OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS REVIEW OF THE U.S. DEPARTMENT OF ENERGY KEY TECHNICAL ISSUES AGREEMENT RESPONSE TO TOTAL SYSTEM PERFORMANCE ASSESSMENT AND INTEGRATION (TSPAI).1.02, 3.37, 3.38 ADDITIONAL INFORMATION NEEDED (AIN)-1, 3.39 AIN-1, 3.41 AIN-1, 4.01 AIN-1, 4.03, 4.04, 4.06 AND COMMENTS 78, 96, 111, and 120 OF GENERAL (GEN) AGREEMENT GEN.1.01, FOR A POTENTIAL GEOLOGIC REPOSITORY AT YUCCA MOUNTAIN, NEVADA

1.0 INTRODUCTION

By letter dated August 31, 2004, the U.S. Department of Energy (DOE) submitted a letter with five enclosures to satisfy the informational needs of numerous key technical issue (KTI) agreement items pertaining to the barrier capability and various aspects of the total system performance assessment (TSPA) models, including model stability, model and parameter uncertainty, and model confidence. The letter and enclosures respond to issues raised, and information requested, by the U.S. Nuclear Regulatory Commission (NRC) related to the TSPA for the potential repository at Yucca Mountain, Nevada. In addition, DOE provided a response to General (GEN) Agreement GEN.1.01 Comment 120, which addressed parameter uncertainty, in an enclosure to a letter dated December 9, 2003. All the information was requested by NRC during technical exchanges in August 2001 and September 2001 and in subsequent letters, including additional information needed (AIN) request letters. Specific agreements and AIN addressed in this NRC review of the information provided by DOE in the letter and five enclosures include total system performance assessment and integration (TSPAI) agreements TSPAI.1.02 (Reamer, 2001a), TSPAI.3.37 (Reamer, 2001a; Schlueter, 2003a), TSPAI.3.38 (Reamer, 2001a; Schlueter, 2002), TSPAI.3.39 (Reamer, 2001a; Schlueter, 2002), TSPAI.3.41 (Reamer, 2001a; Schlueter, 2002), TSPAI.4.01 (Reamer, 2001a; Schlueter, 2002), TSPAI.4.03 (Reamer, 2001a; Schlueter, 2003b), TSPAI.4.04 (Reamer, 2001a), TSPAI.4.06 (Reamer, 2001a), and Comments 78, 96, and 111 of GEN.1.01 (Reamer, 2001b). This NRC review also addresses the information provided in response to GEN.1.01 Comment 120 (Reamer, 2001b).

2.0 AGREEMENTS

Wordings of the agreements, AIN associated with the agreements, and the GEN.1.01 comments are provided next.

TSPAI.1.02

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

of the barriers; (4) independent and interdependent capabilities of the barriers (e.g., including a differentiation of the capabilities of barriers performing similar functions); and (5) barrier effectiveness with regard to individual radionuclides. DOE will also analyze and document barrier capabilities, in light of existing data and analyses of the performance of the repository system. The information will be documented in TSPA for any potential license application expected to be available in FY 2003."

TSPAI.3.37

"Provide a quantitative analysis that the sampling method including the correlations to Np [Neptunium] used by the TSPA code to abstract the GENII-S process model code adequately represent the uncertainty and variability and correlations for the biosphere process model (DOSE3.4.1). DOE will provide a quantitative analysis that the sampling method including the correlations between BDCFs [Biosphere Dose Conversion Factors] utilized by the TSPA code to abstract the GENII-S process model data adequately represent the uncertainty and variability and correlations for the biosphere process model. This will be documented in Nominal Performance Biosphere Dose Conversion Factor Analysis AMR (ANLMGR-MD-000009), Disruptive Event Biosphere Dose Conversion Factor Analysis (ANL-MGR-MD-000003) or other document expected to be available to NRC in FY 2003. Results of these analyses will be documented in the TSPA for any potential license application expected to be available to NRC in FY 2003."

TSPAI.3.37 additional considerations

"DOE should consider the following as they develop their justification for their approach to uncertainty and variability for the biosphere:

1. Any selected approach by DOE should be consistent with the overall approach to uncertainty and variability used for the compliance demonstration (i.e., their "Guidelines for Developing and Documenting Alternative Conceptual Models, Model Abstractions, and Parameter Uncertainty in the Total System Performance Assessment for the License Application").

2. A quantitative analysis should be used to support the justification of the selected approach. Possible quantitative analyses could include: (1) comparing the expected doses calculated from the biosphere dose conversion factors from the original stochastic modeling with the expected doses from the selected approach; or (2) ancillary analyses showing stability in the mean dose to support the claim that the DOE is using a sufficiently large number of samples. If theoretical arguments are used, sufficient information should be provided to show the theoretical basis holds for the approach to be used in the TSPA-LA.

3. DOE asserts that the TSPA-SR approach is conservative, because the approach results in an increased variance of the calculated dose distribution. Because compliance with the postclosure public health and environmental standards is based on the mean of the distribution of projected doses (see 10 CFR 63.303), the claim that the approach is conservative as a consequence of this increased variance does not appear to be sufficiently justified. For example, the response demonstrates that the sampling approach does not affect the mean of the dose distribution if enough samples are taken, so the approach would not be conservative with respect to the mean."

TSPAI.3.38

"DOE will develop guidance in the model abstraction process that can be adhered to by all model developers so that: (1) the abstraction process; (2) the selection of conservatism in components; and (3) representation of uncertainty are systematic across the TSPA model. DOE will evaluate and define approaches to deal with: (1) evaluating non-linear models as to what their most conservative settings may be if conservatism is being used to address uncertainty; and (2) trying to utilize human intuition in a complex system. In addition, DOE will consider adding these items to the internal/external reviewer's checklists to ensure proper implementation of the improved methodology (TSPA0002)[1]. DOE will develop written guidance in the model abstraction process for model developers so that: (1) the abstraction process; (2) the selection of conservatism in components; and (3) representation of uncertainty, are systematic across the TSPA model. These guidelines will address: (1) evaluation of non-linear models when conservatism is being utilized to address uncertainty; and (2) utilization of decisions based on technical judgement in a complex system. These guidelines will be developed, implemented, and be made available to the NRC in FY 2002."

TSPAI.3.38 AIN-1

"DOE should provide a description of the approach used to evaluate the appropriateness of technical-judgment-based conservative selections, with respect to complex and non-linear models, and how the resulting decisions would be documented."

TSPAI.3.39

"In future performance assessments, DOE should document the simplifications used for abstractions per TSPAI.3.38 activities. Justification will be provided to show that the simplifications appropriately represent the necessary processes and appropriately propagate process model uncertainties. Comparisons of output from process models to performance assessment abstractions will be provided, with the level of detail in the comparisons commensurate with any reduction in propagated uncertainty and the risk significance of the model (TSPA0003)[2]. DOE will document the simplifications utilized for abstractions per TSPAI.3.38 activities for all future performance assessments. Justification will be provided to show that the simplifications appropriately represent the necessary processes and appropriately propagate process model uncertainties. Comparisons of output from process models to performance assessment abstractions will be provided, with the level of detail in the

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1 TSPA0002 refers to Total System Performance Assessment and Integration, Subissue 3, Methodology of Model Abstraction (Bechtel SAIC Company, LLC, 2001a, p. MA-135). This item addresses the NRC's concern regarding the use of appropriate methodology for model abstraction simplifications and selection of conservative parameter distributions, conceptual models, or modeling approaches.

2 TSPA0003 in this agreement refers to Total System Performance Assessment and Integration, Subissue 3, Model Abstraction Simplification (Bechtel SAIC Company, LLC, 2001a, p. MA-141). This item addresses the NRC's concern regarding the basis for model abstraction simplifications.

comparisons commensurate with any reduction in propagated uncertainty and the risk significance of the model. The documentation of the information will be provided in abstraction AMRs in FY 2003."

