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 Aclosed@ 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 Aclosed-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 Aopen@ 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.

Summary of Meeting

At the close of the Technical Exchange and Management Meeting, the NRC staff stated that Subissues 1, 2, 3, and 4 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 ENFE subissues (see "Evolution of the Near Field Environment" presentation given by Deborah Barr). In the ENFE Issue Resolution Status Report (IRSR), Revision 3, the NRC stated that ENFE Subissues 1, 2, 3, and 4 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, 3, and 4 as "closed-pending." The DOE presented several viewgraphs which provided a road map identifying which DOE presentations address each NRC comment. The NRC inquired about two of the items listed. First, the NRC staff asked when the TOUGHREACT executable will be available; the DOE stated it would provide that information at a later time (see Agreement 1 of Subissue 4). Second, the NRC asked for some discussion during this meeting of retardation and matrix diffusion parameters under thermal-hydrologic-chemical (THC) conditions.

2) Total System Performance Assessment

NRC Comments Related to TSPA Treatment of Engineered Barrier System Chemical Environments

The DOE gave an overview of the TSPA model treatment of the engineered barrier system (EBS) chemical environment, with reference to NRC comments from Revision 3 of the ENFE IRSR and subsequent telephone discussions emphasizing how couplings are taken into account. Seepage water and gas compositions are calculated using the drift-scale THC seepage model for four periods during repository thermal evolution. The NRC expressed particular interest in how parameter uncertainties are propagated through the models. The DOE responded by addressing hydrologic parameter uncertainties and conceptual model uncertainties and indicated their belief that uncertainty propagation would have insignificant effects on model results. The NRC stated that it was not convinced that uncertainty propagation will have insignificant effects on model results. The DOE stated that this issue will be touched on in subsequent presentations. The presentation then addressed a comment from ENFE IRSR, Rev. 3 concerning the lack of coupling among several process models involving the chemical environment. The DOE responded by describing integration of many models, such as gas flux/composition and precipitates/salts, with THC abstractions. The DOE considers that model integration/coupling will be sufficient for describing the model EBS chemical environment, taking into account completed and ongoing work. The NRC asked for the 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^{o}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.

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