approach to estimating shallow infiltration for present and future climate conditions (see attachment on "Estimated Shallow Infiltration..." by Joe Hevesi). NRC staff expressed concern that DOE upper-bound estimates of shallow infiltration for present and future climates may not be high enough to encompass the uncertainty inherent in the many infiltration model parameters and assumptions. NRC staff indicated that one acceptable approach would be to perform Monte Carlo analyses, similar to that performed for the glacial transition climate in the Analysis of Infiltration Uncertainty AMR (ANL-NBS-HS-000027), and base upper-bound infiltration estimates for each climate state on, for example, the upper 90th percentile. DOE staff proposed that another acceptable approach would be to provide additional model validation through an analysis of site geochemical, isotopic, and borehole temperature data. At the end of the meeting, DOE provided an Action Plan for the open net infiltration issues (See Attachment 2). The NRC stated that the subissue remains open pending its review of a DOE plan and schedule that provides additional justification that the proposed infiltration values are appropriate. This plan is to be provided during October 2000. The NRC also stated that, if the DOE approach is acceptable, this subissue will be considered as closed-pending at the November 2000 saturated zone meeting.

3) Technical Discussion of Matrix Diffusion

A summary of the current status of resolution was presented (see attachment on "Unsaturated Zone (UZ) Flow Under Isothermal Conditions" by Claudia Newbury). Currently NRC considers the subissue open and DOE proposed that the subissue should be closed "pending." There are four acceptance criteria; one of which is considered closed both in the NRC USFIC IRSR and by DOE. One acceptance criterion relates to the saturated zone and is not applicable to this meeting. The third acceptance criterion requires that if credit is taken for matrix diffusion then the transport predictions must be consistent with site geochemical and isotopic data. The fourth acceptance criterion pertains to QA and was determined to be outside the scope of the meeting and will be tracked in NRC's ongoing review of DOE's QA program. In addition to discussing the acceptance criteria DOE indicated that NRC still had three questions regarding matrix diffusion. DOE presented evidence to support its current approach to matrix diffusion (see attachment on "Matrix Diffusion" by Clifford Ho). Data from the Alcove 1 seepage experiments were presented with the conclusion that observed breakthrough of the bromide tracer was difficult to explain without assuming a relatively high rate of matrix diffusion (i.e., effective matrix diffusion coefficient of 2×10^{-9} m^2/s). It should be noted that the bromide breakthrough data available for review in the supporting AMR (MDL-NBS-HS-000006) consisted of only two data points representing the only very early part of the tracer breakthrough curve. However, Hui Hai Liu presented recent data and model results covering a two-year time period that yielded a similar conclusion. Data and model results were also presented by DOE that showed the conceptual model of matrix diffusion in the UZ is not inconsistent with observations of chloride concentration in matrix pore waters in the ESF and ECRB. DOE also presented plans for additional testing specifically designed to validate the matrix diffusion conceptual model wherein tracers will be introduced into ECRB Alcove 8 and monitored 20 m below in ESF Niche 3. NRC staff concluded that this subissue could be considered "closed, pending" if the DOE could agree to (i) provide an analysis with the Site Recommendation showing TSPA model sensitivity to matrix diffusion in the UZ, (ii) provide for NRC comment a work plan for the Alcove 8/Niche 3 study, and (iii) document results of the Alcove 8/Niche 3 study pertaining to matrix diffusion in AMR or other DOE-approved document.

4) Technical Discussion of Deep Percolation - UZ Flow and Transport Beneath the Repository

A summary of the current status of resolution was given in two presentations (see attachments on "Discussion of Deep Percolation - Seepage Into Drifts" by Joe Wang and "Discussion of Deep Percolation - Unsaturated Zone Flow" by Bo Bodvarsson). Currently NRC considers the subissue open and DOE proposed that the subissue should be closed-pending. There are six acceptance criteria; one of which is considered closed both in the NRC USFIC IRSR and by DOE. The sixth acceptance criterion pertains to QA and was determined to be outside the scope of the meeting and will be tracked in NRC's ongoing review of DOE's QA program.

