APR 28 1989

MEMO FOR RB/

MEMORANDUM FOR: Ronald L. Ballard, Chief
Geosciences & Systems Performance Branch
Division of High-Level Waste Management, NMSS

FROM: Donald L. Chery, Jr., Section Leader
Hydrologic Transport Section
Geosciences & Systems Performance Branch
Division of High-Level Waste Management, NMSS

SUBJECT: HYDROLOGIC TRANSPORT SECTION DRAFT SITE CHARACTERIZATION PLAN POINT PAPERS FOR BRANCH CHIEF REVIEW (411412)

Attached for your review are draft point papers resulting from the Hydrologic Transport Section's review of the SCP.

Provided in Attachment 1 is a summary of the status of each CDSCP comment and question for which the Hydrologic Transport Section is responsible. This summary indicates whether each CDSCP comment or question is resolved or open as well as lead staff for each item.

Provided in Attachment 2 are copies of draft point papers for all CDSCP comments or questions that are considered resolved or answered.

Provided in Attachment 3 is a summary of all draft SCP comments, including comments dealing with unresolved CDSCP open items.

As agreed between N. Stablein and the Lead Technical Reviewers the "Section Draft of Concerns and Summary" is being deferred to the Branch Chief review period for preparation.

This submittal satisfies the April 28, 1989 milestone for a section draft SCP point paper package for the Hydrologic Transport Section.

/S/
Donald L. Chery, Jr., Section Leader
Hydrologic Transport Section
Geosciences & Systems Performance Branch
Division of High-Level Waste Management, NMSS

Attachments:
As stated

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102.8
CDC

OFC	HLGP	HLGP					
NAME	JPohle/rl/cj	DChery					
DATE	4/26/89	4/28/89					

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102.
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ATTACHMENT 1

SUMMARY STATUS OF CDSCP COMMENTS AND QUESTIONS

Received w/Ltr Dated 4/28/89

102.8

Section 8.3.1.2 Geohydrology

CDSCP COMMENT 5

It is questionable whether the results of ponding studies at Yucca Mountain can be applied to Fortymile Wash.

BASIS FOR CDSCP COMMENT

- The CDSCP states (page 8.3.1.2-55, Table 8.3.1.2-2) under "saturated zone hydrologic hypotheses," Activity 8.3.1.2.2.1.3, that the activity objective is: "to characterize the range and spatial variability of infiltration rates, flow velocities, and flow pathways in approximately the upper 15 feet of both consolidated and unconsolidated surficial materials, using ponding studies at Yucca Mountain. The results can be applied to conditions at Fortymile Wash."

- Infiltration into Yucca Mountain will occur primarily as direct inflow into fractured tuff. Fortymile Wash consists primarily of alluvium underlain by fractured tuff. The results of infiltration tests on the mountain surface probably will not be transferable to the alluvium of Fortymile Wash.

EVALUATION OF SCP RESPONSE

Ponding studies are to be conducted on Yucca Mountain, as part of Activity 8.3.1.2.2.1.3 (evaluation of artificial infiltration), on various surficial units, including alluvial deposits similar to those underlying Fortymile Wash. The text of Activity 8.3.1.2.1.3.3 (Fortymile Wash recharge study; p. 8.3.1.2-127) was revised to note that ponding tests conducted under Activity 8.3.1.2.2.1.3 are expected to show the relationship of thickness, texture, and porosity of unconsolidated deposits to net infiltration rates and thus, once these relationships are established, the results from the ponding tests may be extrapolated to Fortymile Wash, which has deposits with a similar range of properties. In addition, the results of studies conducted under Activities 8.3.1.2.2.1.1 (Characterization of hydrologic properties of surficial materials) and 8.3.1.2.2.1.2 (Evaluation of natural infiltration) will be considered in the Fortymile Wash recharge study to aid in estimating annual average estimates of recharge occurring along Fortymile Wash for use in the regional and site models of groundwater flow. Thus CDSCP Comment 5 is resolved.

Prepared By J. Pohle and W.H. Ford DATE: 4/12/89

Section 8.3.1.2.2 Investigation: Studies to provide a description of the unsaturated zone hydrologic system at the site

CDSCP COMMENT 6

The CDSCP does not describe the prototype (research) testing program, which will develop the technology and ability to successfully conduct unsaturated zone percolation tests.

BASIS OF CDSCP COMMENT

- Sections 8.3.1.2.2.3 and 8.3.1.2.2.4, which describe percolation tests in the unsaturated zone, identify many areas where prototype tests must be done before field testing can begin. Characterization of the site will depend heavily on the design and results of this prototype testing. However, the CDSCP does not describe the plans and objectives of prototype testing.

EVALUATION OF SCP RESPONSE

Unsaturated prototype testing is described in the SCP. What will be tested is identified in the following sections of the SCP:

(1) 3.9.2.1 Hydraulic characteristics of the unsaturated zone, Page 3-171,

(2) 8.3.1.2.2.1.1 Activity: Characterization of hydrologic properties of surficial material, Pages 8.3.1.2-161 and 162

(3) 8.3.1.2.2.1.2 Activity: Evaluation of natural infiltration, Page 8.3.1.2-165 and 169

(4) 8.3.1.2.2.3 Activity: Characterization of percolation in the unsaturated zone--surface based study, Page 8.3.1.2-182

(5) 8.3.1.2.2.3.1 Activity: Matrix hydrologic properties testing, Page 8.3.1.2-189

(6) 8.3.1.2.2.3.2 Activity: Site vertical borehole studies, Page 210

(7) 8.3.1.2.2.4 Study: Characterozation of yucca mountain percolation in the unsaturated zone--exploratory shaft facility study, Pages 8.3.1.2-234 to 235

(8) 8.3.1.2.2.4.3 Activity: Bulk-permeability test in the exploratory shaft

facility, Page 8.3.1.2-273

(9) 8.3.1.2.2.4.4 Activity: Radial borehole tests in the exploratory shaft facility, Page 8.3.1.2-285

(10) 8.3.1.2.2.4.9 Activity: Multipurpose-borehole testing near the exploratory shafts, Page 8.3.1.2-309

(11) 8.4.2.1.6.2 Other conditionally planned activities Page 8.4.2-35

These activities are accepted as adequate for the initial development of the prototype testing program. Thus CDSCP Comment 6 is resolved.

Prepared by: W. Ford DATE: 4/12/89

Section 8.3.1.2.2.3.2 Activity: Site Vertical Borehole Studies

CDSCP COMMENT 7

Alternative data collection techniques have not been considered should the planned instrumentation of the site vertical borehole studies fail or prove infeasible.

BASIS FOR CDSCP COMMENT

- In Section 8.3.1.2.2.3.2 (page 8.3.1.2-158) it is stated that "downhole sensors, consisting of pressure transducers, thermocouple psychrometers, heat dissipation probes, and thermal sensors will be installed in each of the 17 vertical boreholes." Further, "These will be monitored for an extended period of time (estimated at from 3 to 5 yrs.)". The text also states that "drilling the holes will disturb the hydrologic system" and "it is not known if in situ conditions will return within the time period allotted for monitoring (3 to 5 yrs.)." Two potential problems are identified by these statements which could result in a loss of data or information needed to characterize the site: (1) there may not be enough time to complete long-term monitoring of the unsaturated zone and prototype testing of the instrumentation; and (2) many of the instruments may fail or drift out of calibration during the long period of monitoring.

EVALUATION OF SCP RESPONSE

On page 210 of Section 8.3.1.2.2.3.2 (Site Vertical Borehole Studies) it is stated that "It is recognized that drilling of the borehole will disturb in situ conditions in the rock mass adjacent to the borehole. Numerical analyses are being done to estimate the time required for the rock mass to return to a condition close to its original in situ hydrologic condition. The drilling method to be used to drill the boreholes was chosen to minimize the in situ disturbance of the hydrologic system. It is not known at this time if in situ conditions will return within the time period allotted for monitoring (3 to 5 yr). The objectives and extent of this part of the surface-based borehole investigations study will be evaluated at the completion of the cross-hole prototype testing and the numerical analyses. Prototype testing will also investigate the capabilities and limitations of the instrumentation to be used in the long-term monitoring of the hydrologic characteristics." Because prototype testing will be conducted to determine instrument failure rates and because the objective and extent of the long term monitoring of in situ conditions will be evaluated at the completion of cross-hole prototype testing, CDSCP Comment 7 is resolved.

Prepared by. W.H. Ford DATE: 4/18/89

Section 8.3.1.2.2.3.2 Activity: Site Vertical Borehole Studies

CDSCP COMMENT 8

The CDSCP does not describe the logic used to locate vertical boreholes designed to test the unsaturated zone.

BASIS FOR CDSCP COMMENT

- This section describes the type of tests and the general location of vertical boreholes that will be used to test the unsaturated zone. However, the text does not describe how the general hole locations were selected to best describe the site. Without this information it is difficult to determine if the holes have been correctly located to provide a representative description of the repository setting.

EVALUATION OF SCP RESPONSE

The logic used to select the location of unsaturated-zone vertical boreholes is described in Activity 8.3.1.2.2.3.2, Section 8.3.1.4.1.1, and Section 8.4.2.1 of the SCP. The boreholes were sited principally to (1) provide areal coverage, (2) minimize disturbance to the proposed repository block, and (3) test specific structural and surficial features. CDSCP Comment 8 is resolved.

Prepared by: W.H. Ford DATE: 4/05/89

Section 8.3.1.2.2.4 Study: Characterization Of Yucca Mountain Percolation In The Unsaturated Zone-Exploratory Shaft Facility Study

CDSCP COMMENT 9

The CDSCP does not contain a description of any hydrologic testing activities at the repository level within the drifts to the Ghost Dance fault, beneath Drill Hole Wash and to the Imbricate-Normal fault zone.

BASIS OF CDSCP COMMENT

- The CDSCP indicates that it is important to gain hydrologic information on major faults through the repository. As a result study activities are described to conduct hydrologic tests of:

  (1) the Solitario Canyon fault in Solitario Canyon (Section 8.3.1.2.2.3.3)

  (2) the Ghost Dance fault in the Calico Hills Formation (Section 8.3.1.2.2.4.6)

  (3) the Ghost Dance fault in the Paintbrush non-welded unit (Section 8.3.1.2.2.6).

- It is also stated in the CDSCP that drifting will take place in the Topopah Springs Member to investigate the geology and hydrology of the

Ghost Dance fault, the Imbricate-Normal fault zone, and beneath Drill Hole Wash. However, no study activities are described for these locations.

EVALUATION OF SCP RESPONSE

In response to this comment, a new activity (Activity 8.3.1.2.2.4.10 Hydrologic properties of major faults encountered in the main test level of the exploratory shaft facility Activity 8.3.1.2.2.4.10) was added to Study 8.3.1.2.2.4. This activity describes the hydrologic testing program for major faults observed during geologic mapping of drifts at the main test level. Major faults or fault zones expected to be tested are the Ghost Dance fault, a suspected fault in Drill Hole Wash, and the imbricate normal fault zone. Other faults will be tested if flow is observed. Testing methods include hydraulic and pneumatic tests in boreholes drilled from drifts through fault zones and tests on core collected from coreholes." CDSCP Comment 9 is resolved.

Prepared by. W.H. Ford DATE: 4/05/89

Section 8.3.1.2.2.4 Study: Characterization Of Yucca Mountain Percolation In The Unsaturated Zone-Exploratory Shaft Facility Study

CDSCP COMMENT 10

Hydrologic and geochemical tests planned for the exploratory shaft may have been compromised by past drilling activities associated with hole USW G-4.

BASIS FOR CDSCP COMMENT

- Test hole USW G-4 was drilled at the end of 1982 using an air foam system. During the drilling, coring, and completion activities, a total of 342,255 gallons of water were lost to the various formations. Over 81,000 gallons of soap were used in the operation, however it is unknown as to how much soap was lost.

- Hole USW G-4 is located 708 feet from the proposed exploratory shaft. Wells located farther apart have previously been shown to have influenced the rock between their well bores. Holes USW UZ-1 and USW G-1 are located about 1000 feet apart, but water found in USW UZ-1 was shown to contain polymer used in the drilling fluid of USW G-1. Drilling activities at USW G-4 may have changed the hydrologic characteristics of the rock where the exploratory shaft will be located.

EVALUATION OF SCP RESPONSE

Section 8.4.3.2.1.2 (Ground-water flow in matrix and fractures) presents an evaluation of drilling fluid losses from constructing USW G-4. The evaluation concludes that it is reasonable to assume that most of the drilling fluid lost to the unsaturated zone would have drained back into the borehole and flowed downward to the water table. This conclusion is based on: 1) much less water was used to drill USW G-4 than to drill USW G-1, 2) the borehole was drilled with an air-water-detergent mixture which would tend to inhibit imbibition of fluid into the surrounding rock matrix, 3) low fluid injection pressures were used in drilling, and 4) fluid would drain back into the borehole following well completion, as observed on video logs.

In addition, a multipurpose borehole activity (8.3.1.2.2.4.9) has been designed, among other things, to identify any occurrence of perched water in the vicinity of the exploratory shafts. "Because drilling fluid used during construction of nearby test hole USW G-4 contained water, the occurrence of perched water in either of the two multipurpose boreholes could be the result of drilling fluids lost from USW G-4. Drilling fluids used in USW G-4 contained 20 ppm LiBr tracer; thus, analyses for this tracer will establish whether any perched water samples contain drilling fluid that has migrated laterally from USW G-4 to areas of ESF excavation" (Section 8.3.1.2., page 313). SCP Section 8.4.2.3.1 (Exploratory shaft facility testing operations,

layout constraints, and zones of influence) indicates that observations or measurements made in the multipurpose boreholes could result in some changes to present ESF test plans. CDSCP comment 10 is resolved.

Fred Ross/04-12-89

Section 8.3.1.2.2.4 Characterization of Yucca Mountain Percolation In The Unsaturated-Zone Exploratory Shaft Facility Study

CDSCP COMMENT 11

No laboratory or field tests to confirm the current concept of moisture characteristic relations for fracture/matrix flow in unsaturated fractured rocks, which form a major part of the Yucca Mountain hydrologic conceptual model, are scheduled to be conducted early in the site characterization program.

BASIS FOR CDSCP COMMENT

- Groundwater Travel Time and Total System Performance evaluations depend on the current conceptual model of fracture/matrix flow, which has not been experimentally demonstrated by tests on unsaturated fractured rock. The CDSCP states (Section 3.9.2.1, Page 3-170) that "Standard laboratory methods are not yet available by which to determine the moisture-characteristic relations for fractures and fractured rocks, and reliance must be made on theoretically based models and approximations." Further, the CDSCP states that (page 3-172) "the flow of liquid water within and across fractures is not yet well understood" and that "Theoretical models for liquid-water flow in single fractures have been developed, but have not been field or laboratory tested." In Section 8.3.1.2.2.4, planned tests are described to confirm the current moisture-characteristic relation concepts for fractures and dry fractured

rocks in the exploratory shaft and drifts. The problem is that these tests will require new techniques and devices, which are unproven and experimental. Further, because these tests will be conducted in the exploratory shaft and drifts, they will be conducted at a late date in the exploratory program. If these tests fail, a fundamental premise of the hydrogeologic conceptual model will not have been demonstrated and the program could be significantly delayed. In addition, should these tests require revision to the current concept of fracture/matrix flow, the design of other tests may have to be changed at a date in the program when changes might be difficult or impossible.

EVALUATION OF SCP RESPONSE

Determination of moisture characteristic relations and moisture flow processes for fractured, porous unsaturated media will be included in several activities, especially in the percolation test in the exploratory shaft facility (Activity 8.3.1.2.2.4.2). In Study 8.3.1.2.2.4 on page 8.3.1.2-234 of the SCP it is stated that the percolation "test will be prototyped on a large scale and various pretest numerical analyses will be performed to evaluate test feasibility." Furthermore in Section 3.9.2.1 (page 3-171) it is stated that "Standard field and laboratory methods are not yet available by which to determine the moisture-characteristic relations for variably saturated fractures and fractured rocks. Prototype testing to develop such methods will be conducted on welded tuffs from G-Tunnel which are similar to those expected to be encountered in the exploratory shaft facility. The benefits of this testing are twofold: first, the program will permit development of quality

level 1 methods and procedures for ESF testing, and second, the results of the tests will provide preliminary data regarding the hydrologic behavior of fractured, welded tuff. Thus, preliminary assessment of the appropriateness of the models of flow processes will be possible." Because prototype testing at laboratory and field scales is planned , prior to the exploratory shaft tests, to evaluate the current concepts of moisture characteristic relations for fracture/matrix flow in unsaturated media, and because tests are planned for developing the technology to conduct these tests in the exploratory shaft, CDSCP Comment 11 is resolved.

Prepared by: W.H. Ford DATE: 4/12/89

Section 8.3.1.2.2.5.1 Activity: Diffusion Tests In The Exploratory Shaft Facility

CDSCP COMMENT 12

Diffusion tests in the exploratory shaft may be affected by capillary effects in the unsaturated zone.

BASIS FOR CDSCP COMMENT

- According to the CDSCP (page 8.3.1.2-253, paragraph 1 and 2), "A small volume of nonsorbing tracers in aqueous solution will be introduced into the bottom of the borehole. Next, the borehole will be sealed with a packer of appropriate size to isolate the diffusion volume from the remainder of the underground environment."

- According to the CDSCP, nonsorbing tracers in aqueous solution will be introduced into the bottom of the borehole in the unsaturated zone. The addition of aqueous solution to the bottom of the borehole in the unsaturated zone will produce movement of the solution away from the borehole under a capillary pressure gradient.

EVALUATION OF SCP RESPONSE

DOE made no revision to the consultation draft in response to this comment. The NRC staff recognizes that the study plan for Study 8.3.1.2.2.5 (diffusion

tests in the exploratory shaft facility) will describe the details and objectives of the tests and that this comment is a study plan level comment; therefore CDSCP Comment 12 is resolved.

Prepared by. W.H. Ford DATE:4/05/89

Section 8.3.1.2.3.1.5 Activity: Testing of the C-hole sites with conservative tracers

CDSCP COMMENT 14

One objective of the C-hole tests is to determine matrix diffusion. It is not apparent that matrix diffusion can be determined from these tests as designed.

BASIS FOR CDSCP COMMENT

- In order to determine matrix diffusion, at least two types of tracers are required, one that diffuses into the matrix and one that does not.

EVALUATION OF SCP RESPONSE

A response to the comment was made with the following statement in SCP Activity 8.3.1.2.3.1.5 (Testing of the C-hole sites with conservative tracers; page 8.3.1.2-401):

> "To determine the effect of matrix diffusion on the migration of tracers, colloids of various sizes will be considered for use in conjunction with conservative tracers, such as 3-trifluoromethylbenzoate. Colloidal and other tracers will be selected such that some tracers will be expected to diffuse into the rock matrix whereas others will not."

Also, in Activity 8.3.1.2.3.1.7 (Testing of the C-hole sites with reactive tracers; page 8.3.1.2-418) the following statement is made:

> "This task will also evaluate manufactured polystyrene spheres as colloid tracers. These colloid tracers will be evaluated as to their interaction with other tracers. These spheres have been shown to be conservative, and their size (1 micron) is larger than the dissolved chemical species so the spheres travel through the paths with the largest fractures or pores. It is anticipated that in fractured media, the polystyrene spheres will provide some information on fracture aperture."

Based on these responses in the SCP, CDSCP comment 14 is resolved.

John W. Bradbury/4-12-89

Section 8.3.1.2.3.1.7 Activity: Testing of the C-hole sites with reactive tracers

CDSCP COMMENT 15

Geohydrology Activity 8.3.1.2.3.1.7 will provide information on fundamental sorption mechanism. It is not clear how this activity will be integrated with the geochemistry program.

BASIS FOR CDSCP COMMENT

- The Description section of Activity 8.3.1.2.3.1.7 discusses an extensive laboratory effort to collect information concerning sorption mechanisms such as chemisorption, molecular-sieve adsorption, ion exchange, and electrostatic adsorption.

- For all four types of sorption, adsorption kinetic constants and sorption equilibrium constants will be determined.

- No references to work in the geochemistry program are supplied in the description of this activity.

EVALUATION OF SCP RESPONSE

The SCP has been revised to explain in more detail integration of the work described in the geohydrology activity (8.3.1.2.3.1.7) with work characterizing sorption in both the saturated and unsaturated zone described in the geochemistry program (8.3.1.3). Refer to the evaluation of SCP response for CDSCP comment 19, a related comment, for additional details. This CDSCP comment is resolved.

(TMo 4/12/89)

Section 8.3.1.3.5 Investigation: Studies to provide the information required on radionuclide retardation by precipitation processes along flow paths to the accessible environment.

CDSCP COMMENT 16

It is stated that gamma radiation will not be important in the solubility experiments as it will be relatively minor over the time of the repository. This ignores the potential importance of kinetics.

BASIS FOR CDSCP COMMENT

- Although the period of significant gamma radiolysis is short relative to the time scale of the repository it does have the potential for significantly altering the redox state and speciation of the waste elements.

- If conversion of radionuclide species generated in a high gamma flux environment to other forms is kinetically inhibited, the effects of radiolysis may indirectly influence reactions over a much longer time scale than the period over which the gamma flux is high.

EVALUATION OF SCP RESPONSE

Section 8.3.4.2.4.1.5 (Activity 1.10.4.1.5: Effects of radiation on water chemistry), describes experiments simulating nearfield conditions in a gamma

radiation field. The information from this activity will be used as input in modeling of water rock interactions in the presence of a radiation field. Geochemical modeling code EQ3/6 will be used to extend to long time periods the chemical behavior of the tuff-water sytem in the presence of other materials or radiation.

The geochemistry program also focuses on solubility experimentation under simulated farfield conditions. Commitments are made in the SCP that "if future data from experiments involving Yucca Mountain water and local minerals or waste package material show significant water composition changes" (page 8.3.1.3-90), modification of the experimental matrix will be reviewed. By this commitment, CDSCP comment 16 is resolved.

John W. Bradbury/4-14-89

Section 8.3.1.3.4 Investigation: Studies to provide the information required on radionuclide retardation by sorption processes along flow paths to the accessible environment,

Section 8.3.1.3.4.1.5 Activity: Statistical analysis of sorption, and

Section 8.3.1.3.7 Investigation: Studies to provide the information required on radionuclide retardation by all processes along paths to the accessible environment.

