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TRANSMITTAL OF *EBS RADIONUCLIDE TRANSPORT ABSTRACTION* (REVISION 02 AND ACN 01), ADDRESSING KEY TECHNICAL ISSUE (KTI) AGREEMENTS EVOLUTION OF THE NEAR-FIELD ENVIRONMENT (ENFE) 4.06 AND TOTAL SYSTEM PERFORMANCE ASSESSMENT AND INTEGRATION (TSPAI) 3.17

References: (1) Ltr, Ziegler to Document Control Desk, 10/3/03 (Transmittal of TBD No. 8: Colloids)
(2) Ltr, Schlueter to Ziegler, 12/23/03 (Status of NRC Review of DOE KTI Responses and Information Needed to Complete NRC Reviews)
(3) Ltr, Ziegler to Document Control Desk, 12/28/04 (Transmittal of Reference Document to Support NRC Review of KTIs)
(4) Ltr, Kokajko to Ziegler, 4/15/05 (Pre-Licensing of KTI ENFE 1.06, 4.03, 4. 04, and 4.06; TSPAI 3.17, 3:30, and 3.42; GEN 1.01, Comments 35, 36, 37, and 38)

This letter transmits a hard copy of the model report *EBS Radionuclide Transport Abstraction,* ANL-WIS-PA-000001 Revision 02, and the associated Administrative Change Notice (ACN) 01 for that report (enclosure). As is discussed below, this report contains information on the treatment of colloids in the Engineered Barrier System (EBS), which is relevant to Additional Information Needs (AIN) requested by the U.S. Nuclear Regulatory Commission (NRC) for ENFE 4.06 and TSPAI 3.17.

On October 3, 2003, the U.S. Department of Energy (DOE) submitted *Technical Basis Document No. 8: Colloids* to the NRC (Reference 1).[1] The document directly addressed a number of KTIs including ENFE 4.06 AIN-01 and TSPAI 3.17. In a letter dated December 23, 2003 (Reference 2), the NRC indicated that while an initial review of this information had been

[1] BSC (Bechtel SAIC Company) 2003. *Technical Basis Document No. 8: Colloids.* REV 02. Las Vegas, Nevada: Bechtel SAIC Company.

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completed, additional references were required, including Revision 01F of *EBS Radionuclide Transport Abstraction*.[2] The DOE responded to this letter on December 28, 2004 (Reference 3), by submitting Revision 01 of the document.[3] Subsequently, in a letter dated April 15, 2005 (Reference 4), the NRC noted that this revision of the report was unavailable during the earlier NRC reviews of ENFE 4.06 AIN-01 and TSPAI 3.17 and, as a result, submitted two new AINs: ENFE 4.06 AIN-02 and TSPAI 3.17 AIN-01 regarding various aspects of the technical basis for the EBS radionuclide transport abstraction.

Since the NRC reviews, Revision 2 and ACN 01, of *EBS Radionuclide Transport Abstraction* have been completed. Accordingly, the DOE is submitting Revision 2 and ACN 01 to the NRC (enclosure). The remainder of this letter provides the text for ENFE 4.06 AIN-02 and TSPAI 3.17 AIN-01 and appropriate references to relevant report sections addressing aspects of the technical basis for abstraction as requested by the NRC. For convenience, "the report" or similar language is used to refer to the combination of Revision 2 of the report and ACN 01.

ENFE 4.06 AIN-02

The text for ENFE 4.06 AIN-02 is as follows:

> *...DOE, now has a new approach to modeling plutonium and americium transport from the waste package that takes credit for retention onto stationary iron oxyhydroxide corrosion products, resulting in a significant decrease in released radionuclide mass. This model is directly related to concerns about colloid release and transport in the near field because it involves similar technical bases for the stability of the corrosion products and the irreversibility of attachment of plutonium and americium onto this substrate. Because this new conceptual model was introduced in the colloids technical basis document (Bechtel SAIC Company, LLC, 2003a) and involves transport of colloid-enhanced radionuclides in the perturbed near-field environment, it is appropriate to consider this model in the context of Agreement ENFE.4.06.*
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> *In the new model, plutonium and americium can sorb both reversibly and irreversibly onto the iron corrosion products in the waste package, thereby either slowing or preventing release. Previously, no credit was taken for sorption in the engineered barrier system (CRWMS M&O, 2000). The new model is described only briefly in the available reports. To evaluate DOE's abstraction, which could potentially result in reduced dose from colloid-facilitated plutonium, the NRC staff needs to understand how the model and parameters were developed. Some of the required information may be*

[2] BSC 2003. *EBS Radionuclide Transport Abstraction.* ANL-WIS-PA-000001 REV 01F. Las Vegas, Nevada: Bechtel SAIC Company.