Seepage Into Drifts

The DOE presented the ongoing and planned testing and modeling activities to evaluate seepage into drifts (Slide #2). In addition to discussing the acceptance criteria DOE indicated that NRC still had a number of questions in this area. The DOE then discussed the ongoing passive monitoring and active seepage characterizations. Questions by CNWRA and NRC staff focused on the east-west drift and the need for the drift to equilibrate to pre-ventilation conditions. The NRC staff indicated one reason to continue the passive monitoring, including a drip cloth, is that this approach would allow for an evaluation of the alternate conceptual model of film flow leading to dripping under low flux conditions. The next point addressed was the need to demonstrate for all niche and alcove hydraulic tests that ventilation has not biased the test results. Details on niche studies which attempt to overcome ventilation effects were discussed. The relative importance of micro-fractures on matrix porosity interpretations and concepts of flow was presented by M. Morganstern (Consultant to Nye County). The importance of measuring effects of ventilation in all testing, as is now being conducted in some tests, was mentioned by NRC staff. The use of natural analogs to support short term predictions of long-term seepage estimates was addressed. Finally, results from recent testing in the lower lithophysal unit indicate that the unit has stronger capillarity and higher permeability than middle nonlithophysal tuff. Detailed fracture surveys, where the cutoff for mapping features was 10 cm, support the measured permeability. As a result of measured hydrologic characteristics the predicted seepage threshold for the lithophysal unit is higher than in other units. The next point of discussion was evaluation of the steady-state deep percolation assumption. Information on seepage calibration models matching a sequence of pulses was offered as one line of evidence that the effects are already considered. The importance of the Paintbrush Tuff non-welded unit in damping transient effects was also offered as a line of evidence why transient effects do not need to be considered. NRC staff pointed out the importance of potential high angle fault features that intersect the unit as a way to bypass the dampening effect. In addition, preliminary results by CNWRA staff applying the approach used in the Technical Basis Document for the Viability Assessment indicated that transient effects may not be completely dampened. The next point discussed was the analysis of alternate scenarios of waste-package or drip shield wetting over the performance period. DOE indicated that alternative scenarios are being performed for the TSPA-SR. The final point of discussion was that the effect of drift collapse on seepage rates should account for the scale of asperities in drift geometry caused by rockfall. Information was provided that the effects of both rockfall and drift collapse are being evaluated. CNWRA staff stressed that the scale of those studies is not sufficiently small to address the technical concern. Scales comparable to the inverse van Genuchten alpha parameter are appropriate, so that seepage would not be under-predicted for small scale asperities. During the summary of this topic the importance of the discrepancy between the observation of secondary mineralization in lithophysal cavities at fluxes below the seepage threshold was discussed. The CNWRA staff suggested that this was evidence for the

alternate conceptual model of film flow under low flux conditions and this line of evidence of alternate approach needs to be reconciled.

Unsaturated Zone Flow

The importance of the calibrated properties model to derive parameter sensitivities and uncertainties used in modeling unsaturated flow fields was presented. The chloride and temperature calibrations were described as important constraints on infiltration rates. Perched water calibrations were addressed. The water potential data from the cross-drift was presented. Discussion of the information focused on how different conceptual models of flow (dual permeability and the active-fracture) might lead to different interpretations for matrix saturations. Additional information on the effective damping of episodic transient pulses of surface infiltration was presented and the importance of varying properties sets was discussed. The CNWRA reservations on transient events, presented in the previous discussion on the seepage, were re-iterated. Flow patterns and lateral diversion in the Calico Hills non-welded unit was the next point of discussion. The average quantity of water laterally diverted in DOE models which would then flow down faults and bypass sorptive units was presented. The average value was 50 percent for glacial transition conditions and a lower percent under current climate conditions. CNWRA staff indicated that information only on averages for the whole model was insufficient to assess the current approach. The fraction of diversion under the repository and ranges of diversion in different portions of the model was necessary for the CNWRA assessment. The amount of credit for retardation of radionuclide transport was stated to be highest for the lowest Topopah Spring unit, less for the vitric non-welded portion of the Calico Hills, and still less for the zeolitic Calico Hills unit. CNWRA staff indicated that the information on the geochemistry of perched water, and the pore water adjacent to the perched zones, was not addressed in the presentation and may not be in an analysis and model report (AMR). NRC staff stated that this information is needed to complete their assessment of DOE's approach for flow beneath the repository. The NRC staff stated that the subissue is closed-pending if the DOE would agree to the items listed in Attachment 1.

5) Update on Features, Events and Processes (FEPs).