CDSCP COMMENT 19

The integration of the program emphasizing the measurement of distribution coefficients, expressed in terms of Kd, as a function of water composition, radionuclide composition, and rock type with work described under geohydrology Activity 8.3.1.2.3.1.7 is not clear. The integration of this work is important to gaining an overall understanding of sorption.

BASIS FOR CDSCP COMMENT

- Numerous tests are planned to determine distribution coefficients (Kd) for a few conditions (groundwater chemistry, rock type) and to investigate other potentially mitigating factors (e.g., colloids, particulates, etc.). This information will be used in statistical models to predict sorption characteristics in the vicinity of Yucca Mountain.

- However, statistical models based on the results of experiments simulating a limited range of geochemical conditions may not accurately predict sorption at Yucca Mountain. For example, Palmer, et.al., 1978 show that without an understanding of the mechanism(s), prediction of sorption can be unreliable.

- Activity 8.3.1.2.3.1.7 will provide information concerning the actual mechanisms of sorption.

EVALUATION OF SCP RESPONSE

The integration of the Investigation 8.3.1.3.4 with the Activity 8.3.1.2.3.1.7 will lead to a more fundamental approach to explain sorption. Section 8.3.1.3.4 (p.8.3.1.3-68) has been revised to reflect a planned mechanistic approach to sorption studies, which is to be applied to the whole Yucca Mountain site. It is stated in the SCP Section 8.3.1.3.4.4 (p.8.3.1.3-84) that the overall sorption program described in Section 8.3.1.3.1.4 will be augmented by the C-hole work described in Section 8.3.1.2.3.1.7 while acknowledging that the C-hole sorption mechanism study is very specific to the saturated zone, to one particular stratigraphic unit, and to the particular mineralogy of the unit in which the pump tests will be performed.

The stated objective of the C-hole sorption mechanism work is to characterize the chemical and physical properties of the geologic media in the saturated zone in the vicinity of the C-holes that will affect radionuclide retardation

during ground water flow. This work is designed to characterize and select a set of reactive tracers that exhibit certain types of exchange phenomena to enable them to be used in the planned field tests to hopefully yield useful results which can be modeled and interpreted. The work to elucidate radionuclide sorption mechanisms, especially for the actinide radionuclides, is described in Section 8.3.1.3.4. It was also stated in the SCP Study 8.3.1.3.4.1 (p.8.3.1.3-69) and Section 8.3.1.3.4.4 (p.8.3.1.3-85) that the available empirical sorption data, when used together with the new mechanistic data, will allow extrapolation of sorption data such that a three-dimensional spatial representation of sorption for each radionuclide species can be obtained. These data will then be evaluated in radionuclide transport calculations using solubility data and variable water compositions. Commitments are made in the SCP Section 8.3.1.3.4.4 (p.8.3.1.3-85) as follows: "The study plan for the sorption work (8.3.1.3.4.1 and 8.3.1.3.4.3) and for the reactive tracer tests (8.3.1.2.3.1.7) will provide more detail regarding the study integration." Therefore, CDSCP comment 19 is resolved.

Section 8.3.1.3.5 Investigation: Studies to provide the information required on radionuclide retardation by precipitation processes along flow paths to the accessible environment

CDSCP COMMENT 21

It is stated that solids (tuff) are not needed in the solubility experiments as they have no effect on the water chemistry. However, the presence of a solid phase can be important in trying to reach equilibrium or steady state.

BASIS FOR CDSCP COMMENT

- Precipitation of some phases is kinetically inhibited unless a seed crystal is present; the presence of a solid phase can therefore be important in trying to reach equilibrium or steady state.

- The solubility of radionuclides expected in groundwater in the repository can be predicted most accurately if the effects of physical and chemical conditions on precipitation have been determined from experimental studies.

- From phase rule considerations, the number of restrictions placed on a system involving a precipitation/dissolution reaction must make the system invariant (Crerar et al., 1978). Otherwise, the solubility information acquired may not be reliable to extrapolate to repository conditions.

Solids in contact with groundwater can buffer the solution and, thus, provide a means of restricting the system.

- It is recognized that inclusion of solids in the solubility experiment will make separation of precipitated phases difficult. However, experiments containing solids should more reliably simulate the repository conditions.

EVALUATION OF SCP RESPONSE

In 8.3.1.3.5.1.1 Activity: Solubility measurements, it is stated that "data from tests measuring changes in water chemistry resulting from interactions with the host rock or waste package materials indicate only minor compositional changes. No solubility measurements are planned in which the water compositions are modified to account for these effects. If future data from experiments involving Yucca Mountain water and local minerals of waste package material show significant water composition changes, this decision will be reviewed" (p. 8.3.1.3-90).

It is further stated in this activity that "there are no plans in the present investigation to include other solids such as tuff from Yucca Mountain in the solubility experiments. The presence of tuffs may compromise the ability to obtain meaningful data on the solubility of radionuclides. Including tuffs in the tests greatly increases the complexity of the solubility work because it may not be possible to deconvolute the effects of two operative processes, sorption and precipitation. When sufficient data have been gathered to

generate a fundamental understanding of solution chemistry, then the Project will consider expanding the scope and complexity of the testing to include solubility experiments with tuff. The potential effects of solids on solubility will be addressed in Study 8.3.1.3.6.1."

Based on the testing approach presented in the SCP, CDSCP comment 21 is resolved.

REFERENCE

Crerar, D. A., Susak, N. J., Borcsik, M., and Schwartz, S., 1978, Solubilities of the buffer assemblage pyrite and pyrrhotite and magnetite in NaCl solutions from 200C, Geochimica et Cosmochimica Acta, volume 42, p. 1427-1437.

John W. Bradbury/4-4-89

Section 8.3.1.3.6.1 Study: Dynamic transport column experiments

CDSCP COMMENT 23

Column tests may not provide an adequate assessment of the effects of matrix diffusion and colloid transport on released radionuclides.

BASIS FOR CDSCP COMMENT

- In order to carry out fractured column tests of radionuclide transport, tuff samples containing fractures must be recovered from the rock units of interest.

- Disturbances may produce changes in the physical properties (e.g., fracture aperture) or in the fracture surfaces that will be contacted by the test solutions (e.g., fresh mineral coatings on the fracture surfaces may be exposed).

- If such disturbances occur, these tests may produce results which are not characteristic of in situ repository conditions.

EVALUATION OF SCP RESPONSE

The SCP includes tests to determine the effects of matrix diffusion at several different spatial scales. In addition to studying the effects of matrix diffusion and colloid transport in laboratory experiments (8.3.1.3.6.1 Study:

Dynamic transport column experiments), tests are also planned in the exploratory shaft (Section 8.3.1.2.2.5) and C-wells (Section 8.3.1.2.3.1.5). Furthermore, consideration will be given to information from radionuclide migation work relating to the bomb tests on the Nevada Test Site. Based on these planned studies, the CDSCP comment 23 is resolved.

John W. Bradbury/4-4-89

Section 8.3.1.3.6.1.3 Activity: Unsaturated Tuff Columns

CDSCP COMMENT 24

The effect of rock-water ratio on radionuclide sorption will not be determined because, as stated in this section, "Most of the adsorption isotherms show linear behavior; therefore, the rock-water ratio is not expected to cause a change in the apparent Kd." This statement is invalid.

BASIS FOR CDSCP COMMENT

- Adsorption isotherms describe the effect of radionuclide concentration on Kd.

- The linear region of an adsorption isotherm indicates that there is no effect of radionuclide concentration on Kd.

- Changing the rock-water ratio can cause changes in groundwater chemistry which can affect radionuclide sorption reactions and consequently Kd.

- By decreasing the rock-water ratio of a system it is possible to shift the position on the isotherm from the linear to the nonlinear region.

- Most of the mass of the rock in the repository could be discounted if groundwater is confined to fractures. As a result, the rock-water ratio

of some flow systems of the repository may be less than that in crushed tuff experiments.

EVALUATION OF SCP COMMENT

In Activity 8.3.1.3.6.1.3 it is stated that "it is unclear whether or not the rock-water ratio affects radionuclide sorption. The nonlinear behavior exhibited by some adsorption isotherms may be explained by irreversible adsorption on small numbers of sites, such that increasing the rock-water ratio effectively increases the Kd. Conversely, zeolites generally show a decrease in Kd as the rock-water ratio increases. This may be an experimental artifact related to the difficulty of separating phases. At any rate, the effects of varying rock-water ratio will be investigated and details will be in the study plans" (p. 8.3.1.3-107). Based on the plans to investigate the effects of rock-water ratio on radionuclide sorption, the CDSCP comment 24 is resolved.

John W. Bradbury/4-4-89

Section 8.3.1.3.7.2 Study: Demonstration of applicability of laboratory data to repository transport calculations

CDSCP COMMENT 25

The statement in Chapter 8 of the CDSCP that natural analogs will probably not be used to study radionuclide migration does not agree with a statement made in Chapter 4 discussing the importance of natural analogs.

BASIS FOR CDSCP COMMENT

- Section 8.3.1.7 (p. 8.3.1.3-124) states that "The study of natural analogs to radionuclide migration has not been given attention in this program because these environments typically have chemistry and mineralogy radically different from the potential candidate site."

- Section 8.3.1.7 (p. 8.3.1.3-124) states "It is not considered worthwhile to pursue this technical approach since the applicability of data from such natural analogs in licensing would be questionable."

- In Section 4.3.1.1 (p. 4-129) on Warm and Hot Springs the statement is made that "The study of warm and hot springs in tuffaceous rocks provides information about several important aspects of a repository environment in tuffaceous rock including the transport of certain elements (e.g., strontium, cesium, uranium, thorium, etc.) found in radioactive waste in a hydrothermal system."

- Natural analogs are important to determine the effect of time and scale on geochemical processes and mechanisms expected in a HLW reposiotry (Birchard and Alexander (1983)).

- Results of short-term experiments and models can be partially validated using natural analogs.

- Natural analogs have been used to study radionuclide migration (e.g., Gascoyne, 1987).

EVALUATION OF SCP RESPONSE

The SCP has a discussion in 8.3.1.3.7.2 Study: Demonstration of applicability of laboratory data to repository transport calculations, on the reasons why natural analog studies are important to site characterization along with warnings as to the difficulties of choosing and studying analogs applicable to the repository. Although details concerning the use of natural analogs are not provided in the SCP, the possibility is raised that uranium-series disequilibrium studies could provide information on sorption behavior of selected radionuclides (Finnegan and Bryant, 1987).

A statement is made that "natural analogs will probably be required for several geochemical topics. These include (1) validation of sorption models for individual waste radionuclides, (2) evaluation of the retardation models for elements showing complex and variable geochemical behavior in the natural environment (actinides), (3) validation of transport models involving flow

through fracture networks, and (4) validation of SiO2-kinetics models concerning the stability of secondary alteration minerals in Yucca Mountain." Consequently, the CDSCP comment 25 is resolved.

REVIEW GUIDE

3.3.7, 3.3.9

REFERENCES

Birchard, G.F., Alexander, D.H., Natural Analogues - A Way to Increase Confidence in Prediction of Long-term Performance of Radioactive Waste Disposal, Mat. Res. Soc. Symp., Vol. 15, 1983.

Finnegan, D.L., Bryant, F.A., Methods for Obtaining Sorption Data from Uranium-Series Disequilibria, Los Alamos National Laboratory, LA,11162-MS, 1987.

Gascoyne, M., The use of uranium disequilibrium for site characterization and as an analogue for actinide migration , paper presented at C.E.C. Conference on Natural Analogues in Radionuclide Waste Disposal, Brussels, April 28-30, 1987.

John W. Bradbury/4-4-89

Section 8.3.1.5 Investigation: Studies to Provide the Information Required on Nature and Rates of Change in Climatic Conditions to Predict Future Climates

CDSCP COMMENT 31

Dendroclimatology is absent from the list of activity parameters included in evaluation of regional paleoclimatology. Although tree-ring studies are mentioned briefly in sections on literature review and modern regional climate (Sections 5.2.1.2.3 and 8.3.2.5.1.1.1, respectively), it is not specifically included in the proposed study plans as a separate activity.

BASIS FOR CDSCP COMMENT

- Dendroclimatology is a major, and usually high-resolution, research tool for reconstructing the latest Holocene paleoclimatology at both local and regional scales (Bradley, 1985). Specifically, dendroclimatology is useful for estimating precipitation, temperature, and runoff data over time intervals that extend beyond historical or instrumental records. Techniques exist for cross-correlaion and calibration of present precipitation, temperature, and runoff with time-correlative tree-ring indices. This can provide quantitative calibration for evaluating pre-historic tree-ring data and interpreting past climate over 100 to 1000 year time scales. Dendroclimatology can provide high-resolution proxy data for paleoclimatic interpretations of other proxy data, such as

pollen, sedimentology, recent lake stands and paleofloods, that are already included in the paleoclimatology study.

EVALUATION OF SCP RESPONSE

In the SCP (Study 8.3.1.5.1.2, Paleoclimate: Lake, Playa, Marsh Deposits, and Activity; 8.3.1.5.1.2.4: Chronologic Analyses of Lake, Playa and Marsh Deposits) there are references to "other chronological methods" in which dendrochronology (tree-ring) data collected in central and western Nevada may be used in the development of "paleoclimate transfer functions" on the scale of 10 to 1,000 years. Reference is made in this activity to Chapter 5 for consideration of dendrochronology. The discussion in Chapter 5 (pp. 5-73) is derived from three references - Brubaker and Cook (1983), LaMarche and Marney (1972), and LaMarche (1974). In the Chapter 5 discussion, it is mentioned that dendrochronology has been used to reconstruct seasonal temperature variations for the past 5,500 years in the western U.S.

Staff acknowledges that the duration of past climates (paleoclimates) that can be reconstructed from tree-ring data is quite short (about 5,000 years) in comparison to the reconstruction of past climates for 50,000 to 1,000,000 years by other methods, as are being pursued through activities 8.3.1.5.1.2.1, 8.3.1.5.1.2.2, 8.3.1.5.1.2.3, 8.3.1.5.1.2.4, 8.3.1.5.1.3.2, 8.3.1.5.1.4.1, 8.3.1.5.1.4.2, 8.3.1.5.1.4.3. Staff also acknowledges that appropriate trees do not exist within the controlled area for dendrochronology studies. Staff only notes that the cited literature in Chapter 5 is limited.

Staff concludes that the commitment in the SCP to consider tree-ring data and the published findings of such studies for the region suffices with respect to the entire program of studies and activities for reconstructing past climates at the site. Thus, CDSCP Comment 31 is resolved.

DChery/2/22/89

Section 8.3.1.5.1.5.1 Activity: Paleoclimate-paleoenvironment Synthesis

CDSCP COMMENT 32

The diverse number of theories on the nature of late Pleistocene and Holocene climates derived from various paleovegetation data have not been addressed in this section.

BASIS FOR CDSCP COMMENT

- The impact on repository performance of anticipated and unanticipated processes and events related to future climate must be evaluated. This impact is generally assessed considering Quaternary climate and climatic trends and cycles. The basis for this comment is summarized in the literature review of regional climate hypotheses in Section 5.2.1.2.5. For example, a major controversy exists at present concerning whether vegetation changes observed in packrat middens reflect primarily variations in temperature, precipitation or some combination of these two factors (Bradley, 1985). The proposed studies will probably not provide definitive answers to these types of questions. Possible climatic variations that can produce most of the observed paleovegetation changes can range between: a) increase in precipitation only; b) decreases in temperature only; and c) some intermediate combination of both types of changes. These simple scenarios do not even consider the potential effects on climatic modeling of specific assumptions about seasonal

distribution of climate parameters and the location of storm tracks or air masses.

- While recognizing that the effects of either lower temperature or higher precipitation might be about the same with respect to infiltration, the confidence in the interpretations would be greater if there were not confounding physical processes.

EVALUATION OF SCP RESPONSE

SCP Activity 8.3.1.5.1.5.1 is a summarization (synthesis) of information to be collected in paleolacustrine, terrestrial paleoecology and paleoenvironmental studies (i.e., Studies 8.3.1.5.1.2 [p. 8.3.1.5-42], 8.3.1.5.1.3 [p. 8.3.1.5-54], 8.3.1.5.1.4 [p. 8.3.1.5-57]). Also see Table 8.3.1.5.-2 for a listing of the planned "activity parameters" (pp. 8.3.1.5-7 to 10) for these studies. These several studies are expected to provide complementary data sets and information that will be used to reconstruct climates for the past 50,000-1,000,000 years. The staff's concern about interpretation of packrat middens is just one facet of the many methods that will be used to reconstruct the past climates and the appropriateness of its use will have to be judged at the planned "synthesis" stage.

Also provided in the SCP are Tables 8.3.1.5-3, 4, and 5, "Current representation and alternate hypothesis for regional model, paleoclimate modeling, and paleohydrology modeling for the climate program"

(pp. 8.3.1.5-18 through 31) which provide some idea of the considerations that will be made in synthesizing the information from the three studies.

Staff concludes that the plan in the SCP for synthesis of data and information to determine past climates incorporates the issue raised by CDSCP comment 32. Thus, CDSCP Comment 32 is resolved.

REFERENCE

Bradley, R.S., 1985, Quaternary Paleoclimatology: Methods of Paleoclimatic Reconstruction: Boston, Allen & Unwin.

DChery/3-14-89

Document Name:
SCP/YCCA/DLC/COM/3

Requestor's ID:
POHLE

Author's Name:
N. Coleman

Document Comments:
CDSCP Comment 33

Section 8.3.1.5.2.1.1 Activity: Regional Paleoflood Evaluation

CDSCP COMMENT 33

This activity is concentrated only at the site itself; however, paleoflood data are sparse, and given the regional distribution patterns of rainfall now and probably in at least the recent past, the paleoflood studies should be expanded to the entire region.

BASIS FOR CDSCP COMMENT

- Modern meteorological studies indicate that summer thunderstorms are major sources of extreme flood events in the study area (Section 5.1.1.2). The magnitudes and frequencies of these types of storms and related floods are difficult to predict or estimate at a given locality (Sharon 1981).

EVALUATION OF SCP RESPONSE

Section 8.3.1.5.2.1.1 (Regional paleflood evaluation), where the original plans were for study activities South of Coyote Wash and in the NTS vicinity has been revised. The study activities have been expanded to be "south of Coyote Wash and throughout the region surrounding Yucca Mountain and the Nevada Test Site..." (p. 8.3.1.5-94). This revision of the activities satisfies the recommendation of the NRC comment. Thus, CDSCP comment 33 is resolved.

REFERENCE

Sharon, D., 1981. The Distribution in Space of Local Rainfall in the Namib Desert: Journal Climatology, vol.1, p. 69-75.

D. Chery/3-14-89

Section 8.3.1.12.1 Investigation: Studies To Provide Data On Regional Meteorological Conditions

CDSCP COMMENT 40

The site precipitation monitoring plan will not collect enough data to determine spatial or temporal distribution of extreme events.

BASIS FOR CDSCP COMMENT

- The precipitation monitoring plan states that "the data collected at the site (Section 8.3.1.12.2) will supplement the regional meteorology characterization and provide the relationship between the regional data and site-specific data." Based on the location and extent of existing precipitation stations the adequacy of the planned network is questioned for detection of extreme events producing flash flooding. "These data (specifically precipitation amounts used to track storm trajectories)" (page 8.3.1.12-8) do not appear to be sufficient to track storm trajectories.

- The statistics of extreme precipitation events that cause flash flooding requires both temporal and spatial data, both of which appear insufficient in the plan outline.

- In desert regions, most intense precipitation of the type causing flash

flooding occurs as thunderstorms, often of limited time and areal extent. A long term, dense station network is required to characterize accurately these events. On page 5-20 (Vol. 2, Chapter 5), it is stated that "A more comprehensive precipitation monitoring network is needed both in the immediate vicinity of Yucca Mountain and in sections of the Fortymile Wash drainage to fully evaluate the recharge potential. Plans for such a network are given in Section 8.3.1.2 and 8.3.1.12." If the "comprehensive precipitation monitoring network" is only that proposed in these sections, it is questioned whether that will be adequate for the needed investigations.

EVALUATION OF SCP RESPONSE

The staff recognizes that the purpose of Investigation 8.3.1.12.2 is to collect site-specific meteorological data for calculating dose amounts for accidental surface releases. The five stations provide more meteorological detail than is normally required at other nuclear facilities (such as reactors, reprocessing plants, and spent fuel storage areas). Staff acknowledges that Study 8.3.1.12.2.2 will, in addition, provide meteorological data to investigations 8.3.1.2.1 (Regional hydrologic system), 8.3.1.2.2 (Unsaturated zone hydrologic system), 8.3.1.5.1 (Change in climate conditions to predict future climates), and 8.3.1.14.3 (Schedule for surface characteristics programs). Further, the meteorology data will be used to augment data from such activities as 8.3.1.2.1.2.1 (Surface-water runoff monitoring) in which a network of 28 continuously recording precipitation gages is planned with an additional ten

"weather stations" in the area (see Figure 8.3.1.2-7). The short duration of operation (approximately 5 yrs.) of the precipitation gage network prior to performance evaluation necessitates that the site specific rainfall data must be used to condition spatial and temporal properties known for rainfall in the region to obtain the needed modeling information by methodologies, and relationships that can be applied or have been developed for the region (i.e., Corotis, 1976; Fennessy et. al, 1986; Marshall, 1980; Obsorn et. al, 1980; Rodriguez-Iturbe and Mejia, 1974; Waymire and Gupta, 1981, Wilkinson and Valaderes-Tavares, 1972; and Woolhiser, 1983; Woolhiser, 1988). Specific details of precipitation instrumentation and analyses will be scrutinized in the study plans. Given the purpose of the meteorological stations, possible use of data as a supplement to data from the proposed network of 24 precipitation gages, and the use of existing knowledge about precipitation characteristics in the region, CDSCP comment 40 is resolved.

REFERENCE

Corotis, Ross B., 1976, Stochastic considerations in thunderstorm modeling. Journal of the Hydraulics Division, ASCE, Vol. 102, No. HY7, Proc. paper 12231, 865-879.

Fennessey, N.M., Eagleson, P.S., Wang Qinliang and Rodriguez-Iturbe, I. 1986. Spatial characteristics of observed precipitation fields: a catalog of summer storms in Arizona. Vol. 1. Report No. 307. Department of Civil Engineering, MIT, Cambridge, MA. 404p.

