recd with letter dtd 10/13/89

NRC STAFF REVIEW OF THE DEPARTMENT OF ENERGY'S
SITE CHARACTERIZATION PLAN, YUCCA MOUNTAIN SITE,
NEVADA RESEARCH AND DEVELOPMENT AREA, NEVADA

SECTION DRAFTS OF THE NRC STAFF POINT PAPERS
RESULTING FROM NRC STAFF REVIEW OF THE SCP

May 2, 1989

102.8

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

OFC	HLGP	HLGP				
NAME	JPohle/ll/cj	DChery				
DATE	4/ /89	4/21/89				

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DATE	/ /89	/ /89					

ATTACHMENT 1

SUMMARY STATUS OF CDSCP COMMENTS AND QUESTIONS

QUESTION	STATUS	LEAD	POINT PAPER STATUS
3	Resolved	Coleman	Final Attachment 2
4	Resolved	Coleman	Final " "
5	Resolved	Bradbury	Final " "
6	Resolved	Bradbury	Final " "
7	Resolved	Bradbury	Final " "
8	Resolved	Bradbury	Final " "
9	Resolved	Bradbury	Final " "
10	Resolved	Mo	Final " "
11	Resolved	Ford	Final " "
24	Resolved	Mo	Final " "
28	Resolved	Ford	Final " "
47	Open	Mo	Final Attachment 4

NUMBER OF QUESTIONS	RESOLVED	OPEN
12	11	1

ATTACHMENT 2

POINT PAPERS FOR RESOLVED CDSCP COMMENTS AND QUESTIONS

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 charge 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	Evidênce 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	

<u>NEW SCP QUESTIONS</u>

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.

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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

(3)

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

4

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 judgemental 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

7

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

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

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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

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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

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

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 ir 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.

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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.

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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

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SCP/YUCCA/DJB/COM/4

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

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

NOTE TO: J. BUNTING

MAY 0 2 1989

FROM: M. NATARAJA Raj

SUBJECT: DRAFT ENGINEERING (GT) COMMENTS ON SCP (IQA DRAFT)

Attached is a copy of draft point papers on the SCP and DAA along with a copy of draft Appendix A input for resolved CDSCP point papers. The point papers have undergone the IQA review as required by the SCP review plan.

Attachment: As stated

cc: D. Gupta
J. Peshel
J. Buckley
S. Coplan
P. Justus
D. Chery
J. Kennedy
J. Holonich
K. Stablein
R. Browning
B. J. Youngblood
J. Linehan
R. Ballard

SCP POINT PAPERS

Section 8.4.2.3.1 Exploratory shaft facility testing operations, layout constraints, and zones of influence, pages 8.4.2-93/147

OBJECTION 1

It has not been demonstrated that the test area can accomodate all tests while avoiding interference between tests and between tests and construction operations. Also, it has not been shown that the necessary site characterization data can be gathered for sufficiently long thermal tests without interference problems.

BASIS

- In response to CDSCP objection number 3 the DOE has not established that the approach to avoid test interference has been appropriately implemented to the extent of resolving all NRC staff concerns about potential interference.

- The DOE in its response also does not address the following considerations from NRC CDSCP Objection #3:

  - In planning the underground test facility, the overall performance confirmation testing program and the need for starting at least some of the performance confirmation tests as early as practicable during site characterization should be considered.

  - The conceptual design of the ESF should take into account the need for preliminary information from in situ seal testing to be available at License Application submittal (Ref. 1).

- SCP does not adequately address the compatibility of some of the tests with construction operations. Operational requirements (e.g., storage of mobile equipment, drill steel, blasting materials vent pipes, water pipes, support/reinforcement, disabled equipment, etc.) might encroach on some of the identified test locations. For example, Sequential Drift Mining Test, Heated block test and Canister-scale heater experiment are currently shown to be located adjacent to the first loop access drifts to the shafts and may be subject to operational interference.

- Thermal tests such as the canister-scale heater experiment, heated block test, and heated room experiment are planned to run for relatively short durations (30-months, 100 days, 36 months). The possible need to obtain additional site characterization data beyond these time periods may result in larger zones of influence.

- It is stated that in some cases the same space can be used for more than one test by sequencing the tests. However, it is not clear if it has been considered that (i) any delays during initial testing could affect the timing for the tests to be followed in the same space, and (ii) limited durations of initial tests (resulting form the need to run additional tests in the same space) may not provide sufficient data for performance confirmation.

- It has not been demonstrated that uncertainties have been sufficiently considered in the calculations of zones of influence for various tests. For example, although the uncertainties associated with the numerical models and material properties have not yet been established, allowances have not been made for these uncertainties in calculating zones of influence.

- The location of the canister-scale heater test shown in Figure 8.4.2-39 (page 8.4.2-209) has been erroneously indicated on the layout. As a result, its zone of influence apparently overlays the heated block test.

- The SCP gives the following two constraints for locating the canister scale heater test (page 8.4.2-120)

  - located greater than 9 m from drifts or alcoves running parallel to the axis of the heater.

  - located in a "low traffic" area.

Neither of these constraints have apparently been met.

- The locations of several major tests identified in the SCP have not been specifically identified. These include some tests that have a considerable zone of influence (e.g., Heated room experiment) and some that require extensive test area (e.g., Horizontal drilling demonstration test). Examples of other tests for which specific locations have not been identified include thermal stress measurements, development and demonstration of required equipment, three of the four diffusion tests identified on page 8.4.2-140, seal tests and other performance confirmation tests.

- Page 8.3.2.1-14 of the SCP states that "there are other tests that have not yet been completely defined that will investigate coupled interactions." It is not known which of these tests will be in the main test area.

- All the space within the dedicated test area may not be available for testing purposes. Some areas may not be suitable for use because of faults, lithophysal content, breccia, etc. In addition, offsets from waste emplacement areas (30 m) and from proposed multi-purpose boreholes (two drift diameters) may further reduce the available test area.

- The zone of influence from the drilling activities of existing borehole USW G-4 located within the dedicated test area should be considered in evaluating the size of suitable available test space. During the drilling, coring, and completion activities of USW G-4, a total of 342,255 gallons of water were lost to various formations. Over 81,000 gallons of soap were used in the operation, however, it is unknown as to how much soap was lost.

- Potential impacts of performance confirmation testing on ESF design have not been addressed.

RECOMMENDATION

- The SCP updates should provide a complete conceptual layout of the main test level and related test schedules. The layout and schedule should account for the following:

  (a) uncertainties in zone of influence calculations; (b) construction and facilities operations; (c) contingencies for unsuitable test areas; (d) drilling effects of USW G-4; (e) possibility of tests running longer than anticipated; and (f) effect of sequencing tests on the overall test program. (g) coupled interaction tests mentioned on page 8.3.2.1-14.

- The SCP undates should present basis for selected test durations.

REFERENCE

USNRC Generic Technical Position on In Situ Testing During Site Characterization for High-Level Nuclear Waste Repositories.

Chapter 8: General Design/Rock Mechanics Concern

COMMENT 1

The rationale provided for the specification of information needs does not appear to ensure completeness of those needs. Furthermore, the integration of testing with design and performance assessment is lacking.

BASIS

- In response to CDSCP comments 1, 43, and 44 the DOE has not presented an adequate integrated approach among field testing, design and performance assessment.

- Although a detailed rationale for development of basic information needs is presented, it is not based on comprehensive "sensitivity studies" that can identify the potential areas of concern in rock mass performance and critical parameters to be measured in the laboratory and field.

- In DOE's response to NRC CDSCP comment number 1, sensitivity analyses in Appendix I of the SCPCDR (MacDougall et al., 1987) and Ehgartner (1986) are cited. However, the result from these analyses have not been accurately reflected in the column labled "needed confidences" in Table 8.3.1.15-1. For example, analyses by Ehgartner (1986) show that:

  - rock mass compressive strength, elastic modulus and thermal gradient are highest "design impact factors."
  - rock density, heat capacity and Poisson's ratio are lowest "design impact factors."

  However, SCP Table 8.3.1.15-1 is not consistent with these results.

- The approach portrayed in Table 8.3.1.15-1 focuses on obtaining parameters used primarily in drift stability analyses. The behavior of emplacement hole (near-field) or the repository (far-field) has not been sufficiently analyzed.

- The testing plan does not describe in-situ testing aimed at providing a complete set of joint properties that would be needed as input to design and performance assessment models. For example, in attempting to characterize the modified permeability zone, Case and Kelsall (1987) assume a stress-permeability relation based on a cubic flow rate law and an "equivalent smooth-wall fracture aperture," also known as a conducting aperture. The SCP has stated that "relating aperture to 'equivalent hydraulic aperture' is outside the scope of the SCP" (Response to NRC CDSCP Question 12).

- The SCP has used a compliant joint model to describe joint closure (see, for example, Thomas, 1987). This model requires definition of parameters such as the half-closure stress and the maximum joint closure. Tests to determine these properties are not described.

- The testing plan in the SCP is not uniform and consistent in its attempt to relate individual tests to validation or verification of specific design or performance specifications. For example, Section 8.3.1.15.1.8, Study: In-Situ Design Verification, does not provide any information concerning design verification or validation under repository conditions which include the effects of heat.

RECOMMENDATION

- The SCP updates should provide "parametric performance calculations (sensitivity studies) . . . that will help to refine parameter goals and associated required confidence levels" as stated in the DOE Response to NRC CDSCP Comment 44.

- The SCP updates should provide plans for collecting all necessary data for validating the design and performance assessment models.

REFERENCES

Case, John B., and Peter C. Kelsall. "Modification of Rock Mass Permeability in the Zone Surrounding a Shaft in Fractured, Welded Tuff," Sandia National Laboratories, SAND86-7001, March 1987.

Ehgartner, B. L. "Sensitivity Analyses of Underground Drift Tem-perature, Stresses, and Safety Factors to Variation in the Rock Mass Properties of Tuff for a Nuclear Waste Repository Located at Yucca Mountain, Nevada," Sandia National Laboratories, SAND 86-1250, May 1987.

MacDougall, Hugh R., Leo W. Scully, and Joe R. Tillerson (Compilers). Site Characterization Plan Conceptual Design Report. Sandia National Laboratories, SAND84-2641, September 1987.

Thomas, Robert K. "Near Field Mechanical Calculations Using a Continuum Jointed Rock Model in the JAC Code," Sandia National Laboratories, SAND 83-0070, May 1987.

COMMENT 2

Numerous inconsistencies exist in the SCP. Examples of some of the inconsistencies found in the geomechanical area are listed below by the sections in which they occur.

BASIS

Section 8.3.1.15, Table 8.3.1.15-1, pages 8.3.1.15-2/3

- On p .8.3.1.15-12, it is indicated that the current estimate of ambient temperature in TSw2 is 23°-25°C. In Section 8.4, the ambient temperature is stated to be 31°C. On p. 2-45 of the CDR, it is indicated that the range of temperature is 23°-29°C, with an average of 26°C.

- On pp. 8.3.1.15-10,11, the reference to "tentative goals" for empirical design parameters is given as "See Table 6-15". The correct reference should probably be Table 6-13. However, even Table 6-13 does not give "goals". It gives "design values" (some of which are NA = not applicable).

- On p. 8.3.1.15-7, the tentative goal for Young's modulus of intact rock (TSw2 - Primary Area) is 29-33 GPa. On p. 6-49 of the SCP, the current value is given as 31.4 GPa, with a range of ±6.3 GPa. Additionally, Nimick and Schwartz (1987, p. 127) show that the modulus for dry samples can be considerably higher (twice) than the tentative goal.

Section 8.4.2.3.1, pages 8.4.2-117/120

- The CDR gives an average ambient temperature of 26°C (p. 2-45).

- On page 8.3.2.2-20, the expected value for initial temperature is given as "23°c to 26°c ± 1.5°c".

Section 8.4.2.3.1, pages 8.4.2-93/147
Section 8.4.2.3.3.3, pages 8.4.2-167/175

- Figures 8.3.1.2-16 and 8.4.2-27 show ES-1 to be significantly deeper than indicated in SCP Figure 8.4.2-33.

- Radial borehole tests are shown at different depths below the repository horizon in Figs. 8.3.1.2-16 and 8.4.2-27.

- Description regarding width and length of Upper Demonstration Breakout Room in Figures. 8.4.2-6 (page 8.4.2-112) and 8.4.2-17 (page 8.4.2-138) is inconsistent.

- Fig. 8.4.2-27 shows a shaft convergence test at the deepest point in shaft ES-1. This location conflicts with the description of shaft convergence activity on page 8.4.2-109.