The DOE stated that it was revising the FEPs AMR and would have it completed by December 2000. Following the FEPs AMR revision, the DOE stated that it would revise the FEPs database. The DOE also stated that it was developing a FEPs cross-walk between the UZ FEPs and the USFIC KTI.

The NRC staff stated that two specific FEPs may need to be added to the list of FEPs considered by DOE. Linda Lehman's (consultant to State of Nevada) discussion of the potential for lateral flow in the Topopah Spring tuff resulting from infiltration along the eastern side of the Solitario Canyon Fault is one FEP that should be considered. The other FEP that DOE needs to consider concerns the potential for film flow occurring under low flux rates (see item number 2 under subissue 4 in Attachment 1).

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8/17/2000

Summary of the Resolution of the Key Technical Issue on Unsaturated and Saturated Flow Under Isothermal Conditions

Subissue #	Subissue Title	Status	NRC/DOE Agreements
1	Climate Change	Closed	None
2	Hydrologic Effects of Climate Change	Closed	None
3	Present-Day Shallow Infiltration	Open	See attached DOE Action Plan for Net Infiltration Issues (Attachment 2)
4	Deep Percolation	Closed-Pending	1) The on-going and planned testing (see Attachment 3) are a reasonable approach for a licensing application with the following comments: a. For Alcove 8, Niche 3, consider a mass balance of water. b. Monitor evaporation during all testing. c. Provide testing plans and consider NRC comments, if any. 2) 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. 3) When conducting seepage studies, consider smaller scale tunnel irregularities in drift collapse or justify that it is not needed. 4) Provide final documentation for the effectiveness of the PTn to dampen episodic flow, including reconciling the differences in chloride-36 studies. 5) Provide the analysis of geochemical data used for support of the flow field below the repository.

Attachment 1

5	Saturated Zone Ambient Flow Conditions and Dilution Processes	Open - See Note 1	TBD - See Note 1
6	Matrix Diffusion (UZ)	Closed-Pending	1) The DOE will provide the final sensitivity analysis on matrix diffusion in the TSPA-SR, Rev. 0. Due Date: December 2000 2) The DOE will provide the final detailed testing plan for Alcove 8. The testing plan will be provided by August 28, 2000. The NRC staff will provide comments if any no later than two weeks after receiving the testing plan. 3) The DOE will complete the Alcove 8 testing, taking into consideration the NRC staff comments if any, and document the results in a DOE-approved AMR, due date: May 2001.
	Matrix Diffusion (SZ) See Note 1	Open - See Note 1	TBD - See Note 1

Note 1 - Saturate Zone Ambient Flow Conditions and Dilution Processes (Subissues 5 & 6) were not addressed at this meeting and will be addressed in a future meeting.

ATTACHMENT 2

DOE Action Plan
for
Net Infiltration Issues

Issue:
NRC considers the Modern Climate infiltration upper bound values to be lower than should be expected when considering both data and model uncertainty. The CNRWA provided an extensive discussion of specific and general considerations that were believed to be insufficiently treated in the DOE analysis.

NRC advised that DOE should either:

1. Provide additional justification that the DOE proposed values are appropriate when considering the NRC & CNRWA comments, or

2. Provide revised upper bound values with appropriate justification that would address the NRC's concerns (e.g. perform Monte Carlo simulations using modern climate to determine uncertainty distribution and appropriateness of the upper bound infiltration map).

Proposed DOE Actions:

1. DOE intends to consider the NRC & CNRWA written comments and provide additional justification that the proposed infiltration values are appropriate.

   a) DOE will evaluate the specific NRC comments from the 8-16-00 Technical Exchange session and provide a response to those comments and plan for further activities, if needed.

   b) DOE will review the Modern Day infiltration distribution to affirm the reasonableness of the upper bound infiltration map. If needed for the LA licensing case, any necessary adjustments will be addressed as part of the TSPA-LA.

   c) The plan and schedule will be provided to NRC for review of its scope during October 2000.

2. DOE will schedule an interaction with NRC to present the results of the evaluation by ~~April 1~~ March 1, 2001.

ATTACHMENT #3

Testing and Modeling Activity Description

Niche 4

Conduct seepage threshold tests in an extensively fractured zone in the southern part of the ESF main drift under high humidity conditions. The seepage calibration model based on Niche 2 data will be evaluated against Niche 4 data. Both niches are in the middle nonlithophysal zone with different fracture characteristics and in humidity operation conditions.