Marshall, R.J. 1980. The estimation and distribution of storm movement and storm structure, using a correlation analysis technique and rain-gauge data. Journal of Hydrology, Vol. 48, No. 1/2, 19-39.

Osborn, H.B., Lane, L.J. and Myers, V.A. 1980. Rainfall/Watershed relationships for southwestern thunderstorms. Trans. ASAE. Vol. 23, No. 1. 82-87, 91.

Rodriguez-Iturbe, I. and Mejia, J.M. 1974. On the transformation of point rainfall to areal rainfall. Water Resources Research. Vo. 10, No. 4. 729-?

Waymire, E. and Gupta, V.K. 1981. The mathematical structure of rainfall representations 1. A review of the stochastic rainfall models. Water Resources Research, Vol. 17, No. 5, 1261-1272.

Wilkinson, J.C. and Valaderes-Tavares. 1972. A methodology for the synthesis of spatially distributed short-time increment storm sequences. Journal of Hydrology. Vol. 16, 307-316.

Woolhiser, D.A. 1983. Multivariate Modeling of Precipitation Processes, Presentation of Fall AGU meeting, San Francisco, CA. (Paper on File in NRC NMSS H-T Section Reference File)

D. Chery, Jr., N. Coleman, 3/21/89

Section 8.3.1.12.2 Investigation: Studies to Provide Data on Atmospheric and Meteorological Phenomena at Potential Locations of Surface Facilities

Section 8.3.1.12.2.1 Study: Meteorological Data Collection at the Yucca Mountain Site

CDSCP COMMENT 41

Plans for coordinating meteorological monitoring do not justify the rationale for establishing a fixed averaging period.

BASIS FOR CDSCP COMMENT

- The time period of importance for different meteorological phenomena is not necessarily the same for either the phenomena or for the studies using the data. In Section 8.3.1.12.1.2 (Study: Plan for synthesis of NNWSI project meteorological monitoring) it is stated that a plan will be developed to coordinate meteorological monitoring efforts to satisfy the requirements of different investigations. Yet in this investigation plan, it is stated that a selection of seven meteorological parameters from five towers already established are recorded as hourly averages.

- Several examples are provided in which hourly averages may not be sufficient for input data. The first is precipitation amount: for

investigations of flash flooding, particulary in desert areas, rainfall intensity, i. e., precipitation during time periods much shorter than 1 hour are often required. A second is atmospheric stability: the most dangerous time for local high concentrations of airborne gases and particulates is often during periods of fumigation in the lowest atmosphere. The fumigation period is usually associated with the breakup of ground-based temperature inversions. Often the fumigation period is short, on the order of 15 minutes. Hourly average atmospheric stability would normally not provide information on the frequency, time of occurrence, and duration of fumigation periods. A third is peak gusts: the magnitude of peak gusts, their frequency and duration are of importance for determining blowing dust. Wind gustiness indices are not based on hourly average wind velocities.

EVALUATION OF SCP RESPONSE

Activity 8.3.1.12.2.1.1 states that the meteorological parameters at the four remote stations (meteorological towers) "will be monitored using continuous analyzers" from which the hourly average values will be obtained. At the main site (meteorological tower with line power) the "continuously recorded meteorological parameters will be reduced and averaged" (page 8.3.1.12-19) for the information needed to assess radiological doses by guidance provided by both the Environmental Protection Agency and NRC (refer to page 8.3.1.12-23 for the list of guidance documents used by the DOE).

The data will be reduced by methodologies that "will be in accord with referenced EPA and NRC rules, regulations, and guidelines" (page 8.3.1.12-19). From the description of how the data will be recorded, there are possibilities that the data (with time increments of less than 1 hour) could be used in other investigations. Considering the purpose of Investigation 8.3.1.12.2 and the stated type of recording equipment, CDSCP comment 41 is resolved.

D. Chery, Jr., N. Coleman, 3/21/89

Section 8.3.4 Waste Package Program

Section 7.4.2.6.5 Environmental considerations in localized corrosion initiation

CDSCP COMMENT 71

The CDSCP states that the quality of the water that will contact the waste packages is expected to have little impact on their long-term integrity. Theconceptual model and resulting calculations to determine the composition of water contacting the waste packages are overly optimistic.

BASIS FOR CDSCP COMMENT

- The corrosion rates and mechanisms are dependent, in part, on the composition of groundwater contacting the waste packages.

- The conceptual model chosen for concentrating salts in the vadose zone water results in a maximum TDS of only 20 times that of J-13 well water (Morales, 1985).

- Alternative scenarios are possible that would describe groundwater compositions first contacting the waste packages much in excess of the maximum concentration listed above.

- It is conceivable that the first groundwater to contact the waste packages will be a brine, saturated with salts.

- The scenarios selected drive the testing program on waste package corrosion.

EVALUATION OF SCP RESPONSE

The SCP still includes in Chapter 7 the discussion from Morales (1985) on mechanisms for concentrating salts in the water that will contact the waste packages. This discussion does not present the complete picture on the current understanding about groundwater compositions that will contact the waste packages. For example, no consideration is given to "heat pipe" effects where solutes are concentrated toward the heat source. However, plans described in Chapter 8 appear to address mechanisms for concentrating salts, such as open-system behavior (p. 8.3.4.2-47), and "heat-pipe" effects. Furthermore, it is stated in the SCP that "the water chemistry plays a critical role in determining the performance of the waste package components." Thus, CDSCP Comment 71 is resolved.

REFERENCE

Morales, A. R., 1985, Technical correspondence in support of the final environmental assessment, Sandia Report, SAND-2509, p. 1-10.

John W. Bradbury/4-28-89

Section 8.3.5.12 Issue resolution strategy for Issue 1.6: Will the site meet the performance objective for pre-waste-emplacement groundwater travel time as required by 10 CFR 60.113?

CDSCP COMMENT 86

Procedures for calculating pathways and groundwater travel times presented in the strategy for Issue 1.6 (Regulatory Requirements for Groundwater Travel Time) may not be adequate for determining the groundwater travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment.

BASIS FOR CDSCP COMMENT

- The CDSCP states that the performance measure for groundwater travel time is the probability or frequency distribution expressed as a cumulative distribution function (cdf) of calculated groundwater travel times for each hydrogeologic unit (Section 8.3.5.12; page 8.3.5.12-17; paragraph 1). The amount of spreading or flattening of the cdf's of groundwater travel time results from the following interrelated factors.

  (1) Calculating groundwater travel time as a random process, viewed as the time taken by inert tracer particles, released at the disturbed zone boundary, to reach the accessible environment (Section 8.3.15.12; page 8.3.5.12-17; paragraph 2).

(2) Variable flow path lengths (Section 8.3.15.12; page 8.3.5.12-15; paragraph 2).

(3) Parameter uncertainties in "Monte Carlo" realizations of groundwater travel time for generating groundwater travel time cdf's (Section 8.3.5.12; page 8.3.5.12-43; paragraph 2).

(4) Effects of matrix diffusion and dispersion (Section 8.3.5.12; page 8.3.5.12-17; paragraph 3).

(5) Uncertainty caused by alternative conceptual models (Section 8.3.5.12; page 8.3.5.12-17; paragraph 3).

- The groundwater travel time cdf's may be construed to represent groundwater travel times for ensembles of pathways, flow tubes or particle tracks as opposed to travel times along the fastest path of likely radionuclide travel as required by regulation. Furthermore, the cdf's do not represent "true" travel times (Section 8.3.5.12; page 8.3.5.12-17; paragraph 4). Therefore, the NRC staff presently has a concern that the use of cdf's, as described in the CDSCP, will not fulfill the regulatory requirement.

EVALUATION OF SCP RESPONSE

The text of Section 8.3.5.12 (Issue 1.6, Groundwater Travel Time) has been revised to delineate a strategy for identifying and calculating groundwater

travel times along any significant groundwater flow path of likely radionuclide travel. Travel times along each identified path of likely radionuclide travel will be calculated to determine whether there are travel times less than 1,000 years. Information needs (1.6.1 through 1.6.4) to resolve the groundwater travel time issue have been revised to more clearly focus on identifying, through obtaining site information and modeling, fastest paths of likely radionuclide travel. The groundwater travel time issue resolution strategy utilizes the hypotheses-testing tables (Tables 8.3.1.2.-2a and 8.3.1.2-2b) to link required information needs to the geohydrologic program of investigations. Hydrologic data on characterizing faults and fracture zones, data for model validation of unsaturated flow process, and data for groundwater flow system models will be among the data obtained to satisfy groundwater travel time information needs. Although the NRC staff still has concerns about SCP approaches to constructing groundwater travel time cumulative distribution curves, CDSCP comment 86 is resolved.

Fred Ross/04-03-89

Section 8.3.5.12 Groundwater Travel Time

CDSCP COMMENT 87

The performance parameters for Groundwater Travel Time listed in Tables 8.3.5.12-2 and 8.3.5.12-3 cannot be correlated with tests described in Sections 8.3.1 to 8.3.1.16

BASIS FOR CDSCP COMMENT

- It can be inferred from the CDSCP that the hydrologic investigations are intended to obtain sufficient data for addressing adequately all performance and design issues or regulatory concerns related to hydrology. However, as acknowledged (Section 8.3.1.2; page 8.3.1.2-39; paragraph 1), the process of connecting the geohydrology program of investigations to the Issue Resolution Strategy for groundwater travel time is incomplete with respect to providing logical, direct ties to the parameters defining the bases of the testing program.

- The NRC staff concludes that it is not possible to evaluate effectively the adequacy of the geohydrology program of investigations, with respect to resolving Performance Issue 1.6, unless a connection between the issue resolution strategy and the testing program is provided.

EVALUATION OF SCP RESPONSE

The comment response acknowledges, as did the CDSCP, "that direct links between performance parameters listed in the issue resolution strategies and the parameters to be obtained from the test programs [activity parameters] are not always clearly identified" (U.S. Department of Energy, 1988; page c-115). Although the CDSCP was not revised in response to this comment, the comment response notes that SCP Table 8.3.1.2-1 does provide a cross reference between the performance and design issues and the activity parameters to be provided by the geohydrology program of investigations. In providing this linkage, the table identifies performance parameter categories that are more directly related to specific performance and design parameters. In conclusion, the CDSCP comment response (USDOE, 1988) states that, "More explicit identification of the linkages between the performance parameters needed for issue resolution and the information to be provided by the testing program to evaluate these parameters will be part of a continuing reevaluation of the basis and adequacy of the testing program during the course of site characterization." (page c-115)

The NRC staff concludes that the performance parameters needed for issue resolution and geohydrology program of investigations are sufficiently linked (through the performance parameter categories and activity parameters shown in Table 8.3.1.2-1) to allow the NRC to evaluate effectively the adequacy of the geohydrology program. Thus CDSCP comment 87 is resolved.

REFERENCES

U.S. Department of Energy, Letter from S. Rousso, DOE, to H. Thompson, Jr., NRC; Subject: Issuance of the Site Characterization Plan (SCP) for the Yucca Mountain Site to the U.S. Nuclear Regulatory Commission, December 28, 1988, 4pp. plus 3 enclosures.

Fred Ross/04-12-89

Section 8.3.5.12 Groundwater Travel Time

CDSCP COMMENT 88

No plan incorporating technical or management activities is presented to track progress in providing and closing out information need 1.6.1 with respect to validating flow model concepts as was done for mathematical model validation in Section 8.3.5.12.2. As a consequence, the ability to resolve a potentially significant technical conern related directly to the performance issue on groundwater travel time is reduced.

BASIS FOR CDSCP COMMENT

- The term "geohydrologic" model, used periodically in the CDSCP, is considered to be synonymous with "conceptual" model of the groundwater flow system. The CDSCP emphasizes the importance of developing a "credible geohydrologic model" (Section 8.2.2.4.1, page 181) and "testing the validity of these models" (Section 8.3.5.12.1, page 27) because "descriptions of the conceptual models and associated uncertainties" are "crucial information required by this issue [1.6]" (Section 8.3.5.12.1, page 25). Further, it is stated that "although little scientific information is called out within Table 8.3.5.12-3 [Supporting performance parameters used by Issue 1.6] to define the conceptual hydrologic models, it is evident that definition of alternative conceptual hydrologic models and assessments of their relative likelihood for the unsaturated

and saturated zones is an important requirement for evaluating ground-water travel time."

° Although the CDSCP indicates that the means by which flow models will be developed and plans that describe how specific parameters values will be obtained are described within the geohydrology program (Section 8.3.5.12.1, pages 25-26), only one specific parameter need with respect to "validation of flow models" is presented within the overall issue resolution strategy. Further, the role of expert judgement in formulating and establishing the credibility of conceptual models is not described.

EVALUATION OF SCP RESPONSE

Section 8.3.1.2 (Overview of the geohydrology program: Description of the present and expected geohydrolgic characteristics required by the performance and design issues) has been revised to include hypotheses-testing tables (Tables 8.3.1.2-2a and 8.3.1.2-b) listing current hypotheses regarding models, uncertainty associated with current hypotheses and models, alternative hypotheses, significance of alternative hypotheses, and studies or activities related to evaluating preferred hypotheses and alternatives. Tables 8.3.1.2-2a and 8.3.1.2-b also link "conceptual models" and hypotheses to their respective issue resolution strategies. The hypotheses testing tables, as incorporated into the program of geohydrologic investigations and issue resolution strategy for groundwater time [issue 1.6], constitutes an adequate technical and

management activity for closing out information needs related to validating groundwater flow model concepts. Thus CDSCP Comment 88 is resolved.

Fred Ross/04-12-89

Section 8.3.5.13 Activity: Total System Performance

CDSCP COMMENT 89

The performance allocation for the contribution of the geochemical characteristics of the site to waste isolation indicates that the tentative parameter goal for chemical retardation factors is a value of 1 or greater. It is unclear how this performance allocation will influence the credit taken for chemical retardation in performance assessment calculations.

BASIS FOR CDSCP COMMENT

- No details are provided in the CDSCP concerning the conditions under which a chemical retardation factor of 1 (no retardation) may be used in performance assessment calculations.

- No information is provided in the CDSCP describing how a chemical retardation factor of "greater than or equal to 1" will adequately describe radionuclide retardation in fractures, where enhanced transport of released radionuclides could occur under certain conditions.

EVALUATION OF SCP RESPONSE

Performance allocation considers the parameter goal for geochemical retardation of 1 (no retardation) only for the initial "preferred" flow/transport model

of the site (i.e. advective/dispersive/ matrix flow and transport). The SCP (Section 8.3.1.3) accommodates the comment by stating that for the initial model, no credit is needed for geochemical retardation. Thus, no revisions have been made that incorporate geochemical retardation in this model of site flow conditions. Since this initial model and associated performance allocation is predicated on DOE's judgement, based on their evaluation of available site information, and it is not the purpose of performance allocation to include alternative conceptual models (i.e., fracture flow), CDSCP comment 89 is considered resolved.

D. Brooks 4/6/89

Section 8.3.5.14 Individual Protection

CDSCP COMMENT 96

The CDSCP does not identify the presence or absence of a "significant source" of groundwater outside of the controlled area as an information need to be incorporated in the logic (approach) to resolve Issue 1.2 (regulatory requirement for limiting individual doses).

BASIS FOR CDSCP COMMENT

- Individual protection requirements of 40 CFR 191.15 demand that all potential pathways (associated with undisturbed performance) from the disposal system to people shall be considered, including the assumption that individuals consume 2 liters per day of drinking water from any "significant source" of groundwater outside of the controlled area. A significant source of groundwater is defined in 40 CFR 191.12 as indicated on page 8.3.5.14-1 of the CDSCP.

- The CDSCP does not reach a preliminary conclusion on the presence or absence of a "significant source" at the site and does not include this as an information need to be included in the resolution logic presented in Figure 8.3.5.14-1 (page 8.3.5.14-3).

EVALUATION OF SCP RESPONSE

In response to the NRC comment, the issue resolution strategy for Issue 1.2 (Will the mined geologic disposal system meet the requirements for limiting individual doses in the accessible environment as required by 40 CFR 191.15?) has been revised. On page 8.3.5.14-9, a fourth parameter has been added to the list of parameters required for resolution of the issue: Determination of whether a significant source of groundwater is present or absent (Information Need 1.2.1). The logic diagram shown in Figure 8.3.5.14-1 has been revised to include a decision point for evaluating whether significant sources of groundwater are present. Thus, CDSCP comment 96 is resolved.

N. Coleman, 4/3/89

Section 8.3.1.2.1.2.1 Surface Water Runoff Monitoring

CDSCP QUESTION 3

How will the hydrologic response from the proposed monitored watershed on the unnamed tributary of Fortymile Wash be transferred to Drill Hole Wash?

BASIS FOR CDSCP QUESTION

- One of the current four continuous stream gages is operated on an unnamed 4 square mile tributary in the head waters of Fortymile Wash near Rattlesnake Ridge, at least 20 miles from the proposed repository site. Presumably, the purpose of this site is to obtain data from a small watershed such as those that exist within Drill Hole Wash where the surface facilities will be located.

- It is a common hydrologic technique to monitor one watershed and then transfer information to one or more additional watersheds. The reasons for this approach vary widely, i. e. length of existing monitoring, accessibility, representativeness, etc. However, it is necessary to have a thorough plan to gather sufficient information about all basins involved in the evaluation to insure that a defensible transfer of information can be accomplished.

- It is apparent from the CDSCP that extensive information about the Drill

Hole Wash basin and subwatersheds will be gathered. This information includes meteorological, geologic and topographic data about the watersheds within the Yucca Mountain area. While such information is necessary, similar information on the Rattlesnake Ridge watershed and a methodology to transfer the information appropriately to the watersheds of interest are also needed.

- It is not clear how the surface-water monitoring data from the headwaters of Fortymile Wash will be used to help define the hydrologic characteristics of the watersheds of primary interest. Appropriate meteorological, soils and topographic information needs to be gathered at the headwaters of Fortymile Wash for comparison to the Drill Hole Wash watersheds.

EVALUATION OF SCP RESPONSE

Section 8.3.1.2.1.2.1 has been modified to state more explicitly the purpose of monitoring streamflow in the upper drainage basin of Fortymile Wash. As stated in the SCP, there is no intent or need to transfer the information to Drill Hole Wash. The monitoring will support the Fortymile Wash recharge study, Activity 8.3.1.2.1.3.3, and resulting data will be used to help develop rainfall-runoff models of the Fortymile Wash drainage basin. Based on this response, CDSCP question 3 is answered.

N. Coleman, 4/12/89

Section 8.3.1.2.3.2.2 Activity: Hydrochemical Characterization of Water in the Upper Part of the Saturated Zone

CDSCP QUESTION 4

Why is isotope sampling to date the groundwater in the upper part of the water table not a part of the hydrochemical characterization of the saturated zone?

BASIS FOR CDSCP QUESTION

- The collection of isotope water samples from the top of the saturated zone immediately beneath or adjacent to the proposed site will help determine if modern water is present at this location and provide additional information on the rate of water movement from the surface to the water table.

- Current plans consist of drilling a well to total depth and then pumping the well for a water sample. This water sample would be composed of waters from all depths below the water surface, and therefore would not clearly indicate how fast water might be flowing from the surface to the water table.

EVALUATION OF SCP RESPONSE

Section 8.3.1.2.3.2.2 has been revised. On page 8.3.1.2-427, it is stated that "If determined to be feasible, a packer will be installed at appropriate

locations in selected boreholes to enable collection of [water] samples from both the upper and lower parts of the saturated interval..." The text also specifies analyses for selected radioisotopes and specifies sampling and isotope analyses for the upper 10 m of the saturated zone. Based on this response, CDSCP question 4 is answered.

N. Coleman, 4/3/89

Section 8.3.1.3.1 Investigation: Studies to provide information on water chemistry within the potential emplacement horizon and along potential flow paths.

Section 8.3.1.3.1.3 Schedules and Milestones

CDSCP QUESTION 5

What information will be obtained through Activity 8.3.1.2.2.2.2?

BASIS FOR CDSCP QUESTION

- The second paragraph of this section states that this study is constrained by Activities 8.3.1.2.2.4.2 and 8.3.1.2.2.2.2.

- Activity 8.3.1.2.2.2.2 is not described anywhere in the CDSCP.

EVALUATION OF SCP RESPONSE

The SCP does not have reference to Activity 8.3.1.2.2.2.2; thus, CDSCP question 5 has been answered.

John W. Bradbury/4-12-89

Section 8.3.1.3.4.3 Study: Development of sorption models (isotherms)

CDSCP QUESTION 6

How will iso-betas and iso-Kds be used in performance assessment tasks?

BASIS FOR CDSCP QUESTION

- The "Description" section of this study states that it may be possible to use empirical sorption coefficients to develop maps with iso-betas (curves of equal sorption heterogeneity) and iso-Kds (curves of equal average sorption behavior) for the Yucca Mountain domain.

- It is stated that these maps will provide a convenient representation of sorption behavior for purposes of the performance assessment tasks of the Information Needs 1.1.3, 1.1.4 and perhaps 1.1.5 (Sections 8.3.5.13.3 through 8.3.5.13.5).

- No further information is presented concerning the use of iso-betas and iso-Kds in either Section 8.3.1.3 or 8.3.5.13.

EVALUATION OF SCP RESPONSE

In 8.3.1.3.4.1.2 Activity: Sorption as a function of sorbing element concentrations (isotherms) it is stated that "The interpretation of these contours could support the selection and development of strategies to model

radionuclide transport by providing basic information on the distribution and variability of sorptive characteristics of each radionuclide throughout and within stratigraphic units" (p. 8.3.1.3-75, 76). This approach allows for flexibility concerning the use of iso-betas and iso-Kds. CDSCP question 6 is resolved.

John W. Bradbury/4-14-89

Section 8.3.1.3.4.5 Schedule and Milestones (for 8.3.1.3.4 Investigation: Studies to provide the information required on radionuclide retardation by sorption processes along flow paths to the accessible environment)

CDSCP QUESTION 7

Is there an error in the placement of milestones on the figure in this section?

BASIS FOR CDSCP QUESTION

- Milestone Z372, Final progress report available on sorption modeling; This report completes the study, is placed earlier in time than Milestone R385, Sorption model complete.

- This appears to be an error in logic since it seems that the final report can not be written (completing this Study) before the completion of the sorption model.