Section 8.3.5.2.1, Tables 8.3.5.2-7 and 8.3.5.2-8, pages 8.3.5.2-27/30

- The following potential abnormal conditions in Table 8.3.5.2-8 are not consistent with retrieval-related performance goals in Table 8.3.5.2-7:

  - Rockfall in a vertical emplacement borehole due to a seismic event, faulting, variability in rock strength, or excessive thermal loading resulting from human error is considered as a potential abnormal condition; however, rockfall with an average of less than 250 lb. per foot of an emplacement borehole is considered normal and used as a design or performance goal in Table 8.3.5.2-7.

  - The tilt of a waste container is a potential abnormal condition in Table 8.3.5.2-8. However, a maximum allowable displacement of 2 in. for borehole wall or liner of a vertical emplacement holes is one of the design criteria for retrieval (Tables 8.3.5.2-3 and 8.3.5.2-7). A potentially relative displacement of borehole wall or liner between the top and bottom of a vertical hole will no doubt cause a tilt of a waste container.

Section 8.3.2.2, pages 8.3.2.2-1/96

- Several different tentative goals are listed for limiting excavation induced permeability changes in rock mass:

  - Table 8.3.2.2-3 (p. 8.3.2.2-15): less than one order of magnitude change beyond 3 m.

  - Table 8.3.2.2-5 (p. 8.3.2.2-28): 50% of in situ permeability change around excavations

  - p. 8.3.2.2-38 (3rd paragraph): less than one order of magnitude change beyond 75 percent of the distance to the boundary of the disturbed zone.

Section 8.3.1.15.1.3.2, page 8.3.1.15-42

- According to the first paragraph on p. 8.3.1.15-42 all samples for (mechanical) testing of units other than unit TSw2 will be obtained from the walls of the exploratory shafts. According to Figure 8.4.2-33 the exploratory shaft ES-1 will not penetrate units the CH units.

- On page 8.3.1.15-80, there is a description of overcore stress measurements from "a drilling alcove excavated laterally from the ES at the Calico Hills test level". According to Section 8.4 the exploratory shafts are not currently planned to extend into the Calico Hills unit.

Section 8.3.1.15, Table 8.3.1.15-1, pages 8.3.1.15-2/3

- On p .8.3.1.15-12, it is indicated that the current estimate of ambient temperature in TSw2 is 23°-25°C. In Section 8.4, the ambient temperature is stated to be 31°C. On p. 2-45 of the CDR, it is indicated that the range of temperature is 23°-29°C, with an average of 26°C.

- On pp. 8.3.1.15-10,11, the reference to "tentative goals" for empirical design parameters is given as "See Table 6-15". The correct reference should probably be Table 6-13. However, even Table 6-13 does not give "goals". It gives "design values" (some of which are NA = not applicable).

- On p. 8.3.1.15-7, the tentative goal for Young's modulus of intact rock (TSw2 - Primary Area) is 29-33 GPa. On p. 6-49 of the SCP, the current value is given as 31.4 GPa, with a range of ±6.3 GPa. Additionally, Nimick and Schwartz (1987, p. 127) show that the modulus for dry samples can be considerably higher (twice) than the tentative goal.

Section 8.3.1.15.1.1.2, pages 8.3.1.15-34/36
Section 8.3.1.15.1.3.2, pages 8.3.1.15-41/42
Section 8.3.1.15.1.4.2, pages 8.3.1.15-44/45
Section 8.3.1.15.1.6, pages 8.3.1.15-52/65

- Upper temperature limits for test conditions are different or unspecified on the following pages:

  (1) the upper limit for volumetric heat capacity characterization is 275°C (p.8.3.1.15-34);

  (2) the upper limit for laboratory determination of properties is 290°C (p. 8.3.1.15-42);

  (3) the upper limit for laboratory determination of fracture segments is 200°C (p. 8.3.1.15-44);

  (4) the upper temperature limit for in-situ testing in Section 8.3.1.15.1.6 is not presented;

  (5) the upper limit for thermal conductivity determination is 275°C (p. 8.3.1.15-37); and

  (6) the upper limit for mechanical properties determination is 250°C (p. 8.3.1.15-42).

Section 8.3.1.4, pages 8.3.1.4-1/24

- Figure 8.3.1.4-1 and Table 8.3.1.4-1 are incomplete and inconsistent.

- There is a close correspondence between parameter catagories in fig. 8.3.1.4-1, with the exception of the following catagories, which appear in the table but not in the figure: (a) geologic model synthesis; and (b) geologic framework.

- The first sentence of the third paragraph on p. 8.3.1.4-16 indicates that a "geologic framework" is given in Fig. 8.3.1.4-1 as a "broad group of geologic and geophysical information." This "Geologic Framework" does not appear on the referenced figure.

Section 8.3.1.4 pages 8.3.1.4-87/100

- On p. 8.3.1.4-89, it is stated that boreholes in the systematic drilling program will be drilled to a depth approximately 100 m below the water table. On p. 8.4.2-75, the depth mentioned is approximately 200 feet.

- The location of systematic drilling holes shown on Fig. 8.3.1.4-11a (p. 8.3.1.4-90) does not agree with locations shown in Fig. 8.4.2-2a (p. 8.4.2-41).

RECOMMENDATION

- Inconsistencies in the SCP regarding parameters or tentative design goals should be removed or justified in the SCP update.

REFERENCE

Nimick, Francis B., and Barry M. Schwartz. "Bulk, Thermal, and Mechanical Properties of the Topopah Spring Member of the Paintbrush Tuff, Yucca Mountain, Nevada," Sandia National Laboratory, SAND85-0762, September 1987.

MacDougall, Hugh R., Leo W. Scully, and Joe R. Tillerson (Compilers), 1987. Site Characterization Plan Conceptual Design Report: Volume 1, Chapter 1-3, SAND84-2641. Sandia National Laboratories, Albuquerque, N. Mex.

Section 8.3.1.4 Overview of the Rock Characteristics Program, page 8.3.1.4-1/24

COMMENT 3

Engineering rock parameters are not adequately integrated in the plan to develop the three-dimensional rock characteristics model.

BASIS

- The items "fracture geometry and properties" and "fault geometry and properties" are not given equal weighting in terms of parameters in Table 8.3.1.4-1. The "fault geometry and properties" may be more significant in terms of repository performance.

- No category for geomechanical parameters is included in figure 8.3.1.4-1.

RECOMMENDATIONS

The SCP updates should:

- Integrate the "rock unit geometry and properties", "fracture geometry and properties", "geologic framework", and "geologic model", in the "three dimensional rock characteristic model".

- Complete and make consistent the integration logic presented in figure 8.3.1.4-1 and the corresponding SCP text.

Section 8.3.1.4.2.2 Study: Characterization of the structural features within the site area, page 8.3.1.4-65.

COMMENT 4

The SCP (page 8.3.1.4-65, 4th paragraph) states that "geologic mapping in the underground can aid in recognizing blast-induced fractures . . . ." It is not clear whether the techniques given for identification of blast fracturing are adequate to differentiate them from natural or stre~~s~~-induced fractures.
ss

BASIS

- Fractures on the walls of exploratory shaft and drifts may be classified as natural, blasting-induced, and stress-relief induced fractures.

- Some natural fractures may be readily identified due to their pronounced patterns or existence of mineralization on the fracture surface. However, for those without these evident features, identification may be difficult.

- Characterizing fractures with absence of mineralization on fracture surfaces as blasting-related may underestimate frequencies of natural fractures.

- Identifying blasting-induced fractures using a "tracing back" method as described in the SCP may be difficult and this method may not be able to account for stress-relief induced fractures.

RECOMMENDATION

- Procedures for recognizing blast-induced and stress-relief induced fractures should be provided in a study plan.

Section 8.3.1.4.3.1.1 Activity: Systematic Drilling Program, page 8.3.1.4-93

COMMENT 5

The "rule of thumb" stating that the number of pairs that is acceptable for each spacing range should be at least 30, represents a lower bound for geostatistical analyses and may not ensure that parameter values can be estimated with the desired confidence. The SCP text is unclear on this topic.

BASIS

- The following two SCP statements appear to be contradictory:

  "The two figures show that the systematic drilling program, together with existing boreholes and additional planned drilling, result in greater than 30 borehole pairs in spacing ranges up to 10,000 ft. Thus the systematic drilling program meets the requirements for geostatistical evaluation, and will provide significant additional information for a subset of rock characteristics if integrated with existing boreholes" (p. 8.3.1.4-93, third paragraph).

  "The actual number of pairs that is acceptable for each spacing range will depend heavily on the data values (p. 8.3.1.4-93, first paragraph)."

RECOMMENDATION

- The SCP updates should discuss other aspects of the geostatistical approach, such as viewing the variogram estimation process as estimating the variance of difference and applying the standard formula for confidence of variance estimates using correlated data. For example, see Cressie (1985).

REFERENCE

Cressie, N. "Fitting Variogram Models by Weighted Least Squares," Mathematical Geology, 17(5), 563-586 (1985).

Section 8.3.1.4.3.1.1 Activity: Systematic drilling program, pages 8.3.1.4/87-100

COMMENT 6

The tight clustering of sample locations SD-8 through SD-12, shown on Figure 8.3.1.4-12a, has not been justified to be an appropriate method of increasing the number of sample pairs for short distances and provides no assurance about the quality of the resulting variogram.

BASIS

- In response to CDSCP Comment 30, the DOE response states that the location and drilling of the exploratory boreholes are coordinated with the repository design. However, it is not clear how tight clustering of systematic drilling boreholes SD-8 through SD-12 outside the repository block considers integration of site specific subsurface information need with repository design.

- Counting the number of sample pairs entering into the variogram computation without regard to sample spacing has not been established as an appropriate method of assessing the ultimate quality of the variogram. For example, SD-10 and SD-11 are quite close to each other (200 meters); thus, they are highly correlated (using the assumed 3,000 ft. range of influence). If SD-10 and SD-11 are correlated, any two pairs with SD-10 in one pair and SD-11 in the other pair will likewise be correlated. The net effect is that there are significantly fewer equivalent uncorrelated pairs in any spacing than a simple count would indicate.

- The tight cluster of sample outside of the target area and centered around SD-11 may succeed in characterizing the small area quite well; however, this may be of little value in characterizing the entire area within the repository block.

RECOMMENDATION

The SCP updates should justify its reasoning for clustering systematic drilling holes outside the repository block.

Section 8.3.1.15.1 Investigation: Studies to Provide the Required Information for Spatial Distribution of Thermal and Mechanical Properties, p. 8.3.1.15-23/31

COMMENT 7

The discussion and/or use of statistics in this chapter is not clear. A statistical approach has been suggested to determine numbers of tests required to determine various rock properties, but the approach suggested is confusing and apparently overlooks several considerations that should be factored into such an approach. Also, needed confidences of "low", "medium" or "high" have been assigned without explaining the basis for such assignments. Bases for assigning the needed confidence of low, medium or high are not discussed.

BASIS

- In response to CDSCP comment number 45, the DOE has revised Section 8.3.1.15.1 of the SCP to include some additional information on the statistical rationale for proposed experiments. However, this discussion is incomplete and relies heavily upon the results of future parametric or sensativity studies. Appendix N of SNL, 1987, referenced in the SCP (p. 8.3.1.15-14), contains only a few analyses which can be considered sensativity parametric analyses.

- The discussion regarding means and standard deviations of required properties is confusing. It is not clear from what sample population the mean and standard deviation are to be determined. Furthermore, the confidence to which these parameters must be known (the standard deviation) has apparently been estimated from "expert judgment" and may not be reliable.

- An acceptable way of determining test needs is to conduct sensitivity or parametric calculations of repository performance in which the various input parameters are varied and the response examined. Only limited calculations have been referenced (see Comment 1).

- A statistical analysis is given to determine the number of measurements required to obtain a standard deviation of any given property. This analysis has apparently not considered the following:

  (1) The properties to be determined are not evenly distributed throughout the mass.

  (2) The measured values are a function of testing sample size (and possibly, direction).

  (3) Populations may not be normally distributed.

  (4) Sampling may be biased due to jointing, hole direction, etc.

(5) The determination of the necessary number of samples is based on a Gaussian tolerance interval. The Gaussian assumption may not be appropriate for most of the variables of interest. Also, the method outlined in the text ignores spatial correlation.

(6) "For convenience, (1-alpha) is assumed to be the same as gamma" (p. 8.3.1.15-28). The selection of the "alpha" and "gamma" levels should be based on the sensitivity of the design decisions to the parameters and the potential impact of decision errors.

(7) The arbitrary selection of the necessary number of samples (see p. 8.3.1.15-29) potentially results in too few samples.

RECOMMENDATION

In the SCP updates:

- The proposed statistical approach to determine the number of tests required to determine various rock properties should be clarified.