Niche 5

Conduct at a lower lithophysal tuff site with abundant cavities the air-injection tests to characterize heterogeneity, seepage tests to determine threshold, fracture-matrix tests to determine flux partitioning, and long term tests to evaluate seepage diversion around drift, under humidity conditions. Modify seepage calibration models to account for different capillarity and permeability distributions in lower lithophysal tuff from the model developed for middle nonlithophysal tuff unit.

Systematic Hydrologic Characterization

Use slant boreholes drilled into the crown, and borehole clusters localized systematically (~ one slant borehole every 30 m) along the cross drift to conduct air injection, effective porosity and seepage tests. Determine systematically the spatial variability of hydrological properties in different tuff units, focused initially on lower lithophysal sections, and extended to the other tuffs.

Alcove 1

Analyze the large-scale, multi-year infiltration test results for flow through fractured Tiva Canyon tuff, seepage into Alcove 1, and matrix diffusion along fracture flow paths. Calibrate large scale unsaturated model for the large potential impact of matrix diffusion on transport.

Alcove 8 – Niche 3

Conduct first a localized liquid release test along a fault, to be followed by liquid release test in a 3 x m plot at Alcove 8, located along the Cross Drift directly above Niche 3 in the ESF Main Drift. Monitor plume migration with geophysical imaging technique. Detect wetting front arrivals and seepage at Niche 3 under controlled humidity conditions. Use combination of tracers to evaluate matrix imbibition and matrix diffusion and migration processes between the drifts.

Sealed Cross Drift

Monitor relative humidity, temperature, formation water potentials and drips in sealed drift segments, currently isolated by 3 bulkheads to maintain ventilation-free conditions, including segments with Solitario Canyon fault, below high-infiltration zones, and lower nonlithophysal tuff unit. Compare with Cross Drift seepage predictions.

Alcove 7

Monitor relative humidity, temperature, formation water potentials, and drips in sealed drift segments behind two bulkheads around the Ghost Dance fault. Compare with Cross Drift seepage predictions.

Calcite Filling

Use seepage models developed from niche short term tests to cavities with smaller dimensions. Provide plausible interpretations of the observed calcite deposits mostly at the bottom of the cavities, from accumulation of millions of years.

Modeling Studies

Comparison of Continuum and Discrete Fracture Network Models

Discrete fracture network models are used to simulate seepage into drift and other relevant drift-scale flow and transport processes. Compare results from both modeling approaches on seepage thresholds and other measures.

THC Coupled Model

THC models are used to evaluate thermal-hydrological-chemical processes and their effects on UZ flow and transport, including seepage water chemistry, gas-phase composition and potential change in rock properties from mineral precipitation.

THM Coupled Model

THM models are used to investigate effects of thermal-hydrological-mechanical process on UZ flow and transport, including change in fracture properties and its effect on seepage into drift.

Natural Analogs

Apply conceptual models and numerical approaches developed for Yucca Mountain to natural analog sites with observations of seepage into drifts, drift stability, radionuclide transport, geothermal effects, and preservation of artifacts. Develop confidence in the feasibility of emplacement wastes in underground setting over geological time scales.

Unsaturated and Saturated Flow Under Isothermal Conditions
(Unsaturated Zone Process Model Report)

Wednesday, August 16, 2000

8:00 a.m.	Introduction/Opening Remarks (DOE/NRC) Purpose of the interaction
8:20 a.m.	Key Technical Issue for Unsaturated and Saturated Flow Under Isothermal Conditions -- Identification of issues within the key technical issue that are closed and issues within the KTI that are being proposed as closed - pending confirmatory actions (DOE)
8:40 a.m.	Technical Discussion of Climate Change and Hydrologic Effects of Climate Change DOE Status -- Issue Closure
9:10 a.m.	NRC Comments
9:20 a.m.	Discussion
9:30 a.m.	Caucus
9:40 a.m.	DOE/NRC Closing Comments
9:50 a.m.	Technical Discussion of Present-day Shallow Infiltration DOE status and proposed path forward for issue closure
10:40 a.m.	NRC Comments
10:55 a.m.	Discussion
11:30 a.m.	Caucus
12:00 p.m.	DOE/NRC Closing Comments
12:15 p.m.	Lunch
1:45 p.m.	Technical Discussion of Matrix Diffusion DOE status and proposed path forward for issue closure
2:35 p.m.	NRC Comments
2:50 p.m.	Discussion
3:25 p.m.	Caucus
4:00 p.m.	Closing Comments by DOE, NRC, and others
4:30 p.m.	Adjourn