EVALUATION OF SCP RESPONSE

The error in 8.3.1.3.4.5 Scheduling and Milestones in the CDSCP has been corrected in the SCP. Thus, this question has been answered.

John W. Bradbury/4-12-89

Section 8.3.1.3.5 Investigation: Studies to provide the information required on radionuclide retardation by precipitation processes along flow paths to the accessible environment.

CDSCP QUESTION 8

The term "Eh" is used several times in this section as one of the parameters necessary to determine for inclusion in the modeling activities. What assumptions are used in defining an Eh for model calculations?

BASIS FOR CDSCP QUESTION

- The use of the parameter Eh implies that an overall potential determining reversible reaction(s) is controlling the oxidation state of all other redox-sensitive species.

- Such a condition is rarely achieved in the laboratory and certainly not in the field (Lindberg and Runnells, 1984, Meyer et al., 1983). The use of oxygen saturated solutions" will not define a reversible redox reaction that will define a numerical value of Eh because reactions with oxygen are not generally reversible.

- Groundwater data from Yucca Mountain and vicinity (Kerrisk, 1987) show that various redox couples give different results for Eh values, which also differ from Eh measured in these waters.

EVALUATION OF SCP RESPONSE

The term, Eh is not found in the SCP sections reviewed. CDSCP question 8 is resolved.

REFERENCES

Kerrisk, J.F., 1987, Groundwater Chemistry at Yucca Mountain and Vicinity, LA-10929-MS, Los Alamos National Laboratory, Los Alamos, NM.

Lindberg, R.D., and Runnells, D.D., 1984, "Ground Water Redox Reactions: Analysis of Equilibrium State Applied to Eh Measurements and Geochemical Modeling," Science, volume 225, p. 925-927.

Meyer, R. E., Arnold, W.D., Case, F., Shiao, S.Y., and Palmer, D.A., Valence Effects on Adsorption - A Preliminary Assessment of Valence State Control on Sorption Measurements, NUREG/CR-2863 - ORNL-5905, Oak Ridge National Laboratory, Oak Ridge, TN.

John W. Bradbury/4-5-89

Section 8.3.1.3.5.1 Activity: Speciation Measurements

CDSCP QUESTION 9

Photoacoustic spectroscopy will be relied upon to determine speciation in experimental groundwaters. Can the development and application of photoacoustic spectroscopy be completed in the time frame indicated on page 8.3.1.3-76 (prior to sinking of the exploratory shaft)? Is it essential to rely on an unproven method for a critical part of the program?

BASIS FOR CDSCP QUESTION

- On page 8.3.1.3-88 it is stated that the photoacoustic spectroscopy method is in its infancy and that it "is considered critical in interpreting and validating the results of these two studies that will support total system performance assessment."

- The spectra associated with complex natural groundwaters may be difficult to interpret (e.g., Doxtader et al., 1987).

- Reference spectra of actinides in simple systems will need to be acquired to help interpret spectra of complex groundwaters.

EVALUATION OF SCP RESPONSE

It is stated in 8.3.1.3.5.1.2 Activity: Speciation measurements, that photoacoustic spectroscopy is the most promising technique for obtaining speciation data at low concentrations. CDSCP question 9 is answered.

REFERENCE

Doxtader, M.M., Maroni, V.A., Beitz, J.V., and Heaven, M., 1987, Laser photoacoustic spectroscopy for trace level detection of actinides in groundwater, in Bates, J.K. and Seefeldt, W.B., editors, Scientific Basis for Waste Management X, Materials Research Society Symposia Proceedings, p. 173-184.

John W. Bradbury/4-5-89

Section 8.3.1.3.5.2 Study: Colloid behavior

CDSCP QUESTION 10

Why are only plutonium and americium included in the list of elements that may exhibit significant colloid formation?

BASIS FOR CDSCP QUESTION

- In Section 8.3.1.3.5 and in Section 4.1.3.4.1, it is stated that plutonium and americium have been identified as two waste elements that may form stable colloids. Because these elements also contribute significant radioactivity to the waste inventory, experiments on colloid formation and stability are planned for them, apparently to the exclusion of other waste elements known to form colloids.

- Plutonium and americium are included among the waste elements which are considered "most important." Thorium is present in lesser amounts at most times after closure, but becomes increasingly significant after 1000-10,000 years. Thus, thorium is considered one of the "important" elements (Section 4.1.3.1.1).

- The tetravalent actinide ions undergo extensive hydrolysis in solutions with near-neutral values of pH, leading to polymers of high molecular weight which can disperse as colloids. These processes have been studied

extensively for thorium, largely because of its availability and stability of the (IV) oxidation state (Ahrland, Liljenzin, and Rydberg, 1973). In view of its well known chemical tendency to form high polymers, thorium colloids might provide a means for affecting radionuclide transport.

EVALUATION OF SCP RESPONSE

Activity 8.3.1.3.5.2.1 has been revised to make the following commitment: "Although only plutonium and americium will be investigated during the initial phase of the study of waste element colloids, work will be extended to other radionuclides if performance assessments of engineered barrier system and other field and laboratory data show that other radionuclides are potentially important in colloid formation." Based on this commitment, CDSCP question 10 is answered.

REFERENCE

Ahrland, S., Liljenzin, J.O., and Rydberg, J., 1973, Solution Chemistry, pp. 465-635 in "Comprehensive Inorganic Chemistry," Volume 5, "The Actinides," A. F. Trotman-Dickenson, ed., Pergamon Press.

Tin Mo 4/19/89

Section 8.3.1.3.7 Investigation: Studies to provide information required on radionuclide retardation by all processes along flow paths to the accessible environment

8.3.1.3.7.1 Study: Retardation sensitivity analysis

8.3.1.3.7.1.3 Activity: Transport models and related support

CDSCP QUESTION 11

How will the validation of transport and chemical codes be accomplished through this activity?

BASIS FOR CDSCP QUESTION

- The goal of this activity is to "...verify and validate computer codes...."

- To comply with the Quality Assurance procedure NNWSI-SOP-03-02: Software Quality Assurance, and NRC requirements, the codes being used under this study must be verified and validated.

- The activity gives no information on code validation.

EVALUATION OF SCP RESPONSE

The Geochemistry program verification and validation sections 8.3.1.3.7.1.3 and 8.3.1.3.7.2 have been revised to reflect the validation strategy. Thus CDSCP Question 11 has been answered.

Prepared By: W.H. Ford & T. Mo Date: 4/12/89

Section 8.3.1.12.2.1.1 Activity: Site Meteorological Monitoring Program

CDSCP QUESTION 24

Are the location and number of meteorological monitoring sites sufficient for characterization of the wind flow patterns?

BASIS FOR CDSCP QUESTION

- Five sites were selected to collect meteorological data at potential locations of surface facilities and at a "sufficient number of additional locations deemed necessary to characterize the wind flow patterns in the vicinity of Yucca Mountain." The accurate characterization of wind patterns under different background directions and atmospheric stability is crucial to the correct prediction of trajectories of radionuclides or other materials.

EVALUATION OF SCP RESPONSE

A review of the meteorology program (Investigation 8.3.1.12.1, Studies 8.3.1.12.1.1 and 8.3.1.1.12.1.2) indicates that there will be computerized and on-line meteorological instrumentation that is capable of providing changing wind flow patterns and other relevant meteorological parameters needed for rapid radiation dose assessment every fifteen (15) minutes at five (5) key locations in accordance with EPA standards and NRC regulations and guidance.

Five stations placed strategically as planned should be adequate considering that usually only one monitoring station is required of other nuclear facilities, such as a commercial nuclear power plant. Furthermore, the Description section of Study 8.3.1.12.1.2 (p. 8.3.1.12-12) of the SCP has the following committment; "Some of the monitoring programs involved are ongoing or will be expanded as site characterization proceeds." Thus CDSCP Question 24 is answered.

TM 4/12/89

Section 8.3.1.16.1.1 Site Flood And Debris Hazard Studies

CDSCP QUESTION 28

How will the debris-hazard study approach presented in the CDSCP produce data sufficient to raise confidence regarding the debris flow process from the existing "very low" level of confidence to the needed "high" confidence (Table 8.3.1.16-1)?

BASIS FOR CDSCP QUESTION

- Flash floods, and the associated debris flows with some floods, are among the most active geomorphic processes in the southern Nevada region and Yucca Mountain area (Section 3.2.1). Debris flows appear to be most hazardous in small, steep drainages (Campbell, 1975) such as exist just west of the proposed surface facilities at the Yucca Mountain site. Debris flows could be a hazard to the surface facilities. The conceptual design of the repository calls for dikes and diversion channels to convey potential flood water around the surface facilities. These dikes and diversions appear to be sited and sized on preliminary estimates of "clear water" flood flows. Channel slopes west of the surface facility area range from 5% to 25% where debris flows are possible. Material movement initiated upslope from the surface facilities would encounter channel slopes of no more than 1% to 2% around the facilities. These lower slopes could result in deposition. Thus, the potential would appear to be substantial for debris blockage in diversion facilities.

- Site-specific information about debris hazards will mainly be derived from about six fluvial suspended sediment samplers (Activity 8.3.1.2.1.2.1) and qualitative field evaluations during post flood evaluations. This short-term monitoring of the infrequent, poorly understood process of debris flow may not result in a level of understanding sufficient for adequate engineering design.

EVALUATION OF SCP RESPONSE

In Activity 8.3.1.16.1.1 (page 8.3.1.16-11) of the SCP, it is stated

"As part of Activity 8.3.1.2.1.2.2 (transport of debris by severe run-off), field judgments of the nature and severity of debris transport by flood flows will be evaluated to determine the characteristics of debris hazards from flood flows. No standard techniques are available to sample moving coarse-grained debris, which constitutes the major debris hazard, but flood investigators will describe both qualitatively and somewhat quantitatively (by careful field observations) the character of debris that has moved within and through the drainage during severe runoff events. Also, some debris movement characteristics will be deduced through analysis of the debris deposits. Fresh erosion that has resulted from recent flooding will be noted on maps to allow an assessment of potential slope instability. Assembling this type of semiquantitative information will, with time and experience, form the bases for designating the degrees of debris hazards on different types of slopes. Much of the debris hazard assessment is experimental at this time, and more precise

investigative plans cannot be formalized until experience with debris movement during flooding increases.

After a reasonable amount of experiences and data are gained through field investigations, laboratory experiments would seem to be the next logical step in the study process. However, laboratory efforts are not planned at this time. Scaling problems associated with laboratory models may be insurmountable, and the technology of physical modeling of debris movement is not sufficiently advanced to be a reliable alternative or supplement to the planned activities."

The staff accepts this discussion as a satisfactory response and CDSCP Question 28 is answered.

Prepared by: W.H. Ford Date: 4/12/89

ATTACHMENT 3

SUMMARY STATUS OF NEW SCP COMMENTS

HYDROLOGIC TRANSPORT SECTION

SUMMARY STATUS OF NEW SCP COMMENTS

NEW SCP COMMENTS

FINAL 28

		STATUS	COMMENTS
1. FWR/COM/5	The approach for delineating the boundary of the disturbed zone does not include all physical or chemical properties which will have changed as a result of heat generated by the emplaced radioactive wastes such that the resultant change of properties may have a significant effect on the performance of the repository.	FINAL	
2. FWR/COM/1	The strategy for resolving the regulatory requirement for pre-waste-emplacement groundwater travel time does not include consideration of "anticipated processes and events".	FINAL	
3. FWR/COM/7	The proposed method for constructing cumulative distribution curves (cdf's) for groundwater travel time by weighting (perhaps subjectively based on peer review) "alternative conceptual models" is theoretically inappropriate and would not provide exhaustive (complete) assessments of groundwater travel time for NRC staff review.	FINAL	
4. JAP/COM/5	Identification of all assumptions about features, events and processes related to the hydrologic system incorporated into the initial modeling strategy for the performance analysis of groundwater travel time is not complete. Initial assessments as to whether these assumptions are technically justified are not presented.	FINAL	

5. JAP/COM/1	The technical basis for initial assessments of the significance of individual features, events and processes of the hydrogeologic system to performance measures or design and performance parameters is not discussed. In addition, some aspects of the current descriptions of the regional and site hydrogeologic systems are not well stated.	FINAL	
6. JAP/COM/2		DELETED	COVERED BY OTHER COMMENTS
7. JAP/COM/3	There are no hypotheses presented about thermal effects on the hydrologic system caused by emplaced waste. As a result, the staff is not confident that the limited testing program to understand the response of the hydrologic system to the thermal load is adequate. Further, some information from the geohydrology program expected by other program areas can not be provided.	FINAL	
8. JAP/COM/4		DELETED	MERGED INTO NO. 7
9. WHF/COM/15	The hypothesis that liquid water flow in the Calico Hills is restricted to the rock matrix and the hypothesis that matrix properties of the altered Calico Hills nonwelded zeolitized unit are probably largely isotropic, because chemical alteration can be expected to destroy preferred orientations of rock properties are not stated in Table 8.3.1.2-2a and no definite activities to test them are found in the plan.	FINAL	

10 WHF/COM/7	The Solitario Canyon horizontal borehole activity is inadequate to discriminate between the hypotheses that faults are everywhere barriers to fluid flow in nonwelded tuff units or are everywhere conduits for liquid-water flow in nonwelded tuff units. Further, it is doubtful that this activity is adequate to discriminate between the hypotheses that faults are conduits or barriers to liquid water flow in welded tuff units, depending on ambient matrix saturation or alternatively, faults are everywhere conduits for liquid water flow in welded tuff units.	FINAL	
11 WHF/COM/17		DELETED	BASED ON NO.'S 4, 5 AND 17
12 WHF/COM/10		DELETED	Merged into No. 10
13 WHF/COM/8	There are no plans to collect in situ hydrologic properties of the tuffaceous beds of the Calico Hills nonwelded unit in the northern and central areas of the site.	FINAL	
14 WHF/COM/14	The SCP does not contain a plan to adequately characterize the hydrologic properties of the Calico Hills unit, which has been designated the primary barrier to ground water flow and radionuclide transport.	FINAL	
15 WHF/COM/11		DELETED	
16 WHF/COM/16		DELETED	BASED ON NO. 17

17	JAP/COM/6	Technical issues to be addressed by these activities represent only a partial consideration of all features, events or processes that may be essential for a valid mathematical representation of the hydrogeologic system for use in performance assessment analyses. As a consequence, planned activities are insufficient to provide technical justification for initial modeling strategies.	FINAL	
18	WHF/COM/13		DELETED	
19	WHF/COM/9		DELETED	Merged into No. 20
20	FWR/COM/8	No plan for sampling and analyzing pore and fracture fluids from rock core samples in order to detect the possible presence of the LiBr tracer used to identify drilling fluid from USW G-4 is included in the activity on multipurpose-borehole testing near the exploratory shafts. In addition, no contingency plans are presented should tracer used during construction of USW G-4 be discovered in the multipurpose boreholes.	FINAL	
21	NMC/COM/13	Activities presented for the study of the saturated zone flow system are not adequate to characterize saturated zone hydrologic boundaries, flow directions and magnitudes, and flow paths. (CDSCP Comment 13 open)	FINAL	
22	NMC/COM/7		DELETED	MERGED INTO NO. 21
23	NMC/COM/8	The potentiometric surface in the controlled area is not adequately defined by existing well locations, and will not be adequately defined by proposed additional well sites.	FINAL	

24	NMC/COM/16		DELETED	MERGED INTO NO. 23
25	NMC/COM/9	Technetium-99 and Iodine-129 are not explicitly included in studies to characterize groundwater flow and radionuclide background concentrations in groundwater.	FINAL	
26	NMC/COM/25		DELETED	BASED ON ADDITIONAL REVIEW
27	NMC/COM/17		DELETED	
28	NMC/COM/26		DELETED	
29	NMC/COM/27		DELETED	
30	NMC/COM/19		DELETED	
31	NMC/COM/20		DELETED	
32	NMC/COM/21		DELETED	DEFER TO STUDY PLAN
33	NMC/COM/22		DELETED	
34	NMC/COM/23	Use of packers to isolate saturated zone intervals for water sample collection is less than optimal. Where possible, collecting water samples as drilling progresses will maintain a higher level of confidence that the data are representative of the sampled interval.	FINAL	
35	NMC/COM/24		DELETED	

36	NMC/COM/28	The stream flow, precipitation gage and micro-meteorological station locations for the site watershed study may need to be redistributed and increased to adequately support the studies of natural infiltration.	FINAL	
37	JWB/COM/3	Standard solubility approaches alone are not sufficient for determining reliable thermodynamic properties of zeolites. (CDSCP Comment 17 open)	FINAL	
38	JWB/COM/4	The SCP does not provide the rationale for deciding on additional testing to obtain information on the effects of waste package degradation products and the interactions between and among radionuclides on sorption. (CDSCP Comments 18 and 20 open)	FINAL	
39	JWB/COM/5		DELETED	MERGED INTO NO. 38
40	JWB/COM/14	The determination of some parameters and conditions, such as speciation, kinetics, and matrix diffusion under fracture-flow conditions are not planned. (CDSCP Comment 22 open)	FINAL	
41	JWB/COM/10		DELETED	CDSCP COM 71 NOW RESOLVED
42	JWB/COM/11	Planned experimental batch sorption tests involving pure minerals can not result in a mechanistic understanding (i. e., differentiation of surface complexation and ion exchange) of sorptive processes.	FINAL	
43	JWB/COM/12	The geochemistry program is incomplete because a potentially important transport mechanism in unsaturated, fractured media has not been considered.	FINAL	

44 JWB/COM/13	The Investigations to characterize radionuclide retardation is focused on the determination of a Kd for use in the equations Rm=1+rhobkd/thetam and 1 + rhofKd/thetaf, equations 8.3.5.13-14a and b. It has not been demonstrated in the SCP that the use of these equations to model the complex heterogeneous medium of Yucca Mountain is valid for all expected (i. e., anticipated) states of the natural flow system (i. e., full range of unsaturated and saturated).	FINAL	
45 DJB/COM/2		DELETED	MERGED INTO NO. 44
46 DJB/COM/3	Evidence presented is not adequate to conclude that existing sorption characterization data for alkali and alkaline earth elements are sufficient for performance assessment analyses. As a result, data collection plans are not complete.	FINAL	
47 DJB/COM/4	Modeling of solubility and speciation of waste elements is concentrated on equilibrium methods. Equilibrium models require thermodynamic data for solids that are likely to precipitate and for aqueous species that may be present in the water. A key element of this activity is the evaluation of existing data. No specific methods or procedures for these evaluations have been provided in the SCP. The definition of methods and procedures is key to NRC review of the results of this activity.	FINAL	
48 TM/COM/4	Activities to evaluate the effects of radioactive decay heat, the nuclear radiation field, and the effect of non-site specific microorganisms (introduced during site construction) on microbial activity and ecology, and the subsequent effects of these microbial processes on the groundwater chemistry, mineralogy, biogeochemical cycling and transport of high-level radioactive waste radionuclides are not included in the SCP. As a result, there is no way to evaluate the adequacy of this aspect of the DOE program.	FINAL	

49 TM/COM/3	Evidence presented is not adequate to conclude that iodine can be eliminated as as important radionuclide which can be transported in the gaseous phase. As a result, data collection plans are incomplete.	FINAL	
50 TM/COM/5	The SCP does not include studies to evaluate the effects of colloid formation due to stable (non-radioactive) elements formed from anthropogenic sources such as corrosion of the waste cannisters, and organic compounds from drilling muds and explosives used in site construction.	FINAL	

NEW SCP QUESTIONS

1. JWB/QUES/6	DELETED	DEFER TO STUDY PLAN

ATTACHMENT 4

DRAFT POINT PAPERS FOR NEW SCP COMMENTS
(INCLUDING "OPEN" CDSCP COMMENTS AND QUESTIONS)
COMPLETED TO DATE

Section 8.3.5.12 Issue resolution strategy for Issue 1.6: Will the site meet the performance objective for pre-waste-emplacement groundwater travel time as required by 10 CFR 60.113?

COMMENT XX

The approach for delineating the boundary of the disturbed zone does not include all physical or chemical properties which will have changed as a result of heat generated by the emplaced radioactive wastes such that the resultant change of properties may have a significant effect on the performance of the geologic repository.

BASIS

- Calculation of the site groundwater travel time is based on the flow of groundwater from the boundary of the disturbed zone to the accessible environment (10 CFR 60.113 (a)(2)). Therefore, the extent of the disturbed zone is an information need (1.6.5) for resolving Issue 1.6 on groundwater travel time.

- It is stated in the SCP that, "the [10 CFR Part 60.2] definition of the disturbed zone poses two questions: 1. What physical or chemical changes can have a significant effect on the repository's performance? 2. What constitutes a significant effect on the repository's performance?

The NRC staff addressed these questions in a draft generic technical position (GTP) 'Interpretation and Identification of the Disturbed Zone in the High Level Waste Rule; 10 CFR Part 60' (NRC, 1986). The NRC staff proposed that the disturbed zone be defined 'by the zone of significant changes in intrinsic permeability and effective porosity caused by construction of the facility or by the thermal effects of the emplaced waste.' This position presumes that permeability and porosity changes are appropriate surrogates for changes in performance" (page 8.3.5.12-55; paragraphs 3 and 4).

- It is also stated in the SCP that, "Because of the general importance of effective porosity and intrinsic permeability in calculating travel times, changes in these two properties along the paths (probably confined to the matrix, not the fractures) will be taken as measures used to define the boundary of the disturbed zone" (page 8.3.5.12-56; paragraph 2). Thus, the NRC staff concludes that DOE plans to consider only these properties, during site characterization, for delineation of the disturbed zone boundary. For example, the issue resolution approach would not consider thermal loading on the physical and chemical properties of groundwater and the flow process in the unsaturated zone, and the consequent effect on repository performance.

- Not with standing the interpretation made in the NRC draft technical position, 10 CFR 60.2 (definition of disturbed zone) requires that the extent of the disturbed zone be determined by all construction and waste

induced physical and chemical property changes to the rock/water system that could significantly affect repository performance. Such changes would include perturbations to groundwater and geochemical systems resulting from waste generated heat. The draft NRC technical position on the disturbed zone limits determination of disturbance to only construction and waste emplacement mechanical and thermal mechanical changes to intrinsic rock properties, and resultant effects on groundwater travel time. Although, the draft technical position, and consequently the proposed approach stated in the SCP, may be adequate in this respect, the draft technical position is being evaluated for major revision because its narrow interpretation is unsubstantiated by the regulatory record and has limited technical support.