- Results of on-going sensitivity studies as the bases for assigning needed confidence levels of "low", "medium" or "high" should be presented.

Section 8.3.1.15.1 Investigation: Studies to provide the required information for spatial distribution of thermal and mechanical properties, p. 8.3.1.15-31

Section 8.3.5.20 Analytical Techniques Requiring Significant Development

COMMENT 8

The validation of models should be part of the overall test program. It is not clear that these aspects have been addressed by the test program.

BASIS

- On p. 8.3.1.15-31 (2nd paragraph), it is stated that "temperature fields induced during the heater tests will be modeled using numerical techniques, with values for thermal properties being varied until an optimum match of predicted and actual temperatures is obtained." Such an approach does not address the uniqueness of the final set of thermal properties.

- Chapter 6 of the SCP discusses several potential constitutive models and numerical model types to be used for performance assessment and design analysis. However, the discussion does not clearly show how testing will be used to resolve the issue of proper constitutive model and numerical method, and how this testing will feed into design and license application.

- The discussion on validation in Section 8.3.5.20 is general in nature. However, it does discuss two (2) parts to the validation process: "(1) ascertaining when the model has achieved a good representation of the system, and (2) comparing predictive results to appropriate observations and experimental results" (p. 8.3.5.20-8). It is not clear how the second part of the validation procedure will be evaluated.

RECOMMENDATION

A testing rationale which addresses validation of models should be presented in the study plans.

Section 8.3.1.15.1.5	Study: Excavation investigations, pg. 8.3.1.15-45/52
Section 8.3.1.15.1.8	Study: In situ design verification, pg. pg. 8.3.1.15-70/76
Section 8.3.2.2.5	Information need 1.11.5, pg. 8.3.2.2-63
Section 8.4.2.3.4.4	Exploratory shaft facility underground construction and operations--blasting, pg. 8.4.2-180/195

COMMENT 9

Studies relating to design verification do not consider investigating the behavior of underground excavation in the tuff using alternate excavation methods.

BASIS

- Section 8.3.2.2 (p. 8.3.2.2-63) indicates that continuous mining methods are being considered but the method has not yet proved practical in welded tuff. However, no substantiation of this statement has been made through references.

- Planned testing of emplacement holes appears to be limited. At present the only data planned to be obtained to study mechanical excavation results from these emplacement size tests.

RECOMMENDATION

- Alternate methods of excavation should be evaluated and results provided in SCP updates.

Section 8.3.1.15.1.8 Study: In-Situ Design Verification, p. 8.3.1.15-70

COMMENT 10

Activity descriptions presented in the In-Situ Design Verification Section do not include tests to verify design aspects under repository conditions.

BASIS

- The repository will be subject to thermal effects as a result of emplaced waste. None of the activities described in this section evaluate thermal effects.

- According to the CDR, mechanical mining is planned for some parts of the repository. However, Section 8.3.1.15.1.8.1 (Evaluation of mining methods) describes tests to study only the effects of drill and blast excavation.

- Section 8.3.1.15.1.8.4 (Air quality and ventilation experiment) does not explicitly indicate whether or not thermal effects will be considered. If thermal effects are to be considered, the ventilation experiment should determine parameters in addition to those identified on p. 8.3.1.15-75. For example, if the convective heat transfer coefficient is to be determined by experiment, the surface rock temperature must be known. In addition, ventilation calculations in Appendix C of the CDR (MacDougall et al., 1987) use a "wetness factor." There is no explanation for how this factor will be determined by this experiment.

RECOMMENDATION

- An identification of the activities to verify the design under repository conditions should be presented in a study plan.

REFERENCE

MacDougall, Hugh R., Leo W. Scully, and Joe R. Tillerson (Compilers). Site Characterization Plan Conceptual Design Report. Sandia National Laboratories, SAN84-2641, September 1987.

Section 8.3.2.2 Funçtion 3 Permeability modification associated with excavation process, pages 8.3.2.2 - 14/16

COMMENT 11

The statement in the SCP (page 8.3.2.2-14, paragragh 3) that the blast control procedures are less important to postclosure performance has not been justified.

BASIS

- The supporting Section 6.4.1 of the SCP-CDR essentially states this position but does not provide any supporting analyses.

- Reliance is placed on the concept of matrix flow to support the conclusion that blasting induced fractures are less important to postclosure performance (SCP page 8.3.2.2-4, paragragh 3). However, the DAA Review Record Memorandum, Appendix J, page 2-4, paragraph 3 states that potential for flow in fractures is a special concern because this flow mode could provide a mechanism for . . . rapid movement of radionuclides . . . to the saturated zone underlying the repository.

RECOMMENDATION

- Significance of blast control procedures and blasting induced fractures should be discussed in SCP updates.

Section 8.3.3.1 Overview of Seal Program, page 8.3.3.1-1/9

COMMENT 12

The SCP does not assess the need for permanent or temporary seals in repository ramps or shafts.

BASIS

- In response to CDSCP comment number 65, the SCP has not included analyses to evaluate the need for seals in the repository shafts and ramps.

- The SCP Section 8.3.3.1 states that no sealing will be necessary for repository shafts and ramps. However, the SCP does not provide analysis or references supporting the statement.

- The effects of vertical structural features such as faults and joints providing direct connections to flood-prone surface depressions or need for seals have not been addressed.

- The following Specific concerns have not been addressed.

  Man and Materials Shaft

  - Surface runoff on face of the hill slope above the shaft could possibly enter the shaft. High water velocities can be anticipated if the runoff becomes channeled.

  - Assuming that the surface plug is likely to deteriorate with time, settlement of shaft backfill (proposed seal) could cause a depression at the location of the shaft collar and additional rock fracturing of the unsupported rock around the shaft walls, and could become a possible source of recharge because of ponding of water in the depression.

  Location of Waste Emplacement Ventilation Exhaust Shaft

  - The shaft is proposed to be located in the drainage channel of an unnamed tributary to Drill Hole Wash. The location appears to be susceptible to the hazards of flooding and debris deposits. The slope of the ground surface in this area appears to be approximately 4%. Very high flow velocities can be expected on such a slope, particularly in localized channels and gullies. Furthermore, the shaft location is essentially in the channel bottom.

  Muck Handling Ramp Portal

  - The ramp entrance is proposed to be located in an area of numerous gullies. Potential hazards of flooding, and deposition across the alluvial fan coming from Pagany Canyon appear to exist.

Waste Handling Ramp Portal

- At the proposed location, the eastern slopes of Exile Hill are relatively steep (approximately 25%) and are subject to gullying. Surface runoff may be a potential problem, particularly if the runoff becomes channeled in the immediate vicinity of the surface entrance. Very high water velocities can be expected on 25% slopes of Exile Hill and the 8-10% slopes in the immediate ramp vicinity. These flow velocities could pose groundwater intrusion problems during pre- and post-closure phases.

RECOMMENDATION

- The SCP updates should evaluate the need for temporary and permanent seals for accesses based on conditions inherent at each location of proposed shafts and ramps.

Section 8.3.3.2.1 Information Need 1.12.1, Technical Basis for Addressing the Information Need, Parameter 8 (p. 8.3.3.2-34)

COMMENT 13

Conservative design approach has not been used to determine required backfill hydraulic conductivity.

BASIS

- CDSCP comment 70 expressed concern about the narrow basis for determining backfill requirements. According to the SCP response the recommended analysis is given in Fernandez et al (1987). As stated in the original CDSCP comment the design chart Fig. F-10 is developed for a single rock mass permeability (Fernandez et al, 1987, pages F-12 through F-14). The sensitivity analysis claimed in the SCP response can not be located in Fernandez et al (1987).

- The CDSCP concern about other inflow and outflow scenarios, and, specifically preferential channel flow, remains unaddressed.

- The determination of the required backfill hydraulic conductivity (10^{-2} cm/s) appears to be driven by comparisons of relative flow i.e., allowable shaft inflow as a fraction of total flow, (Fernandez et al., 1987, p.3-22, top paragraph). The basic reference design chart (Fernandez et al., 1987, Fig. F-10) is developed for the case where the hydraulic conductivity of the rock mass is taken as 10^{-2} cm/s. It is not clear that a broad range of possible hydraulic conductivities of the rock mass has been considered in determining the required backfill hydraulic conductivity.

- On p. 8.3.3.2-34, it is stated that "The rock mass hydraulic conductivity for one analysis (Fernandez et al., 1987) was varied from 10^{-2} to 10^{-5} cm/s." It is not clear that the results of this variation were considered in selecting the required backfill hydraulic conductivity.

RECOMMENDATION

It is recommended that the sensitivity analysis in which the broad range of possible hydraulic conductivities of the rock mass (e.g., 10^{-2} to 10^{-5} cm/s) was considered, be specifically referenced. In-situ tests should be planned and initiated to obtain the needed data as soon as practical. Alternative inflow and outflow scenarios (e.g., preferential channel flow) should be presented.

REFERENCE

Fernandez, Joseph, Peter C. Kelsall, John B. Case, and Dann Meyer. Technical Basis for Performance Goals, Design Requirements, and Material Recommendations for the NNWSI Repository Sealing Program. Sandia National Laboratories, SAND84-1895, September 1987.

Section 8.3.3.2.2.3 Study 1.12.2.3: In-Situ Testing of Seal Components, pg. 8.3.3.2-41/62.

COMMENT 14

This section describes a four-step process to determine the need for in-situ testing of seal components. However, no indication is given as to whether and when testing "to initiate in-situ testing to evaluate the behavior of selected sealing components under realistic in-situ conditions as well as under unlikely conditions (p. 8.3.3.2-41)" will be initiated.

BASIS

- In response to CDSCP comment 64, the SCP has not included details of in situ testing of the proposed seal design concepts.

- Section 8.3.3.2.5, Schedule for Seal Characteristics (Issue 1.12), does not discuss when steps 3 and 4 of the four-step process mentioned above will be completed, or when a decision can be expected relative to the need for in-situ testing.

- Table 8.3.5.16-2 (p. 8.3.5.1-8) indicates that in-situ testing of seal components will commence by approximately January 1993. It is not clear that all information for steps 3 and 4 discussed in Section 8.3.3.2.2.3 will be available by that time.

- No in situ seal testing is presently included in ESF in situ test plans, and no provisions are made in the ESF layout for such testing.

- The Safety Analysis Report to be submitted by the DOE for License Application is required to include an evaluation of the performance of the proposed geologic repository after permanent closure (10 CFR 60.21(c)(1)(ii)(C)). Figure 8.3.3.1-1 of the SCP shows that the DOE plans to complete the performance analysis without results of any in-situ tests on seals.

RECOMMENDATION

- The SCP updates should indicate when a decision will be reached concerning the need for in-situ seal testing and when such tests might be carried out.

- A plan should be in place for in-situ seal testing prior to license application in case site characterization data indicate a need for reliance on seals.

- The in-situ tests for seal components should commence as early as practical during the site characterization program, such that adequate preliminary information would become available at License Application submittal.

REFERENCE

10 CFR 60 (Subpart B).

Section 8.3.5.2 Issue Resolution Strategy for Issue 2.4 (p. 8.3.5.2-1/52)

Section 8.3.5.5 Issue Resolution Strategy for Issue 2.3 (p. 8.3.5.5-1/35)

COMMENT 15

In evaluating potential effects of credible accidents on projected pre-closure radiological exposures (10 CFR 60.111), the SCP has not sufficiently considered retrieval operations.

BASIS

- In response to CDSCP comment number 72, it is stated that "retrieval looks much like the reverse of emplacement and, in that sense, retrieval operations may be considered to have been addressed in existing accident analyses." The NRC staff considers that the operations related to waste retrieval may be more complex than emplacement operations, primarily due to the environmental effects of waste disposal. These may include: 1) operational problems due to the increased temperature of the rock mass and disposal room; 2) potential physical deterioration of the emplacement room and emplacement boreholes; and 3) potential deterioration or breaching of the waste package.

- The SCP has not adequately addressed the effects of credible accidents on projected radiological exposures during retrieval operations.

RECOMMENDATION

- SCP updates should discuss retrieval operations in evaluating the effects of credible accidents on radiological exposures.

Section 8.3.5.16 Issue Resolution Strategy for Issue 1.7, p. 8.3.5.16-1/10

COMMENT 16

The information presented in the SCP, Section 8.3.5.16 - Performance Confirmation Testing, is insufficient to allow NRC staff to determine if the confirmation program meets the requirements of 10 CFR 60.140.

