THE U.S. NUCLEAR REGULATORY COMMISSION OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS REVIEW OF THE U.S. DEPARTMENT OF ENERGY'S KEY TECHNICAL ISSUES AGREEMENT RESPONSES RELATED TO THE POTENTIAL GEOLOGIC REPOSITORY AT YUCCA MOUNTAIN, NEVADA: RADIONUCLIDE TRANSPORT 1.02 AND 3.10, GENERAL 1.01 COMMENT 27

1.0 INTRODUCTION

The U.S. Nuclear Regulatory Commission (NRC) issue resolution goal during this interim pre-licensing period is to ensure the U.S. Department of Energy (DOE) has assembled sufficient information on a given issue for NRC to accept a potential License Application for review. It is important to note that resolution of an issue by NRC during the pre-licensing period does not prejudge the NRC staff evaluation of the issue during the licensing review. Issues are resolved by the NRC staff during pre-licensing when the staff have no further questions or comments about how DOE is addressing an issue. Pertinent new information could raise new questions or comments on a previously resolved issue. The NRC licensing decision will be based on information provided as part of a potential License Application.

By letter dated April 12, 2004, DOE submitted a report titled "Technical Basis Document No. 10: Unsaturated Zone Transport" (Bechtel SAIC Company, LLC, 2004), about the transport of radionuclides in the unsaturated zone. The three appendices of the report contained DOE responses to several key technical issue agreements about unsaturated zone transport.

In the following sections, NRC reviews of DOE responses to agreements are grouped by appendix, as they were presented by DOE in the technical basis document.

2.0 REVIEW OF TECHNICAL BASIS DOCUMENT NO. 10, APPENDIX A: DOE RESPONSE TO AGREEMENTS RADIONUCLIDE TRANSPORT (RT).1.02, 3.10, AND GENERAL (GEN).1.01 (COMMENT 27)

Appendix A of Bechtel SAIC Company, LLC (2004) provides DOE responses to Agreements RT.1.02 and RT.3.10 and to GEN.1.01 (Comment 27).

Agreements RT.1.02 and RT.3.10 were reached during a technical exchange meeting between NRC and DOE about radionuclide transport (Reamer, 2000). The wording of these two agreements is identical because the NRC request for information was considered pertinent to two topics—Radionuclide Transport Subissue 1, radionuclide transport through porous rock, and Radionuclide Transport Subissue 3, radionuclide transport through fractured rock.

Agreement GEN.1.01 (Comment 27) was documented during a technical exchange meeting about the range of thermal operating temperatures for a potential repository (Reamer, 2001a). DOE presented a brief initial response to GEN.1.01 (Comment 27) during the meeting. In Appendix A of Bechtel SAIC Company, LLC (2004), DOE elaborated the response to GEN.1.01 (Comment 27) and included the text of the initial response.

2.1 Wording of Agreements

2.1.1 RT.1.02 and RT.3.10 (identical)

"Provide analog radionuclide data from the tracer tests for Calico Hills at Busted Butte and from similar analog and radionuclide data (if available) from test blocks from Busted Butte. DOE will provide data from tracers used at Busted Butte and data from (AECL) test blocks from Busted Butte in an update to the AMR *In Situ* Field Testing of Processes in FY 2002."

2.1.2 GEN.1.01 (Comment 27)

"There appears to be conflicting evidence with regard to matrix flow and transport at Busted Butte and Peña Blanca."

"Although qualitative information is provided, the DOE does not clearly establish how information from anthropogenic and natural analogue sites (Peña Blanca, Oklo, INEEL) are [sic] being used to verify/validate conceptual models, numerical models, and data/model uncertainty with regard to Performance Assessment. Uncertainty introduced by the lack of characterization of the larger repository footprint (southern extension) considered in the lower temperature operating mode is not characterized."

In addition to providing information requested in Agreements RT.1.02, RT.3.10, and GEN.1.01 (Comment 27), the DOE response addressed related NRC concerns about matrix diffusion and radionuclide transport representation in the unsaturated zone transport model (NRC, 2002). DOE responded to the agreements in terms of the following four concerns (Bechtel SAIC Company, LLC, 2004, p. A–3):

"(1) Provide justification for the inclusion of matrix diffusion (the diffusion of solutes from flowing water in fractures into stagnant or nearly stagnant water in the matrix, which can result in significant transport attenuation) in the unsaturated zone transport model.

(2) Provide justification for the inclusion of sorption in the unsaturated zone transport model.

(3) Demonstrate that nonradioactive tracers used in field tests are appropriate homologs for sorbing radionuclides.

(4) Discuss how conflicting observations from Busted Butte and Peña Blanca are both consistent with and supportive of unsaturated zone flow and transport models."