RECOMMENDATION

The approach for delineating the disturbed zone boundary should include consideration of all physical and chemical properties which will have changed as a result of heat generated by the emplaced radioactive wastes. The significance of these changes on repository performance should be ascertained and the delineation of the disturbed zone boundary based on those changes significant to repository performance.

REVIEW GUIDES

3.3.16, 3.2.2, 3.3.19

REFERENCES

U. S. Nuclear Regulatory Commission, "Draft Generic Technical Position: Interpretation and Identification of the Extent of the Disturbed Zone in the High-Level Waste Rule (10 CFR 60)", June 21, 1986.

Fred Ross/04-19-89

Section 8.3.5.12 Issue resolution strategy for Issue 1.6: Will the site meet the performance objective for pre-waste-emplacement groundwater travel time as required by 10 CFR 60.113?

COMMENT XX

The strategy for resolving the regulatory requirement for pre-waste-emplacement groundwater travel time does not include consideration of "anticipated processes and events".

BASIS

- 10 CFR 60.113, Performance of Particular Barriers After Permanent Closure, prescribes numerical performance standards for the waste packages, the engineered barrier system and the geologic setting. 10 CFR 60.113 (a)(2), the regulatory requirement for a 1,000 pre-waste-emplacement groundwater travel time, is the performance standard for the geologic setting and is identified as Issue 1.6 in the SCP.

- In explaining the Commission's concept of the "multibarrier approach", the Statement of Considerations for Final Rule 10 CFR 60 states, "The numerical criteria for the individual barriers included in the rule [10 CFR 60.113] are appropriate, insofar as anticipated processes and events are concerned, in assisting the Commission to determine with reasonable assurance that the proposed EPA standard has been satisfied", (48 FR 28197, June 21, 1983).

- In discussions concerning "anticipated/unanticipated processes and events", the Statement of Considerations for Final Rule 10 CFR 60 states, "In the final rule, numerical performance objectives are established for particular barriers, assuming 'anticipated processes and events'" (48 FR 28200).

- 10 CFR 60.2 defines anticipated processes and events as "those natural processes and events that are reasonably likely to occur during the period the intended performance objective must be achieved. To the extent reasonable in light of the geologic record, it shall be assumed that those processes operating during the Quaternary Period continue to operate but with the perturbations caused by the waste superimposed thereon" (48 FR 28217). "By definition, however, the portion of the geologic setting significantly affected by waste emplacement constitutes the 'disturbed zone.' The groundwater travel time provision applies to transport from the disturbed zone to the accessible environment. This parameter is not dependent upon the effects of waste emplacement" (48 FR 28210). Therefore, because the "disturbed zone" concept in pre-waste-emplacement groundwater travel time accounts for waste induced perturbations in the geologic setting after permanent closure, assumed "anticipated processes and events" for groundwater travel time relate solely to natural processes and events affecting the "pre-waste-emplacement" geologic setting existing beyond the disturbed zone.

RECOMMENDATION

The strategy to resolve the regulatory requirement for pre-waste-emplacement groundwater travel time should include anticipated processes and events.

REVIEW GUIDES

3.3.16, 3.2.2. 3.2.4.2

REFERENCES

U. S. Nuclear Regulatory Commission, "Disposal of High-Level Radioactive Waste In Geologic Repositories, Technical Criteria": 10 CFR 60 Final Rule, Federal Register, Vol. 48, No. 120, June 21, 1983, 28194-28229.

Fred Ross/04-25-89

Section 8.3.5.12 Issue resolution strategy for Issue 1.6: Will the site meet the performance objective for pre-waste-emplacement groundwater travel time as required by 10 CFR 60.113?

COMMENT XX

The proposed method for constructing cumulative distribution curves (cdf's) for groundwater travel time by weighting (perhaps subjectively based on peer review) "alternative conceptual models" is theoretically inappropriate and would not provide exhaustive (complete) assessments of groundwater travel time for NRC staff review.

BASIS

- It is stated in the SCP that, "... the uncertainty in the travel time caused by alternative conceptual models will be incorporated in the cumulative distribution curves, perhaps by subjective weighting of the alternatives based on peer review" (page 8.3.5.12-17; paragraph 2). It is also stated in the SCP that, "...the curves will represent the uncertainty associated with parameter measurements as well as the uncertainty associated with many professional judgments about the effects of the various sources of parameter and conceptual model uncertainty on flow mechanisms" (page 8.3.5.12-17; paragraph 3).

- The NRC staff interprets that "alternative conceptual models" in the

above quoted statements to mean reduced or simplified models (supported by defensible technical evaluations) that represent the complex natural physical system and hydrologic processes (ie. geologic structure, hydrologic system flow boundaries, and flow and transport processes) that will be used in generating a cdf.

- The combining of two or more simplified hydrologic flow-transport models to generate a cdf is inappropriate. The effect of combining weighted "conceptual models" into one overall cdf is in effect a "shrinkage towards the mean" for the predicted variable (ie. groundwater travel time) of the cdf's that would have been generated for each individual and distinct "conceptual model." Thus, information about the extremes of individual cdf's would be lost. The demonstration of shrinkage towards the mean was made in studies by Hill (1982) and Hill et.al. (1984) using Stein's estimators for finding the best estimator of several cdf's for nuclear reactor failures.

RECOMMENDATION

Generate, individually, groundwater travel time cumulative distributions for each defensible "alternative conceptual model" so that information from the extremes of cdf's can be evaluated by the NRC technical review staff.

REFERENCES

Hill, Joe R., 1982, "Improving Failure Rate Estimation Using Parametric Empirical Bayes, USNRC Report NUREG/CR-2994, October 1982.

Hill, J. R., Heger, A.S., and Koen, B.V., 1984, "The Application of Stein and Related Parametric Empirical Bayes Estimators to the Nuclear Plant Reliability Data System, USNRC Report NUREG/CR-3637, April 1984.

REVIEW GUIDES

3.3.16, 3.2.2, 3.2.4.2

Fred Ross/04-27-89

Section 8.3.5.12 Issue resolution strategy for Issue 1.6: Will the site meet the performance objective for pre-waste-emplacement groundwater travel time as required by 10 CFR 60.113?

COMMENT XX

Identification of all assumptions about features, events and processes related to the hydrologic system incorporated into the initial modeling strategy for the performance analysis of groundwater travel time is not complete. Initial assessments as to whether these assumptions are technically justified are not presented.

BASIS

- It is stated in the SCP that "the first step in the five-part process to establish a strategy to resolve Issue 1.6 (Groundwater travel time) is to identify all hydrogeologic units along potential flow paths to the accessible environment and identify all potentially operating processes within each of those units" (page 8.3.5.12-6). Hypotheses posed about the geometric configuration of "hydrogeologic units and potentially operating processes within those units" are listed in Tables 8.3.1.2-2a and 8.3.1.2-2b in Section 8.3.1.2 (Geohydrology Program).

- In Table 8.3.1.2-2b, it is noted that the "current hypothesis" on flow in the saturated zone is that "fractures in Tertiary volcanic rocks serve

as principal pathways for groundwater flow" (page 8.3.1.2-70). Various field tests are planned to evaluate this hypothesis. However, on page 8.3.5.12-70 it is noted that "for purposes of conservatively evaluating ground-water travel time, the saturated zone will probably be treated solely as an equivalent porous medium where fracture properties characterize the medium". This example of a simplified modeling assumption demonstrates a general modeling procedure for performance analyses wherein physical features or complex flow processes are simplified with respect to what information from the field testing program would indicate (in effect, the complexity of features or processes is reduced or specific features or processes are omitted from the analysis). This modeling procedure is clearly acknowledged in the SCP as is the need for analyses to support these simplifying assumptions (page 8.3.5.12-41). This example also demonstrates that certain simplifying assumptions have been incorporated into the initial modeling strategy with out a technical justification to indicate that the effect of these simplifying assumptions on performance predictions is negligible (it is noted that technical justification for eliminating those processes that can be shown to be of sufficiently negligible effect in performance analyses is to be provided by Activity 8.3.1.2.2.9.3; Simulation of the natural hydrogeologic system, although results of work completed to date, if any, have not been presented). Further, the discussion on page 8.3.5.12-5 indicates that the only flow process of significance in calculating groundwater travel time is whether flow in the unsaturated zone is predominately in the matrix or alternatively, flow in fractures is

continous. Although it may be that these alternatives are the most significant to calculating groundwater travel time, the manner that other physical features or complex flow processes are treated in performance analyses may also be significant. For example, neither the method for, or significance of, defining upper, lower or lateral boundaries of the unsaturated zone in performance analyses is considered in the strategy presented.

- It is the position of the staff that "the use of models to represent features, events, processes, or repository components or subsystems should be justified through a discussion of the assumptions, application(s), and limitations of the mathematical model. These should not contradict any of the hypotheses embedded in the corresponding conceptual model(s). While mathematical models should not be unnecessarily complex, all processes that could effect model results should be considered and decisions to omit certain processes should be technically justified. The assumptions, application(s) and limitations of the procedures identified should be discussed" (Review Guide 3.2.4.4.2; page 35). That has not been done in this section. Further, that has not been adequately done elsewhere in the SCP (Refer to comments SCP/YUCCA/JAP/COM/1 and SCP/YUCCA/JAP/COM/6).

RECOMMENDATION

Identify all assumptions about features, events and processes, related to the hydrologic system, that are incorporated into the initial modeling strategy for the performance analysis of groundwater travel time. Indicate which

assumptions are believed to be technically justified based on currently available information. Indicate which assumptions require additional support before they can be considered to be justified and reference specific plans to obtain needed supporting information.

REVIEW GUIDES

3.2.4.4, 3.2.4.5

POHLE 4/28/89

Section 8.3.1.2 Overview of the geohydrology program: Description of the present and expected geohydrologic characteristics required by the performance and design issues

COMMENT XX

The technical basis for initial assessments of the significance of individual features, events and processes of the hydrogeologic system to performance measures or design and performance parameters is not discussed. In addition, some aspects of the current descriptions of the regional and site hydrogeologic systems are not well stated.

BASIS

- General descriptions of the regional and site geohydrologic systems are presented in Chapter 3. These general descriptions represent the overall "conceptual models" for these systems. Further, these "conceptual models" have been summarized by dividing them into a series of "model elements" as presented in Section 8.3.1.2 (Tables 8.3.1.2-2a and 8.3.1.2-2b). Each "model element" represents a specific physical feature, event or process related to the regional or site hydrologic system. For each feature, event or process related to the regional or site hydrologic system, the current understanding about the feature, event or process is discussed. Initial estimates as to the significance of each feature, event or process to repository performance are made by assessing the

relevant performance measure, design or performance parameter and noting the sensitivity of these parameters for each feature, event or process. Finally, specific studies or activities are correlated with each feature, event or process to demonstrate that plans have been developed to provide information to support each hypothesis.

- To determine whether proposed studies will provide all the information necessary to describe the regional and site hydrologic systems, the staff has reviewed the information presented in Chapter 3 and Section 8.3.1.2. As a result of that review, the staff has made the following observations:

  (1) A clear distinction between specific physical features, events, processes, techniques for deriving hydrologic parameters and simplifying modeling assumptions that may be used in performance analyses is not made. For example, in Table 8.3.1.2-2a the assumption that discrete fractures and fracture flow can be modeled as equivalent porous media is not differentiated from such hypotheses as "matric potential is definable and measureable in terms of capillarity/adsorption theory (Kelvin equation)" (page 8.3.1.2-65), "the rock-matrix hydrologic properties within distinct hydrogeologic units can be characterized by using classical-statistical and geostatistical methods" (page 8.3.1.2-67) and "laboratory-scale measurements of matrix hydrologic properties can be extrapolated to evaluate field-scale problems" (page 8.3.1.2-67; all under the category of "data-reduction models". Although it may well be that these hypotheses need to be

confirmed in order to support the modeling assumption, the significance of the lack of distinction is that a complete presentation of initial modeling assumptions (that are to be used in planned analyses of the performance objectives of 10 CFR 60) has not been made for the geohydrology program.

(2) Some statements of hypotheses are unclear. For example, in Table 8.3.1.2-2a, under the model element entitled "conservation of energy", the current representation reads "although the presence of the geothermal temperature gradient vitiglobal isothermal approximation, local thermodynamic equilibrium (LTE) can be assumed for localized regions within the system" (page 8.3.1.2-60). Without a clear presentation of hypotheses, it is difficult to evaluate the hypotheses as they relate to existing evidence from field or laboratory tests. Determining the appropriateness of the planned testing program also is difficult.

(3) Assessments presented in tables 8.3.1.2-2a and 8.3.1.2-2b as to whether specific performance measures, design or performance parameters are sensitive to each hypothesis about features, events or processes related to the hydrologic system appear to be <u>judgemental</u> because no specific analyses are referenced to support these assessments. The need to reduce the uncertainty in individual hypotheses is dependent on these assessments.

(4) For almost all features, events or processes presented for the unsaturated zone hydrologic system, the related performance measure, design or performance parameter is either groundwater travel time, water inflow to the repository, or both. Of the 48 items presented representing features, events or processes, only 4 are explicitly identified as relevant to radionuclide transport to the accessible environment. If the intent is to propose that most aspects of the hydrologic system are irrelevent to radionuclide transport to the accessible environment, considerable justification is necessary which has not been provided in the SCP.

RECOMMENDATION

The geohydrology program should be reevaluated considering these observations.

REVIEW GUIDES

3.2.4.4, 3.2.4.5

POHLE 4/28/89

Section 8.3.1.2 Overview of the geohydrology program: Description of the present and expected geohydrologic characteristics required by the performance and design issues

Section 8.3.2 Repository Program

Section 8.3.4 Waste Package Program

COMMENT XX

There are no hypotheses presented about thermal effects on the hydrologic system caused by emplaced waste. As a result, the staff is not confident that the limited testing program to understand the response of the hydrologic system to the thermal load is adequate. Further, some information from the geohydrology program expected by other program areas can not be provided.

BASIS

- Hypotheses about the hydrologic system presented in Tables 8.3.1.2-2a (current representation and alternative hypotheses for unsaturated-zone hydrologic system conceptual models for the geohydrology program) and 8.3.1.2-2b (current representation and alternative hypotheses for the saturated-zone hydrologic system conceptual models for the site geohydrology program) in Section 8.3.1.2 (Geohydrology Program) relate both to ambient and future state conditions of the system. Hypotheses

related to future state conditions are incomplete because there are no hypotheses presented about thermal effects on the hydrologic system caused by emplaced waste.

- In other instances, hypotheses about the effects on the hydrologic system resulting from various causative events (external forcing functions) are presented in other sections of the SCP. For example, hypotheses about the effects of tectonics on the hydrologic system are presented in Table 8.3.1.8-7 (page 8.3.1.8-38) of Section 8.3.1.8 (Postclosure Tectonics Program). No hypotheses regarding thermal effects on the hydrologic system caused by emplaced waste are presented in other sections of the SCP dealing with the various site programs.

- Chapter 7 (Waste Package) provides a description of the waste package components, emplacement environment, design, and status of research and development supporting the waste package program. Section 7.1 (Emplacement Environment) provides some of the "anticipated conditions of the setting relevant to waste package design and performance" (pages 7-8 through 7-10). Further, on page 7-52 it is noted that the "essential features of a conceptual model of the near-field hydrothermal response to the emplacement of the waste packages are described in Preuss et al. (1984)." While it is clearly stated in the SCP that "there is very little information, experimental or theoretical, on thermally driven flow in partially saturated rocks" (page 7-46), these "anticipated conditions" and "essential features" are not clearly categorized in terms of which are

unsupported hypotheses and which are supported by available data or analyses so as to form a foundation for developing a sound testing program.

- There are planned studies and activities for coupled interaction tests such as Study 1.10.4.2 (Hydrologic properties of waste package environment; laboratory activities and modeling analyses) and Study 1.10.4.1 (Engineered barrier system field tests; larger scale tests to validate the laboratory activites). Although lists of activity parameters are presented for these studies, little detail is provided in terms of a discussion of complex processes to be evaluated. Further, these studies and activities for coupled interaction tests are referenced in Table 8.3.4.2-4 (pages 8.3.4.2-11 through 8.3.4.2-22) wherein they are correlated only with performance parameters and characterization parameters for the waste package program. Correlation of these studies and activities with performance and design parameters for repository design criteria for radiological safety are provided only in general terms (program level) in Section 8.3.2.3-3 (such as Table 8.3.2.3-3; pages 8.3.2.3-30 through 8.3.2.3-35). In neither case are studies and activities correlated with specific hypotheses about the thermal effects on the hydrologic system in the vicinity of the repository. Thus, no clear statement of the specific technical issues (complex processes) to be addressed by these activities is provided. As a consequence, staff is not confident that these limited studies and activities are adequate to

evaluate all significant coupled thermo-hydrologic processes.

- Failure to present hypotheses regarding thermal effects on the hydrologic system has resulted in problems integrating information needs with planned characterization activities. For example, a parameter required for Issue 2.7 (Repository design criteria for radiological safety) is the "water content of the host rock as a function of temperature and time" (Table 8.3.2.3-3; page 8.3.2.3-30). That table indicates the parameter is to be provided by the geohydrology program. Review of the geohydrology program indicates that there are no studies or activities presented to evaluate future changes in water content of the host rock resulting from thermal effects (temperature) from emplaced waste, although there are activities presented for testing the response of the hydrologic system to the natural geothermal gradient.

RECOMMENDATION

Hypotheses regarding thermal effects on the hydrologic system should be presented and related to the specific studies and activities that will evaluate them. Assure that the information to be provided by the geohydrology program satisfies the needs of other program areas.

REVIEW GUIDES

3.2.2, 3.2.4.4, 3.2.4.5

POHLE 4/28/89

Section 8.3.1.2 Overview of the geohydrology program: Description of the present and expected geohydrologic characteristics required by the performance and design issues

Table 8.3.1.2-2a Current representation and alternative hypotheses for unsaturated-zone hydrologic system conceptual models for the geohydrology program

COMMENT XX

The hypothesis that liquid-water flow in the Calico Hills is restricted to the rock matrix and the hypothesis that matrix properties of the altered Calico Hills nonwelded zeolitized unit are probably largely isotropic, because chemical alteration can be expected to destroy preferred orientations of rock properties are not stated in Table 8.3.1.2-2a and no definite activities to test them are found in the plan.

BASIS

- The Calico Hills nonwelded unit has been identified in the SCP as a principal barrier to unsaturated ground water flow and transport of radionuclides from the repository. Therefore, it is critical to have a good understanding of this unit's hydrologic processes.

- Two important hypotheses concerning the Calico Hills unit are not identified in Table 8.3.1.2-2a. First, while the table does contain a

hypothesis (current representation) on page 8.3.1.2-66 that "liquid-water flow in the Topopah Spring is restricted to the rock matrix", it does not include a similar hypothesis for nonwelded units such as those of the Calico Hills. This is identified as an hypothesis in Chapter 3 where it is stated that flow in the Calico Hills nonwelded units is predominately vertical through the matrix (page 3-196). Second, in Section 3.9.2.1, it is stated that the matrix properties of the altered Calico Hills nonwelded zeolitized unit are probably largely isotropic, "because chemical alteration can be expected to destroy preferred orientations of rock properties" (page 3-175).

- No definite activities are found in the plan to test these hypotheses. However, it may be that the first hypothesis will be tested by activities 8.3.1.2.2.4.6 and 8.4.2.1.6.1 when details of these activities are available. No planned activities were found that test the second hypothesis. This hypothesis which assumes that the matrix properties of altered Calico Hills nonwelded zeolitized unit is largely isotropic can probably be best tested in the saturated zone. The use of multiple wells in saturated rocks to test for anisotropy is an established technology that allows a much larger volume of rock to be tested than unsaturated zone technology.

RECOMMENDATION

Activities should be developed to test the hypothesis that liquid-water flow in the Calico Hills is restricted to the rock matrix and the hypothesis that

matrix properties of the altered Calico Hills nonwelded zeolitized unit are probably largely isotropic, because chemical alteration can be expected to destroy preferred orientations of rock properties. Testing the hypothesis that the matrix of the altered Calico Hills nonwelded zeolitized unit is largely isotropic, by using multiple well tests in the saturated zone, should be considered.

REVIEW GUIDES

3.2.3, 3.2.4.4, 3.2.4.5

Prepared By: W.H. Ford and the Center DATE: 5/01/89

Section 8.3.1.2.2.3.3 Activity: Solitario Canyon Horizontal Borehole Studies

COMMENT XX

The Solitario Canyon Horizontal borehole activity is inadequate to discriminate between the hypotheses that faults are everywhere barriers to fluid flow in nonwelded tuff units or are everywhere conduits for liquid-water flow in nonwelded tuff units. Further, it is doubtful that this activity is adequate to discriminate between the hypotheses that faults are conduits or barriers to liquid water flow in welded tuff units, depending on ambient matrix saturation or alternatively, faults are everywhere conduits for liquid water flow in welded tuff units.

BASIS

- Activity 8.3.1.2.2.3.3 (Solitario Canyon Horizontal borehole study) is identified as the sole activity to discriminate between the hypotheses that faults are either barriers to fluid flow in nonwelded tuff units for all matrix saturations or that faults are everywhere conduits for liquid-water flow in nonwelded tuff units (Table 8.3.1.2-2a; page 8.3.1.2-53). However, because this activity does not contain any tests in nonwelded tuff units these hypotheses will not be tested. In addition, it is not evident that any other planned activities will test these hypotheses.

- This activity is also identified as the sole activity to discriminate between the hypotheses that faults are conduits or barriers to liquid water flow in welded tuff units, depending on ambient matrix saturation or alternatively, faults are everywhere conduits for liquid water flow in welded tuff units (Table8.3.1.2-2a; page 8.3.1.2-53). However, it is very doubtful that this can be accomplished with a single horizontal borehole.

RECOMMENDATIONS

Specific activities should be developed to discriminate between the hypotheses that faults are either barriers to fluid flow in nonwelded tuff units for all matrix saturations or alternatively, faults are everywhere conduits for liquid-water flow in nonwelded tuff. The adequacy of this activity to discriminate between the hypotheses that faults are conduits or barriers to liquid water flow in welded tuff units, depending on ambient matrix saturation or alternatively, faults are everywhere conduits for liquid water flow in welded tuff units should be re-evaluated because it is very doubtful that this can be accomplished with a single horizontal borehole.

