

BSC

Scientific Analysis
Administrative Change Notice

QA: QA
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Complete only applicable items.

1. Document Number:	ANL-NBS-HS-000031	2. Revision:	02	3. ACN:	01
4. Title:	Saturated Zone Colloid Transport				
5. No. of Pages Attached:	3				

6. Approvals:

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7. Affected Pages	8. Description of Change:			
4-2	<p>Removed an input from section 4.</p> <p>Table 4-1 "Direct Inputs" on page 4-2, delete entire 1st row:</p> <table border="1"> <tr> <td>Calculations to determine detachment rate constant of microspheres in a single-well tracer test in saturated alluvium</td> <td>LA0303PR831352.001 [DIRS 163138]</td> <td>Calculations to Determine detachment rate constant of microspheres in a singlewell tracer test in saturated alluvium</td> </tr> </table> <p>Note: Data from DTN LA0303PR831352.001 need to be removed from Section 4 of this report because these values are detachment rates which are not used in this AMR. Removing this input from this report will not impact the product output of this AMR.</p> <p>This change is identified in CR-7155</p>	Calculations to determine detachment rate constant of microspheres in a single-well tracer test in saturated alluvium	LA0303PR831352.001 [DIRS 163138]	Calculations to Determine detachment rate constant of microspheres in a singlewell tracer test in saturated alluvium
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6-20	<p>Citation update (Correct DIRS as appropriate)</p> <p>Section 6.8 "USE OF POLYSTYRENE MICROSPHERES AS TRACER SURROGATES FOR INORGANIC GROUNDWATER COLLOIDS", 1ST paragraph, 7th line, change:</p> <p>(BSC 2004 [DIRS 170025], Section 6.5. To (BSC 2004 [DIRS 170010], Section 6.5).</p> <p>This change is identified in CR-6851</p>			

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8-5	<p>Delete a reference</p> <p>Section 8.3 "SOURCE DATA, LISTED BY DATA TRACKING NUMBER", page 8-5, delete source data with DIRS number 163138, delete:</p> <p>LA0303PR831352.001. Calculations to Determine Detachment Rate Constant of Microspheres in a Single-Well Tracer Test in Saturated Alluvium. Submittal date: 03/31/2003. 163138</p> <p>This change is identified in CR-7155</p>				

Table 4-1. Direct Inputs (Continued)

Data Description	Data Tracking Number	Data Used
Model interpretations of ER-20-6 field tracer transport experiment	LA0303PR831352.002 [DIRS 163136] See Note 1 below for the justification of the use of UGTA/NTS data	Model Interpretations of ER-20-6 field tracer transport experiment
Model interpretations of NTS fractured core colloid and colloid-facilitated transport experiments	LA0403PR831352.001 [DIRS 171416] See Note 1 below for the justification of the use of UGTA/NTS data	Model interpretations of NTS fractured core colloid and colloid-facilitated transport experiments
RELAP computer code interpretations of laboratory rate constants in alluvium	LA0303PR831361.001 [DIRS 163135]	RELAP V2.0 Model Interpretations of solute and colloid transport in alluvium-packed column transport experiments
Breakthrough curves of CML microspheres, silica colloids, and bromide in alluvium-packed Column A, Run 1	LA0206MH831361.001 [DIRS 162426]	S02152_001
Breakthrough curves of CML microspheres, silica colloids, and bromide in alluvium-packed Column B, Run 1	LA0206MH831361.002 [DIRS 162427]	S02153_001
Breakthrough curves of CML microspheres, silica colloids, and bromide in alluvium-packed Column A, Run 2	LA0206MH831361.003 [DIRS 162428]	S02154_001
Breakthrough curves of CML microspheres, silica colloids, and bromide in alluvium-packed Column B, Run 2	LA0206MH831361.004 [DIRS 162430]	S02155_001
Breakthrough curves of tritium, Pu, and natural colloids in two alluvium-packed columns	LA0301AA831352.001 [DIRS 162433]	S03043_001
Field-scale attachment/detachment rates and retardation factors for colloids in alluvial material	Schijven et al. 1999 [DIRS 162423] See Note 2 below for the justification of the use of literature data	Rate constants and retardation factors obtained from model interpretations of colloid breakthrough curves.

NOTE 1: Justification for use of data obtained from outside sources (AP-SIII.9Q, *Scientific Analyses*): The UGTA/NTS data used in this report were obtained from outside sources. These data were obtained from the U.S. Department of Energy UGTA program, which has a quality assurance program in place. In addition, the researchers collecting the data are the same researchers conducting the Yucca Mountain colloid research (e.g., Paul Reimus, coauthor of this report). The data were collected at the same laboratory facilities as the Yucca Mountain data. Therefore, the reliability of the data source and the qualifications of personnel or organizations generating the data is sufficient. The data apply to this analysis because the UGTA program operates in close proximity to Yucca Mountain, making it a good analog due to similarities in geology, mineralogy, and hydrology. Specifically, NTS shares many of the same geologic units as Yucca Mountain. The mineralogy consists of fractured volcanic tuffs and alluvium which is the same mineralogy found at the Yucca Mountain site. Therefore, colloid transport parameters measured at NTS are applicable to Yucca Mountain (DTNs: LA0302PR831352.002 [DIRS 162440];

Bahr and Rubin caution that both Damköhler numbers, $Da_{att}+Da_{det}$, should be used to assess the kinetic term (Bahr and Rubin 1987 [DIRS 144539]). In this analysis only Da_{att} is used, which should, therefore, be conservative. Another conservative aspect of this analysis is that there is no probability of a detachment rate constant of zero. In reality, it is very likely that some colloids will irreversibly attach.