TSPAI.3.39 AIN-1

"The information requested in TSPAI Agreement 3.39 needs to be addressed."

TSPAI.3.41

"To provide support for the mathematical representation of data uncertainty in the TSPA, the DOE will provide technical basis for the data distributions used in the TSPA. An example of how this may be accomplished is the representation on a figure or chart of the data plotted as an empirical distribution and the probability distribution assigned to fit these data. DOE will provide the technical basis for the data distributions utilized in the TSPA to provide support for the mathematical representation of data uncertainty in the TSPA. The documentation of the technical basis will be incorporated in documentation associated with TSPA for any potential license application. The documentation is expected to be available to NRC in FY 2003."

TSPAI.3.41 AIN-1

"In addition to the information that DOE has already acknowledged that it needs to provide in response to this agreement (i.e., documentation, justification, and comparisons that are to be provided in the model reports), the following information is needed from DOE.

1. Justification that the DOE's use of the information entropy approach is appropriate, when used to develop the expected annual dose to the reasonably maximally exposed individual and demonstration of compliance with the groundwater concentration limits should be provided.

2. The approach that DOE will use to address variability, specifically, the lumping (smoothing) of variability, when parameters are defined, should be provided."

TSPAI.4.01

"DOE will document the methodology that will be used to incorporate alternative conceptual models into the performance assessment. The methodology will ensure that the representation of alternative conceptual models in the TSPA does not result in an underestimation of risk. DOE will document the guidance given to process-level experts for the treatment of alternative models. The implementation of the methodology will be sufficient to allow a clear understanding of the potential effect of alternative conceptual models and their associated uncertainties on the performance assessment. The methodology will be documented in the TSPA-LA methods and assumptions document in FY02. The results will be documented in the appropriate AMRs or the TSPA for any potential license application in FY 2003."

TSPAI.4.01 AIN-1

"In addition to the information that DOE has already acknowledged that it needs to provide in response to this agreement (i.e., the documentation that is to be provided in the respective model reports), the following information is needed from DOE.

1. Clarification of DOE's use of reasonableness (see, for example, page 13 of the Guidelines) and/or additional justification for the criteria that alternative conceptual model must be "reasonable" as used in Regulatory Guide 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," should be provided.

2. Clarification of how DOE intends to apply its criterion on consistency with available data and scientific understanding. If the absence of validation information (e.g., data) is used to reject an alternative conceptual model, this approach and subsequent decisions where this is done should be documented and justified.

3. Clarification of DOE's approach to documenting the effects of alternative conceptual models and how it will be sufficient to allow a clear understanding of the potential effects of alternative conceptual models and their uncertainty on the performance assessment. This clarification should include DOE's approach to presenting dis-aggregated results of alternative conceptual models.

4. Clarification of how DOE's approach — which, according to the Guidelines, involves weighting alternative conceptual models — will avoid underestimating the risk when the results are presented.

5. Clarification of its approach to using sensitive or key parameters from previous analyses when evaluating potential future alternative conceptual models. If DOE intends to use a threshold for discriminating these parameters from others, this should be expressed.

6. Clarification of the guidance that will be given to the model developers that would provide consistency in the development of model validation criteria, such that the representation of uncertainty is systematic throughout the performance assessment."

TSPAI.4.03

"DOE will document the method that will be used to demonstrate that the overall results of the TSPA are stable. DOE will provide documentation that submodels (including submodels used to develop input parameters and transfer functions) are also numerically stable. DOE will address in the method the stability of the results with respect to the number of realizations. DOE will describe in the method the statistical measures that will be used to support the argument of stability. The method will be documented in TSPA LA Methods and Assumptions Document in FY02. The results of the analyses will be provided in the TSPA (or other appropriate documentation) for any potential license application in FY 2003."

TSPAI.4.03 AIN-1

"In addition to the information that DOE has already acknowledged that it needs to provide in response to this agreement — i.e., the results of the analyses (used to demonstrate stability), which are to be provided in the TSPA to support the potential LA (or any other appropriate documentation) — the following information is needed from DOE.

1. A description of the method that will be used to demonstrate stability in the TSPA to support the potential LA. As indicated in the Methods and Approach Document, DOE has not yet decided on its approach.

2. Documentation that submodels (including submodels used to develop input parameters and transfer functions) are numerically stable, as requested in the original agreement."

TSPAI.4.04

"DOE will conduct appropriate analyses and provide documentation that demonstrates the results of the performance assessment are stable with respect to discretization (e.g. spatial and temporal) of the TSPA model. This will be documented in the TSPA for any potential license application in FY 2003."

TSPAI.4.06

"DOE will document the implementation of the process for model confidence building and demonstrate compliance with model confidence criteria in accordance with the applicable procedures. This will be documented in the respective AMR revisions and made available to NRC in FY 2003."

GEN.1.01 Comment 78 [3]

"Page 3-6: Uncertainties are addressed by bounding and sensitivity studies as discussed in DOE 2001. Sensitivity studies can be an effective mechanism to assess uncertainties, however if the uncertainties show up as contributing to the output then they must be represented in the abstraction to the TSPA."

[3] The specific page number referral cited below is from FY01 Supplemental Science and Performance Analyses, Volume 1: Scientific Bases and Analyses (Bechtel SAIC Company, LLC, 2001b).

GEN.1.01 Comment 96 [4]

"Page 4-56: The analytical work is an excellent example of alternative methods that can be pursued as multiple lines of evidence. However, in this case it does raise additional technical questions. For example, would the chemistry of the solution in the above boiling region influence the behavior? In particular, if the solution were a chloride-brine would it have different physical characteristics than dilute water? Secondly, if 15% of the realizations predicted penetration, then roughly 1600+ waste packages (on average) should experience these conditions. Finally, where is the support for the original modeling result if the analytical result contradicts the conclusions made with the original model? Page 4-57 describes "more extreme conditions", but it was not obvious that the conditions were more extreme in the analytical work, rather it appeared that the analytical work evaluated processes on a scale that the numerical model can not evaluate."

GEN.1.01 Comment 111 [5]

"Page 6F-3: The information presented in Figure 6.3.1.4-2 potentially indicates that the time-steps utilized for the THC simulations may be too coarse and therefore important information may be eliminated. The liquid saturation is shown to go from 0.0 to 0.10 in one time step, whereas the rewetting process would be expected to be a gradual process."

GEN.1.01 Comment 120 [6]

"Page 7-11, The use of a triangular distribution for the residual stress uncertainty dictates that the endpoints of the distribution are well known. Showing the data compared to the distribution would support the selection of a triangular distribution."

3.0 RELEVANCE TO OVERALL PERFORMANCE

NRC synthesized existing information to categorize the KTI resolution agreements according to the risk significance of the agreement (NRC, 2003a). In classifying agreements into the three categories (i.e., low-, medium-, and high-risk significant), risk information (i.e., risk insights) was drawn and synthesized using many types of existing quantitative analyses. Complementing the

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[4] The specific page number referral cited below is from FY01 Supplemental Science and Performance Analyses, Volume 1: Scientific Bases and Analyses (Bechtel SAIC Company, LLC, 2001b).

[5] The specific page number referral cited below is from FY01 Supplemental Science and Performance Analyses, Volume 1: Scientific Bases and Analyses (Bechtel SAIC Company, LLC, 2001b).