[3] BSC 2004. *EBS Radionuclide Transport Abstraction.* ANL-WIS-PA-000001 REV 01. Las Vegas, Nevada: Bechtel SAIC Company.

contained in the analysis model report, EBS Radionuclide Transport Abstraction, Revision 1; however, this report was unavailable at the time this review was conducted.

Staff considers Agreement ENFE.4.06 to be open because the technical basis for the new engineered barrier system transport abstraction was not provided.

The technical basis for the EBS radionuclide transport abstraction requested in ENFE 4.06 AIN-02 is provided in the enclosed report. The report provides further information on modeling of plutonium and americium transport from the waste package, including retention on stationary iron oxyhydroxide corrosion products as well as reversible and irreversible sorption onto the iron corrosion products in the waste package. For example, Sections 8.1 and 8.2 summarize the conceptual model for the abstraction and the model inputs and outputs, respectively. Section 6.3.4.2 provides a more detailed description of the conceptual model and parameters for transport through the degraded EBS, including appropriate K_d values and a description of irreversible sorption of radionuclides. Colloidal transport in the EBS is discussed in Section 6.3.4.4. Section 6.5.1.2 and Appendix B show the mathematical incorporation of the K_d approach in the EBS transport model, and Section 6.5.2 describes the base case model inputs, including those required for irreversible sorption onto iron oxyhydroxides (Section 6.5.2.2). Section 6.5.3 summarizes the computational model including the calculation of corrosion products mass and saturation (Section 6.5.3.2) and irreversible sorption onto iron oxyhydroxide colloids and stationary corrosion products (Section 6.5.3.4). Section 6.4 lists various alternative conceptual models including reversible sorption of radionuclides onto waste package corrosion products (Section 6.4.6 with mathematical description in Section 6.6.6) and plutonium sorption from stationary corrosion products and colloids (Section 6.4.7 with mathematical description in Section 6.6.7). Validation and confidence-building efforts for the EBS transport model are discussed in Section 7.2.

TSPAI 3.17 AIN-01

The text for TSPAI 3.17 AIN-01 is as follows:

The NRC staff has not been able to evaluate the diffusion data used in the appendix because the report in which they were developed, Revision 1 of EBS Radionuclide Transport Abstraction, was not available at the time this review was conducted. In addition, staff has not been able to confirm that uncertainty from variability in conditions affecting radionuclide transport (e.g., water content, invert physical characteristics, and colloid sizes) was incorporated into the diffusion coefficient used for dissolved or colloidal species. Although sensitivity of the diffusion coefficient to the volumetric water content was shown and the standard deviation of the measured diffusion coefficients for dissolved species was provided, Bechtel SAIC Company, LLC (2003a) did not provide information about how the volumetric moisture content, from which the diffusion *coefficients are apparently calculated, is modeled. The argument that invert transport characteristics are not significant relative to the unsaturated zone was not presented in detail. Therefore, it is not clear that invert diffusion provides a barrier significantly less effective than fractured unsaturated tuff, which may accommodate advection.*

Furthermore, Bechtel SAIC Company, LLC (2003a) was not clear about the set of diffusion coefficients actually used in the TSPA abstraction. Section 4.2 of that document indicated that diffusion coefficients for granular materials are used by DOE to model diffusion in the invert (Bechtel SAIC Company, LLC, 2003a, Table 4-1). In Appendix F, it was implied that diffusion in the invert is modeled with new diffusion coefficients derived from experiments with crushed tuff (Bechtel SAIC Company, LLC, 2003a, Tables F-1 and 4-2), and the granular materials data set was not discussed. Because the difference between diffusion coefficients in the two data sets is approximately two orders of magnitude at the low volumetric moisture contents predicted by DOE for the invert, DOE should specify which set of diffusion coefficients are being used to model diffusion in performance assessment.

In Bechtel SAIC Company, LLC (2003a) and other available reports, DOE has not satisfied the intent of Agreement TSPAI.3.17. Although this agreement has been rated as having a low risk significance (Travers, 2003), DOE: (i) has not yet provided the data supporting model parameters and uncertainties; (ii) has not made clear what set of parameters will be used; and (iii) has not supported the assertion that the invert is an insignificant barrier. This agreement is, therefore, open.