BASIS

- The SCP indicates, in its response to NRC CDSCP comment 103, that Section 8.3.5.16 has been revised to clearly define the phased volume of the DOE's performance confirmation program. SCP recognizes "that 10 CFR 60.140(b) requires that a performance confirmation program shall have been started during site characterization" (p. 8.4.2-147). However, the staff considers that the SCP does not adequately address NRC CDSCP comment 103. The SCP does not provide sufficient details on confirmation of geotechnical and design parameters, design testing and monitoring and testing waste package required by 10 CFR 60, Subpart F. Potential impact of performance confirmation testing on ESF design have not been addressed.

- Section 60.137 of 10 CFR Part 60 requires a performance confirmation program that meets the Subpart F requirements.

- 10 CFR 60.140(b) requires that the performance confirmation program shall have been started during site characterization.

- The Annotated Outline for the SCP (DOE, 1987, page xiii) states that one of the objectives of the SCP is to provide details of the performance confirmation testing program. This information is needed to allow evaluation of the effects of performance confirmation activities, in particular, the ability of the natural and engineered barriers of the repository system to meet the performance objectives.

- The USNRC Generic Technical Position on In Situ Testing During Site Characterization for High-Level Nuclear Waste Repositories, section 5.6 states that "DOE should identify in its test plan which tests will be completed at the time of construction authorization application, and which tests and long-term monitoring activities will continue after that."

- It is not clear if the laboratory tests of intact rock mechanical properties under various environmental conditions (see 8.3.1.15.1.3.2) would be continued during performance confirmation. Blacic et al. (1986) has reported strength changes in intact tuff as a result of exposure to repository conditions over time. Further quantification of these effects during performance confirmation may be necessary.

- No testing is described in the SCP to verify by direct observation the behavior of thė waste package and waste package environment under repository conditions.

RECOMMENDATION

- The SCP updates should demonstrate that the performance confirmation program meets the requirements of 10 CFR 60 subpart F.

REFERENCES

10 CFR 60.

DOE's Annotated outline for the Site Characterization Plan, Rev. 1, 1987.

USNRC Generic Technical Position on In Situ Testing During Site Characterization of High-Level Waste Repository.

Blacic, J. D., D. T. Vaniman, D. L. Bish, C. J. Duffy and R. C. Gooley. "Effects of Long-term Exposure of Tuffs to High-Level Nuclear Waste Repository Conditions: Final Report," Los Alamos.

Section 8.4.2.1.2 Principal data needed for preclosure performance evaluations and design - Data needed for underground facility design, pages 8.4.2-14/15

COMMENT 17

Seismic design criteria for the ESF are not sufficiently described in the SCP.

BASIS

- The implicit assumption appears to be that the jointed rock mass in which the shafts are to be constructed will exhibit continuum behavior in the modified local stress field around the shaft. Effects such as local slip or separation on joint surfaces are not taken into account.

- The analysis of dynamic interaction of the peripheral rock mass with the shaft liner assumes continuous deformation of the rock. Under the conditions of dynamic loading imposed on the medium, it is possible that rock deformation will be discontinuous, resulting in highly localized loading of the shaft liner.

- The ground motions which are to be the basis for shaft design and performance assessment are stated in terms of probable bounds on the orthogonal components of peak acceleration and peak velocity which may be induced by earthquakes and UNEs. However, seismic loading results in cyclic loading of the rock mass. Experiments on jointed rock show that it is the number of excursions of dynamic loading into the plastic range of joint deformation which determines the performance of the joint (Brown and Hudson, 1974). A particular effect is that joint peak-residual behavior is modified. Further, tuff-like materials demonstrate strength loss under dynamic loading. Both effects (i.e. shear strength reduction of joints and reduction of material strength) are analogous to fatigue of metals under cyclic loading. These observations suggest that the design basis motions should be prescribed in terms of full time histories of acceleration and velocity, and not merely the peak ground motions. (Lemos, 1987).

RECOMMENDATION

- The seismic design basis for the exploratory shaft facility should be clarified in SCP updates.

REFERENCES

Brown, E. T., and J. A. Hudson 1974. Fatigue failure characteristics of some models of jointed rock. Earthquake Eng. and Struct. Dyn., 2, 379-386.

Lemos, J., 1987. A Distinct Element Model for Dynamic Analysis of Jointed Rock with Application to Dam Foundations and Fault Motion. Ph.D. Thesis, University of Minnesota, June 1987.

Section 8.4.2.1.5.5 <u>Drifting to the Southern Part of the Repository Block, pages 8.4.2-31/32</u>

<u>COMMENT 18</u>

It has not been demonstrated that the proposed site characterization plan is aimed at sufficient amount of underground drifting to collect data for designing and analyzing the repository performance.

<u>BASIS</u>

- In response to CDSCP comment number 100 it has not been demonstrated that the amount of subsurface drifting and exploration planned in the SCP would be sufficient to yield the data needed for repository design at license application.

- Need for additional drifting, if not adequately accounted for in planning, may result in potential significant disruption to characterization schedules that would substantially reduce the ability of DOE to obtain information necessary for licensing.

- The drifting plan is limited to explore a comparatively small area in the northeast of the repository block. Also, it has not been shown that the planned surface investigations (e.g., borings, geophysical surveys) would be sufficient to adequately supplement the needed characterization information for the repository block.

- It has not been established that the areas planned to be explored by the proposed drifts in the northeast are likely to have characteristics similar to those in the remaining portion of the repository block. In particular, little justification has been presented to assume that the area explored by the proposed drift to the east will have characteristics similar to those in the south of the repository block.

- SCP Section 8.4.2.1.6 (page 8.4.2-32) States th~~e~~at "Discussed below are options for obtianing the needed information . . . . . . for the southern part of the repository and factors that will be considered in determining which approaches will be used." This information is not included in SCP Section 8.4.2.

- Drifting through the repository block, similar to that conducted at similar projects elsewhere (e.g., WIPP), has not been committed.

<u>RECOMMENDATION</u>

- The SCP updates should demonstrate that the planned site characterization will provide sufficient data for designing and analyzing the repository performance. The discussion should include factors to be considered in determining which site characterization approaches will be used.

REFERENCE

o "SPDV Shaft Outfitting and Underground Excavation," WIPP-DOE-197, 1984.

Section 8.4.2.2.2.3 Basis for surface-based testing construction controls
page 8.4.2-80/87

COMMENT 19

The SCP (page 8.4.2-81) states that "A key aspect of construction control for surface-based testing, including infiltration testing, unsaturated-zone hydrology testing, and the systematic drilling program, (and multipurpose borehole drilling program), is the selection of dry coring methods. The technology for a dry coring method is yet to be proven." The SCP (page 8.4.2-86) does include a program to demonstrate the method. However, since the drilling program is developed based on the assumption that dry coring is feasible, the program might be jeopardized if this method is not proven feasible.

BASIS

- The SCP states (pages 8.4.2-86) that "based on prior drilling history at Yucca Mountain, dry drilling is the only demonstrated means of controlling formation invasion by fluid" (emphasis added). The SCP (page 8.4.2-87) further states that "dry drilling methods are therefore specified for planned drilling in the unsaturated-zone within the CPDB and immediate vicinity".

- The SCP (page 8.4.2-35, section 8.4.2.1.6.2) also states that "a practical drilling method for dry, continuous coring to depths of up to 2,600 ft in fractured tuff is needed for site characterization, but has not yet been demonstrated."

RECOMMENDATION

- The SCP updates should discuss the impact on the site characterization program if the dry coring method with continuous coring is not proven feasible.

Section 8.4.2.3.1 Exploratory shaft facility testing operations, layout constraints, and zones of influence, pages 8.4.2-93/147

COMMENT 20

The ESF design described in the SCP does not demonstrate that during site characterization, the license review period and for some time after construction authorization, direct observation of the waste package and waste package environment under repository conditions would be possible.

BASIS

- 10 CFR 60.140 (b) requires that the performance confirmation be started during site characterization.
- It is not clear how the proposed in situ tests and laboratory tests can provide meaningful waste package-repository interaction data to fulfill the requirements of the license application.
- Other similar projects [e.g., WIPP (Matalucci, 1988)] have proposed tests including actual waste packages in the waste package environment to collect needed data.
- The SCP has failed to demonstrate that in situ data on waste package interaction with the host rock under repository conditions involving coupled hydrological-mechanical-thermal-geochemical-radiological effects are not required before license application.
- The SCP notes (page 8.3.5.2-19) that the ability of the host rock to provide an acceptable level of shielding is "of primary concern." The SCP does not discuss testing aimed at evaluating rock radiation shielding which accounts for jointing, damaged rock, etc. (See CDSCP question 37 and SCP question 37N).
- It is not clear how the current design for the shafts and hoist system of the ESF would permit transfer of the waste package and the cask (about 55 tons) from surface to underground facility for testing purposes.
- The current ESF design does not permit direct observations of the waste package and waste package environment during site characterization, license review period or for some time after construction authorization.
- ESF design in the SCP does not discuss possible incorporation of a ramp or other design feature that could handle transfer of waste package and cask during site characterization as an alternative major design feature.

RECOMMENDATION

- The SCP updates should demonstrate that the in-situ waste package testing will not be necessary prior to submittal of license application. If necessary, the test facility design should permit in situ waste package testing.

REFERENCES

- 10 CFR 60

- Matalucci, R.V., 1988. In-Situ Testing at the Waste Isolation Pilot Plan. SAND87-2382, Sandia National Laboratories, Albuquerque, NM.

Section 8.4.3.2.1.1 Water infiltration from the surface, (3) <u>Water accumulation in the exploratory shaft</u>, page 8.4.3-10/11

<u>COMMENT 21</u>

The discussion of the potential causes for a reduction in the drainage capacity of the shaft bottom does not include certain plausible mechanisms.

<u>BASIS</u>

- Of several possible ways in which the sump drainage could be rendered ineffective, silting is the only mechanism addressed (Fernandez et al, 1988). Dissolution and remineralization effects are not mentioned. Omitted from consideration are thermal, mechanical, and geochemical effects (e.g., p. 8.4.3-58: Geochemical changes).

- Permeability tests on fractured tuff suggest a high risk of rapidly reducing permeability during flow tests as a result of precipitation (e.g., Lin and Daily, 1984, as summarized in SCP section 7.4.1.5).

<u>RECOMMENDATION</u>

- SCP updates should include a broader range of scenarios that could affect drainage.

<u>REFERENCES</u>

Lin, W., and W. Daily, 1984, Transport Properties of Topopah Spring Tuff, UCRL-53602, Lawrence Livermore National Laboratory, Livermore, California.

Fernandez, J. A., T. H. Hinkebein, and J. B. Case, 1988, Selected Analyses to Evaluate the Effect of the Exploratory Shafts on Repository Performance at Yucca Mountain, SAND88-0548, Sandia National Laboratories, Albuquerque, NM

Section 8.3.1.4 Overview of rock characteristics program - Table 8.3.1.4-2, current representation and alternative hypotheses for models for the rock characterization program, page 8.3.1.4-22

QUESTION 1

What is the current understanding of the relation between mechanical and hydraulic apertures, and how will the data from "aperture" measurements made during site characterization be used in design and performance assessment analyses?

BASIS

- The aperture information alone may not be useful in design and performance assessment analyses. In particular, it is widely accepted that "fracture aperture is very sensitive to small changes in stress" (p. 8.3.1.4-22). This suggests that measured apertures are to be related in some fashion to stress. It is not clear in the SCP how this relation will be evaluated.

- The effects of blasting on measured apertures may need to be accounted for.

- In its response to NRC's CDSCP question number 12 it is stated that, "relating aperture to equivalent hydraulic aperture is not within the scope of the SCP." Fracture flow is discussed in Section 8.4, where it is related primarily to hydraulic conductivity. It has been shown that the Cubic Law (Witherspoon et al., 1979), relating flow rate to aperture cubed is not physically correct when values of mechanical aperture are used to represent aperture (Barton et al., 1983). However, an acceptable model results when values of conducting (equivalent hydraulic) aperture are used (Barton, 1982). Hydraulic aperture has been empirically related to mechanical aperture through a roughness coefficient (Barton, 1982).

- Geometric observations may not be the source of the best estimates currently available, and an integration of direct and indirect approaches is likely to be more useful.

RECOMMENDATION

- Plans to characterize aperture dependence and relations between mechanical and hydraulic aperture should be described in the SCP updates.

REFERENCES

Barton, N., 1982. "Modeling Rock Joint Behavior form In-Situ Block Tests: Implications for Nuclear Waste Repository Design," Office of Nuclear Waste Isolation, Columbus, Ohio, ONWI-308.

Barton, N., K. Bakhtar and S. Bandis. "Rock Joint Description and Modelling for Prediction of Near-Field Repository Performance," Materials Research Society Annual Meeting (Boston, 1983), Proc. Symp. D., "Scientific Basis for Nuclear Waste Management.