[6] The specific page number referral cited below is from FY01 Supplemental Science and Performance Analyses, Volume 1: Scientific Bases and Analyses (Bechtel SAIC Company, LLC, 2001b).

risk insights is the concept of multiple barriers (i.e., both engineered and natural barriers) in geologic disposal of high-level radioactive wastes (NRC, 2003a). Multiple barriers, as an element of a defense-in-depth approach, results in a robust repository system that is more tolerant of failures and external challenges (e.g., poor or highly degraded performance is necessary in multiple areas to have a significant effect on risk). The baseline of risk insights (NRC, 2003a) also addressed the risk significance of general post-closure performance assessment review items (i.e., system description and demonstration of multiple barriers; scenario analysis and event probability; model abstraction; and demonstration of compliance with the post-closure public health and environmental standards). These review topics relate to post-closure performance objectives and to items needed to support confidence in the total system performance assessment risk calculations. For these topics, the risk ranking also considered the significance of the information to build confidence in the calculations and the safety attributes of the repository system (NRC, 2003a).

Agreement TSPAI.1.02 is related to treatment of multiple barriers in the TSPA. Post-closure performance objectives specified in Part 63 require a system of multiple barriers (at least one engineered and one natural). As defined in the regulations, barriers are materials or structures that prevent or substantially delay movement of water or radionuclides. Thus, a key element of the safety case is the identification and description of the capabilities of the repository barriers. DOE must provide a description of the capabilities of each of the barriers and the technical basis for the capability of the barriers. The technical basis for the capability of the barriers needs to be consistent with the technical basis used to support the TSPA abstractions. Agreement TSPAI.1.02, which identified that information on the capabilities of individual barriers, in light of existing parameter uncertainty (e.g., in barrier and system characteristics) and model uncertainty was needed, was identified as low-risk significance (NRC, 2003a).

Agreement TSPAI.3.37 is related to the incorporation of uncertainty, variability and correlations in the biosphere process model of the performance assessment. The biosphere process model assesses radionuclide transport processes in the biosphere and the associated human exposure that may result from radionuclide transport from the repository to the accessible environment. The regulation specifies mean values to be used for many important biosphere parameters, which limits the consideration of uncertainties propagated in biosphere calculations. Uncertainties related to the biosphere calculations are low relative to other model abstractions in the performance assessment, thereby limiting the effect of biosphere modeling assumptions and parameters on total system risk estimates. Thus, TSPAI.3.37 was assigned as low-risk significance (NRC, 2003a).

Agreements TSPAI.3.38, 3.39, 3.41, 4.01 and Comments 78, 96, and 120 of GEN.1.01 are related to treatment of alternative conceptual models, model abstractions and parameter uncertainty in the performance assessment. These agreements are general in nature and apply to all portions of DOE's model abstractions in their performance assessment. Two review areas were identified (NRC, 2003a) as high-risk significance: (i) the need for a systematic process across the total system performance assessment model to ensure appropriate documentation and justification for: (1) abstraction of models; (2) selection of conservatism in components; and (3) representation of uncertainty; and (ii) the need for technical bases for the data distributions used in the TSPA to support mathematical representation of data uncertainty in the TSPA. The first review area corresponds to TSPAI.3.38. The second review area corresponds to TSPAI.3.41. Agreements TSPAI.3.39 and 4.01 were considered to be of medium-risk significance (NRC, 2003a). Finally, although GEN.1.01 was assigned as high-risk

significance, the individual comments within GEN.1.01 were not separately categorized within the significance framework.

Agreements TSPAI.4.03, 4.04 and Comment 111 of GEN.1.01 are related to model stability, both overall stability, and with respect to temporal and spatial discretization. Within the demonstration of compliance with the post-closure public health and environmental standards review area, TSPAI.4.03 and 4.04 were identified as low-risk significance. Although GEN.1.01 was assigned as high-risk significance, the individual comments within GEN.1.01 were not separately categorized within the significance framework.

Agreement TSPAI.4.06 is related to implementation of a process for model confidence building. Within the demonstration of compliance with the post-closure public health and environmental standards review area, TSPAI.4.06, the need for development and implementation of a process for model confidence building and demonstrating compliance with model confidence criteria, was identified as high-risk significance (NRC, 2003a).

4.0 RESULTS OF THE NRC REVIEW

The structure of the NRC review of the DOE responses parallels the structure of DOE responses. DOE responded to the agreements and comments, grouped by topic, in five separate enclosures in its August 2004 letter (Ziegler, 2004). Enclosure 1 responded to TSPAI.1.02. Enclosure 2 responded to TSPAI.3.37. Enclosure 3 responded to TSPAI.3.38, 3.39, 3.41, 4.01 and Comments 78 and 96 of GEN.1.01. Enclosure 4 responded to TSPAI.4.03, 4.04 and Comment 111 of GEN.1.01. Enclosure 5 responded to TSPAI.4.06. DOE responded to Comment 120 of GEN.1.01 in Appendices B and G of the Technical Basis Document No.6, which was an enclosure to its December, 2003 letter (Ziegler, 2003). Previously, the NRC staff indicated that it would continue to evaluate the response to Comment 120 of GEN.1.01 in conjunction with TSPAI.3.41 (Schlueter, 2002). Thus, the NRC review of Comment 120 will be included in the review of Enclosure 3 (Ziegler, 2004).

4.1 TSPAI.1.02

Agreement TSPAI.1.02 is associated with the system description and demonstration of multiple barriers. This agreement resulted from a staff review of the DOE documentation that is consistent with Section 2.2.1.1.2, Review Methods 2 and 3, of the Yucca Mountain Review Plan (NRC, 2003b). The NRC staff review of the response for this agreement also was conducted in accordance with the aforementioned review methods. Review Method 2 includes confirming that DOE adequately describes the capability of each barrier, including uncertainties, consistent with the quantitative analyses in the DOE TSPA (e.g., sensitivity and uncertainty analyses, and intermediate results for individual barriers). Also Review Method 2 includes confirming that DOE's description of barrier capability is explained in terms of a capability to prevent or substantially reduce the rate of movement of water or radionuclides from the Yucca Mountain repository to the accessible environment, or prevent the release or substantially reduce the release rate of radionuclides from the waste. Review Method 3 includes verifying that DOE has provided technical bases to support the descriptions of barrier capability commensurate with the significance of each barrier's capability and the associated uncertainties and confirming that the

technical bases are based on and consistent with the technical bases for the performance assessment.

The focus of TSPAI.1.02 was to address: (1) parameter uncertainty; (2) model uncertainty (i.e., the effect of viable alternative conceptual models); (3) spatial and temporal variability in the performance of the barriers; (4) independent and interdependent capabilities of the barriers (e.g., including a differentiation of the capabilities of barriers performing similar functions); and (5) barrier effectiveness with regard to individual radionuclides in the description of barrier capability and the corresponding technical bases. The DOE response (Ziegler, 2004) identifies how parameter uncertainty, model uncertainty, spatial and temporal variability, independent and interdependent capabilities, and barrier effectiveness with regard to individual radionuclides has been addressed in the description of barrier capability and their corresponding technical bases. The requested information for description of barrier capability and corresponding technical bases is provided in Enclosure 1 (Ziegler, 2004). The enclosure indicates that the discussions and analyses supporting the DOE's approach to the description of barrier capability and their corresponding technical bases are documented in the total system performance assessment-license application (TSPA-LA), which will be available at license application (Ziegler, 2004).

Enclosure 1 (Ziegler, 2004) describes both the general approach, and specific examples associated with different DOE-proposed barriers, for treatment of parameter uncertainty, model uncertainty, and spatial and temporal variability in the description of barrier capability and their corresponding technical bases. The response sufficiently discusses, via specific examples (e.g., parametric uncertainty and spatial and temporal variability of processes affecting the drip shield), how parameter uncertainty and spatial and temporal variability are treated in the description of barrier capability and their corresponding technical bases. Regarding model uncertainty, the response discusses model uncertainty in terms of developing and evaluating alternative conceptual models, and provides specific examples (e.g., general corrosion) where alternative conceptual models have been considered. In Enclosure 1 (Ziegler, 2004) DOE indicated that several alternative conceptual models were considered, however, it is not clear how alternative conceptual models were evaluated relative to performance of the repository. Any performance assessment must consider alternative conceptual models of features and process that are consistent with available data and current scientific understanding and evaluate the effects that alternative conceptual models have on the performance of the geologic repository. While DOE has provided a discussion of model uncertainty, it is not clear how the effects of model uncertainty in the description of barrier capability and their corresponding technical bases, addressed through the use of alternative conceptual models, have been evaluated. Elsewhere in Ziegler (2004, Enclosure 3) the DOE treatment of alternative conceptual models is addressed more fully in response to agreement TSPAI.4.01 and the NRC staff review of this topic is documented in Section 4.3.