Unsaturated and Saturated Flow Under Isotherm... Conditions
(Unsaturated Zone Process Model Report)

Thursday, August 17, 2000

8:00 a.m.	Technical Discussion of Deep Percolation - Seepage into Drifts DOE status and proposed path forward for issue closure
9:00 a.m.	NRC Comments
9:15 a.m.	Discussion
10:00 a.m.	Caucus
10:30 a.m.	Technical Discussion of Deep Percolation - UZ Flow and Transport beneath the Repository DOE status and proposed path forward for issue closure
11:50 a.m.	NRC Comments
12:05 p.m.	Lunch
1:15 p.m.	Discussion
2:20 p.m.	Caucus
2:50 p.m.	DOE/NRC Closing Comments on Deep Percolation
3:20 p.m.	Closing Discussion of the Key Technical Issue and Status and Treatment of Features, Events, and Processes
4:30 p.m.	Closing remarks by other attendees
4:45 p.m.	Adjourn

UNSATURATED AND SATURATED FLOW UNDER ISOTHERMAL CONDITIONS
TECHNICAL EXCHANGE AND MANAGEMENT MEETING
AUGUST 16-17, 2000
BERKELEY, CALIFORNIA

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NRC/DOE Technical Exchange on Yucca Mountain Pre-Licensing Issues
Las Vegas, Nevada
April 25-26, 2000

The U.S. Nuclear Regulatory Commission (NRC) and the U.S. Department of Energy (DOE) held a technical exchange on April 25-26, 2000, at the Yucca Mountain Site Characterization Project (YMP) office in Las Vegas, Nevada. The purpose of this meeting was to review Key Technical Issue (KTI) status, discuss and identify the path forward for resolution of subissues at the staff level, and discuss the objective of the NRC sufficiency review of the DOE Site Recommendation.

The attendee list is attached. Also attached are the agenda and the briefing materials presented at the meeting. Below is the summary of the most important points and discussions from the meeting.

APRIL 25, 2000

W. Reamer (NRC) presented a summary of the NRC strategy for resolving KTIs. Mr. Reamer stated that the NRC goal is to develop the schedule for KTI resolution by September 2000 and resolution of issues before DOE submits any License Application (LA). He added that DOE must comply with proposed 10 CFR 63, but alternatives to strict compliance may be presented by DOE. The alternatives would be considered as a means for meeting the regulation. Mr. Reamer also indicated that the NRC plans to complete the Yucca Mountain Review Plan by September 2000, and will tailor it to focus staff review. Mr. Reamer emphasized the importance of maintaining schedule and that the NRC would take a risk-informed approach to the safety review.

S. Brocoum (DOE) presented the DOE process for completing the Site Recommendation Consideration Report. Dr. Brocoum pointed out that the Process Model Reports (PMRs) would be revised only if the Total System Performance Assessment (TSPA) results changed significantly as a result of a change to the process models described in the respective PMRs; otherwise Interim Change Notices (ICNs) would be issued. Dr. Brocoum indicated that the DOE would revise the AMRs to incorporate ICNs to support the LA. Dr. Brocoum stated that the target date for submitting the TSPA-Site Recommendation (TSPA-SR) to the NRC is June 1, 2000. Dr. Brocoum stated that the Analysis and Model Reports (AMRs), the PMRs, and the System Description Documents (SDDs) form the foundation for the DOE safety case.

J. Bailey (M&O) presented the status of the Repository Safety Strategy (RSS). Mr. Bailey pointed out that the waste package (WP) design is the principal contributor with regard to overall repository system performance. D. Brooks (NRC) stated that the AMRs were not discussed and that they form the basis for the PMRs. A representative of the CNWRA also commented that a sufficient technical basis for removal of issues from consideration has not yet been developed.

Total System Performance Assessment and Integration (TSPAI)

J. Firth (NRC) presented the status of the TSPAI KTI from the NRC perspective. Mr. Firth placed emphasis on the importance of the transparency and traceability of data sources to the analysis results. He stated that the NRC should be able to go up or down the hierarchy of information such that the linkages between various levels of information are clear and traceable. He added that the TSPA-Viability Assessment (TSPA-VA) was lacking in this regard. Mr. Firth emphasized the importance of ensuring that the features, events, and processes (FEPs) list is complete and that the process for screening FEPs out was sound. He stated further that the potential for underestimating the effects based on the elimination of a FEP should not result in overestimating the performance capability of the repository. He added that the NRC needed to gain an understanding of the process for identifying FEPs and that the DOE's basis for concluding the model is acceptable for event screening.