Witherspoon, P. A., J.S.Y. Wang, K. Iwai and J. E. Gale, 1979. "Validity of Cubic Law for Fluid Flow in a Deformable Rock Fracture," Lawrence Berkeley Laboratory, LBL-9557, SAC-23.

Section 8.3.1.4.1.1 Activity: Development of an Integrated Drilling Program
pages 8.3.1.4-24/26

QUESTION 2

Has the site characterization program been developed based on the total area that may be needed for repository development?

BASIS

- In response to CDSCP Question 49, the SCP does not provide sufficient basis for the investigation of area with adequate flexibility in repository development.

- The development of an integrated program must be based on the total area needed for the repository. The SCP states that the area needed for repository development is judged to be 1,420 ± 210 acres, based on uncertainty in the aerial power density of 40 to 80 kw/acre (p. 6-227). Furthermore, as much as 300 additional acres may be needed to ensure availability of adequate area for contingency (p. 6-227). Therefore, the final repository may encompass up to 1,930 acres. It is not specified in the SCP how much area is contained within the respository perimeter drift in Fig. 8.3.1.4-2.

- The area coverage rationale for development of the systematic drilling program is based on the CPDB (conceptual perimeter drift boundary) as stated on p. 8.3.1.4-89.

RECOMMENDATION

- The SCP updates should address the total area requirements, including the area required for adequate flexibility in the repository development, in planning the site investigation program.

Section 8.3.1.4.2.2.3 Borehole evaluation of faults and fractures, pages 8.3.1.4-70/74

QUESTION 3

In the CDSCP reference (p. 8.3.1.4-91) was made to drilling vertical and angled exploratory boreholes. Discussion of angled holes is remosed from SCP, which raises a concern regarding the collection of representative data. What is the rationale for planning only vertical exploratory holes?

BASIS

- The SCP recognizes, in this section among many other places, that vertical jointing is likely to be strongly dominant.
- The SCP (p. 8.3.1.4-72) states the severe limitations of trying to characterize vertical jointing with vertical holes.
- If vertical discontinuities are encountered in the borehole, they may break up core and make core recovery difficult, possible biasing the results.
- At only a very small number of locations will other planned access allow characterizing vertical fractures below and above the repository horizon.
- The CDSCP (DOE, 1988) mentioned that "several angled boreholes approximately minus 60 degrees to the west may be drilled" (P. 8.3.1.4-91, paragraph 1). The SCP does not discuss angled boreholes in Section 8.3.1.4.

RECOMMENDATION

- The basis for deleting plans given in CDSCP for drilling several angled boreholes for site characterization should be explained in SCP updates.

REFERENCE

U.S. DOE, "Consultation Draft Site Characterization Plan Overview, Yucca Mountain Site, Nevada Research and Development Area, Nevada", January 1988.

Section 8.3.1.4.2.2.4 Activity: Geologic Mapping of the Exploratory Shaft and Drifts, pages 8.3.1.4-74/79

QUESTION 4

Why is face mapping of exploratory drifts restricted to areas where anomalous conditions are exposed?

BASIS

- Mapping the face of the exploratory drifts will provide an opportunity to map in a plane perpendicular to the drift direction, thus greatly reducing the bias introduced by mapping only on surfaces parallel to the drift direction.

- Cording et al. (1975) provide the following reasons for mapping the face of advancing excavations. "The face of each heading advance in the vicinity of instruments should be mapped. . . Observations at the heading are useful, because the relation of geology to initial support can best be observed at the time of scaling and initial support placement."

- Three-dimensional descriptions of fracture systems can be evaluated by systematic mapping of exploratory shafts and drifts, including mapping of some reaches of shaft floor and drift faces. Such mapping or photography evaluation permits direct characterization of in-situ fracture networks instead of being inferred from fractal analyses of surface data.

RECOMMENDATION

- Mapping and/or photographing floors and faces of shafts and drifts over short reaches should be considered in a study plan to characterize fracture networks and provide supplementary information for instrumentation and for correlating required support.

REFERENCE

Cording, E. J., A. J. Hendron, Jr., H. H. MacPherson, W. H. Hansmire, R. A. Jones, J. W. Mahar and T. D. O'Rourke, 1975. "Methods for Geotechnical Observations and Instrumentation in Tunneling," Vol. 1, University of Illinois at Champaign-Urbana, Department of Civil Engineering, NSF Research Grant G1-33644X, UILU-ENG 75 2022.

Section 8.3.1.4.3 Investigation: Development of Three-Dimensional Model of Rock Characteristics at the Repository Site, pages 8.3.1.4-84/86

QUESTION 5

What measure of predictability will accompany the computer models, maps, and other illustrations? How will uncertainties be explicitly transmitted to the model users?

BASIS

- The SCP states that "The principal result of this investigation will be the development of computer-based representations of the three-dimensional distribution of physical property data. Contour maps or cross sections will show the spatial distribution of such parameters as rock compressive strength, thermal conductivity, or gas permeability" (p. 8.3.1.4-85). A local estimate (as rendered by a map, for example) without an associated local quantitative measure of certainty may permit model users to view the model as uniformly "good", while, in fact, certain areas may be well understood and others not, and certain parameters may be well predicted and others not. A global confidence interval for the average of a particular parameter does not adequately address the issue of local uncertainty.

- The SCP also states that "The quantitative descriptive data will then be interpolated and projected using a standard mathematical algorithm to create a model of the desired property(ies) as requested by performance assessment and design issues" (p. 8.3.1.4-86). A contour map generated by interpolating from a relatively small number of measurement locations is not likely to represent the entire range of values for the parameter in question. The fewer the measurements upon which an interpolation is based, the more uniform the results. For example, the probability of a small number of measurements capturing both the highest and the lowest values across the entire field of interest is zero; yet, the interpolation will estimate values between the highest and lowest sample value.

RECOMMENDATION

SCP updates should describe how local variability in the data will be presented in the block model.

Section 8.3.1.4.3.1.1 Activity: Systematic drilling program (Analysis and sampling strategy), page 8.3.1.4-98

QUESTION 6

The SCP (page 8.3.1.4-98) states that "determination of multiple properties from the same specimens is important for correlating variability of different parameters with nonuniform measurements support." How will this testing strategy be implemented?

BASIS

- The sampling program in Section 8.3.1.15.1 discusses only the number of samples necessary. It neither discusses how and where those samples are going to be selected nor does it discuss integration with the sampling program for Section 8.3.1.4.3.4.1.1 for the purpose of correlating variability of different parameters.

RECOMMENDATION

- Integration between the sampling and testing programs in Section 8.3.1.4.3.1.1 and Section 8.3.1.15.1 should be discussed in the SCP updates to provide a basis for correlating variability of different parameters.

Section 8.3.1.4.3.2.1 Activity: Development of three-dimensional models of rock characteristics at the repository site, page 8.3.1.4-102, first paragraph

QUESTION 7

How will

The proposed method for formulation of a three-dimensional block model by dividing it into numerous orthogonal blocks is based on the assumption that each block is sufficiently small and that the parameter of interest may be treated as constant within the block. The method described in the SCP ~~does not~~ account for possible variability within the blocks?

BASIS

- The SCP states that "The most detailed approach to this phase of modeling involves the formulation of a three-dimensional block model, wherein the site is divided into numerous orthogonal blocks and each block is sufficiently small that the parameter of interest may be treated as constant within the block" (8.3.1.4-102). The implication appears to be that a model will be built with each block being virtually homogeneous and perfectly predicted. However, proper block size is a function of the density of available information, not need. A computer can subdivide the blocks into finer and finer units, but in doing so, the resulting estimation accuracy disappears. Different parameters have different levels and forms of in-situ variability. Some parameters (e.g., thickness of a continous unit) may change gradually and will not vary significantly within the block. Other parameters (e.g., rock mass permeability) will be erratic and may vary greatly across a single block. Thus, scale of local variability can not be used to determine the model block size.

- The available site characterization data must dictate the precision of the block model. If some areas are much more densely sampled than the average, then the size of the blocks can be reduced in these areas but only in these areas. Fig. 8.3.1.4-12a indicates that the minimum block size in plan would be roughly 1/4 mile on a side. If this is too coarse for the ultimate purposes of the model, then more measurements may have to be taken.

- The large volume of rock to be characterized suggests that individual blocks may be relatively large.

- Given the origin of welded tuff, considerable variability in properties over short distances may be expected.

RECOMMENDATION

- It is recommended that analyses in the SCP updates accompany determinations of necessary block sizes, and that justification be provided for implementing block models which assume constant parameter values within each block.

Section 8.3.1.4.4 Schedule for the Rock Characteristics Program, page 8.3.1.4-105

QUESTION 8

What is the
~~The SCP does not provide~~ rationale for the plan to start drilling prior to approval of study plans for drilling?

BASIS

- Figure 8.3.1.4-16 indicates that drilling will begin in early 1989, whereas approval of study plans for drilling are all shown as occurring at a later time.

- Schedule does not appear to make provision for air drilling feasibility demonstration.

RECOMMENDATION

- It should be explained in the SCP updates why drilling is scheduled to begin without approval of study plans for that activity.

Section 8.3.1.13.2.4 Activity: Evaluate the Impact of Ground Motion from Nuclear Testing Activities at the NTS, p. 8.3.1.13-11

QUESTION 9

What methods will be used to determine the impact of ground motion from underground nuclear explosions on repository design?

BASIS

- The response to CDSCP question number 25 and referenced SCP sections do not provide a discussion of the type of analysis which will be done to evaluate the effects of UNE's on the repository design.

- The only statement in this section related to evaluation of the impact of ground motion from nuclear testing is: "This activity is addressed in the resolution of Investigation 8.3.1.17.3." However, the referenced investigation relates only to determining vibratory ground motion and does not indicate how to evaluate its impact.

- Item 5 on p. 8.3.2.1-24 states that "Ground motion at any point in the repository horizon will be analyzed to determine its effect on the state of stress and deformation, and the stability of underground openings." Analysis methods are not discussed.

RECOMMENDATION

- Methods to evaluate impact of vibratory ground motion from underground nuclear explosions on repository design should be explained in a study plan.

Section 8.3.1.15 Performance and Design Parameters, Tentative Goals, and Characterization Parameters for Thermal and Mechanical Properties Program, Table 8.3.1.15-1, pp. 8.3.1.15-2/13

QUESTION 10

What activities are planned to investigate the effects of radiation on thermal and mechanical rock properties?

BASIS

- The response to NRC CDSCP Question 51 implies that no direct investigations of radiation effects on thermal and mechanical properties are planned. The DOE response gives no indication as to how the indirect effects will be evaluated in terms of potential rock damage or deterioration.

- The SCP (p. 6-205) states that "the effects of radiation on thermal and mechanical rock properties have been identified as needed information in issue 4.4." However, an activity to investigate this effect has not been included in the SCP.

RECOMMENDATION

- Activities planned to evaluate the potential for rock damage induced by radiation should be presented in SCP updates.

Section 8.3.1.15.1 Investigation: Studies to provide the required information for spatial distribution of thermal and mechanical properties, p. 8.3.1.15-23/31.

QUESTION 11

How will the allowable movement on joints be related to rock-mass strength?

BASIS

- On page 8.3.1.15-26, the SCP defines rock-mass strength as "allowable movement on joints, the strength of the intact rock, or a combination of the two." It is not clear how allowable movement on joints can be translated as rock-mass strength. How will the allowable movement for a rock with multiple joints be determined?

- In Section 8.3.1.15.1.7.2, page 8.3.1.15-68 (Activity: Rock-mass strength experiment), rock-mass strength means uniaxial load-bearing capacity of large blocks (up to 1 by 1 by 2 m) of rock that include multiple joints.

RECOMMENDATION

- The SCP updates should explain how proposed tests will be used to correlate allowable movements on joints to rock-mass strength.

Section 8.3.2.5 Issue resolution strategy for Issue 4.4: Are the technologies of repository construction, operation, closure and decommissioning adequately established for the resolution of the performance issues?, pages 8.3.2.5-7/17.

QUESTION 12

What is the rationale for selecting some of the tentative performance goals given in Tables 8.3.2.5-1 and 2?

BASIS

- Slope stability safety factors of 1.5, 1.3, 1.2 (page 8.3.2.5-9) are presented. For critical slopes adjacent to important installations, a factor of safety of 1.5 is usually preferred (Hoek and Bray, 1977, p.28)
- Allowable scour and bed erosion of 13 m in 100 yr., 5 m in 100 yr. (page 8.3.2.5-10).
- Allowable displacements and settlements of 3 in., 2 in., 2 in., 4 in., etc. (page 8.3.2.5-10/11).
- Probability of 0.1 in 100 yrs. (i.e., 1 in 1,000 yrs.) of 7 cm fault displacement in areas of waste emplacement. (page 8.3.2.5-13)

RECOMMENDATION

- More detail should be provided in SCP updates regarding rationale for determination of tentative goals.