REVIEW GUIDES

3.2.4.5, 3.2.4.6

Prepared by W.H. Ford DATE: 4/18/89

Section 8.3.1.2.2.3.2 Activity: Site Vertical Borehole Studies

COMMENT XX

There are no plans to collect in situ hydrologic properties of the tuffaceous beds of the Calico Hills nonwelded unit in the northern and central areas of the site.

BASIS

- Vertical boreholes will be used to provide the only in situ data on hydrologic parameters such as matrix potential, water potential, thermal potential, pneumatic potential, pneumatic bulk permeability, and hydraulic bulk permeability of the Calico Hills nonwelded unit.

- The boreholes that will be used to collect data on the Calico Hills are located in three general locations. Two of these locations are located outside and south of the repository block and one is located inside the southern end of the repository block. Boreholes at these locations will not provide any information on in situ conditions in the central and northern areas of the repository. To the south, the Calico Hills is more vitirc and contains fewer zeolitized rocks than the central and northern areas of the repository (Activity 8.4.2.1.6.1, page 8.4.2-33 and Nimick et al, 1988). Further, the saturated matrix permeability of the Calico Hills zeolitic tuff is generally several orders of magnitude less than that of the vitric facies of the Calico Hills tuff (Peters et al., 1986; Montazer

and Wilson, 1984). As a result, distributions of hydrologic parameters in the central and northern areas of the repository block will likely be very different than the southern areas. By not testing the Calico Hills nonwelded unit in the central and northern areas of the repository, a primary barrier will not be adequately characterized.

RECOMMENDATION

The Site Vertical Borehole Study should be expanded to characterize the in situ hydrologic conditions of the Calico Hills unit in the northern and central areas of the site.

REFERENCES

Montazer, P., and W.E. Wilson, 1984, Conceptual Hydrologic Model of Flow in the Unsaturated Zone, Yucca Mountain, Nevada, USGS-WRI-84-4345, Water-Resources Investigations Report, U.S. Geological Survey.

Nimick et al, 1988, Preliminary Evaluation of the Exploratory Shaft Representativeness for the Yucca Mountain Project, Sandia Report, SAND87-1685

Peters, R.R., J.H. Gauthier, and A.L. Dudley, 1986, The Effect of Percolation Rate on Water-Travel Time in Deep Saturated Zones, SAND85-0854, Sandia National Laboratories, Albuquerque, N. Mex.

REVIEW GUIDES

3.2.3, 3.2.4.4, 3.2.4.5

Prepared by: W.H. Ford and the Center DATE: 4-28-89

Section 8.4.2.1.6.1 Characterization of the Calico Hills Nonwelded Unit

Section 8.3.1.2.2.4.6 Activity: Calico Hills Test in the Exploratory Shaft Facility

COMMENT XX

The SCP does not contain a plan to adequately characterize the hydrologic properties of the Calico Hills unit, which has been designated the primary barrier to ground water flow and radionuclide transport.

BASIS

- In Section 8.4.2.1.6.1 it is stated "the Calico Hills nonwelded unit has been designated as the primary barrier to ground-water flow and radionuclide transport. As such, the flow processes and conditions in that unit must be sufficiently understood to have a high degree of confidence in the effectiveness and limitations of that barrier" (page 8.4.2-32)." Specifically, it is important to understand the effects that fractures and faults have on flow paths and travel times, and the conditions under which fracture flow may occur.

- To collect these data the present plan commits only to using vertical boreholes drilled from the surface. However, this plan will provide "little information about the distributions and flow characteristics of fractures and faults in the Calico Hills nonwelded unit" (page 8.4.2-34).

Specifically, it is doubtful that the sole use of vertical boreholes will allow an important hypothesis with respect to repository performance to be tested. The hypothesis is that flow in the Calico Hills nonwelded units is predominantly vertical through the matrix (although a lateral component may occur parallel to the bedding within the Calico Hills nonwelded vitric unit) and continues directly to the water table wherever the water table transects the Calico Hills nonwelded unit (Section 3.93, GROUND-WATER FLOW SYSTEM CONCEPTUAL MODEL, page 3-196). This hypothesis is important, because if flow in the Calico Hills unit is predominantly through the matrix, the Calico Hills unit may provide an effective barrier that would contribute singificantly to meeting the groundwater travel time and radionuclide solute transport criteria.

- In activities 8.3.1.2.2.4.6 and 8.4.2.1.6.1, it is recognized that "the planned boreholes of the feature-sampling program and the systematic drilling program have some limitations, because they provide little information about the distributions and flow characteristics of fractures and faults" (page 8.4.2-34). Therefore other methods of collecting this information are being considered such as shaft sinking, drifting and angled boreholes. It is also recognized that whatever methods are chosen to characterize the Calico Hills, assurance must be given that the gathering of data should not jeopardize the effectiveness of this unit as a barrier (pages 8.3.1.2-300 and 8.4.2-32). Therefore, the decision on how hydrologic data will be gathered on the Calico Hills unit will be "based on a review of the data needs for this unit, an analysis of the risks and benefits of acquiring these data with a variety of techniques,

and an evaluation of the potential impacts on site performance. Before taking action, DOE will consult with the NRC on the basis for the decision" (page 8.4.2-33).

RECOMMENDATIONS

Provide a complete plan to adequately characterize the hydrologic properties of the Calico Hills unit.

REVIEW GUIDES

3.2.3, 3.2.4.4, 3.2.4.5

Prepared By: W.H. Ford and the Center DATE:4/28/89

Section 8.3.1.2.2.9.3 Activity: Simulation of the natural hydrogeologic system

Section 8.3.1.2.3.3.2 Activity: Development of a fracture network model

Section 8.3.1.2.3.3.3 Activity: Calculation of flow paths, fluxes, and velocities within the saturated zone to the accessible environment

COMMENT XX

Technical issues to be addressed by these activities represent only a partial consideration of all features, events or processes that may be essential for a valid mathematical representation of the hydrogeologic system for use in performance assessment analyses. As a consequence, planned activities are insufficient to provide technical justification for initial modeling strategies.

BASIS

- A primary objective of the activity on simulation of the natural hydrogeologic system (unsaturated zone only) is to "identify those hydrogeologic processes and concepts that are essential for a valid mathematical representation for performance assessment analyses and to eliminate those that can be shown to be of sufficiently negligible effect"

(page 8.3.1.2-357). Thus, it is evident from that objective that results of this activity are to provide technical justification for simplifying assumptions incorporated into planned modeling strategies for performance analyses. Specific technical issues to be addressed by this activity include: 1. strategies and methodologies for constructing three-dimensional, fluid-flow models for the site hydrogeologic system; 2. relative contributions of liquid-water and water-vapor fluxes to the net moisture flux within the three-dimensional system; 3. likelihood for the occurrence of upward diffusion or advection of water vapor in fractures coupled to a corresponding downward return flow of liquid water within the rock matrix; 4. limiting conditions under which capillary barriers and perched water body zones can be expected to occur; 5. effects produced by variations with space and time in assumed land-surface net-infiltration rates; and 6. the impact of time-dependent stress and thermal fields [ambient] on the unsaturated-zone hydrogeologic flow system (page 8.3.1.2-357). Although the issues that are identified are reasonable, they cannot be correlated directly with modeling assumptions incorporated into planned modeling strategies for performance analyses because all initial assumptions have not yet been identified (refer to comment SCP/YUCCA/JAP/COM/5). Thus, there is no basis to conclude that planned work to provide technical justification for those simplifying assumptions that relate to the unsaturated zone is complete.

- The objectives of the activities on development of a fracture network model and calculation of flow paths, fluxes, and velocities within the

saturated zone to the accessible environment are not explicitly associated with identifying "those processes and concepts essential for a valid mathematical representation for performance assessment analyses" as is the similar activity for the unsaturated zone. However, complete review of the text indicates that it is reasonable to conclude that the primary objective of these activities is essentially the same, that is to "identify processes and concepts essential for a valid mathematical representation". However, the only technical issue discussed in any detail that is to be addressed in these activities is to "identify geohydrologic conditions at Yucca Mountain where ground-water flow and conservative solute transport can be properly evaluated using the porous-medium assumption" (page 8.3.1.2-436) and similarly to "evaluate the porous-media concept and fracture-network concept for determining flow paths, fluxes, and velocities" (page 8.3.1.2-441). Because the current modeling strategy for groundwater travel time, for example, assumes that "for purposes of conservatively evaluating ground-water travel time, the saturated zone will probably be treated solely as an equivalent porous medium where fracture properties characterize the medium" (page 8.3.5.12-70), it is necessary to provide technical justification for calculating groundwater flow using the porous-medium assumption. However, there are other technical issues related to the saturated zone that need to be evaluated under these activities. For example, numerous hypotheses about physical features, events and processes related to the saturated zone are presented in Table 8.3.1.2-2b (e. g., hydrogeologic units, faults, lineaments, upper boundary, lower boundary, lateral

boundary, coupled effects, volcanism effects, stress/strain effects, future climate effects and geothermal effects). These have not been discussed. Therefore, plans need to be presented as to how these features, events and processes will be evaluated and incorporated in the performance assessment models by specifying what are the simplifying assumptions and what analogous technical issues will have to be evaluated to provide technical justification for the simplifying assumptions. Thus, the planned activities are insufficient to determine significant flow processes and provide technical justification for potential modeling strategies.

RECOMMENDATION

Technical issues to be addressed by these activities should be developed in a more complete and systemmatic manner so as to allow correlations to be made with initial modeling assumptions being used in performance analyses and increased confidence that technical justification for all features, events or processes that will be omitted from performance analyses will be provided.

REVIEW GUIDES

3.2.4.4, 3.2.4.5

POHLE 4/24/89

Section 8.3.1.2.2.4.9 Activity: Multipurpose-Borehole Testing Near the Exploratory Shafts

COMMENT XX

No plan for sampling and analyzing pore and fracture fluids from rock core samples in order to detect the possible presence of the LiBr tracer used to identify drilling fluid from USW G-4 is included in the activity on multipurpose-borehole testing near the exploratory shafts. In addition, no contingency plans are presented should tracer used during construction of USW G-4 be discovered in the multipurpose boreholes.

BASIS

- Matrix hydrologic property measurements will be conducted on consolidated rock samples taken from excavations and boreholes in ES-1 as part of the investigation designed to develop a comprehensive matrix-property data base to be used in the calculation of matrix flux within the unsaturated zone at Yucca Mountain (8.3.1.2-183; paragraph 4). Water will also be extracted from rock samples for geochemical analyses (8.3.1.2-184; paragraph 2). An important assumption of this investigation is that samples represent ambient hydrologic and geochemical conditions of the unsaturated zone.

- The two multipurpose-boreholes are to provide confirmation of conditions expected to be encountered during shaft construction (8.3.1.2-312; paragraph 2).

- A potential condition that could be encountered in ES-1 is the presence of water used in the construction of test hole USW G-4, which contained 20 ppm LiBr tracer. This would be the result of lateral migration of USW G-4 drilling fluid to areas of exploratory shaft excavation.

- One task of the multipurpose-borehole activity is to sample any perched water discovered in either of the multipurpose-boreholes. However, the absence of perched water alone does not preclude the possibility that some pore and fracture fluids near the areas of ESF excavation is the result of water lost during the drilling of USW G-4. Thus, if traces of LiBr are detected in fluids from rock core samples, the ability to measure ambient moisture content, matric potential, and water chemistry at the ESF location will have been compromised.

- Under Activity 8.3.1.2.2.7.2 (Aqueous-phase chemical investigations), samples of pore and fracture fluids will be collected from selected wells in the unsaturated zone (Figure 8.3.1.2-20; page 8.3.1.2-336). These samples will be checked for the presence of various tracers that will be used during the drilling of wells and the construction of the exploratory shafts. The multipurpose boreholes are not among the wells selected for inclusion into this activity.

- No discussion is provided on how needed hydrologic and hydrochemistry data will obtained should it be determined from the multipurpose boreholes that plans for tests at the proposed ES-1 location have been compromised.

RECOMMENDATION

The multipurpose-boreholes should be added to the wells sampled under Activity 8.3.1.2.2.7.2 and pore and fractures fluids from rock core samples analyzed for the LiBr tracer used to identify drilling fluid from USW G-4. In addition, a plan should be prepared for collecting needed hydrologic and hydrochemical data should it be determined that samples from the multipurpose boreholes contain the LiBr tracer.

REVIEW GUIDES

3.2.3, 3.3.12

Fred Ross/04-28-89

Section 8.3.1.2.3.1 Study: Characterization of the site saturated-zone groundwater flow system

Section 8.3.1.2.3.1.1 Activity: Solitario Canyon fault study in the saturated zone

Section 8.3.1.2.3.1.3 Activity: Analysis of single- and multiple-well hydraulic-stress tests

Section 8.3.1.2.3.1.4 Activity: Multiple-well interference testing

COMMENT XX (CDSCP COMMENT 13)

Activities presented for the study of the saturated zone flow system are not adequate to characterize saturated zone hydrologic boundaries, flow directions and magnitudes, and flow paths.

BASIS

- In review of the CDSCP, the staff commented that activities for characterizing the saturated zone at the site do not appear to be adequate for characterizing saturated zone hydrologic boundary conditions, flow directions, and magnitudes. It was recommended that the hydrologic influence of faults within and east of the repository block be studied. In response, Section 8.3.1.2.3 was revised to explain why the present

program is considered to be sufficient to define the influence of faults, within and east of the repository block, on saturated-zone flow directions and magnitudes. On page 8.3.1.2-367 of the SCP, it is stated that the normal faults east of the repository block are assumed to act as conduits because the faults occur in an area of nearly flat hydraulic gradient. Based on that assumption, no tests are designed to specifically evaluate the hydrologic nature of those faults. The observation that the faults occur in an area of nearly flat hydraulic gradient does not support the assumption that those faults act as conduits to water flow (i. e., zones of relatively high hydraulic conductivity). Without large-scale pumping tests, the assumption that the faults act as conduits cannot be tested, and thus the response to the comment was unsatisfactory.

- The objectives of the study to characterize the saturated zone are "(1) to determine the internal and external boundary conditions that can be applied to the saturated zone model and (2) to determine the ground-water flow magnitudes and directions at the site" (Section 8.3.1.2.3.1; page 8.3.2-297; paragraph 4). Eight activities are described under the study to characterize the saturated zone groundwater flow system.

- One activity (Solitario Canyon fault study in the saturated zone) is designed to assess the influence of the Solitario Canyon Fault on the saturated groundwater flow system. The Solitario Canyon fault is on the

west side of the repository block. West-dipping normal faults lie within and east of the repository block. The faults within and east of of the repository block lie generally across the assumed groundwater flow path from the repository to the accessible environment. Because groundwater flow can be influenced by faults (CDSCP Section 8.3.1.2.3, page 8.3.1.2-292, paragraph 7), an important objective of studies of the saturated zone will be an evaluation of the effects of structure on hydrologic boundary conditions (CDSCP Section 8.3.1.2.3, page 8.3.1.2-292, paragraph 5). The influence of the repository block (and faults east of it) on flow directions and magnitudes is not evaluated by this study and will not be adequately evaluated by testing at the C-hole complex.

- The first step in the activity on multiple-well interference testing will include many tests at the C-hole complex (SCP, page 8.3.1.2-370). Further, it is stated that "The second step in well testing will consist of either a series of single-well tests at existing wells throughout Yucca Mountain, or drilling and testing at a second multiple-well complex. The purpose of the second step is to refine and confirm the understanding of geologic structure and saturated flow parameters determined during tests at the C-hole complex." Additional single-well testing is considered in the SCP to be a possible alternative to constructing an additional cluster well site. However, for reasons given below, it is the opinion of the staff that this proposed alternative will not provide the information necessary to

describe physical features and determine flow parameters representative of the bulk behavior of the saturated zone.

- The discussion presented on page 8.3.1.2-369 acknowledges the limitations of single-well testing. Specifically it is stated that "In general, multiple-well tests will be needed to evaluate complex heterogeneous flow models. While useful for investigating many aspects of saturated-zone hydrology beneath Yucca Mountain, results of single-well tests have limited use in understanding the nature and areal distribution of bulk aquifer properties." The importance of multiple-well testing for characterizing saturated flow has been expressed previously by staff (NRC, 1983a). The staff's position has been that "Such tests would facilitate objective verification of any conceptual model, provide bulk values of hydraulic parameters including vertical hydraulic conductivity, improve hydraulic head data, provide information on hydrogeologic boundaries, and permit calibration of the numerical model so that defensible groundwater travel times can be estimated" (NRC, 1983a, p. 3-11). However, the staff also recognizes that there are conditions where single-well testing is necessary (NRC, 1983b). For example, if no response to well-pumping is observed in piezometers a short distance away from a pumping well, then the only viable exploratory technique available may be single-hole testing. However, compared with multi-well tests, results from single-borehole testing will not be representative of large-scale hydrogeologic conditions across the site

and at scales of importance to repository performance.

- Proposed multiwell tests at the C-hole complex will be used to evaluate hydrologic conditions along flow paths east-southeast of the repository block. However, there is an area of 12 square km to the south and south-southeast in which there is only one well, WT-17. Included in the western part of this area is a zone of high horizontal gradient that is poorly defined. This area, which is entirely within the controlled area, includes potential groundwater flow paths from the repository to the accessible environment. Numerous faults occur in this area, including the Solitario Canyon, Abandoned Wash, Bow Ridge, Midway Valley, Paintbrush Canyon, and other faults. Multiwell testing in this area would provide information necessary for evaluating flow system parameters, hydrologic boundaries and bulk hydrologic properties, and for making estimates of groundwater travel time in the saturated zone.

- Testing at only one multiple-well complex will not be adequate to develop the geometrical and structural models and flow parameters of the groundwater flow system between the repository site and the accessible environment. Although the SCP refers to additional "multi-well" testing at sites USW H-6 and USE H-7, this testing is not planned for an area that includes probable transport paths to the accessible environment.

- Data from tests at additional well complexes are necessary to

confirm hypotheses formulated from tests at the C-hole complex. In particular, it is important to obtain representative values of effective porosity at one or more additional multi-well complexes. This is perhaps the most difficult aquifer coefficient to obtain, and representative values at appropriate scales cannot reliably be obtained from single-well tests.

- In Figure 8.3.1.2-32 (Schedule for studies in Site Program), a decision point occurs in late 1990 regarding a decision to proceed with additional saturated-zone tracer tests at new sites. However, it is not clear whether these tests are proposed for single-well sites or multiple-well sites.

RECOMMENDATIONS

Additional activities need to be planned to adequately characterize the saturated flow system, such as:

(1) Construction and testing of one or more additional multiple-well complexes similar to the C-hole complex should be included in plans for study 8.3.1.2.3.1 (Characterization of the site saturated-zone groundwater flow system).

(2) Large-scale pumping tests are needed to evaluate assumptions about the role of faults within and east of the repository block.

(3) Activities should be planned to evaluate saturated zone conditions in the Solitario Canyon fault zone, including a corehole drilled through the fault below the water table interface.

REFERENCES

USNRC, 1983a. Draft Site Characterization Analysis of the Site Characterization Report for the Basalt Waste Isolation Project: NUREG-0960, U. S. Nuclear Regulatory Commission, March, 1983.

USNRC, 1983b. BWIP Site Technical Position No. 1.1: Hydrogeologic Testing Strategy for the BWIP Site: Div. of Waste Management, U. S. Nuclear Regulatory Commission, December, 1983.

REVIEW GUIDE

3.3.16

Neil M. Coleman, 4/27/89

Section 8.3.1.2	Overview of the geohydrology program: Description of the present and expected geohydrologic characteristics required by the performance and design issues
Section 8.3.1.2.3.1.2	Activity: Site potentiometric-level evaluation
Figures 3.28 and 8.3.1.2-21	Preliminary composite potentiometric surface map of the saturated zone

COMMENT XX

The potentiometric surface in the controlled area is not adequately defined by existing well locations, and will not be adequately defined by proposed additional well sites.

BASIS

- As stated in the SCP, the objectives of the activity to evaluate site potentiometric levels (page 8.3.1.2-375) are:

  1. Refine time and configuration of the spatial dependence of the potentiometric surface.

  2. Measure water-level variations with time in existing boreholes and

calculate average levels, as input data for hydraulic gradient calculations.

3. Analyze the character and magnitudes of water-level fluctuations to determine their causes, and, if possible, to estimate formation elastic and fluid-flow properties.

- Based on a review of existing and proposed well locations, few wells are located to monitor the saturated zone in an area south and south-southeast from the site. Only one well (WT-17) occurs in an area of over 12 square km, located south of wells WT-1 and G-3 and east of well WT-10. Included in the western part of this area (near well WT-10) is a zone of steep horizontal hydraulic gradient that is poorly defined. This area with few wells is entirely within the controlled area and more detail is needed on the potentiometric surface to support performance assessments of the site.

- Potentiometric contours in the vicinity of well USW G-1 are questionable based on data from borehole USW UZ-1, which suggests that the potentiometric surface is significantly different from that shown in the present SCP figures. This possibility should be investigated through additional saturated zone activities in the vicinity of the Solitario Canyon borehole study.

- One of the objectives for drilling USW UZ-1 was to check for the presence

of perched water zones (Whitfield, 1985). Prior to drilling, the unsaturated section had been estimated to be about 470 m thick at UZ-1. However, drilling was stopped when a large volume of water was encountered at a depth of 387 m, the level of which could not be significantly lowered. Whitfield (1985) interpreted the water to be either (1) derived from the drilling of nearby USW G-1 or (2) a naturally occurring perched water zone. In a report prepared for the NRC, WWL (1986) concluded that a discontinuity may exist between wells USW UZ-1 and USW G-1 causing the piezometric surface of the regional aquifer to be significantly different from that currently assumed [in other words, the ground-water encountered in UZ-1 is the water table and not a perched zone]. If the groundwater encountered in USW UZ-1 is in fact the water table and not a locally perched zone, then a very steep hydraulic gradient exists between this well and USW G-1.

RECOMMENDATIONS

Additional wells should be constructed, and other data collected, in the controlled area south of the perimeter drift in the area south of wells G-3 and WT-1 and east of WT-10 to adequately characterize the potentiometric surface in that area.