TSPAI 3.17 AIN-01 consists of three aspects involving invert diffusion. The first is the unavailability of data supporting model parameters and uncertainties. The technical basis for the model parameters and uncertainties is provided in the enclosed report. Section 6.3.4.1 of the report describes the invert diffusion submodel, which provides the TSPA model with an effective diffusion coefficient. This is a reasonable-bound value corresponding to the bulk self-diffusion coefficient of water, modified for the volumetric water content and temperature of the invert ballast. The effects of aqueous chemical concentration and of uncertainty in the invert porosity are considered, and the submodel is shown to be conservative at the process level or to encompass these effects. Diffusion coefficient measurements listed in Table 4.1-17 are used to analyze the dependence of the diffusion coefficient on volumetric moisture content for a wide variety of granular materials (i.e., unsaturated soil, gravel, bentonite, rock, and crushed tuff from Yucca Mountain, Nevada). The section also discusses uncertainty in the experimental data due to variability and its propagation to the TSPA. Appendix H documents an evaluation of the measured data in the context of their use in the EBS radionuclide transport abstraction. The evaluation considered the availability of corroborating data, the reliability of data sources, and the degree to which the data demonstrate the properties of interest. As a result of the evaluation, the data are considered qualified for use in the abstraction.

The second aspect addresses the lack of clarity over the set of parameters that will be used in the abstraction - the data in Table 4-1 of *Technical Basis Document No. 8: Colloids* or the data in Tables 4-2 and F-1 of the same document.[4] The parameters used in invert diffusion submodel (Section 6.3.4.1.1 of the enclosed report) relies on a statistical fit, based on Archie's Law, of the data in Table 4.1-17 of the enclosed report. (Archie's Law is an empirical function relating the electrical resistivity and porosity of a porous medium, and by substitution for terms, can provide a relationship between resistivity and the diffusion coefficient.) This table includes the data listed in Table 4-1 of *Technical Basis Document No. 8: Colloids*. As discussed above, the data in Table 4.1-17 of the enclosed report are measurements of diffusion coefficients of unsaturated soil, gravel, bentonite, rock, and crushed tuff from Yucca Mountain over a broad range of volumetric moisture content (i.e., 1.5 percent to 66.3 percent).

Tables F-1 and 4-2 in *Technical Basis Document No. 8: Colloids* are the equivalent of Table 7.2-2 of the enclosed report. The measurements in Table 7.2-2 are used for confidence-building activities as described in Section 7.2.2.2 of the enclosed report, and as such, cannot be used to develop the model itself.

The third aspect involves the barrier capability of the invert. In Appendix F of *Technical Basis Document No. 8: Colloids*, the discussion focused on diffusion through the invert.[5] Section 7.2.2 of the enclosed report summarizes why the invert diffusion submodel is not expected to play a major role in the assessment of system performance. Section 6.7 discusses the barrier capability of the invert in general. As discussed in Section 7.2.2 of the enclosed report, radionuclide releases from breached waste packages in the nominal scenario are limited, so that the contribution of invert diffusion to waste isolation is correspondingly limited. It is noted that the EBS radionuclide transport abstraction supports advective as well as diffusive transport through the invert. Advective transport can readily dominate diffusive transport at locations where seepage or drift-wall condensation occurs. For scenarios in which more waste packages are breached, as may be the case for disruptive events scenarios, advective transport in the invert becomes more important. Thus, the invert diffusion submodel is not expected to play a major role in the assessment of overall system performance considering the nominal and disruptive events scenarios. By comparing the invert to the unsaturated zone below the repository, two key differences can be seen: the relatively short transport path in the invert, and the possibility for diffusion-dominated conditions in the invert caused by diversion of percolation flux by the drift opening. The contribution to waste isolation of diffusion-dominated conditions in the invert is limited for the reasons discussed above, and also because of the relatively short transport path.

Based on the information presented in this letter and in the enclosed document, pending NRC review and approval, DOE recommends that ENFE 4.06 and TSPAI 3.17 be closed.

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[4] See note 1.
[5] See note 1.

Please direct any questions concerning this letter and its enclosure to William J. Boyle at (702) 794-5506 or e-mail William_boyle@ymp.gov, or Deborah L. Barr at (702) 794-1479 or e-mail Deborah_barr@ymp.gov. There are no new regulatory commitments in this letter or its enclosure.

Mark H. Williams, Director
Regulatory Authority Office

RAO:WJB-1584

Enclosure:
Hard copy of *EBS Radionuclide Transport Abstraction*, ANL-WIS-PA-000001
Revision 02 and ACN 01

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