A. Van Luik (DOE) indicated that Revision 2 of the TSPAI issue resolution status report (IRSR) should be available by June 1, 2000. Mr. Van Luik presented an example of traceability of data back to the source in the GoldSim software package. The NRC participants indicated that they were very interested in obtaining the GoldSim software for use in their review.

Unsaturated and Saturated Flow under Isothermal Conditions

N. Coleman (NRC) presented the status of this KTI. Mr. Coleman stated that the data from drill holes NC-EWDP-22S, NC-EWDP-23S, and NC-EWDP-4PA/PB are key in resolving this issue. He pointed out that seepage testing in sealed-off portions of the East-West drift has been affected by alteration of the natural environment due to heating from lights and a power transformer on the tunnel boring machine. DOE needs to measure heat and mass losses through the bulkhead in the drift-scale test to adequately characterize the thermal effects. Mr. Coleman pointed out that about 5 percent of the repository footprint underlying Solitario Canyon has no PTn cover (Paintbrush non-welded tuff), so this area could be exposed to additional percolation without the damping effect of the PTn, resulting in accelerated chemical interaction with the waste package (WP). He also suggested that the presence of calcite in the bottom of lithophysal cavities needs to be explained if no seepage is assumed, and he added that chlorine-36 data suggest seepage. The use of carbon-14 dating of organic carbon in groundwater (method of J. Thomas, USGS/Carson City) should be considered.

R. Patterson (DOE) explained the measures that were being taken to restore a more natural environment to the sealed-off section of the test drift. He added that drip cloths will also be installed.

In response to a question from the State of Nevada (L. Lehman), DOE indicated that temperature measurements are not required to determine thermal conductivity values, as the thermal conductivities for the materials in question can be obtained in existing literature. DOE stated that they would consider using temperature data from drill holes as a tracer.

Container Life and Source Term

T. Ahn (NRC) presented NRC's status on this KTI. He discussed the need for the NRC to have detailed information on the materials being used for construction and the manufacturing techniques that will be used to fabricate the drip shield and the waste packages. He stated that the NRC is not yet convinced that the DOE has adequately evaluated the effects of in-package criticality on waste package and engineered barrier performance.

P. Russell (DOE) discussed the projected failure rates of the waste package. The values of 10^{-4} vs. 10^{-3} are in question based on NRC feedback. Further discussion is needed to determine acceptable technical basis for any failure rate. Ms. Russell pointed out that an issue regarding verification of fuel burnup had been raised in the past, and that NRC has agreed to consider DOE's proposal for use of a statistically accurate random sampling if possible.

In response to a question from Clark County (E. Tiesenhausen) DOE indicated that J-13 water is representative of water that may seep into the emplacement drifts. However, they have considered a wide range of chemistry in performing the analysis.

Evolution of the Near-Field Environment

B. Leslie (NRC) presented the NRC status on this KTI. Four of the five subissues for this KTI remain open. Mr. Leslie continued to emphasize the need for DOE to provide the NRC with a sound technical basis for excluded FEPs (15–20 percent still require additional basis). A key point was the concern that the neglect of some THC processes will result in underestimating dose. NRC needs to understand the disparity in pH values, predicted 7, measured fluids 4, and why use of an incorrect value may result in overestimating repository performance (underestimate negative effects of process on system performance). With regard to THC modeling there is a concern as to whether kinetics had been factored into the modeling. NRC needs to understand how the THC processes can be decoupled, evaluated separately, then relinked.

D. Barr (DOE) presented DOE's perspective on this KTI. Based on the NRCs questions, she stated that adequate assessment and evaluation of the drift environment are considered essential for putting together a sound safety case for the repository. The NRC is focused on these analyses, and would like to receive more detail regarding the methodologies used to evaluate the analysis of the drift conditions and the effects drift conditions have on the WP over time.