REFERENCES

Whitfield, M. S., 1985. Vacuum Drilling of Unsaturated Tuffs at a Potential

Radioactive-Waste Repository, Yucca Mountain, Nevada: Proceedings of NWWA Conference on Characterization and Monitoring of the Vadose (Unsaturated) Zone, National Water Well Association, November.

Water, Waste & Land, Inc., 1986. Analyses of Observed Flow Between Test Wells USW G-1 and USW UZ-1: Mini-Report #6, prepared for U. S. Nuclear Regulatory Commission, Division of Waste Management, Washington, DC.

REVIEW GUIDES

3.3.16

Neil M. Coleman, 4/28/89

Section 8.3.1.2.3.2 Study: Characterization of the Saturated Zone Hydrochemistry

Section 8.3.1.2.3.2.1 Activity: Assessment of Saturated-Zone Hydrochemical Data Availability and Needs

Section 8.3.1.2.3.2.2 Activity: Hydrochemical Characterization of Water in the Upper Part of the Saturated Zone

Section 8.3.1.2.3.2.3 Activity: Regional Hydrochemical Characterization

COMMENT XX

Technetium-99 and iodine-129 are not explicitly included in studies to characterize groundwater flow and radionuclide background concentrations in groundwater.

BASIS

- The study to characterize saturated zone hydrochemistry has three principal objectives: (1) describe the chemical composition of, and spatial compositional variations in, saturated-zone groundwaters using new and existing data; (2) identify the chemical and physical processes that influence ground-water chemistry; and (3) aid in the identification and quantification of fluxes to, from, and within the

saturated zone. Existing hydrochemical data from previous sampling will be compiled and evaluated. Additional groundwater samples will be analyzed for inorganic chemical concentrations; activities of selected radioisotopes, including tritium, carbon-14, chlorine-36; and ratios of selected stable isotopes, including those of carbon, hydrogen, oxygen, strontium, and sulfur. The radioisotopes to be analyzed do not include the highly mobile and long-lived radioisotopes technetium-99 and iodine-129. These radioisotopes, like tritium and chlorine-36, are potentially of great value as groundwater tracers, and can provide important data about groundwater flow paths and groundwater travel time.

- Iodine-129 and technetium-99 are among those radioisotopes identified in Appendix A of EPA (1985) regarding release limits for containment requirements. The background levels and variability of these radioisotopes in the saturated zone at the site should be assessed as part of site characterization to provide baseline information for a performance confirmation program at the site. Insofar as perched groundwater represents localized zones of saturation, any perched zones that are discovered during drilling or excavations should likewise be sampled and analyzed for these radioisotopes.

- The need for data on technetium-99 and iodine-129 in the saturated flow system is consistent with guidance provided in Regulatory Guide 4.17, Standard Format and Content Guide for HLW SCP's (NRC, 1987). In Section 3.9.1.3 of that document (hydrochemistry), it is stated

that "at sites where human activity may have introduced radioactivity into the ground water, analysis should be done for those radioisotopes that are known or suspected to have been added to the system. Using this information, provide assessments of temporal and spatial variations of the hydrochemistry." At Yucca Mountain, anthropogenic sources of mobile radioisotopes, such as iodine-129 and technetium-99, would include underground nuclear testing at the nearby Nevada Test Site, and groundwater recharge from precipitation containing contaminants from past atmospheric nuclear tests.

- Analyses of radioisotopes in the saturated zone will be used in interpreting data from the infiltration and transport studies in the vadose zone. The analyses of technetium-99 and iodine-129 at the water table and in perched zones may provide insight about groundwater travel time and rates of migration of these isotopes in the vadose zone.

- Further, characterization of technetium-99 and iodine-129 in the saturated zone may help support modeling work under Section 8.3.1.2.2.5, diffusion tests in the exploratory shaft facility. The objective of this modeling is to determine in situ the extent to which nonsorbing tracers diffuse into the water-filled pores of the tuffs of the Topopah Spring unit. Test results will be used to model the transport of technetium-99 and iodine-129 from the repository to the water table. Evaluation of the concentrations of these radioisotopes at and below the water table and in perched zones can aid in calibration and validation of repository scale models.

RECOMMENDATIONS

Technetium-99 and iodine-129 should be added to the group of radioisotopes that will be analyzed from samples collected in the upper part of the saturated zone and in any discovered zones of perched groundwater.

REFERENCES

EPA, 1985. Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes: 40 CFR Part 191, U. S. Environmental Protection Agency, Federal Register 9/19/85.

NRC, 1987. Standard Format and Content of Site Characterization Plans for High-level-Waste Geologic Repositories: Regulatory Guide 4.17, Revision 1, U. S. Nuclear Regulatory Commission, Washington, D. C.

REVIEW GUIDES

3.3.12

Neil Coleman, 4/28/89

Section 8.3.1.2.3.2.2 Activity: Hydrochemical Characterization of Water in the Upper Part of the Saturated Zone

COMMENT XX

Use of packers to isolate saturated zone intervals for water sample collection is less than optimal. Where possible, collecting water samples as drilling progresses will maintain a higher level of confidence that the data are representative of the sampled interval.

BASIS

- Sampling from the top of the saturated zone below the repository block has the potential to detect the presence of high flux or high velocity pathways. Identification of modern water in the upper portion of the water table may be indicative of rapid groundwater flow from the surface through the unsaturated zone. Hence, data integrity from the hydrochemical tests is potentially very important with respect to groundwater travel time.

- Use of packers lessens confidence in the quality of the data collected. Representative data from the partitioned interval could be compromised by failure to provide an adequate seal in the borehole or prior mixing with waters from some depth. Presence of vertical gradients will increase the likelihood of mixing (and dilution). Scalf et al.

(1981) discuss the need to avoid vertical intercommunication within wells.

- Withdrawal of water samples when the water table is encountered during drilling will increase the confidence level in the representativeness of the water quality data.

RECOMMENDATION

In order to avoid potential comtamination (or modification of the water quality due to mixing), it is recommended that plans be made to collect water samples first in the upper portion of the saturated zone and then in deeper portions (as necessary) as drilling advances into the units beneath the water table.

REFERENCES

Scalf, M. R., J. F. McNabb, W. J. Dunlap, R. L. Cosby, and J. S. Fryberger, 1981. Manual of Ground-Water Quality Sampling Procedures: Office of Research and Development, U. S. Environmental Protection Agency, Ada, Oklahoma, 93 p.

REVIEW GUIDES

3.2.3, 3.3.16

ABC, Coleman, 4/27/89

Section 8.3.1.2.1.2 Study: Characterization of Runoff and Streamflow

Section 8.3.1.2.1.2.1 Activity: Surface-water Runoff Monitoring

Section 8.3.1.2.2.1 Study: Characterization of Unsaturated-zone Infiltration

Section 8.3.1.2.2.1.2 Activity: Evaluation of Natural Infiltration

COMMENT XX

The stream flow, precipitation gage and micro-meteorological station locations for the site watershed study may need to be redistributed and increased to adequately support the studies of natural infiltration.

BASIS

- Characterization of the upper flux boundary condition at Yucca Mountain is an essential data need for evaluating site performance with respect to groundwater travel time and the EPA release standards. One advantage of vadose zone studies is that the land surface area, the upper boundary which is an important boundary with respect to moisture migration, is everywhere accessible at the site, and directly amenable to

investigations of shallow subsurface conditions. This accessibility creates a unique opportunity to evaluate moisture flux into the repository block over large areas.

- The stated objective of the study on unsaturated zone infiltration is "to characterize present-day infiltration processes and net-infiltration rates in the surficial soils and rocks covering Yucca Mountain." Numerous activities under this study are proposed, including the use of neutron access holes and investigations using both natural and artificial infiltration plots. As stated on page 8.3.1.2-169, water budget studies will be used to supplement direct measurements of infiltration. The discussion on pages 8.3.1.2-169 and -170 mentions the difficulties encountered in attempting to perform water budget studies. However, the activities planned will require comprehensive and exacting measurements of precipitation, runoff, meteorological phenomena, and soil moisture.

- Evaluating the natural water budget on a selected range (in sizes and configurations) of site watersheds (such as the set proposed in Activity 8.3.1.2.1.2.1 (Surface-Water Runoff Monitoring) incorporates the net effects of soil thicknesses, geologic structure, varied slopes and floral cover, etc. The site water budget studies on the site watersheds (Section 8.3.1.2.1.2.1), which extend the planned plot activities (8.3.1.2.2.1.2 and 8.3.1.2.2.1.3), will rely on careful measurements of surface-water runoff, precipitation, evaporation-transpiration, and

soil moisture with depth. However, the number and distribution of precipitation gages and meteorological stations as shown in Figure 8.3.1.2-7 and Table 8.3.1.2-4 may not be adequate to properly estimate the water balance for these site watersheds.

- As stated on page 8.3.1.2-165, prototype work has not begun on water budget studies. However, given that extreme precipitation events in arid southern Nevada are very infrequent, it is important to allow as much time as possible during the site characterization phase for natural water budget investigations.

RECOMMENDATION

Allow flexibility in the plans of Study 8.3.1.2.1.2 (Runoff and Streamflow) to relocate and expand the instrumentation of the site watersheds to adequately complement the activities of Study 8.3.1.2.2.1 (Unsaturated-zone Infiltration). Consider establishing the site watershed studies as soon as possible to capture information from events that will occur during the site characterization period.

REVIEW GUIDES

3.3.16

N. Coleman and D. Chery, 4/27/89

Section 8.3.1.3.3.2.2 Activity: Determination of end-member free energies for clinoptilolite-heulandite, albite, and analcime

Section 8.3.1.3.3.2.3 Activity: Solid solution descriptions of clinoptilolite-heulandite and analcime

COMMENT XX (CDSCP COMMENT 17)

Standard solubility approaches alone are not sufficient for determining reliable thermodynamic properties of zeolites.

BASIS

- NRC staff previously made this comment in its review of the CDSCP. DOE claims to have responsed (U. S. Department of Energy, 1988); however, the NRC staff cannot find a response in the SCP (Section 8.3.1.3.3.2.1).

- It is stated by DOE that "solubility measurements will be used as a means to collect data from which free energies can be calculated" (p.8.3.1.3-61), and that "the equilibrium solution compositions will be combined with knowledge of the thermodynamics of the aqueous phase to calculate mineral free energies for the specific compositions studied" (p. 8.3.1.3-61).

- However, it has been shown by Hemingway and Robie (1984) that "because

many zeolites are metastable, they are formed through irreversible reactions that do not attain thermodynamic equilibrium, e.g., Dibble and Tiller (1981)."

- Hemingway and Robie (1984) states that " unlike most of the phases of importance to geologists, the stability of zeolites cannot be completely determined from reversed phase equilibrium reactions because, in this system, the metastable equilibria can only be reached experimentally from conditions of supersaturation." Furthermore, Hemingway and Robie (1984) states that

> "zeolites can be expected to show disorder in the cations, water, and the aluminum and silicon tetrahedra in the framework. Therefore, traditional calorimetric procedures also will not be able to completely define the thermodynamic properties of zeolites. The best estimates of the thermodynamic properties of zeolites will be obtained from simultaneous analysis of synthesis and stability data, calorimetric data, and various metastable equilibrium measurements, each of which will place limits upon one or more of the thermodynamic properties of a given zeolite phase."

RECOMMENDATION

Plan additional activities needed to determine the thermodynamic properties of zeolites.

REFERENCES

Dibble, W. E., Jr. and Tiller, W. A., 1981, Kinetic model of zeolite paragenesis in tuffaceous sediments, Clays and Clay Minerals, 29, p. 323-330.

Hemingway, B. S. and Robie, R. A., 1984, Thermodynamic properties of zeolites: low-temperature heat capacities and thermodynamic functions for phillipsite and clinoptilolite. Estimates of the thermodynamic properties of zeolitic water at low temperature, Am. Min., vol. 69, p. 692-700.

Johnson, G.K., Flotow, H.E., and O'Hare, P.A.G., 1982, Thermodynamic Studies of Zeolites: Analcime and Dehydrated Analcime, American Mineralogist, Volume 67, p. 736-748.

Johnson, G.K., Flotow, H.E., and O'Hare, P.A.G., 1985, Thermodynamic Studies of Zeolites: Heulandite, Ameican Mineralogist, Volume 70, p. 1065-1071.

U.S. Department of Energy, Letter from S. Rousso, DOE, to H. Thompson, Jr., NRC; Subject: Issuance of the Site Characterization Plan (SCP) for the Yucca Mountain Site to the U.S. Nuclear Regulatory Commission, December 28, 1988, 4pp. plus 3 enclosures.

REVIEW GUIDES

3.3.9, 3.3.11, 3.3.12, 3.3.13

John W. Bradbury/4-28-89

Section 8.3.1.3.4 Investigation: Studies to provide the information required on radionuclide retardation by sorption processes along flow paths to the accessible environment

COMMENT XX (CDSCP COMMENTS 18 and 20)

The SCP does not provide the rationale for deciding on additional testin to obtain information on the effects of waste package degradation products and the interactions between and among radionuclides on sorption.

BASIS

- NRC staff previously wrote CDSCP Comment 18 noting the absence of sorption tests that would use solutions containing waste package degradation products and CDSCP Comment 20 noting the lack of sorption tests that would involve multiple radionuclides. A response to the CDSCP Comment 18, is found in Table 8.3.1.3-5 (p. 8.3.1.3-77) that says that future tests may involve well J-13 water spiked with probable contaminants (e.g., iron and zirconium) from the near field. In addition, it is stated in Section 8.3.1.3.4.1.3 (Sorption as a function of ground-water composition), that "Although not part of the present investigation, additional testing may be necessary in future studies to evaluate the effects of waste package degradation products in altering sorption characteristics in the ground-water chemistry of the far field." As a response to the CDSCP Comment 20, it is stated in the

SCP that "other studies may be initiated at a later time to measure the effects of competition and interaction among radionuclides, such as possible increases in iron and zirconium concentrations" (p. 8.3.1.3-77). The SCP does not state the criteria that will be used to determine how future studies will be required to evaluate the effects of waste package degradation products and the interactions between and among radionuclides on sorption.

- Consideration of the effect of waste package degradation products on sorption is important because:

  1. Contaminated solutions that move away from the waste package may not establish equilibrium conditions in the new location. Thus, solution compositions may not reequilibrate or change on contacting minerals downstream. For example, "the kinetics of sorption are apparently slow for plutonium" (Rundberg, 1987).

  2. Groundwater chemistry and mineralogy do not necessarily control the speciation and oxidation state of dissolved waste elements. For example, "plutonium feed solutions have contained a mixture of oxidation states from IV to VI" (Rundberg, 1987).

  3. Complex chemical systems such as those expected at Yucca Mountain commonly behave in a nonequilibrium manner (Lindberg and Runnells, 1984).

- To evaluate the effects of waste package degradation products on sorption, experiments using actual or simulated solutions generated from waste package tests were suggested in CDSCP Comment 18.

- In addition to the interactions between radionuclides and nonradionuclides in the liquid phase and competition on/in the solid phases, interactions can also occur between and among radionuclides in the liquid or on/in the solids. The need to measure such effects when evaluating sorption in geologic systems has been recognized in the literature (Serne and Relyea, 1981).

- To evaluate the effect of interactions and competition between and among radionuclides on sorption, experiments involving multiple radionuclides were suggested in CDSCP Comment 20.

RECOMMENDATION

Provide the rationale to be used in deciding on the need for additional testing using solutions containing waste package degradation products and for additional testing to measure the effects of competition and interaction between and among radionuclides.

REFERENCES

Lindberg, R.D., and D.D. Runnells, 1984, Groundwater Redox Reactions: Analysis of Equilibrium State Applied to Eh Measurements and Geochemical Modeling, Science, Vol. 225, p. 925-927.

Rundberg, R. S., 1987, Assessment Report on the Kinetics of Radionuclide Adsorption on Yucca Mountain Tuff, Los Alamos National Laboratory, LA-11026-MS.

Serne, R. J. and Relyea, J. F., 1981, Technology of High-Level Nuclear Waste Disposal, Report DOE/TIC-4621, Volume 1, p. 203-254.

REVIEW GUIDES

3.3.9, 3.3.11, 3.3.12, 3.3.14

John W. Bradbury/4-28-89

Section 8.3.1.3.6 Investigation: Studies to provide the information required on radionuclide retardation by dispersive, diffusive, and advective transport processes along flow paths to the accessible environment

COMMENT XX (CDSCP COMMENT 22)

The determination of some parameters and conditions, such as speciation, kinetics, and matrix diffusion under fracture-flow conditions are not planned.

BASIS

- This comment was made previously by the NRC staff as a result of the NRC review of the CDSCP. In response to the CDSCP Comment 22, Table 8.3.1.3-2 has been included in the SCP, which lists the current and some alternative hypotheses for geochemical models for site characterization. However, no apparent change has been made to the experimental geochemistry Investigation, 8.3.1.3.6, Studies to provide the information required on radionuclide retardation by dispersive, diffusive, and advective transport processes along flow paths to the accessible environment with regard to fracture-flow conditions.

- Current representations (Table 8.3.1.2-2a) state that "fractures are conduits or barriers to liquid water flow in welded tuff units, depending on ambient matrix saturation."

- The geochemical retardation testing program concentrates most of its effort into evaluating processes in the matrix. Only one activity, 8.3.1.3.6.1.4, is planned that will measure transport and diffusion through naturally fractured tuff.

- From Table 8.3.1.3-7, only some of the parameters needed to characterize radionuclide retardation will be determined in experiments under fracture-flow conditions. For example, the effects of the "parameters", Rd, speciation, kinetics, and matrix diffusion will only be observed on the parameters measured in the fractured tuff column experiments. These "observed parameters" will be fit or derived from other experiments involving nonfractured tuff.

- The primary source of data for speciation will come from the crushed tuff column tests (Activity 8.3.1.3.6.1.1). However, speciation may be different in groundwater contacting crushed or intact rock versus fractured rock, inasmuch as minerals associated with the fractures can be different from those in the matrix (Carlos, 1985). Consequently, radionuclide retardation could be different.

- The primary source of data for kinetics will come from the mass transfer kinetics tests (Activity 8.3.1.3.6.1.2) which involve only crushed and intact tuff. Reactions and their rates may be different in the fractures than in the matrix due to the different mineralogy.

- The primary source of data for matrix diffusion will come from the diffusion experiments (Study 8.3.1.3.6.2). These experiments neither simulate diffusion at natural fracture surfaces nor advection in the fracture.

- In 8.3.1.3.7.1 Study: Retardation sensitivity analysis, modeling investigations of geochemical processes affecting transport will be used to design future experiments are discussed (p.8.3.1.3.-119). However, no criteria are provided concerning how this study might direct experimentation in Investigation 8.3.1.3.6.

RECOMMENDATION

Include plans to determine the effect of speciation, kinetics, matrix diffusion and any other conditions or processes on radionuclide retardation in fractures.

REVIEW GUIDES

3.3.9, 3.3.14

REFERENCE

Carlos, B. A., 1985, Minerals in Fractures of the Unsaturated Zone from Drill Core USW G-4, Yucca Mountain, Nye County, Nevada, Los Alamos National Laboratory, LA-10415-MS.

John Bradbury/4-28-89

Section 8.3.1.3.4.1.1 Activity: Batch sorption measurements as a function of solid phase composition

COMMENT XX

Planned experimental batch sorption tests involving pure minerals can not result in a mechanistic understanding (i.e., differentiation of surface complexation and ion exchange) of sorptive processes.

BASIS

- It is stated in the SCP that "sorption studies on pure minerals will consist of two areas of investigation: (1) sorption by surface complexation and (2) ion exchange. A mechanistic understanding of the sorptive process is sought through these two efforts" (p.8.3.1.3-70). It is also stated that "the ion exchange mechanism will be studied by developing isotherms describing the sorption of selected radionuclides in pure minerals" (p.8.3.1.3-71). However, it is stated as a footnote to Table 8.3.1.3-3 that "tests will be run at only one concentration" (p. 8.3.1.3-73).

- Isotherms are plots of radionuclide sorption versus radionuclide concentration. Thus, tests must be run at more than one concentration.

RECOMMENDATION

Correct the inconsistency so that a mechanistic understanding is obtainable.

REVIEW GUIDES

3.3.9, 3.3.14

John Bradbury/4-28-89

Section 8.3.1.3 Overview of the geochemistry program: Description of the present and expected geochemical characteristics required by the performance and design issues

COMMENT XX

The geochemistry program is incomplete because a potentially important transport mechanism in unsaturated, fractured media has not been considered.

BASIS

- Table 8.3.1.2-2a describes the current representation of faults and fractures as structural features which act as barriers to or conduits for liquid-water flow, depending on the ambient matrix saturation.

- Table 8.3.1.2-2a also describes the current representation of faults and fractures as structural features which act as conduits for air and water-vapor flow in fractured tuffs.

- Table 8.3.1.2-2a states that the current representation of open faults and fractures are as stuctural features in which transient nonequilibrium flow occurs.

- Coupling the three basis points above, it is possible to conceive of faults and fractures as structural features where radionuclides could be

concentrated. Under transient flow conditions, the radionuclides concentrated at/on the fractures might be readily leached and transported to the accessible environment (Bradbury, Brooks, and Mo, 1988).

- A description of this possible transport mechanism is provided below:

  Transient conditions are common in the unsaturated zone. In a desert environment there are long periods of drying and short periods of wetting.

  In dry periods, fractures dry out before the matrix.

  In wet periods, fracture systems that intersect the ground surface can wet first.

  Thus, water moves toward or away from fractures.

  During the dry period the dewatering of the fractures increases their connectivity with regard to the gas phase. Consequently, chances for gas phase advection are enhanced.

  The advecting gas within the fractures is moisture laden. Thus, the system containing the fractures is open with respect to water.

  Liquid water, driven by a water potential gradient, flows in the

porous matrix toward the drying fractures. This water contains radionuclides.

On reaching the walls of the fracture, evaporation of some of the water may occur, promoted by the gas flow. Concentrations of radionuclides in the liquid film along the fracture wall will increase, possibly resulting in precipitation of solids.

During the wet period, water flows down the fractures that intersect the ground surface.

At the same time, by capillary action the matrix imbibes water flowing down the fracture.

The radionuclides precipitated during the dry period may be leached from the fracture surface.

- This possible transport is not discussed in the geochemistry program. As a result, there are no tests planned to demonstrate whether radionuclides could be concentrated in faults and fractures.