REFERENCE

Hoek, E. and J. W. Bray, 1977, Rock Slope Engineering, 2nd Edition, Institution of Mining and Metallurgy, London.

Section 8.3.3.2-2 Issue Resolution strategy for Issue 1.12, Table 8.3.3.2-2 General Design constraints passed to Issue 1.11, configuration of underground facilities (post-closure) for major repository features from sealing program, page 8.3.3.2-13.

QUESTION 13

Does ES-1 have 150 m^3 water storage capacity at base of shaft for attaining the tentative design goal identified on page 8.3.3.2-13?

BASIS

- The height required to accommodate 150 m^3 of water, assuming a 12 foot internal diameter and backfill porosity of 0.3, would be 155 feet. Figure 8.4.2-27 indicates a depth below repository level of less than 155 feet. ES-1 (Title I design (Fig. 8.4.2-33)) has only 50' depth below main test level.

RECOMMENDATION

- The means for attaining a tentative design goal of $150m^3$ of water storage capacity at base of shaft assuming backfill porosity of 0.3 should be presented in the SCP updates.

Section 8.3.2.2.3 Information needed 1.11.3, Design Concepts for Orientation, Geometry, Layout and Depth of the Underground Facility That Contribute to Waste Isolation, Including Flexibility to Accommodate Site-Specific Conditions, p. 8.3.2.2-48/50

Section 8.3.2.5.6 Information Need 4.4.6, Development and Demonstration of Required Equipment.

QUESTION 14

What site information will be used for product 1.11.3-3, Vertical vs Horizontal Emplacement Orientation Decision (pp. 8.3.2.2-48 and 8.3.2.2-50)?

BASIS

- o According to Table 8.3.2.2-15 (p. 8.3.2.2-89), the selection of waste package orientation will be made by September 1989. Site information and the results of field demonstrations at the repository horizon will not be available until after this date.
- o The field demonstrations and proof of concept "for horizontal drilling and waste emplacement" are not discussed in detail in Section 8.3.2.2.3. It is not clear where or how they will be made.
- o Site data are needed to support development of a prototype boring machine (p. 8.3.2.5-59).
- o According to Table 8.3.2.5-18 (p. 8.3.2.5-104), the waste package emplacement/retrieval equipment demonstrations will begin in December 1991.

RECOMMENDATION

- o The role of site characterization activities and field demonstration in the decision process should be clarified in SCP updates.

Section 8.3.2.3-3 Parameters Required for Issue 2.7 (Radiological Safety), page 8.3.2.3-30

QUESTION 15

Is the list of parameters for performance goal C2 (radiation shielding properties of the host rock), given on p. 8.3.2.3-30, comprehensive, and are the expected parameter values (e.g., 65% saturation of host rock) realistic?

BASIS

- The response to CDSCP question 37 answers a subsidiary part of the question dealing with local rock saturation. However, it does not address the main question dealing with how the radiological shielding properties of the host rock will be determined. Several aspects that might influence rock radiation shielding have not been considered.

- Given the proximity of the package to the floor for vertical emplacement, the influence of vertical jointing and of a damaged rock zone around the emplacement drift might need to be considered.

- It is unlikely that a 65% saturation will be maintained in this zone.

RECOMMENDATION

- The SCP updates should include a complete list of parameters for performance goal C2.

Section 8.3.2.5.7 Information Need 4.4.7, Design Analyses, Including Those Addressing Impacts of Surface Conditions, Rock Characteristics, Hydrology, and Tectonic Activity, p. 8.3.2.5-61/83

QUESTION 16

Section 8.3.5.20 discusses verification of computer codes and validation of models and makes the following points.

1. "Verification studies are used to demonstrate that the numerical values produced by a computational procedure correspond to mathematical formulas on which they are based" (p. 8.3.5.20-2). (Note that no site characterization data are required for verification studies).
2. The validation problem can be separated "into two aspects: 1. ascertaining when the model has achieved a good representation of the system, and 2. comparing predictive results to appropriate observation and experimental results" (p. 8.3.5.20-8).

What are ~~Have~~ the plans for code verification and model validation, presented in Section 8.3.2.5.7, ~~been developed~~ for each analysis type?

BASIS

- This section introduces "qualification" of codes (e.g., HEFF qualification, pp. 8.3.2.5-79, 83) as being different from verification or validation.

- Many analyses in Table 8.3.2.5-16 include two analyses for a single test (i.e., pre-test and post-test analyses). It is not clear from this section what procedures will be followed if test results do not agree with predictions - that is, is the process a sequential one in which knowledge gained by post-test analysis is used in the next pretest analysis, and so on?

- On p. 8.3.2.5-83 it is stated that "codes used for the design of the ventilation system should not require additional work for validation." The two reasons given for this statement are not convincing, since they do not address the aspects of validation given on p. 8.3.5.20-8.

- Code verification and model validation are not discussed with respect to seismic codes. On p. 8.3.2.5-83, it is stated that methodologies for predicting ground motion and seismic hazards "require testing through the planned field program (Section 8.3.1.17.3.5)." The referenced section discusses only synthesis and compilation of data collected by other activities. It is not clear how the collected data will be used to validate the seismic codes (i.e., what component will be predictive?)

- On p. 8.3.2.2-16, it is stated that "the present design basis is that the underground excavations will be backfilled before closure of the underground facility." On p. 8.3.2.2-73, it states that "Because primary reliance will be placed on performance assessment to evaluate the acceptability of the system, detailed validation of thermomechanical models of the backfilled drifts is not considered necessary."

- The DOE acknowledges "that one of the difficulties associated with model validation is that the nature of validation need, and even the meaning of validation, may change at different stages of the modeling and research process" (p. 8.3.5.20-10). The program given in Section 8.3.2.5 does not address this concern.

RECOMMENDATION

- Plans for verifcation and validation for each analysis type (e.g., thermomechanical, ventilation, seismic, etc.) should be presented in SCP updates.

Section 8.3.3.1 Overview of the Seal Program (p. 8.3.3.1-1, second paragraph)

QUESTION 17

What is the justification for concluding that the shaft liner does not provide structural support for the formation and that the removal of the liner does not significantly modify the permeability?

BASIS

- No specific analysis of the effect of liner removal has been found in SCP Section 8.4.3.2.3, referenced in response to CDSCP point paper comment number 66.

- In response to CDSCP comment number 66, the SCP states that the shaft liner does not provide structural support for the formation. In view of this SCP statement, the purpose of a liner is not clear.

- According to p. 8.3.3.1-1, last sentence of second paragraph, "Because the liner does not provide structural support for the formation, removal of the liner is not expected to cause significant additional stress redistribution or to significantly modify the permeability." This statement is contradicted by several shaft analysis summaries in Section 8.4.3.2.3.1, which indicate a high probability of stress/deformation interactions (in particular 8.4.3.2.3.1, Items 2 and 3). None of these account for concrete, rock bolt and rock deterioration over a period of nearly 100 years.

- In Section 8.4.3.2.3 it is stated that "the MPZ model implicitly includes the effect of liner removal." (p. 8.4.3-26). The MPZ (modified permeability zone) model discussed is that presented by Case and Kelsall (1987). In developing this model, no liner was assumed to be present and no thermal, time, or three-dimensional effects were considered. If the rock or lining has time dependent behavior, or if thermal loading is experienced, or if the liner is installed near the face of an advancing shaft, then the liner will be stressed and will provide some support to the surrounding rock. It is not obvious, therefore, that the MPZ model adequately accounts for liner removal.

- The supporting reference (Fernandez et al, 1988) does not provide an analysis to justify the conclusion that the shaft liner removal at closure is not expected to cause stress redistribution, and implies that a supporting function may be required (e.g. Fernandez et al, 1988, Sections 8.1.1, 8.1.3).

- Cumulative displacement and convergence rate limitations imposed by other SCP sections (in particular Tables 8.3.2.4-1/2/5/8) recognize the potential for rock movements sufficient to stress the shaft liners.

RECOMMENDATION

- It is recommended that analyses be provided in SCP updates in support of the statement that shaft liner removal is not expected to cause additional stress redistribution or significant permeability changes.

REFERENCE

Fernandez, J. A., T. E. Hinkebein, and J. B. Case, 1988, Selected Analyses to Evaluate the Effect of the Exploratory Shafts on Repository Performance at Yucca Mountain. SAND85-0598. Sandia National Laboratories, Albuquerque, NM.

Case, John B., and Peter C. Kelsall, 1987, Modification of Rock Mass Permeability in the Zone Surrounding a Shaft in Fractured, Welded Tuff, SAND 86-7001, Sandia National Laboratories, Albuquerque, NM

Section 8.3.3.1 Overview of the Seal Program (p. 8.3.3.1-1/4)

QUESTION 18

The SCP and supporting documents (e.g., Fernandez et al., 1987) emphasize characterization and design "to ensure that water will not compromise the containment and isolation of radionuclides from the accessible environment" (p. 8.3.3.1-1). How are air flow characteristics of the site, particularly faults, to be evaluated?

BASIS

- In developing performance goals for the sealing subsystem, Fernandez et al. (1987) assume uniform air conductivities (p. 3-22) for the overlying tuff rock. However, some zones, particularly faults, may have conductivities which differ significantly from assumed uniform conductivities.

- The SCP recognizes that the "potential for flow through discrete fractures or faults are important hydrologic aspects that require further evaluation" (p. 8.3.1-4).

- In discussing seal subsystem concepts and performance goals for gaseous species, Fernandez et al. (1987) address goals for shafts, ramps, drifts and exploratory boreholes, but do not discuss faults explicitly.

RECOMMENDATION

The SCP updates should discuss the need for plans to characterizae the site air flow conductivities and patterns, particularly as they relate to the need for sealing faults.

REFERENCE

Fernandez, Joseph, Peter C. Kelsall, John B. Case, and Dann Meyer. Technical Basis for Performance Goals, Design Requirements, and Material Recommendations for the NNWSI Repository Sealing Program. SAND84-1895. September 1987.

Section 8.3.3.2 Issue Resolution Strategy for Issue 1.12, pg. 8.3.3.2-1/62

QUESTION 19

There is apparent inconsistency between Tentative Design Goals (Table 8.3.3.2-1) and Design-Basis Performance Goals (Table 8.3.3.2-5) for shafts and ramps inflow for the first 400 years after closure. What are the potential impacts of inconsistencies in tentative design goals and design-basis performance goals for shafts and ramps?

BASIS

- Based on a review of the response to CDSCP question number 41, the inconsistency in Tentative Design Goals (Table 8.3.3.2-1) and Design-Basis Performance Goals (Table 8.3.3.2-5) for shaft and ramp inflow seems to remain, for the first 400 years after closure. The inconsistency is not addressed by the response which essentially deals with goals beyond 500 and 1,000 years.

- Table 8.3.3.2-1 (Item 1) shows tentative design goal as 1,700 cu m/yr., whereas Table 8.3.3.2-5 (lines 1 and 2) shows design-basis performance goal as 0 cu m/yr.

RECOMMENDATION

- The impact of the said inconsistency on the results of the preliminary performance analysis should be clarified in SCP updates.

Section 8.3.3.2-2 Issue resolution strategy for Issue 8.12, Table 8.3.3.2-2, page 8.3.3.2-13

QUESTION 20

If it is decided that ES-1 will penetrate Calico Hills unit, what will be the impacts on the current sealing program and issue resolution strategy for Issue 4.4?

BASIS

- Penetration into the Calico Hills unit by ES-1 is currently under evaluation by the DOE. The SCP states that the decision on the penetration will be made at a later date (Section 8.4.2.1.6.1, page 8.4.2-35).

- Current design or performance goals for sealing and System Element 1.2.1.1 (access construction) of Issue 4.4 are that no shaft should penetrate into the Calico Hills unit. If a decision is made at a later date that the penetration is necessary, the potential impact of such penetration on the sealing program and resolution of Issue 4.4 would have to be considered.

RECOMMENDATION

- If a decision is made to penetrate the Calico Hills unit, an analysis of the impact on the sealing program should be presented in SCP updates. Corresponding changes for the sealing program and Issue Strategy 4.4 should be included.

Section 8.3.3.2.2.3 Study 1.12.2.3: In situ testing of seal components, pg. 8.3.3.2-41/62

QUESTION 21

What is the basis to justify that
~~Are~~ the references cited on p. 8.3.3.2-58 are representative of the conditions present at the Yucca Mountain site?