APRIL 26, 2000

Repository Design and Thermal-Mechanical Effects

M. Nataraja (NRC) presented NRC's status on this KTI. Subissue 1 is closed; Subissues 2 and 4 are closed pending confirmatory information. NRC will be evaluating the DOE implementation of the design control process (Subissue 1) through audit observations and will reopen the related subissue, if needed. Dr. Nataraja suggested the need for more input data that are consistent with the seismic design methodology and the PA methodology (Subissue 2). He expressed concern that STR-3 was not scheduled to be completed until November 2001, perhaps too late to support review in time for LA approval, and that options other than the topical report approach are available. He stated that Seismic Topical Report-3 (STR-3) should discuss inputs to the PA in addition to the design. He expressed the need for additional data and analysis related to the thermal-mechanical (TM) effects on the underground facility design/performance (Subissue 3). Consideration of TM effects in estimating quantities of seepage and dripping characteristics into emplacement drifts must be well integrated in the KTI assessment. In closing Subissue 4, he indicated that NRC will review the topic of seal design in the overall context of the repository performance.

P. Harrington (DOE) stated that the DOE has addressed the one concern related to design control (Subissue 1) identified in the IRSR. The DOE has investigated the extent of the problem, issued lessons learned, performed a self-assessment, provided to the NRC the status of subissue resolution in recent DOE comment letters on the IRSRs, and closed the associated deficiency report. Mr. Harrington discussed the divergence of opinion between the NRC and the DOE concerning the predicted rock mass friction angles used as input to predicting rockfall. He indicated that the NRC and DOE approach to assessing rock mass friction angle was the same. However, the stress ranges were different. NRC's S. Hsiung expressed the opinion that DOE has neglected the degradation of strength (50–70 percent) with time under elevated temperatures.

Mr. Harrington addressed a concern from the November 1999 Appendix 7 meeting during which NRC expressed a concern about additional dynamic analyses to validate the existing approach. He indicated that DOE has performed a new calculation, currently under review, which includes revised block sizes based on new emplacement drift alignment and excluding backfill. Planning is in progress for performing a revised drift degradation analysis to include the current drift alignment, exclusion of backfill, and consideration of additional dynamic analyses for seismic effects on rockfall. He noted that the seismic cases analyzed did not produce a significantly greater expected number of key blocks per drift unit length over the static case. He also indicated that the DOE and NRC do not agree on the need for repository-scale modeling, as discussed in the IRSR. He stated that this issue is a good candidate for upcoming Appendix 7 meetings.

Mr. Harrington noted that the NRC has not yet included acceptance criteria for seals in its IRSR. Based on work completed to date, he indicated that no factors associated with this issued have been demonstrated to be important to waste isolation in the RSS. The seals have been classified CQ (Conventional Quality) and are not subject to the Quality Assurance (QA) program, but this classification is exclusively based on considerations of moisture infiltration. Work is continuing regarding evaluation of other aspects of seal performance.

Thermal Effects On Flow

J. Pohle presented the status of resolution of the Thermal Effects on Flow (TEF) KTI. He indicated that the three subissues currently remain open.

Generally, Mr. Pohle indicated that the DOE is focusing on the identified principal factors, while the NRC is focusing on why issues become "downgraded" from the principal factors. He indicated further that a key NRC interest is understanding the background and basis for identification of those processes that could have an impact on seepage, those that don't, and the corresponding justification. He stated that it appears to be a design objective to control water flow and send the flow down the pillars. He stated that the NRC needed to know if the analysis is considering heat and orientation of the drifts, effects of fractures, etc., and how these characteristics might be coupled to impact flow. T. McCartin (NRC) added that the NRC wanted to ensure that the interactions between these characteristics are adequately understood and addressed in the waste package corrosion performance analysis.

D. Barr (DOE) summarized, from a DOE perspective, the three subissues associated with TEF, and she described recent and near-term future key activities. She indicated that there were several areas of disagreement between the DOE and the NRC that require resolution. She said that a number of NRC requirements appear to be more prescriptive than DOE's understanding of the intent of proposed 10 CFR 63, which provides performance-based acceptance criteria. She stated further that some of the acceptance criteria inappropriately call for conservatism. Finally, she indicated that DOE does not consider it necessary to directly measure all heat and mass loss through the bulkhead in the drift scale test to adequately characterize the thermal effects.

Radionuclide Transport

J. Bradbury described and provided the status of the four subissues associated with radionuclide transport (RT) KTI. For RT through fractured rock, he indicated that the model was acceptable for the $K_d = 0$ approach. However, the NRC needed additional information concerning effective porosity, demonstration that the $K_d = 0$ doesn't underestimate dose, and justification of the length of the pathway to which these fracture transport conditions apply.