Enclosure 1 (Ziegler, 2004) describes the general approach for treatment of independent and interdependent capabilities of the barriers (e.g., including a differentiation of the capabilities of barriers performing similar functions), and barrier effectiveness with regard to individual radionuclides in the description of barrier capability and the corresponding technical bases. Independent and interdependent capabilities of the barriers will be addressed in Section 8 of the TSPA-LA by evaluating the capability of each barrier with respect to flow and (or) transport (Ziegler, 2004). The barriers will be evaluated interdependently for their capabilities with respect to flow and (or) transport as a total system. Barrier effectiveness with regard to

individual radionuclides will be addressed, in Section 8 of the TSPA-LA, for the rate of release of radionuclides from the waste and the rate of movement of radionuclides from the repository for the engineered barrier system and for the release rate of radionuclides to the water table and the release rate of radionuclides to the accessible environment for the Lower Natural Barrier (Ziegler, 2004). The NRC staff has also previously provided observations (Schlueter, 2003b) that addressed how DOE might implement its multiple barrier approach to develop information identified in Agreement TSPAI.1.02. In particular, the staff noted: (1) that discussions of barrier effectiveness should be thorough with regard to individual radionuclides and (2) barrier capabilities should be presented for most, if not all, of the radionuclides and should not be limited only to those radionuclides that contribute significantly to the calculated dose to the reasonably maximally exposed individual. Elsewhere in Ziegler (2004, Enclosure 3) the Total System Performance Assessment-License Application Methods and Approach document (Bechtel SAIC Company, LLC, 2003a) is identified as addressing the abstraction process, the selection of conservatism in components, and the representation of uncertainty, including the use of alternative conceptual models in the performance assessment. That document (Bechtel SAIC Company, LLC, 2003a) also provides additional discussion of the treatment of independent and interdependent capabilities of the barriers (e.g., including a differentiation of the capabilities of barriers performing similar functions), and, to a lesser extent, barrier effectiveness with regard to individual radionuclides in the description of barrier capability and the corresponding technical bases. The methods and approach document (SAIC Company, LLC, 2003a) does not indicate the extent to which barrier effectiveness will be evaluated with regard to individual radionuclides.

The discussion of the “upper natural barrier,” “engineered barrier system,” and “lower natural barrier” in Enclosure 1 provides the specific examples which demonstrate how parameter uncertainty, model uncertainty and spatial and temporal variability will be treated in the description of barrier capability and their corresponding technical bases. As described in Enclosure 1 (Ziegler, 2004) the “upper natural barrier” consists of two different features: the topography and surface soils of the mountain; and the unsaturated tuff units above the repository and to the repository horizon. The “lower natural barrier” consists of two different features: saturated and unsaturated volcanic rocks; and alluvial material below and downgradient from the repository to the accessible environment (Ziegler, 2004). DOE’s approach for treatment of multiple barriers in the TSPA-LA (Bechtel SAIC Company, LLC, 2003a) correctly identifies that term “barrier” means “any material, structure or feature that, for a period to be determined by NRC, prevents or substantially reduces the rate of movement of water or radionuclides from the Yucca Mountain repository to the accessible environment, or prevents the release of or substantially reduces the release rate of radionuclides from the waste.”

As described above, the DOE (Ziegler, 2004) discussed: (1) parameter uncertainty; (2) model uncertainty (i.e., the effect of viable alternative conceptual models); (3) spatial and temporal variability in the performance of the barriers; (4) independent and interdependent capabilities of the barriers (e.g., including a differentiation of the capabilities of barriers performing similar functions); and (5) barrier effectiveness with regard to individual radionuclides in the description of barrier capability and the corresponding technical bases.

Although the staff considers this agreement closed, DOE should consider the following comment:

- The extent to which barrier effectiveness will be evaluated with regard to individual radionuclides is not clear. For instance, barrier capabilities for most, if not all, of the radionuclides could be presented, which would better enable barrier effectiveness to be demonstrated and understood.

Based on the NRC review of the DOE response to Agreement TSPAI.1.02 in accordance with methods discussed in the appropriate section of NRC (2003b, Section 2.2.1.1.2, Review Methods 2 and 3), NRC found the DOE response met the intent of the agreement.

4.2 TSPAI.3.37

Agreement TSPAI.3.37 is included in the biosphere characteristics integrated subissue. This agreement resulted from a staff review of the DOE documentation that is consistent with Section 2.2.1.3.14.2, Review Method 3, of the Yucca Mountain Review Plan (NRC, 2003b). The NRC staff review of the response for this agreement was conducted in accordance with the aforementioned review method. This review method includes evaluation of the assessment of uncertainty and variability in parameters.

The focus of TSPAI.3.37 is related to DOE's approach to uncertainty and variability for the biosphere model used in the TSPA for site recommendation (TSPA-SR). Enclosure 2 (Ziegler, 2004) indicates DOE has replaced the approach used in the TSPA-SR with a new approach. DOE indicates that the Environmental Radiation Model for Yucca Mountain Nevada (ERMYN) will replace the previous approach used for biosphere modeling. ERMYN models radionuclide transport processes in the biosphere and the associated human exposure that may result from radionuclide transport from the repository to the accessible environment. DOE indicates, that regarding TSPAI.3.37 AIN-1, a quantitative analysis is not necessary because DOE no longer correlates or abstracts the results of the biosphere model and that the ERMYN model is consistent with the overall approach to uncertainty and variability as described in the "Guidelines for Developing and Documenting Alternative Conceptual Models, Model Abstractions, and Parameter Uncertainty in the Total System Performance Assessment for the License Application" (Bechtel SAIC Company, LLC, 2002a). DOE also indicates that the results of the analyses will be in the TSPA-LA, which will be available at license application. In Enclosure 2 (Ziegler, 2004) the discussion of the approach to uncertainty and variability for the new biosphere model (ERMYN) is responsive to the concerns raised in the original agreement TSPAI.3.37. Because DOE has changed its approach for the biosphere model and has described how uncertainty and variability will be addressed in the new biosphere approach, the staff believes that DOE has satisfied the intent of the agreement and the staff has no further questions on this topic.

Based on the NRC staff review of the DOE response to Agreement TSPAI.3.37 in accordance with methods discussed in the appropriate section of the Yucca Mountain Review Plan (NRC, 2003b; Section 2.2.1.3.14.2, Review Method 3), the NRC staff found that the DOE response to met the intent of the agreement and that no additional information is needed.