2.2 Relevance to Overall Performance

Agreements RT.1.02, 3.10 and GEN.1.01, Comment 27 pertain to analog data DOE uses to support radionuclide transport in the unsaturated zone. As part of the NRC risk insights initiative (NRC, 2004) retardation in the porous rock units, notably Calico Hills Non-welded vitric has been ranked a medium significance to waste isolation. In the DOE hydrogeological model (Bechtel SAIC Company, LLC, 2004), this is the only unit beneath a potential repository in which water flow remains in the matrix (i.e., no fracture flow). Field and laboratory tracer tests using samples of the Calico Hills nonwelded vitric unit from Busted Butte, which is located about 8 km [4.97 mi] southeast of Yucca Mountain, are the main source of data about unsaturated

zone transport behavior in the Calico Hills Formation. Similarly, agreement RT.102 has been rated as medium risk significance (NRC, 2003). Agreement RT.3.10 has been rated as low risk significance as it relates to fractured rock (NRC, 2003). The individual comments within GEN.1.01 were not separately rated within the significance framework.

2.3 NRC Evaluation and Comment

Agreements RT.1.02 and RT.3.10 requested that DOE provide data from *in-situ* tracer tests in the Calico Hills Formation at Busted Butte and from laboratory-based tracer tests in large quarried blocks of the same rock unit from Busted Butte. The DOE response, it summarized some Busted Butte test results in a discussion of NRC concerns about matrix diffusion, sorption in the unsaturated zone, use of nonradioactive homologs for sorbing radionuclides, and differences in unsaturated zone flow and transport models. Detailed results of the laboratory tracer test experiments involving large quarried blocks from Busted Butte are available in a separate report (Vandergraaf, et al., 2004). In addition, some Busted Butte field test data are presented in Sections 4 and 5 of Bechtel SAIC Company, LLC (2004). The DOE response also indicated that comprehensive presentations of the *in-situ* tracer test data are provided in a revised DOE report about *in-situ* field testing of processes; however, until recently, the cited report was not publicly available, and thus, not examined by NRC reviewers. Even though some of the Busted Butte field test data were not available for review, the DOE response to RT.1.02 and RT.3.10 is sufficient to meet the intent of the agreements. These items are considered closed.

Agreement GEN.1.01 (Comment 27) noted that flow and transport processes appeared to be different at Busted Butte compared with the Peña Blanca natural analog in Mexico. In the response, DOE explained that the differences were expected, due to different hydrogeological conditions at the two sites. At Busted Butte, the dominant rock type was an unfractured, high-porosity, non-welded tuff which promoted matrix flow. At Peña Blanca, the dominant rock type was fractured, lower-porosity welded tuff, which promoted fracture flow. The technical information supplied in the DOE response is sufficient to satisfy the intent of the agreement, and this item is considered closed.

In responses to items RT.1.02, RT.3.10, and GEN.1.01 (Comment 27), DOE included discussions of four items related to unsaturated zone flow and transport, namely: (1) matrix diffusion; (2) radionuclide sorption in the unsaturated zone transport model; (3) to demonstrate that non-radioactive tracers used in field tests were appropriate homologs for sorbing radionuclides; and (4) to explain how conflicting observations from Busted Butte and Peña Blanca were consistent with and supportive of unsaturated zone flow and transport models. With the exception of the fourth concern, which was covered by GEN.1.01 (Comment 27), these additional concerns were not included as part of agreements RT.1.02 and 3.10. The NRC review and evaluation of the DOE response was performed in the context of the information presented for the agreement items themselves. In the interest of a high-quality License Application, however, NRC provides the following comments about the DOE discussion of the additional concerns.

The information presented by DOE in response to items 2 and 3 is adequate. DOE cited Busted Butte data and supporting laboratory experiments to support the inclusion of radionuclide sorption in the unsaturated zone transport model and to demonstrate that non-radioactive tracers could be used, under specific conditions, as homologs for radionuclides

under the same set of conditions. At this time, NRC has no further questions about these two concerns.

The DOE discussion of item 1 acknowledged that the Busted Butte *in situ* and large-block tracer tests were unable to provide direct justification for the inclusion of matrix diffusion in the model. In the porous, non-welded tuff at Busted Butte, the system was dominated by matrix flow instead of fracture flow. DOE stated that the potential for matrix diffusion can be inferred from the Busted Butte data, but the unsaturated flow of water and solutes in these tests was entirely within the rock matrix, even at high infiltration rates. Thus, these data should not be used to infer the effectiveness or likelihood of unsaturated zone matrix diffusion, in which flow is assumed to occur in fractures and solutes diffuse into the matrix. For example, the observation that breakthrough concentrations of pentafluorobenzoates (PFBAs) in crosshole tracer tests at Busted Butte peaked and then declined, even though they were continuously injected at constant concentrations, leads the staff to question if similar processes have affected the results of other tests in the unsaturated zone.

3.0 SUMMARY AND STATUS OF THE AGREEMENTS

NRC has reviewed the DOE responses to key technical issue Agreements RT.1.02, RT.3.10, and GEN.1.01 (Comment 27), to determine if sufficient information was provided to close the agreements. Notwithstanding new information that could raise other questions or comments concerning the above agreements, DOE has provided sufficient information to address the intent of the items. Based on this review, NRC considers Agreements RT.1.02, RT.3.10, and GEN.1.01 (Comment 27) closed.

4.0 REFERENCES

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