J. Houseworth (M&O) indicated that for Subissues 1-3, the focus was on one acceptance criterion. He discussed areas of potential disagreement between the NRC and DOE, as discussed in a March 22, 2000, letter from S. Brocoum to B. Reamer. These included DOE's position that homogeneity of porous rock and alluvium only needs to be demonstrated at the level assumed in the models. Regarding the concern that "bounding" future water chemistry cannot be identified, "reasonable" future water chemistry should be adequate.

Igneous Activity

J. Trapp stated that the two Subissues, "Probability of Igneous Activity" and "Consequence of Igneous Activity," remain open. Mr. Trapp pointed out that there are several differences between the DOE assessment of the Yucca Mountain region and the NRC assessment of the region. He emphasized the need to meet and discuss these issues at the technical level to obtain resolution.

E. Smistad summarized, from DOE's perspective, the current status of resolution of this KTI, and he described recent and future key activities. He indicated that estimates of volcanic hazard were determined based on expert elicitation results as described in the Probabilistic Volcanic Hazard Analysis (PVHA) report, and the probability (estimated at 1.6×10^{-8}) is given in the TSPA-SR. He stated further that DOE's position is that definitions of igneous events are used consistently and that probabilities of intrusive and extrusive events should be estimated separately. Documentation of these analyses will be presented in the asssociated AMRs and PMRs.

Smistad indicated that it is also DOE's position that a full range of annual frequencies of igneous intersection should be used in lieu of a single value preferred by the NRC. DOE believes that use of a single value is overly conservative and does not represent the appropriate range of interpretations and uncertainties. He added that the analyses in the AMRs should be responsive to NRC's remaining concerns concerning the consequences of igneous activity.

Structural Deformation and Seismicity (SDS)

D. Ferrill presented the NRC's position on this KTI. He stated that the objective of this issue is to ensure that the seismotectonics FEPs that may significantly affect repository design or performance are adequately identified and characterized, sufficiently understood and considered, and consistently used to assess design and performance.

T. Sullivan (DOE) presented the DOE's position on the SDS KTI. He summarized the related issues and described the key activities performed recently and planned for the near future.

Closing Remarks

W. Reamer provided the NRC's closing remarks. He stressed the need for organizational focus, at both the management and technical levels, on NRC open issues. He stated that it would be beneficial if DOE assisted NRC in locating the sources of technical analyses and data to support NRC's informational needs. Timely NRC access to the preliminary AMRs will foster timely resolution of the KTIs at the staff level. Prompt transmittal of design changes to NRC will enhance effective coordination with DOE and allow NRC to properly focus resources. He expressed the need to obtain a copy of the GoldSim code to support its review of the SRCR and the LA.

Mr. Reamer also indicated that NRC and DOE should be actively looking for strategies to foster issue resolution in concert with the SR work. For example, for issues closed, pending further information or review, he encouraged aggressive pursuit of complete closure. He added that, when DOE has ruled out a FEP from further consideration, DOE needs to clearly understand that the NRC has to have sufficient technical basis in order to close out the issue.

He stated that the KTI tables in the DOE presentations were beneficial. That information, coupled with the discussions, has enabled NRC to close (pending receipt of information) seven subissues as an outcome of the meeting. These include four subissues (mechanical failure, rate of release/spent fuel, rate of release/glass and alternative designs identified) under the Container Life and Source Term KTI. The other three subissues identified under Repository Design and Thermal-Mechanical effects KTI are design control process, design for seismic/fault disruption, and design of repository seals.

As part of a risk-informed, performance-based approach, NRC can suggest how to resolve issues, but the ultimate responsibility rests with DOE. DOE needs to provide sufficient information for NRC to perform its review and evaluation of the LA and prelicensing documents.

A. Brownstein (DOE) provided closing remarks for the DOE. He indicated that he felt significant progress had been made in the last two days and was pleased with the apparent agreement between DOE's work plans and NRC's expectations. He added that he believes licensing in a risk-informed means will be an efficient way of doing business. However, he indicated that it is critical that expectations for licensing do not become de facto requirements for SR.

Mr. Greeves concluded by stating that receipt of AMRs/PMRs is crucial to of NRC completing its review, and also requested DOE to expedite transmittal of the GoldSim code.

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