To calculate Damköhler numbers for the fractured volcanics, the rate constants in Figure 6-2 are transformed to a Damköhler number distribution by multiplying the rate constants on the x -axis by an assumed transport time. We determine the fraction that has a Damköhler number greater than 100, which according to Valocchi is a good approximation of equilibrium conditions (Valocchi 1985 [DIRS 144579], p. 813, Figure 2). For a 100-year transport time, 96 percent of the colloids will have a Damköhler number greater than 100. For a 1000-year transport time, it will be over 98 percent; and for a 10-year transport time, it will be 94 percent. An analysis of the alluvium rate constants results in very similar results with an even greater percentage with Damköhler numbers greater than 100. Thus, the vast majority of colloids that are not part of the unretarded fraction will transport in accordance with the local equilibrium assumption.

6.8 USE OF POLYSTYRENE MICROSPHERES AS TRACER SURROGATES FOR INORGANIC GROUNDWATER COLLOIDS

Many of the laboratory and field experiments used to develop the R_{col} distributions in this analysis use CML microspheres to study colloid transport. This section describes the effectiveness of CML microspheres as analogs to inorganic groundwater colloids. CML microspheres were used as colloid tracers in the multiple-tracer tests in both the Bullfrog Tuff and the Prow Pass Tuff at the C-wells complex (BSC 2004 [DIRS 170010], Section 6). CML microspheres were also used in one of the three single-well tracer tests in the saturated alluvium at NC-EWDP-19D1 (BSC 2004 [DIRS 170010], Section 6.5). CML microspheres were selected as colloid tracers in these field tests because they are very monodisperse (i.e., they have a very narrow range of diameters) and they can be obtained with various fluorescent dyes incorporated into their polymer matrix, which allows them both to be detected at very low concentrations and to be discriminated from natural, nonfluorescing colloids using methods such as epifluorescent microscopy and flow cytometry. Flow cytometry has been used as the microsphere detection and quantification method for all field tracer tests in which microspheres have been used as tracers. This technique allows quantification at microsphere concentrations as low as 100 mL^{-1} in the presence of natural background colloid concentrations that are 2 to 4 orders of magnitude higher. These levels of detection and discrimination are currently not attainable using any other type of colloid tracer except perhaps viruses/bacteriophages (Bales et al. 1989 [DIRS 104333], pp. 2,063 to 2,064).

CML microspheres were chosen over other types of polystyrene latex microspheres as field colloid tracers for two reasons: 1) they have surface carboxyl groups that give them a negative surface charge at pH greater than about 5 and 2) they have relatively hydrophilic surfaces compared to other types of polystyrene microspheres (Wan and Wilson 1994 [DIRS 114430], p. 858, Table 1). These properties are consistent with those of natural inorganic groundwater colloids. The hydrophilic surfaces of CML microspheres are the result of their matrix being comprised of a copolymer of styrene and acrylic acid rather than pure styrene. This copolymer gives the CML microspheres a higher surface density of carboxyl groups and also a significantly

LA0302PR831231.002. Solute Data from ER-20-6#2 in the BULLION Forced-Gradient Field Tracer Test at the ER-20-6 Wells at NTS. Submittal date: 02/03/2003.	162437
LA0302PR831231.003. Solute Data from ER-20-6#3 in the BULLION Forced-Gradient Field Tracer Test at the ER-20-6 Wells at NTS. Submittal date: 02/03/2003.	162438
LA0302PR831352.001. Transport of CML Microspheres in Field Tracer Test at ER-20-6#2 Site at the Nevada Test Site (NTS). Submittal date: 03/06/2003.	162439
LA0302PR831352.002. Transport of CML Microspheres in Field Tracer Test at ER-20-6#3 Site at the Nevada Test Site (NTS). Submittal date: 03/06/2003.	162440
LA0303PR831231.003. Model Interpretations of C-Wells Field Tracer Transport Experiments. Submittal date: 03/31/2003.	163756
LA0303PR831352.002. Model Interpretations of ER-20-6 Field Tracer Transport Experiment. Submittal date: 03/31/2003.	163136
LA0303PR831361.001. RELAP V2.0 Model Interpretations of Solute and Colloid Transport in Alluvium-Packed Column Transport Experiments. Submittal date: 03/31/2003.	163135
LA0306PR831321.001. Mineralogy of ATC Colloids and Bentonite Drilling Muds. Submittal date: 06/03/2003.	164492
LA0403PR831352.001. Model Interpretations of NTS Fractured Core Colloid and Colloid-Facilitated Transport Experiments. Submittal date: 03/18/2004.	171416
LAPR831231AQ99.001. Prow Pass Reactive Tracer Test Field Data. Submittal date: 02/10/1999.	140134
MO0407SEPFELA.000. LA FEP List. Submittal date: 07/20/2004.	170760

8.4 OUTPUT DATA, LISTED BY DATA TRACKING NUMBER

DTN: LA0303HV831352.002. Colloid Retardation Factors for the Saturated Zone Fractured Volcanics.

DTN: LA0303HV831352.004. Colloid Retardation Factors for the Saturated Zone Alluvium.

DTN: LA0303HV831352.003. Fraction of Colloids that Travel Unretarded.