4.3 TSPAI.3.38, 3.39, 3.41, 4.01 and Comments 78, 96 and 120 of GEN.1.01

Agreements TSPAI.3.38, 3.39, and 3.41 and Comments 78, 96, and 120 of GEN.1.01 are related to treatment of alternative conceptual models, model abstractions and parameter uncertainty in the performance assessment. These agreements are general in nature and apply to all portions of DOE's model abstractions in their performance assessment. These agreements resulted from a staff review of the DOE documentation that is consistent with Section 2.2.1.3, Review Methods 1, 3, and 4, of the Yucca Mountain Review Plan (NRC, 2003b). These review methods include: (1) examining assumptions, technical bases, data, and models for consistency with other related model abstractions; (2) evaluating the technical bases for parameter values, assumed ranges, probability distributions, and bounding values used in conceptual models, process models, and alternative conceptual models, considered in the total system performance assessment abstractions; and (3) evaluating alternative conceptual models used in developing the total system performance assessment abstractions. Agreement TSPAI.4.01 is included within the demonstration of compliance with the post-closure public health and environmental standards review area. This agreement resulted from a staff review of the DOE documentation that is consistent with Section 2.2.1.4.1.2, Review Method 3, of the Yucca Mountain Review Plan (NRC, 2003b). This review method includes verifying that the "important" assumptions and parameters identified in each of the abstracted models are adequately captured in the integrated total system performance assessment. The NRC staff review of the response for these agreements was conducted in accordance with the aforementioned review methods.

The focus of TSPAI.3.38, 3.39, and 3.41 and Comments 78, 96, and 120 of GEN.1.01 is on treatment of alternative conceptual models, model abstractions and parameter uncertainty in the performance assessment. The DOE response in Enclosure 3 (Ziegler, 2004) replies to the NRC staff information requests in two parts: the first part of the response addresses the TSPAI agreements; and the second part of the response address the specific issues raised in the GEN.1.01 Comments 78 and 96.

4.3.1 TSPAI.3.38, 3.39, 3.41, and 4.01

In Enclosure 3 DOE discusses guidance provided to their staff and the status of implementation of the guidance to respond to the information needs embodied in the TSPAI agreements (i.e., the abstraction process, selection of conservatism in components, systematic representation of uncertainty across the TSPA model, and their implementation by model developers). The DOE response (Ziegler, 2004) indicates that the DOE has confidence that this guidance addresses the concerns in the KTI agreements and AINs and has been implemented by the model developers. The enclosure indicates that TSPA-LA describes how the guidance has been implemented, and that the TSPA-LA will be available at time of license application (Ziegler, 2004). As described below, the previously requested additional information (Schlueter, 2002) on model abstraction guidance (TSPAI.3.38 AIN-1), mathematical representation of data uncertainty (TSPAI.3.41 AIN-1), and treatment of alternative conceptual models (TSPAI.4.01 AIN-1) has not been directly addressed in Enclosure 3 (Ziegler, 2004).

Enclosure 3 (Ziegler, 2004) identifies that project technical staff were provided with guidance to ensure consistent treatment of alternative conceptual models, model abstractions, and parameter uncertainty within the Guidelines for Developing and Documenting Alternative

Conceptual Models, Model Abstractions, and Parameter Uncertainty in the TSPA-LA (Bechtel SAIC Company, LLC, 2002a); and TSPA-LA Methods and Approach (Bechtel SAIC Company, LLC, 2003a) documents. DOE also indicates that the guidelines describe DOE's approach to the abstraction process and the methodology for representation of uncertainty in a systematic fashion, and were applied systematically across the TSPA-LA model. The NRC staff previously reviewed (Schlueter, 2002) the guidelines document (Bechtel SAIC Company, LLC, 2002a) and reviewed (Schlueter, 2003b) a previous version of the methods and approach document (Bechtel SAIC Company, LLC, 2002b). The NRC staff's review of the methods and approach document (Bechtel SAIC Company, LLC, 2002b) indicated that the document provides an overview of approaches that DOE plans to use in its TSPA-LA (Schlueter, 2003b). Both versions of the methods and approach document (Bechtel SAIC Company, LLC, 2003a; Bechtel SAIC Company, LLC, 2002b) indicate the guidelines document (Bechtel SAIC Company, LLC, 2002a) as the source for DOE staff guidance to ensure consistent treatment of alternative conceptual models, model abstractions, and parameter uncertainty. Because staff's review of the guidelines document (Bechtel SAIC Company, LLC, 2002a) identified the need for additional information, and DOE has not provided the information in either the guidelines document (Bechtel SAIC Company, LLC, 2002a) or the revised methods and approach document (Bechtel SAIC Company, LLC, 2003a), the NRC staff's need for additional information (TSPAI.3.38 AIN-1, TSPAI.3.41 AIN-1, and TSPAI.4.01 AIN-1) has not been addressed by DOE's response (Ziegler, 2004). Nonetheless, DOE indicates (Ziegler, 2004) that it has confidence that this guidance addresses the concerns in the KTI agreements and AINs and has been implemented by the model developers.

Agreement TSPAI.3.39 focuses on the implementation of guidance for the performance assessment. The NRC staff's review (Schlueter, 2002) of the Guidelines for Developing and Documenting Alternative Conceptual Models, Model Abstractions, and Parameter Uncertainty in the TSPA-LA (Bechtel SAIC Company, LLC, 2002a), document identified that it was premature to characterize TSPAI.3.39 as complete solely on the basis of the guidelines document (Bechtel SAIC Company, LLC, 2002a) provided by DOE. The staff indicated that it was premature because: (1) there is no objective evidence of successful implementation of the guidelines (Bechtel SAIC Company, LLC, 2002a); and (2) the guidelines (Bechtel SAIC Company, LLC, 2002a) do not embody the same gravity as do quality assurance procedural requirements, where audits are conducted to evaluate adherence to the procedures. DOE's response in Enclosure 3 (Ziegler, 2004) does address the implementation issues identified in the NRC staff's need for additional information (TSPAI.3.39 AIN-1, and also referenced in staff's review of DOE's response to TSPAI.3.41 and TSPAI.4.01; Schlueter, 2002).

DOE identified three areas where implementation of the guidance has been evaluated or discussed: (1) an ongoing implementation evaluation process; (2) use of a regulatory integration team; and (3) other independent reviews. To address the NRC staff's information needs on implementation of the guidance, DOE listed in Table 1 of Enclosure 3 (Ziegler, 2004) the following comments: audits, surveillances, a quality assurance assessment, management assessments, chief science officer assessments, and management reviews, and documenting the ongoing evaluation process. DOE indicates (Ziegler, 2004) that the quality assurance audits, surveillances, self-assessments, management assessments and reviews (Table 1), and peer reviews "demonstrate reasonable assurance that the guidelines (Bechtel SAIC Company, LLC, 2002a) and implementing procedures have been adequately constituted and implemented, that these guidelines achieved the general level of rigor indicated by the NRC staff's issues, and that when discrepancies were identified, they were properly dispositioned."

Most of the identified documents in Table 1 are not publicly available and the discussion in Enclosure 3 summarizing the evaluation of implementation does not provide objective evidence of the successful implementation of the guidelines. Thus NRC staff are unable to determine the adequacy of the implementation of the guidelines directly from the information DOE provided (Ziegler, 2004).

To the extent that guidance for developing and documenting alternative conceptual models, model abstraction and parameter uncertainty is revised to address the informational needs for TSPAI.3.38, 3.41, and 4.01 identified below, implementation of the revised guidance by DOE will need to be re-assessed before the NRC staff will be able to confirm whether the updated guidance has been implemented in the TSPA-LA.

The NRC staff have conducted an independent assessment of publically available documents, identified by DOE as being used directly in TSPA-LA model and documentation (Ziegler, 2004), or as "second level feeds to TSPA-LA" (Bechtel SAIC Company, LLC, 2004a), to determine if the guidance addresses the concerns in the KTI agreements and AINs and has been implemented by the model developers. This review focused primarily on DOE's treatment of alternative conceptual models because model uncertainty, as embodied by the use of alternative conceptual models, is a focus of agreements TSPAI.3.38, 3.39, and 4.01. Any performance assessment must consider alternative conceptual models of features and process that are consistent with available data and current scientific understanding and evaluate the effects that alternative conceptual models have on the performance of the geologic repository. Thus this review focuses on whether DOE has both considered alternative conceptual models of features and processes and evaluated the effects that alternative conceptual models have on the performance of the geologic repository.