- It is stated in the SCP that "the present approach to modeling chemical interactions in unsaturated rock is to treat the chemistry in a way identical to that of saturated rock, except for modifying the effective porosity" (p. 8.3.1.3-107).

RECOMMENDATION

The SCP should include testing for radionuclide transport under conditions unique to the unsaturated zone.

REVIEW GUIDES

3.3.9, 3.3.12, 3.3.14

REFERENCE

Bradbury, J. W., D. J. Brooks, and T. Mo, 1988, Effects of evaporation in unsaturated fractured rock on radionuclide transport, AGU Fall Meeting.

John Bradbury/ 4-28-89

Section 8.3.5.13 Issue resolution strategy for Issue 1.1: Will the mined geologic disposal system meet the system performance objective for limiting radionuclide releases to the accessible environment as required by 10 CFR 60.112 and 40 CFR 191.13?

Section 8.3.1.3.4 Investigation: Studies to provide the information required on radionuclide retardation by sorption processes along flow paths to the accessible environment

Section 8.3.1.3.5 Investigation: Studies to provide the information required on radionuclide retardation by precipitation processes along flow paths to the accessible environment

COMMENT XX

The Investigations to characterize radionuclide retardation is focused on the determination of a Kd for use in the equations $R_m = 1 + \rho_b K_d/\theta_m$ and $R_f = 1 + \rho_f K_d/\theta_f$, equations 8.3.5.13-14a and b. It has not been demonstrated in the SCP that the use of these equations to model the complex heterogeneous medium of Yucca Mountain is valid for all expected (i.e., anticipated) states of the natural flow system (i.e., full range of unsaturated and saturated).

BASIS

- It is stated in the SCP that radionuclides showing consistently high sorption coefficients will not need further testing (p. 8.3.1.3-28). In fact, because numerous variables can affect sorption, for those radionuclides for which sorption credit is required, sorption coefficients greater than 0 are more likely to be an indication of where further work is needed.

- The use of maps contouring iso-Kds and iso-β's in two and three dimensions at Yucca Mountain (8.3.1.3-75) suggests that these parameters are invariant for in the total system performance calculations. Thus, the Kd's assigned to the various portions of Yucca Mountain in the total system performance calculations will be held constant over the history of the repository. Further evidence suggesting the time independence on Kd's comes from Tables 8.3.1.3-3, 4 and 5 (p.8.3.1.3-72, 73,and 75) which describe the matrix of batch sorption experiments that are planned. These tests will not simulate all conditions expected in the repository.

- Current representations of the sorption model state that sorption is a function of many parameters including the specific sorbing element, water composition, solids, temperature, rock texture, hydrologic properties and to a lesser extent, colloids and particulates. In turn, the current representation of the water chemistry model states that the water composition is controlled by water-rock interactions. Furthermore, the current representation of the mineral evolution model states that the

alteration of secondary minerals (particularly sorptive minerals) will be predictable based on thermodynamic considerations and is a function of time. Thus, Kd's should vary over the history of the repository.

- Tripathi et al., (1989) simulates one dimensional transport of uranium in a column packed with two different sorbing solid phases - a less sorptive phase followed abruptly by a more sorptive phase. This simulation uses HYDROGEOCHEM, a finite element method that computes mass transfer with equilibrium and disequilibrium speciation, sorption, ion exchange and dissolution/precipitation. The results of the simulation demonstrate that concentrations of uranium downstream can exceed even the inlet concentration. Furthermore, Kd's determined along the column length vary over orders of magnitude as a function time. The reason for the variation is that at some points along the column the chemistry of the water changes with time.

- Not all nonzero Kd's result in retardation. Comment 8 of the NRC staff review of the Yucca Mountain Environmental Assessment (1986) provides an example:

> "Rundberg (1987) states that precipitation which would yield an apparent soption ratio, cannot be ruled out in the batch measurements. If precipitation instead of sorption has occurred in the batch test, retardation is not proven. In such a case, concentration of a radionuclide species in the solution would be

limited by the solubility of the radionuclide-bearing solid and insensitive to the presence of other solids in the substrate. For example, if precipitation occurred in a batch test using a nonsorptive solid and a radionuclide-bearing solution, an 'apparent sorption ratio' could be determined. This 'apparent sorption ratio' could be erroneously inserted into equation 8.3.5.13-14 for calculating a retardation factor. However, if the liquid from the batch test were then decanted into a column containing the same nonsorptive solid, the concentration would not exceed the solubility limit (i.e., no additional precipitation would occur) and the radionuclide would travel down the column as fast as the liquid (no retardation). Thus, if precipitation is not disproved in a sorption test, credit cannot be taken for retardation of the radionuclide."

- Table 8.3.5.13-4 lists typical distribution coefficients and approximate retardation factors for welded and nonwelded Yucca Mountain hydrogeologic units. Values for radium are included in the table that have been determined from experiments (Daniels et al., 1982) using barium as a chemical analogue. In some of the sorption experiments involving barium the ion activity product exceeds the solubility product (Weast, 1970) for barium sulfate. Thus, it can be assumed that precipitation occurred in these sorption experiments. Nevertheless, Table 8.3.5.13-4 converts the distribution factor for radium (barium) to a retardation factor.

- Further evidence suggesting that credit will be taken for precipitation

as a retardation mechanism comes from 8.3.1.3.5 Investigation: Studies to provide the information required on radionuclide retardation by precipitation processes along flow paths to the accessible environment.

- The appropriate application of Kd in the equation 8.3.5.13-14 requires that the solute-solid reactions are reversible and fast and the isotherm is linear (Freeze and Cherry, 1979). These limitations are recognized in the SCP (p. 4-60). However, the existing sorption data has been fit using a Freundlich isotherm formulation. Cesium, strontium, barium, europium, and plutonium exhibit nonlinear behavior in welded tuff (p. 4-81 and 4-82). However, these elements are included in Table 8.3.5.13-4 and retardation factors are calculated from corresponding distribution coefficients.

- The Kd appropriately applied to equation 8.3.5.13-14 is not the ratio of the radionuclide on the solid to that in the liquid but the slope of the isotherm measured at points along its length. Thus, although a nonzero Kd calculated as the ratio of radionuclide on the solid to that in the liquid exists at the cation exchange capacity, the tangent to the isotherm at the CEC has a slope of zero and no net sorption occurs. Consequently, no retardation would be expected.

- Daniels et al., 1982 show that sorption ratios can vary over four orders of magnitude in distances less than one hundred feet. Considering that the sorption ratios will determine the distances contaminants will travel

when coupled with a given flow rate, uncertainties in the sorption ratios lead to uncertainties in the chemistries of the contaminant plume with respect to space and time. The method for handling sorption heterogeneities of this magnitude and whether the equation 8.3.5.14 will remain valid for modeling the complex system at Yucca Mountain is not described in these Investigations.

- Although not explicitly stated, it appears that the mobile moisture content in equation 8.3.5.13-14 will be determined in the laboratory. Wierenga and Van Genuchten (1989) mention that "in some cases the retardation factor can be less than one, indicating that only a fraction of the liquid phase participates in the transport process." Plans to determine mobile versus immobile water in unsaturated fractured rock at the scale of the repository are not described in these Investigations.

RECOMMENDATION

It is recommended that those Investigations of the geochemistry program studying retardation expand the experiments to demonstrate that Kd's are appropriate for use under the conditions expected at Yucca Mountain or that information is obtained for developing the transport model(s) needed for performance assessment.

REVIEW GUIDES

3.3.9, 3.3.14

REFERENCES

Daniels, W.R. et al., 1982, Summary report on the geochemistry of Yucca Mountain and environs, Los Alamos National Laboratory, LA-9328-MS.

Freeze, R. A. and Cherry, J. A., 1979, Groundwater, Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Rundberg, R. S., 1987, Assessment report on the kinetics of radionuclide adsorption on Yucca Mountain tuff,Los Alamos National Laboratory, LA-11026-MS.

Tripathi, V., Yeh, G. T., and Jacobs, G., 1089, Simulation of groundwater-transport-dynamics of chemically reactive radionuclides, NRC Letter Report LR-287-84.

Weast, R. C., 1970, Handbook of chemistry and physics, The Chemical Rubber Company, Cleveland, Ohio.

Wierenga, P. J. and M. Th. Van Genuchten, 1989, Solute transport through small and large unsaturated soil columns, Ground Water, vol. 27, no. 1, p. 35-42.

John Bradbury/ 4-28-89

Section 8.3.1.3.4.1 Study: Batch Sorption Studies

COMMENT XX

Evidence presented is not adequate to conclude that existing sorption characterization data for alkali and alkaline earth elements are sufficient for performance assessment analyses. As a result, data collection plans are not complete.

BASIS

- Numerous variables can affect sorption (p. 8.3.1.3-28). For example, if the standard deviations given in Table 4-15 are taken as the uncertainties in the measurements, most of the sorption ratios (12 out of 15) measured using a batch method do not agree with those determined with a circulating system within the uncertainties of the two methods.

- The information required to characterize radionuclide retardation by sorption is delineated in the SCP (p. 8.3.1.3-66). Information includes:

  Sorption coefficients as a function of:

  a) Ground-water composition
  b) Mineralogy and surface structure
  c) Sorbing species

d) Waste element concentration

e) Atmosphere

f) Temperature

g) Coloidal material

h) Organic Complexation

i) Sorption Kinetics

j) Biological sorption and transport

- References (SCP Chapter 4) regarding the adequacy of sorption data for alkali and alkaline earth elements did not provide information concerning sorption as a function of a) Ground-water composition, b) Mineralogy and surface structure, c) Sorbing species, d) Waste element concentration, e) Atmosphere, f) Temperature, g) Coloidal material, h) Organic Complexation, i) Sorption Kinetics, and j) Biological sorption and transport. Sorption coefficients in the absence of this information, will not be adequate for modeling in performance assessments (Tripathi, and others, 1989).

RECOMMENDATION

Provide evidence to adequately support the conclusion that existing data for alkali and alkaline earth elements are sufficient for performance analyses, or expand sorption characterization work to include the collection of the needed information.

REFERENCES

Tripathi, V., Yeh, G. T., and Jacobs, G., 1989, Simulation of Groundwater-Transport-Dynamics of Chemically Reactive Radionuclides, NRC Letter Report LR-287-84.

REVIEW GUIDES

3.3.9, 3.3.14

DBrooks 4/28/89

Section 8.3.1.3.5.1.3 Activity: Solubility Modeling

COMMENT XX

Methods or procedures needed for evaluating thermodynamic data to be used in solubility modeling are not included in the SCP and, thus, the adequacy of this activity cannot be evaluated.

BASIS

- The objective of this activity is the evaluation of existing thermodynamic data in order to evaluate data uncertainties, and the need for supporting data collection.

- Modeling of solubility and speciation of waste elements relies on equilibrium methods. Equilibrium models require thermodynamic data for solids that are likely to precipitate and for aqueous species that may be present in the water.

- Differences discussed in chapter 4 (pp.4-99-100) between calculated and experimental solubilities in J-13 well water indicate that solubility mechanisms in complex solution compositions and/or thermodynamic data are not well known.

- A critical evaluation of thermodynamic data is important to defining the work and priority of work that needs to be done to understand the uncertainty of modeled radionuclide solubility.

- According to Wanner (1988), a systematic and comprehensive review of thermodynamic data requires consistancy in the following: data selection, extrapolation to zero ionic strength, assignment of uncertainties, temperature corrections, and standards and conventions.

RECOMMENDATION

Provide descriptions of the methods or procedures needed for evaluating thermodynamic data to be used in solubility modeling.

REFERENCES

Wanner, H., "Thermodynamic Data Base - Guidelines for the Review Procedure and Data Selection," OECD Nuclear Energy Agency, September 28, 1988.

REVIEW GUIDES

3.3.9

D. Brooks 4/27/89

Section 8.3.1.3.4.2 Study: Biological Sorption and Transport

COMMENT XX

Activities to evaluate the effects of radioactive decay heat, the nuclear radiation field, and the effect of non-site specific microorganisms (introduced during site construction) on microbial activity and ecology, and the subsequent effects of these microbial processes on the groundwater chemistry, mineralogy, biogeochemical cycling and transport of high-level radioactive waste radionuclides are not included in the SCP. As a result, there is no way to evaluate the adequacy of this aspect of the DOE program.

BASIS

- The objective of this study is to determine the effects of microorganisms on the movement of radionuclides from the high-level waste repository (i.e. effects on sorption) and to determine if microbial activities play a role significant enough to be included in a performance calculation for Yucca Mountain.

- A sorption ratio, Rd, of 10,000 for plutonium-239 by microorganisms native to the NTS is quoted (unreferenced) in the Objective Section of Section 8.3.1.3.4.2. Mo and Lowman (1975) found a similar sorption ratio of 10,000 for plutonium-239/240 by marine microorganisms. Therefore, biological (microbial) sorption and transport must be considered as a potentially significant transport mechanism for radionuclides.

- Section 8.3.1.3.4.2 acknowledges that Study 8.3.1.3.4.2 (p.8.3.1.3-80) is being undertaken because (1) large amounts of biodegradable organic materials have been, or will be, introduced into or near the potential repository area, (2) microorganisms isolated from the NTS are capable of biodegrading these organic materials and have been shown to bind plutonium-239 and (3) the mobility of the microorganisms through the tuff and their effect on the solubility of radioactive wastes is unknown.

- The current site characterization plans do not adequately consider the presence (in the repository after closure) of anthropogenically introduced microorganisms such as sulfate reducing bacteria, genus-desulfovibrio (Stanier et al. 1963 and Landa et al. 1986). In addition, other microorganisms that could be introduced into the repository include (but are not limited to) iron and manganese oxidizing and reducing bacteria, genera - thiobacillus ferroxidans, bacillus circulans, gallionella (Lundgren and Dean, 1979), conventional bacteria (Arthrobacter, Pseudomonas), prosthecate bacteria and sheathed bacteria (Marshall, 1963). For example, researchers at the DOE's Savannah River Plant, Aiken, South Carolina reported the discovery of 2,000 new and different species (principally bacteria) in groundwater at depths as deep as 1,000 feet beneath the soil surface (Nuclear Waste News, 1988). Thus biological (microbial) sorption and transport must be considered as a potentially significant transport mechanism for radionuclides.

- After site closure, the temperatures in and around the immediate vicinity of the waste package environment will be in the range of 190 to 230

degrees centigrade at 10 to 20 years and 9 years respectively, after waste package emplacement (SCP Section 7.4.1.2, p.7-40). If the moisture content is also appreciable due to other initiating events or scenarios, it is conceivable that these conditions might lead to a small hydrothermal system where microorganisms introduced during site construction which are resistant to heat (Brock 1985) and the nuclear radiation fields (U.S. DOE 1986 and West, et al. 1985) might thrive on the anthropogenically introduced organic materials, proliferate and significantly enhance the transport of high-level radioactive waste radionuclides.

RECOMMENDATION

The SCP should include the activities, procedures and methods under the study in Section 8.3.1.3.4.2 which are designed to evaluate and consider the effects of radioactive decay heat the nuclear radiation field, and the role and impact of non-site specific microorganisms introduced during site construction on microbial activity and ecology and the subsequent effects of these microbial processes on the ground-water chemistry, mineralogy, biogeochemical cycling and transport of high-level radioactive waste radionuclides.

REFERENCES

Nuclear Waste News, "Microbe Discovery May Add Release Pathways to DOE's Proposed Permanent Repository," September 15, 1988, p.297. Brock, T.D., "Life at High Temperatures," Science, 230, pp. 132-138 (1985).

U.S. Department of Energy, (U.S. DOE), "Geochemistry Review Panel Report on the SRP Geochemistry Program and Draft Geochemistry Summary Program Plan (May 1986) and Discussion of Panel Recommendations," DOE/CH/10140-06, p. 114, (1986).

West, J.M., N. Christofi and I.G. McKinley, "An Overview of Recent Microbiological Research Relevant to the Geological Disposal of Nuclear Waste," Radioactive Waste Management and the Nuclear Fuel Cycle, 6, p. 79 (1985).

Stanier, R.Y., M. Doudoroff, E.A. Adelberg, "The Microbial World." Second Edition - Prentice Hall, Inc. Englewood Cliffs, N.J. (1963), p.541.

Landa, E.R., C.L. Miller and D.M. Updegraff, "Leaching of ^{226}Ra from U Mill Tailings by Sulfate - Reducing Bacteria," Health Phys. 51, No.4, pp.509-518 (1986).

Lundgren, D.G. and W. Dean, "Biogeochemistry of Iron," in Studies in Environmental Science 3, Biogeochemical Cycling of Mineral - Forming Elements. P.A. Trudinger and D.J. Swaine, Editors, Elsevier Scientific Publishing Company, N.Y. (1979), pp.211-251.

Marshall, K.C. "Biogeochemistry of Manganese Minerals," ibid, (1963), pp.253-293.

Mo, T. and F.G. Lowman, "Laboratory Experiments on the Transfer Dynamics of Plutonium from Marine Sediments to Seawater and to Marine Organisms." CONF-750503-5, (1975).

REVIEW GUIDES

3.3.8-3.3.14

Tin Mo 4/28/89

Section 8.3.1.5.13 Issue Resolution Strategy for Issue 1.1: Will the mined geologic disposal system meet the system performance objective for limiting radionuclide releases to the accessible environment as required by 10 CFR 60.112 and 40 CFR 191.13?

Overview of the performance assessments for this issue

3. Technical discussion of the release-scenario classes

Nominal case (E): gas-phase releases

COMMENT XX (CDSCP QUESTION 47)

Evidence presented is not adequate to conclude that iodine can be eliminated as an important radionuclide which can be transported in the gaseous phase. As a result, data collection plans are not complete.

BASIS

- Section 8.3.5.13 of the CDSCP asserted that the transport of gaseous iodine will not be a concern because "elemental iodine is extremely reactive and likely to be released in a liquid or solid phase" (P.8.3.5.13-36). NRC Question 47 asked about the existence of DOE analyses or assessments which support this assertion. Section 8.3.5.13,

p.8.3.5.13-75 of the SCP made the same assertion without any supporting documentation. Therefore, the SCP response is inadequate and does not address the basic NRC concern regarding the effect of repository temperatures on the vapor pressure of some low boiling iodine compounds and their potential transport to the accessible environment.

- The NRC staff was particularly interested in the assessments that may have been done to show that the vapor pressure of iodine will be low enough such that gaseous iodine will not be formed in the repository system and transported in the vapor phase to the accessible environment.

- The NRC staff concern about the potential for vapor phase transport of iodine from the repository is based on the work by Binnall et al. (1987) which pointed out that iodine and some of its tin compounds will have considerable vapor pressures at repository temperatures and must also be considered as candidates for vapor phase transport.

RECOMMENDATION

Provide evidence to adequately support the conclusion that iodine can be eliminated as an important radionuclide which can be transported in the gaseous phase, or expand characterization work to include the collection of that needed information.

REFERENCE

Binnall, E.P., S.M. Benson, L. Tsao, H.A. Wollenberg, T.K. Tokunaga, and E.M Didwall, 1987, Critical Parameters for a High-Level Waste Repository, Volume 2: Tuff, NUREG/CR-4161, UCID-20092, Volume 2, p.68.

REVIEW GUIDES

4.2.1, 4.2.2, 4.2.3, 4.2.4, 4.2.6, 4.2.8, 4.3.8, 4.3.14

Tin Mo 5/1/89

Section 8.3.1.3.4.1.4 Activity: Sorption on Particulates and Colloids

Section 8.3.1.3.5.2.1 Activity: Colloid Formation Characterization and Stability

COMMENT XX

The SCP does not include studies to evaluate the effects of colloid formation due to stable (non-radioactive) elements formed from anthropogenic sources such as corrosion of the waste canisters, and organic compounds from drilling muds and explosives used in site construction.

BASIS

- According to Siegel (1988) colloid transport is important as a factor for radionuclides in geologic repositories. There are three sources of colloids that could affect radionuclide mobilization: (1) radioactive colloids formed directly from waste radionuclides, (2) radioactive colloids formed from natural colloids interacting with radioactive elements in groundwater and, (3) colloids formed from anthropogenic sources interacting with radioactive elements in groundwater.

- Activity 8.3.1.3.4.1.4 evaluates colloids formed by interactions of radionuclides with natural colloids in the ambient groundwater system.

- Activity 8.3.1.3.5.2.1 evaluates colloid formation behavior of waste radionuclides.

- There are no activities that evaluate colloid formation due to the interaction of waste radionuclides with colloids formed from anthropogenic sources. One complication for the interaction of waste radionuclides with colloids formed from inorganic elements such as iron, manganese, zirconium, and aluminum is that the radionuclides can also coprecipitate with the oxyhydroxides of these same relatively abundant elements. These particulates and coprecipitates may move with the saturated flow of groundwater if they are of the right particle size distribution. Coprecipitation of trace amounts of radionuclides with macro quantities of nonradioactive particulates, colloids and precipitates called "carriers" is a well studied and established process (Hahn, 1936 and Friedlander, Kennedy and Miller, 1964).

RECOMMENDATION

The SCP should include an analysis of colloids and colloid formation of stable, nonradioactive elements such as iron, zirconium, which can be present in the repository as corrosion products, or iron, manganese and aluminum from the minerals in the bedrock and/or from the organic compounds in drilling muds and explosives used duration site construction activities on the hydrologic transport of radionuclides. The analysis should also include the other mechanism for enhancing the transport of high-level waste radionuclides by concentration on particulates and precipitates by coprecipitation with

oxyhydroxides of iron and manganese or other stable elements such as aluminum and subsequent release of these radionuclides through dissolution of the iron and manganese or aluminum particulates and precipitates by ground water.

REFERENCES

Friedlander, G., J.W. Kennedy, and J.M. Miller, "Nuclear and Radiochemistry" John Wiley & Sons, Inc., New York (1964).

Hahn, O. "Applied Radiochemistry" Cornell University Press, Ithaca, New York (1936).

Siegel, M.D. et al., "Progess in Development of a Methodology for Geochemical Sensitivity Analysis for Performance Assessment: Volume 1. Parametric Calculations, Preliminary Databases, and Computer Code Evaluation," NUREG/CR-5085, SAND 85-1644, WH (1988).

REVIEW GUIDES

3.3.8-3.3.12 and 3.3.14

Tin Mo 5/01/89