BASIS

- Contrary to what is stated in the second paragraph of SCP page 8.3.3.2-58, kelsall et al, 1984, does not describe the laboratory test on anhydrite.

- Lingle and Bush (1982) is incomplete in the reference list. A related reference, Bush and lingle (1986) and a more detailed materials study of this test by Scheetz et al (1986) describe an anhydrite sealing test in which the permeability of the seal and interface was many orders of magnitude larger than the values reported here.

- While it is correct that Daemen et al (1983) have measured extremely low interface permeabilities in many tests, it is also true that they have observed relatively high interface flows under certain conditions which may be more representative for Yucca Mountain sealing, e.g., in dry environments (Adisoma and Daemen, 1988).

RECOMMENDATION

- It is recommended that a more representative set of results be selected for determining test conditions to be implemented in sealing study plans.

REFERENCES

Bush, D. D. and R. Lingle, 1986, A Full-Scale Borehole Sealing Test in Anhydrite Under Simulated Downhole Conditions. Volumes, BMI/ONWI-581(1). Prepared by Terra Tek, Inc. for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Scheetz, B. E., P. H. Licastro, and D. M. Roy, 1986, A Full-Scale Borehole Sealing Test in Anhydrite Under Simulated Downhole Conditions, Volume 2, BMI/ONWI-581(2). Prepared by Materials Research Laboratory, The Pennsylvania State University, for office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Adisoma, G. and J. J. K. Daemen, 1988, Experimental Assessment of the Influence of Dynamic loading on the Permeability of Wet and of Dried Cement Borehole Seals, NUREG/CR-5129, Prepared for U.S. Nuclear Regulatory Commission by the Deportment of Mining and Geological Engineering, University of Arizona, Tucson.

Daemen, J.J.K., et al, 1983, "Rock Mass Sealing - Annual Report, June 1, 1987 - May 31, 1983," NUREG/CR-3473, prepared for the U.S. Nuclear Regulatory Commission, Division of Health, Siting and Waste Management, for Contract NRC-04-78-271, by the Department of Mining and Geological Engineering, University of Arizona, Tucson.

Section 8.3.5.2 Issue resolution strategy for Issue 2.4: can the repository be designed, constructed, operated, closed, ad decommissioned so that the option of waste retrieval will be preserved as required by 10 CFR 60.112?, p. 8.3.5.2-1/3.

QUESTION 22

Why is 10 CFR 60.132(a), "Facilities for receipt and retrieval of waste" not given as a regulatory basis for the resolution of Issue 2.4?

BASIS

- 10 CFR 60.132(a) relates directly to waste retrievability.

RECOMMENDATION

- SCP updates should include Regulation 10 CFR 60.132(a) in the regulatory basis for the resolution of Issue 2.4 or a rationale should be provided for not considering it.

REFERENCE

10 CFR 60 (Subpart E)

Section 8.3.5.2.3 Information Need 2.4.3, logic, p. 8.3.5.2-39, Point 2

QUESTION 23

Where are the analyses given to support the expectation that vertical emplacement holes will remain stable throughout the retrieval period?

BASIS

- It is stated on p. 8.3.5.2-39 that "For the vertical emplacement concept, the borehole is expected to be stable with negligible amounts of rockfall into the emplacement borehole under normal conditions." Analyses to support this expectation are not included.

- Neither in SCP Section 8.3.5.2 nor in Appendix J of the SCP-CDR are any supporting references provided for the analysis of vertical emplacement holes.

- Given the high frequency of vertical jointing, the potential for anisotropy in the horizontal stresses, and the potential for rock deterioration with time and temperature, unlined vertical emplacement holes may not remain stable.

RECOMMENDATION

SCP updates should provide the reference to the analyses that justify the expectation that vertical emplacement holes will remain stable throughout the retrievability period.

Section 8.4.2.1.2 Principal data needed for preclosure performance evaluations and design/Preclosure tectonics data needs, page 8.4.2-15

QUESTION 24

What is the justification for selecting a tolerance of 5 cm fault displacement?

BASIS

- If a 5 cm fault displacement does occur at the emplacement area, the container may be subjected to extension, shear, and bending stresses due to borehole deflection. Containers may be damaged during the shearing and bending process. Also, high stress in the container may accelerate corrosion and consequently compromise its designed function. It has not been demonstrated in the SCP that the current design of the air gap between the waste package and the borehole wall or liner will accommodate the movements along discontinuity planes.

- The SCP states that stability of emplacement borehole openings is of concern during preclosure and for the 1,000-year period after closure (Section 7.4.1.1). It also recognizes the possibility of sliding and falling involving translational movement of rock blocks into the emplacement holes. However, the potential adverse impact of these types of movement does not appear to be sufficiently evaluated in the SCP.

RECOMMENDATION

The SCP updates should provide:

- A justification for the 5 cm allowance for fault displacement.

- An analysis of the effects of potential fault displacement on the stability of exploratory shaft facilities, drifts, ramps, emplacement boreholes, and liners.

- An evaluation of the effect of change in corrosion rate of containers under stress.

- The design of emplacement holes and the corresponding ESF tests taking into account the potential effects of displacements along faults.

Section 8.4.2.2.2.2 Drilling-related activities, (Multipurpose borehole activity), page 8.4.2-74 Exploratory shaft facility testing operations, layout constraints, and zone of influence (Activity: Multipurpose borehole testing near the exploratory shafts), page 8.4.2-145 Section 8.4.2.3.1

QUESTION 25

How has the effect of drilling of possibly three multi-purpose boreholes (including a borehole between ES-1 and ES-2) been considered with respect to (i) design flexibility of Upper Demonstration Breakout Room due to potential interference, and (ii) interference with underground testing at the main test level?

BASIS

- The SCP (page 8.4.2-145, third paragraph) states that "The holes are planned . . . complying with the 10 CFR 60.15 requirement that, to the extent practical, shafts and boreholes be located where large, unexcavated pillars are planned." The upper demonstration breakout room and the main test area layout need to be planned to meet this requirement.

- It is not clear if the effect of drilling the proposed three Multi-purpose Boreholes on the flexibility of locating upper demonstration breakout room has been considered.

- The holes are planned to be at least two drift diameters away from any mined openings in the dedicated test area in the ESF. Due to the potential for deviation of the borehole from verticality during drilling, the maximum expected deviation should be considered in selecting boerhole locations.

- The SCP (page 8.4.2-145), states that "A decision on the need for a third multipurpose borehole would be made on the basis of additional analyses before constructing ES-2". This borehole would be drilled between ES-1 and ES-2. However, it has not been demonstrated that SCP considers the potential interference between this third borehole and underground layout of ESF has been considered.

RECOMMENDATION

- It is recommended that the SCP updates should evaluate the influence of the location of multipurpose boreholes on (i) design flexibility of Upper Demonstration Breakout Room due to potential interference, and (ii) interference with underground testing at the main test level.

Section 8.4.2.3.1 Exploratory Shaft Facility Testing Operations, Layout Constraints, and Zones of Influence, Activity: Canister-Scale heater experiment, pages 8.4.2-117/120

QUESTION 26

Thermal tests such as the heater experiment in Unit TSw1, canister-scale heater experiment, heated block test, and heated room experiment are planned to run for relatively short durations (1 month, 30 months, 100 days, 36 months, respectively). What is the basis for the selected test duraLions?

BASIS

- The equivalent experiments in the G-Tunnel were run for longer time periods (see for example Zimmerman et al 1986a, 1986b).
- Short test durations are not likely to allow for performance confirmation testing.
- It is not demonstrated that long-term, time-dependent effects can be studied reliably with the planned short-term testing.
- Although the need to "overdrive" the canister-scale heater test has been acknowledged, it is not clear that time for this portion of the test is included in the planned duration of the test.
- Need for running these tests for longer time may dictate planning of locations for test sequencing at different locations.

RECOMMENDATION

- SCP updates should present rationale for the selected test durations or propose longer durations for experiments.

REFERENCES

Zimmerman, R. M., R. L. Schuch, D. S. Mason, M. L. Wilson, M. E. Hall, M. P. Board, R. P. Bellman, and M. L. Blanford, 1986a. Final Report: G-Tunnel Heated Block Experiment, SAND84-2620, Sandia National Laboratories, Albuquerque, N. Mex.

Zimmerman, R. M., M. L. Blanford, J. F. Holland, R. L. Schuch, and W. H. Barrett, 1986b. Final Report G-Tunnel Small-Diameter Heater Experiments, SAND84-2621. Sandia National Laboratories, Albuquerque, N. Mex.

Section 8.4.2.3.1 Activity: Radial borehole tests, page 8.4.2-136/137

QUESTION 27

What is the timing of the exploratory shaft radial borehole tests? ~~Has the~~ What is the basis to justify that operational interference for these tests has been considered?

BASIS

- The radial borehole tests will require extensive drilling, borehole logging and testing, instrument installation and instrument monitoring in ES-1. Yet, according to Table 8.4.2-13, pg. 8.4.2-100, there are no constraints for this test. It is not clear if sequencing, construction and/or (shaft) operational interferences for these tests have been considered.

RECOMMENDATION

- It is recommended that the timing of the radial borehole tests be specified in the SCP updates, and that their potential interference with shaft construction and/or operations be identified.

Section 8.4.3.2.4 Design features that may contribute to performance, (1) Separation of ESF tests from potential emplacement drifts, page 8.4.3-34

QUESTION 28

What is the basis for the design requirement of a 30 m separation between the ESF and potential waste emplacement panels and for a design decision to allow waste emplacement within approximately 500 ft. distance from the exploratory shafts?

BASIS

- It has not been shown that the close proximity of waste to the exploratory shafts will not compromise the waste isolation. For example, it has not been demonstrated that the flow is likely to be primarily vertical under repository conditions. Thermally driven water flow is likely to include a lateral component.

- Thermal conditions in the repository may lead to saturation at some horizontal distance from the emplaced waste and may cause enhanced hydraulic conductivity and water flow.

RECOMMENDATION

- The SCP updates should provide a basis for the design requirement of a 30 m separation between the ESF and waste emplacement panels and design decision to allow waste emplacement within 500 ft. distance from the exploratory shafts.

COMMENTS ON DESIGN ACCEPTABILITY ANALYSIS

COMMENT 1

Several applicable 10 CFR 60 requirements have not been considered in evaluating the acceptability of ESF Title I design.

BASIS

- The DAA lists fifty two (52) 10 CFR 60 requirements that are considered in ESF Title I Design Acceptability Analysis (DAA). This list of (52) requirements does not include all applicable 10 CFR 60 requirements. The following requirements are missing from the list and are not considered in the DAA:

  60.17 Contents of Site Characterization Plan

  The ESF will be used to obtain information called for by (a) the SCP, (b) the waste package program, and (c) the repository design. As such, this requirement could potentially affect ESF requirements.

  60.24(a) Updating of Application and Environmental Report

  This section requires applications (e.g., license application) to be as complete as possible in light of information that is reasonably available at the time of docketing. This requirement is applicable to ESF design because it provides guidance regarding scope and possible sequencing of activities.

  60.113(a)(2) Performance of Particular Barriers After Permanent Closure - Geologic Setting

  This regulation is applicable because the ESF design could impact the location of the disturbed zone boundary.

  60.113(b(2) Performance of Particular Barriers After Permanent Closure

  These requirements are applicable to the ESF design, as the ESF design should be capable of obtaining information necessary to evaluate factors which bear upon:

  - the time during which the thermal pulse is dominated by decay heat from the fission products

  - geochemical characteristics of the host rock

- sources of uncertainty in predicting the performance of the geologic repository

60.122 Siting Criteria

This requirement is applicable, as it provides detailed descriptions of the information which must be obtained (largely in ESF) to assess the adequacy of the site and other adverse conditions. In particular, 60.122(c)(1) imposes a design criterion on the location of underground accesses.

60.131(a) General Design Criteria for the Geologic Repository Operations Area - Radiological Protection

This requirement is applicable because it imposes requirements on all components of the ventilation systems, not just mechanical equipment. DOE's statement that "Compliance with the specified criteria is a function of equipment design and operational procedures, which imposes future requirements on equipment and operation, but not on the ESF permanent components" (Attachment I, p. 32) is too narrow. See, also, Attachment J (TOG's Members' Statement, filed by D. Michlewicz).

Also, 10CFR60.15(d)(4) requires coordination of subsurface excavation with the geologic operation area design and construction. As currently planned, ESF shafts and drifts will be part of ventilation system for the repository.

60.131(b)(4)(ii) General Design Criteria for the Geologic Repository Operations Area - Emergency Capability

See Attachment H, p. 7.