DOE identified that the documents in Enclosure 5 (Ziegler, 2004) are being used directly in TSPA-LA model and documentation and have been subject to an independent, DOE sponsored, technical review. However about one third of the documents that DOE identified are not publically available. Thus, the NRC staff reviewed the publically available documents identified in Table 1, a subset of the documents identified in Enclosure 5 (Ziegler, 2004), to evaluate whether DOE has addressed the concerns in the KTI agreements and AINs through their guidance and whether the guidance has been implemented by the model developers. A couple of the documents reviewed (Bechtel SAIC Company, LLC, 2003g, 2003j) do not address model uncertainty or alternative conceptual models, however, given the report's subject matter, this was considered appropriate. Based upon the NRC staff independent review of the remaining documents the staff identified the following issues: (1) ambiguity whether what was described as a treatment of model uncertainty was in fact just an evaluation of parameter uncertainty; (2) alternative conceptual models were considered, but may not have been evaluated for their effects on the abstraction, or were only evaluated with respect to the model abstraction, rather than evaluated for their effects on the performance of the geologic repository; and (3) alternative conceptual models that are consistent with available data and current scientific understanding were considered and the effects that alternative conceptual models have on the performance of the geologic repository were assessed, but it appeared as if alternative models will not be used in the TSPA-LA, potentially resulting in model uncertainty not being propagated in the TSPA-LA.

Table 1. Documents Reviewed by NRC Staff to Determine Adequacy of DOE's Guidance and Its Implementation

Document Title	Reference
Abstraction of Drift Seepage	Bechtel SAIC Company, LLC, 2004b
Advection Versus Diffusion in the Invert	Bechtel SAIC Company, LLC, 2003b
Analysis of Infiltration Uncertainty	Bechtel SAIC Company, LLC, 2003c
Calibrated Properties Model	Bechtel SAIC Company, LLC, 2003d
Characterize Framework for Igneous Activity at Yucca Mountain, Nevada	Bechtel SAIC Company, LLC, 2003e
Clad Degradation—Summary and Abstraction for LA	Bechtel SAIC Company, LLC, 2003f
Clad Degradation—Summary and Abstraction for LA	Bechtel SAIC Company, LLC, 2004c
Disruptive Event Biosphere Dose Conversion Factor Analysis	Bechtel SAIC Company, LLC, 2003g
Dissolved Concentration Limits of Radioactive Elements	Bechtel SAIC Company, LLC, 2003h
Drift Degradation Analysis	Bechtel SAIC Company, LLC, 2004d
Drift-Scale Coupled Processes (DST and TH Seepage) Models	Bechtel SAIC Company, LLC, 2004e
Drift-Scale Radionuclide Transport	Bechtel SAIC Company, LLC, 2004f
Engineered Barrier System: Physical and Chemical Environment	Bechtel SAIC Company, LLC, 2004g
EBS Radionuclide Transport Abstraction	Bechtel SAIC Company, LLC, 2001c
General and Localized Corrosion of Waste Package Outer Barrier	Bechtel SAIC Company, LLC, 2003i
Multiscale Thermohydrologic Model	Bechtel SAIC Company, LLC, 2004h
Nominal Performance Biosphere Dose Conversion Factor Analysis	Bechtel SAIC Company, LLC, 2003j
Particle Tracking Model and Abstraction of Transport Processes	Bechtel SAIC Company, LLC, 2004i
Radionuclide Transport Models under Ambient Conditions	Bechtel SAIC Company, LLC, 2003k
Seepage Model for PA Including Drift Collapse	Bechtel SAIC Company, LLC, 2004j
Seismic Consequence Abstraction	Bechtel SAIC Company, LLC, 2004k
UZ Flow Models and Submodels	Bechtel SAIC Company, LLC, 2004l
WAPDEG Analysis of Waste Package and Drip Shield Degradation	Bechtel SAIC Company, LLC, 2003l

The first issue documented by the NRC staff in their independent review, ambiguity on whether alternative models were considered and evaluated, was identified in several of the documents (Bechtel SAIC Company, LLC, 2004j, 2004k, 2003b, 2003c, and 2003l). For instance, in the Advection Versus Diffusion Report (Bechtel SAIC Company, LLC, 2003b) the discussion of model uncertainty identifies Section 6.11 as addressing model uncertainty. However, this section only addresses the uncertainty associated with a series of model parameters (e.g., retardation for individual radionuclides, and matrix retention properties) and not model uncertainty.

The second issue identified by the NRC staff review was that alternative conceptual models were considered, but not evaluated for their effects on the abstraction, or were only evaluated with respect to the model abstraction, rather than evaluated for their effects on the performance of the geologic repository. This issue was identified in several of the documents reviewed (Bechtel SAIC Company, LLC, 2004b, 2004d, 2004e, 2004g, 2004h, 2003d, 2003e, and 2003f). In several instances rather than propagating model uncertainty into the performance assessment, the alternative conceptual model was used to corroborate the base case conceptual model (Bechtel SAIC Company, LLC, 2004e, 2004g, and 2004h). In others, alternative conceptual models that are consistent with available data and current scientific understanding are considered but screened out from further evaluation (e.g., Bechtel SAIC Company, LLC, 2004d, 2003e).

The NRC staff identified a third issue associated with the DOE approach to addressing model uncertainty. In several of the documents reviewed (Bechtel SAIC Company, LLC, 2004c, 2004f, 2004i, 2004l, 2003h, 2003i, 2003k, and 2001c), DOE considered and evaluated the effects of alternative conceptual models on repository performance, but it is not clear that DOE has included the models or propagated the associated model uncertainty into the TSPA-LA. For instance, a couple reports identify alternative conceptual models [e.g. cladding (Bechtel SAIC Company, LLC, 2004c), and flow thru degraded waste packages (Bechtel SAIC Company, LLC, 2001c)] that have been evaluated in previous total system performance assessments through use of sensitivity analyses. However, each of these reports then screens out the use of the alternative conceptual model in the TSPA-LA. In other reports, it is not clear whether, and if, alternative conceptual models, that are consistent with available data and current scientific understanding, that have been developed [e.g., alternative models for Neptunium solubility (Bechtel SAIC Company, LLC, 2003h), and radionuclide transport in the drift (Bechtel SAIC Company, LLC, 2004f)] will be considered in the TSPA-LA or a justification provided for it to be screened out. Finally, although the Particle Tracking Model and Abstraction of Transport Processes report (Bechtel SAIC Company, LLC, 2004i) indicated that model uncertainty was not propagated into the TSPA-LA, the report clearly described the various alternative conceptual models considered and their key assumptions, summarized the results of subsystem evaluation, and identified the recommend TSPA evaluation.

The issues, described above, identified by the NRC staff review of documents that are being used directly in TSPA-LA model and documentation, indicate that the guidance that DOE has developed and attempted to implement does not address concerns in the KTI agreements and AINs. The efficacy of DOE's independent technical review in addressing NRC's concerns can be seen in those documents that have been revised subsequent to the independent technical review. For example, the Clad Degradation—Summary and Abstraction for LA (Bechtel SAIC Company, LLC, 2003f) was reviewed by DOE's independent technical review effort and subsequently revised (Bechtel SAIC Company, LLC, 2004c); however the review, as reflected

in the revised report, did not identify what effects, if any, that the alternative conceptual model had on performance of the repository. Thus, it appears that DOE's guidance may not result in the evaluation of the effects that alternative conceptual models have on the performance of the geologic repository, which is required for a performance assessment for a repository at Yucca Mountain.

4.3.2 GEN.1.01 Comments 78 and 96

DOE provided specific responses to Comments 78 and 96 of GEN.1.01 in Enclosure 3 (Ziegler, 2004). Comment 78 focuses on whether uncertainties contributing to model output are represented in the abstraction to the TSPA-LA. DOE identified that this issue is covered in Section 3.2.1 of the guidelines (Bechtel SAIC Company, LLC, 2002a) in the description of duties for the subject matter expert. Enclosure 3 provides specific information on the process subject matter experts will use for handling important uncertainties, contributing to model output, in the abstraction to the TSPA-LA.

Comment 96 of GEN.1.01 focuses on an analysis of water penetration into superheated rock using the Phillips analytical solution. DOE identified that this topic is also the subject of KTI Thermal Effects on Flow (TEF) Agreement TEF.2.08 and Enclosure 3 identifies no other specific response to Comment 96. The issue raised in Comment 96 has been addressed in DOE's response to TEF.2.08 (Appendix A of Bechtel SAIC Company, LLC, 2003m). NRC has reviewed the information that DOE provided in response to TEF.2.08 (Appendix A of Bechtel SAIC Compnay, LLC, 2003m) and determined that DOE has acceptably addressed the information needs identified in TEF.2.08 (Reamer, 2004). Thus through the information provided in Enclosure 3 (Ziegler, 2004), DOE addressed the informational needs associated with Comments 78 and 96 of GEN.1.01.

4.3.3 GEN.1.01 Comment 120

Appendix B and G of the DOE Technical Basis Document on Waste Package and Drip Shield Corrosion (Bechtel SAIC Company, LLC, 2003n) provide information related to agreements CLST.1.13, CLST.1.12 and GEN.1.01 Comment 120. These agreements requested DOE to provide the data that characterizes the distribution of residual stresses due to laser peening and induction annealing of Alloy 22, and to show the data to support the assumed triangular distribution of residual stress uncertainty. Appendix B addresses mitigation of closure weld residual stresses using laser peening and low plasticity burnishing. Induction annealing is no longer planned for mitigation of the residual stresses in the waste package closure welds. The change in waste package design from the site recommendation to the proposed license application design is described in Technical Basis Document No. 6 (Bechtel SAIC Company, LLC, 2003n). Because the proposed license application waste package design (Bokhari, 2003) does not use induction annealing to mitigate residual stresses in the Alloy 22 outer container closure weld, the distribution of residual stresses after induction annealing was not provided. The revised waste package design will have two Alloy 22 closure lids. The outer Alloy 22 lid closure weld stresses will be mitigated by either laser peening or controlled plasticity burnishing. The inner Alloy 22 closure lid weld stresses will not be stress mitigated.

The focus of the agreement is on the mitigation of residual stresses in the waste package closure welds. Mitigation of tensile residual stresses will remove the mechanical driving force for the initiation and propagation of stress corrosion cracking. The DOE response (Bechtel SAIC Company, LLC, 2003n) identifies that the originally proposed induction annealing processes will not be used and closure weld residual stress mitigation will be accomplished using laser peening or controlled plasticity burnishing. Although residual stress measurements were conducted on a test plate which may not be representative of the actual waste package closure weld, data presented in Technical Basis Document No. 6 (Bechtel SAIC Company, LLC 2003n) show that compressive residual stresses are present at depths of 6 mm [0.24 in] after laser peening and more than 7 mm [0.28 in] for controlled plasticity burnishing. Compressive stresses to depths of at least 6 mm [0.24 in] would mitigate stress corrosion cracking in the closure weld and would be unlikely to be removed by corrosion as long as passivity is maintained. In addition, DOE provided information in Appendix G (Bechtel SAIC Company, LLC, 2003n) on the uncertainty in the residual stress distribution that was responsive to the issue raised in GEN.1.01 Comment 120 (i.e., the basis for the distribution of residual stress uncertainty).

DOE has provided appropriate information to characterize the residual stress profile after laser peening and low plasticity burnishing. Based upon NRC staff's review of the DOE response to CLST.1.12, 1.13 and GEN.1.01 Comment 120, in accordance with methods discussed in the appropriate section of the Yucca Mountain Review Plan (Section 2.2.1.3.1.2, Review Method 2), DOE addressed the informational needs associated with GEN.1.01 Comment 120.

4.3.4 Summary of Review of TSPAI.3.38, 3.39, 3.41, 4.01 and Comments 78, 96 and 120 of GEN.1.01

The staff considers agreements TSPAI.3.38, TSPAI.3.41 and TSPAI.4.01 to need additional information, DOE should address the following, existing, informational needs:

TSPAI.3.38

- DOE should provide a description of the approach used to evaluate the appropriateness of technical-judgment-based conservative selections, with respect to complex and non-linear models, and how and where the resulting decisions would be documented.

TSPAI.3.41

In addition to the information that DOE has already acknowledged that it needs to provide in response to this agreement (i.e., documentation, justification, and comparisons that are to be provided in the model reports), the following information is needed from DOE:

- Justification should be provided that the DOE's use of the information entropy approach is appropriate when used to develop the expected annual dose to the reasonably maximally exposed individual and demonstration of compliance with the groundwater concentration limits .

- The approach that DOE will use to address variability, specifically, the lumping (smoothing) of variability, when parameters are defined, should be provided.

TSPAI.4.01

In addition to the information that DOE has already acknowledged that it needs to provide in response to this agreement (i.e., the documentation that is to be provided in the respective model reports), the following information is needed from DOE:

- Clarification of DOE's use of reasonableness (see, for example, page 13 of the Guidelines) and/or additional justification for the criteria that alternative conceptual model must be "reasonable" as used in Regulatory Guide 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," should be provided.

- Clarification of how DOE intends to apply its criterion on consistency with available data and scientific understanding. If the absence of validation information (e.g., data) is used to reject an alternative conceptual model, this approach and subsequent decisions where this is done should be documented and justified.

- Clarification of DOE's approach to documenting the effects of alternative conceptual models and how it will be sufficient to allow a clear understanding of the potential effects of alternative conceptual models and their uncertainty on the performance of the geologic repository. This clarification should include DOE's approach to presenting dis-aggregated results of alternative conceptual models.

- Clarification of how DOE's approach — which, according to the Guidelines, involves weighting alternative conceptual models — will avoid underestimating the risk when the results are presented.

- Clarification of its approach to using sensitive or key parameters from previous analyses when evaluating potential future alternative conceptual models. If DOE intends to use a threshold for discriminating these parameters from others, this should be expressed.

- Clarification of the guidance that will be given to the model developers that would provide consistency in the development of model validation criteria, such that the representation of uncertainty is systematic throughout the performance assessment.

TSPAI.3.39

Regarding implementation of guidance, because the staff considers agreements TSPAI.3.38, TSPAI.3.41 and TSPAI.4.01 to need additional information, DOE should address the following informational needs:

- To the extent that guidance for developing and documenting alternative conceptual models, model abstraction and parameter uncertainty is revised to address the additional informational needs for TSPAI.3.38, 3.41, and 4.01 identified above, implementation of the revised guidance should be re-assessed and documented by DOE.

Based on the NRC review of the DOE response to Agreement TSPAI.3.38, 3.39, 3.41 and 4.01 and Comments 78, 96, and 120 of GEN.1.01, in accordance with methods discussed in the

appropriate sections (Section 2.2.1.3, Review Methods 1, 3, and 4; and Section 2.2.1.4.1.2, Review Method 3) of the Yucca Mountain Review Plan (NRC, 2003b), the NRC staff found the DOE response to Comments 78, 96, and 120 of GEN.1.01 met the intent of the agreement and that no additional information is needed. However, additional information is needed for agreements TSPAI.3.38, 3.39, 3.41, and 4.01.

4.4 TSPAI.4.03, 4.04 and Comment 111 of GEN.1.01

Agreements TSPAI.4.03, 4.04 and Comment 111 of GEN.1.01 are included within the demonstration of compliance with the post-closure public health and environmental standards review area. This agreement resulted from a staff review of the DOE documentation consistent with Section 2.2.1.4.1.2, Review Method 2, of the Yucca Mountain Review Plan (NRC, 2003b). This review method includes confirming that the DOE has conducted a sufficient number of realizations for each scenario class using their TSPA computer code to verify that the results of the TSPA are statistically stable.

The focus of TSPAI.4.03, 4.04 and Comment 111 of GEN.1.01 is on the numerical stability, including temporal and spatial discretization, of the total system performance model and supporting submodels. The DOE response in Enclosure 4 (Ziegler, 2004) identifies how model stability will be addressed through several analyses documented in the TSPA-LA. Those analyses will include evaluations of the number of realizations, time-stepping, number of particles required for unsaturated zone transport, and spatial discretization. The requested information for model stability is provided in Enclosure 4 (Ziegler, 2004). The enclosure indicates that both TSPA-LA model runs and postprocessing of the results will be conducted to evaluate the stability of the model results and that model stability will be documented in the TSPA-LA model report, which will be available at the time of license application (Ziegler, 2004).

Enclosure 4 (Ziegler, 2004) provides a general description of the methods used to assess numerical stability, including spatial and temporal discretization, and identifies specific techniques. DOE indicated the following techniques, among others, have been used for evaluating stability of the TSPA-LA model results: graphical comparison of the computed model outcome (e.g., expected dose) versus sample size; testing for difference in means; testing for difference in distributions; and application of a statistical quitting rule. Regarding temporal discretization, several different TSPA-LA model runs are performed to evaluate the potential for variability in model output due to time-step size, focusing on the most significant scenario class contributing to dose (Ziegler, 2004). DOE indicates that comparison of the TSPA-LA model runs with different time-step sizes is done with several techniques identified for testing the stability of the model. Regarding spatial discretization, DOE has conducted a spatial discretization evaluation to determine how representative subregions used in the TSPA-LA model are in comparison with the overall spatial variability simulated within the multi-scale thermal-hydrologic model (a submodel, whose results are abstracted into the TSPA-LA). Through presentation of the general approach and specific techniques used to evaluate numerical stability, and by identifying that the results of the numerical stability evaluations will be documented and available at time of license application, DOE has provided the information requested by the NRC staff.

Based on the NRC staff review of the DOE response to Agreements TSPAI.4.03, 4.04 and Comment 111 of GEN.1.01 in accordance with methods discussed in the appropriate section

(Section 2.2.1.4.1.2, Review Method 2) of the Yucca Mountain Review Plan (NRC, 2003b), the NRC staff found the DOE response met the intent of the agreements and that no additional information is needed.

4.5 TSPAI.4.06

Agreement TSPAI.4.06 is included within the demonstration of compliance with the post-closure public health and environmental standards review area. This agreement resulted from a NRC staff review of the DOE documentation consistent with Section 2.2.1.4.1.2, Review Method 3, of the Yucca Mountain Review Plan (NRC, 2003b). This review method includes confirming that the TSPA code is properly verified, such that there is confidence that the code is modeling the physical processes in the repository system in the manner that was intended.

The focus of TSPAI.4.06 is the documentation of the implementation of the process for model confidence building and demonstration of compliance with model confidence criteria in accordance with the applicable DOE procedures. The DOE response in Enclosure 5 (Ziegler, 2004) describes how DOE has utilized multiple processes for model validation and confidence building during and after model development. Specific information on processes such as natural analogs, auxiliary analysis, and independent technical review that have documented the implementation of the process for model confidence building and demonstrated compliance with model confidence criteria in accordance with the applicable procedures are described in Enclosure 5. The requested information on documentation of the implementation of the process for model confidence building and demonstration of compliance with model confidence criteria is provided in Enclosure 5. The enclosure indicates that the discussion on this topic will be in the TSPA-LA, which will be available at the time the license application is submitted (Ziegler, 2004).

DOE indicates that input verification, calibration, and uncertainty assessments are the validation activities conducted during model development. Specific information on each of the model development validation activities is provided, and DOE identifies where documentation of each of the activities can be found. In the discussion of uncertainty assessment during model development DOE describes that conceptual model uncertainty refers to a state of incomplete understanding, where multiple alternative process models may be considered equally likely or defensible for any given component of the disposal system. DOE also indicates that such uncertainty is addressed by explicitly evaluating the effects of an ensemble of plausible alternative models (Ziegler, 2004). This description appears to be inconsistent with information provided in Enclosure 1 (Ziegler, 2004), where DOE describes that several alternative conceptual models were considered, however, no alternative conceptual model was recommended for inclusion in the TSPA-LA model. Thus, it is not clear how DOE will evaluate the effects of an ensemble of plausible alternative models. Elsewhere in Ziegler (2004, Enclosure 3), the DOE treatment of alternative conceptual models is addressed more fully in response to agreement TSPAI.4.01, and the NRC staff review of this topic is documented in Section 4.3. Nevertheless, the discussion of validation activities during model development in Enclosure 5 is responsive to the information requested in TSPAI.4.06.

DOE identifies that: (1) corroboration of model results with data acquired from the laboratory, field experiments, analog studies, or other relevant observations, which were not previously used to develop or calibrate the model; (2) independent technical review; and (3) auxiliary

analyses are the three validation activities conducted after model development. Specific information on each of post-model development validation activities is provided, and DOE identifies where documentation of each of the activities can be found. For instance, DOE indicates (Ziegler, 2004) that the independent technical review will be summarized in section 7 of the TSPA-LA and included as an appendix to the document. DOE also indicates that the summary and supporting appendix supports DOE's claim that the validation review was a thorough evaluation of the TSPA-LA and its supporting documentation. In describing the independent technical review, DOE lists four conditions that were assumed prior to finalization of findings related to a particular condition. For the purpose of the model confidence information requested in TSPAI.4.06, these are acceptable assumptions. In addition, DOE identifies the general criteria for independent technical review and specific review criteria for submodels included in the TSPA-LA and for the total system model. The discussion of validation activities after model development in Enclosure 5 is responsive to the information requested in TSPAI.4.06. It describes the implementation of the process for model confidence building and identifies where demonstration of compliance with model confidence criteria in accordance with the applicable DOE procedures is documented.

Based on the NRC staff review of the DOE response to Agreement TSPAI.4.06 in accordance with review methods discussed in the Section 2.2.1.4.1.2 of the Yucca Mountain Review Plan (NRC, 2003b), the NRC staff found the DOE response met the intent of the agreement and that no additional information is needed.

5.0 SUMMARY

NRC staff reviewed DOE's KTI agreement responses in enclosures to a letter dated August 31, 2004, to determine whether any important aspect of Agreements TSPAI.1.02, 3.37, 3.38, 3.39, 3.41, 4.01, 4.03, 4.04, 4.06 and Comments 78, 96, 111, and 120 of GEN.1.01 was excluded from the responses. In addition, the NRC staff performed an independent assessment to determine whether the information provided addressed information requested by the agreements. Notwithstanding new information that could raise new questions or comments concerning these agreements, the information provided satisfies the intent of some of the agreements and all of the comments. On the basis of this review, the NRC staff considers that the information DOE assembled in response to agreements TSPAI.1.02, 3.37, 4.03, 4.04, and 4.06, and Comments 78, 96, 111, and 120 of GEN.1.01 met the intent of the agreements and no additional information is needed. The NRC staff needs additional information for Agreements TSPAI.3.38, 3.39, 3.41, and 4.01.

6.0 STATUS OF THE AGREEMENTS

Based on the preceding review, NRC staff has no further questions at this time with respect to Agreements TSPAI.1.02, 3.37, 4.03, 4.04, 4.06 and Comments 78, 96, 111, and 120 of GEN.1.01. Therefore, the NRC staff considers these agreements closed. DOE should provide additional information for TSPAI.3.38, 3.39, 3.41, and 4.01.

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