60.131(b)(8) General Design Criteria for the Geologic Repository Operations Area - Instrumentation and Control Systems

This requirement is applicable, because it could impact ESF design by requiring allowances for instrumentation and control systems.

60.131(b)(10) General Design Criteria for the Geologic Repository Operations Area - Shaft Conveyances Used in Radioactive Waste Handling

This requirement is applicable because 60.74 requires flexibility to perform tests directed by the Commission. If radioactive wastes are placed in the ESF, then this requirement is applicable.

60.134 Design of Seals for Shafts and Boreholes

This requirement is applicable, because it provides design quidance relative to future sealing requirements. The SCP recognizes the relevance of this requirement in Section 8.3.3 (see, for example, p. 8.3.3.2-52, Table 8.3.3.2-9b).

60.143 Monitoring and Testing Waste Packages

This requirement is applicable for the same reasons that 60.131(b)(10) is applicable - namely, that 10 CFR 60.74 requires flexibility in testing.

RECOMMENDATION

Design criteria corresponding to the 10CFR60 requirements missing in the DAA should be developed and used for Title II design.

COMMENT 2

The various appendices of the DAA and the YMP ESF TITLE I Design Report do not consider the applicability of 10 CFR 60 requirements to the ESF Title I design in a consistent manner.

BASIS

- The following is a listing of sources that itemize applicability of 10 CFR 60 requirements to ESF design in an inconsistent manner:

A. Yucca Mountain Project Exploratory Shaft Facility, Title I Design - Volume I, Narrative Report

Section 7.2 of this report is entitled "Repository Licensing Requirements Applicable to the ESF" and gives a "list of repository licensing requirements that are considered applicable to the design of the ESF" (p. 7-2).

B. Applicability of 10 CFR Part 60 Requirements to the Yucca Mountain Exploratory Shaft Facility (Technical Oversight Group Report) - Attachment I (TOG Conclusions)

Attachment I documents in table form the consensus reached by TOG members "regarding Part 60 applicability" (p. 3).

C. Applicability of 10 CFR Part 60 Requirements to the Yucca Mountain Exploratory Shaft Facility (Technical Oversight Group Report) - Attachment H (Expanded TRG Rationales for Applicability)

Attachment H provides "rationales for applicability provided in the TRG Report, reflecting the discussions that took place at the TRG review meetings" (p. 3).

D. Review Record Memorandum - Exploratory Shaft Facility (ESF) Title I Design Applicability Analysis and Comparative Evaluation of Alternative ESF Locations, Volume 2, Appendix I, Supporting Documentation for Design Acceptability Analysis

Appendix I contains the following four sub-appendices, each of which list 10 CFR 60 requirements:

I-1 Association of SDRD Functional Requirements with Relevant 10 CFR 60 Requirements

I-2 Association of Supplemental SDRD Information with Relevant 10 CFR 60 Requirements

I-3 ESF-Applicable Criteria Related to 10 CFR 60 Requirements for NRC Concerns 1, 2, 3

I-4 ESF Criteria Addressed in Title I SDRD

RECOMMENDATION

The inconsistencies and incompleteness identified in this comment should be resolved in Title II design.

COMMENT 3

Out of the fifty-two (52) 10 CFR 60 requirements considered applicable to ESF design by the DOE in reviewing the acceptability of Title I design, the DAA focuses on only 22 requirements that belong to the three areas specifically outlined by NRC. Other requirements (e.g., retrievability, preclosure radiological safety, performance confirmation, and QA program) are said to be qualitatively evaluated (see p. 2-1, second paragraph). The approach adopted in the DAA raises questions about completeness and rigor of the design acceptability analysis, as detailed design criteria were not developed for all applicable requirements.

BASIS

- The DAA has considered only 52 requirements from the applicable 10 CFR 60 requirements as stated in DAA comment number 1; thus apparently the DAA did not consider all applicable 10 CFR 60 requirements in evaluating the acceptability of ESF Title I design.

- On page 2-1 of the DAA, it is stated that out of the 52 requirements considered applicable to ESF Title I design "30 requirements were outside the scope of this Technical Assessment Review and, hence, were not considered further. These requirements addressed the areas of preclosure radiological safety, retrievability, types of tests to be conducted during performance confirmation, the QA program, and procedural requirements." These 30 requirements are as follows:

60.15(d)(4)
60.16
60.21(c)(1)(ii)(E)
60.72(a)
60.72(b)
60.111(a)
60.111(b)(1)
60.111(b)(3)
60.131(b)(1)
60.131(b)(2)
60.131(b)(3)
60.131(b)(4)(i)
60.131(b)(6)
60.131(b)(9)
60.133(c)
60.133(e)(1)
60.133(g)
60.140(b)
60.140(c)
60.141(a)
60.141(b)
60.141(c)
60.141(d)
60.141(e)
60.142(a)
60.142(b)
60.142(c)
60.142(d)
60.151
60.152

- Qualitative evaluation of the above listed 30 requirements does not ensure that they have been adequately considered because detailed design criteria were not developed in evaluating if those requirements were considered in ESF Title I design.

- Some of these requirements are potentially important in evaluating the acceptability of the Title I design. Examples follow.

  60.15(d)(4) - As pointed out in the ESF Title I summary report, this requirement imposes constraints on the design of the ESF in order to limit adverse effects on the long-term performance of the repository" (p. 7-3). As pointed out in Attachment I of the TOG report, this requirement also calls for "the ESF to be coordinated with the geologic repository operations area" (p. 4).

  60.111 - ESF should be designed to meet the two performance objectives of this requirement because the ESF will potentially be incorporated into the geologic repository operations area and, for example, "this potential use dictates that the drift stability be designed to meet repository requirements for the operational and retrieval life of the repository." As pointed out by Attachment I of the TOG report, "the ESF may contribute to waste retrieval by conveying ventilation supply air to the retrieval area. Therefore, the design, construction, and operation of the ESF must bear in mind its later utility" (p. 26).

  60.131(b) - Because the ESF will become part of the operating repository, it should be determined if any of the structures, systems or components could potentially impact radiological safety (see p. 7-5 of the ESF Title 1 Design summary report). Attachment I of the TOG report recognizes that at least some subparts [(1), (2), (3), (4)(i), (6) and (9)] of this paragraph impose requirements on the ESF (see pp. 35-37 and 39).

  60.140(b) and(c), 60.141, 60.142 - These sections impose requirements on the ESF. The ESF must be designed to accommodate 54, of the TOG report).

RECOMMENDATION

The SDRD used in Title II design should consider all applicable 10CFR60 requirements.

REFERENCES

Lugo, M., et al., Technical Oversight Group for U.S. DOE OCRWM, Office of Facilities Siting and Development. Applicability of 10 CFR Part 60 Requirements to the Yucca Mountain Exploratory Shaft Facility (Technical Oversight Group Report). December 1988.

MacDougall, Hugh R., Leo W. Scully, and Joe R. Tillerson (Compilers). Site Characterization Plan Conceptual Design Re-port: Volume 1, Chapters 1-3. Sandia National Laboratories, SAND84-2641. September 1987.

U.S. Department of Energy, Nevada Operations Office. Yucca Mountain Project Exploratory Shaft Facility Title I Design Summary Report. YMP/88-20, DB01-0206, 1988.

COMMENT 4

The Design Acceptability Analysis does not evaluate the SDRD to determine if any parts of the SDRD conflict with, or require actions contrary to, 10 CFR 60 requirements. The approach also does not ensure that criteria developed by DAA do not conflict with each other.

BASIS

- The SDRD contains constraints which do not allow designers necessary flexibility to make rational design decisions. For example:

  (1) the location of ES-1 is specified on p. 4-3 of the SDRD;

  (2) the collar elevation for ES-1 is specified on p. 4.1-1;

  (3) the location of ES-2 is specified on p. 5-3 of the SDRD; and

  (4) the collar elevation for ES-2 is specified on p. 5.1-1 of the SDRD.

- Table I-4 of the DAA includes the following two criteria:

  (1) "The exploratory shafts shall be located, to the extent practicable, where shafts are planned for the repository facility" (p. I.4-3); and

  (2) "The exploratory shaft locations should be selected, consistent with other goals of site characterization, to limit impact on isolation" (p. I.4-4).

For the first requirement, the table indicates that the SDRD addresses this criteria by citing centerline coordinates of ES-1 and ES-2. For the second criteria, the table indicates that the criteria are not addressed in the SDRD.

RECOMMENDATION

The Title II SDRD should be screened to ensure requirements do not conflict with 10 CFR 60 requirements or with each other.

COMMENT 5

One of the key steps in the DAA process was to review the adequacy of data used in Title I design. It appears that the DAA does not reasonably address this step.

BASIS

- A basic step in evaluating the adequacy of the data should have been to identify what data were used in the Title I design. The DAA focuses attention only on reviewing supporting documents in Section 8.4 of the SCP. This raises concerns about the relevance of the documents reviewed in Section 2.4 of the DAA. For example, it is not clear why the following Title I design documents were not reviewed:

  (1) "Free Field Load Calculations for ESF Drifts," 1988, by B. L. Ehgartner, manuscript dated 9/30/88;

  (2) "Design of Shaft Liner," 1988, by H. Gleser, Fenix and Scission, FS-CA-0004;

  (3) "Preliminary Stability Analysis for the Exploratory Shaft," 1984, by W. Hustrulid, Contractor Report for Sandia National Laboratories, SAND83-7069;

  (4) "Seismic Design Analysis," 1988a, by M. J. Mrugala, Fenix and Scisson, TI-ST-0053; and

  (5) "Pillar Stability Analysis," 1988b, by M. J. Mrugala, Fenix and Scisson, TI-ST-0054.

- The DAA includes a review of RIB Version 3.001, however, it is not clear to what extent parameter ranges have been included in the RIB. The ESF Title I design summary report does not discuss ranges for any parameters.

- The ESF Title I design references only the RIB values, but, numerous parameters used in the design are not included in the RIB.

- Although it is evident that the adequacy of the RIB data was reviewed, there is no indication that other relevant design data were reviewed as part of the DAA. The following are examples:

1. In-situ ground stresses are given on p. 2-9. The vertical stress is said to be derived from the product of the unit weight of rock and the depth at which the stress is required. Because not all rock units have the same unit weight, it is not clear how the vertical stress is determined or how the stress components conform to RIB Version 3.001.

2. Seismic design considerations are discussed on p. 2-10 and in Tables 2-6 and 2-7. All of the seismic design components are not discussed in the RIB.

3. Design basis events are discussed in Section 5.2.4. The events address important design considerations, such as flood potential (p. 5-4). It is not clear that any of these design basis events are covered by the RIB. The DAA reviews of RIB Version 3.001 did not cover meteorological data because they were not "primary information related to subjects of this technical assessment review" (p. I.6-107).

- Some of the documents reviewed as part of the DAA Section 2.4 used RIB Version 1.001 (see, for example, Bauer et al., 1988). Other documents were written prior to the development of the RIB. In both cases, it is not clear how the data used relates to data used in Title I design.

- Introduction of data through SCP Section 8.4 documents complicates the acceptability analysis and understanding because some documents use RIB 3.001 and others use RIB 1.001, and still others use no RIB values at all. For example, Bauer et al. (1988) use RIB Version 1.001 and give an ambient temperature of 31°C at the main test level. Appendix B-2 of the Title I design uses RIB Version 3.001 and indicates an ambient temperature at the main test level of 18°C.

- Review of documents in Appendix I-6 is not consistent. Some reviewers simply provided summaries of documents (see, for example, the review of Appendix B-2 of the ESF Title I Design Summary Report) without critical evaluation of the appropriateness of data, approach, etc.

- As pointed out on p. C.6-40, comparison of the RIB to EA and/or SCP data does not necessarily assure reasonableness because, in many cases, data are derived from the same source.

- There is little, if any, indication of how the documents reviewed for Section 2.4 were used in Title I design (i.e., what conclusion do they support, what decision they affect, etc.). Table 2.4-2 is a summary of DAA Reasonableness Reviews and includes a heading entitled "Use of Analysis in Title I Evaluation". However, entries under this heading relate almost exclusively to use in SCP Section 8.4.

RECOMMENDATIONS

- Title II design should be based on a complete set of appropriate data which indicate to designers the expected ranges, not just average values. It should be clarified if all ESF design data are contained in the RIB or additional design data are given in other documents including, for example, the SEPDB (Site Engineering Properties Data Base).

- The DOE should explain the differences between end uses of the RIB and SEPDB.

- Recommendations of document reviewers presented in the DAA should be considered for Title II design. In particular, the following recommendation (for one document) should be applied to most, if not all, supporting documents: "The objectives and use of the analyses should be clarified if used to support Title II design. The sections discussion of the results of the analyses should be expanded and focused on design considerations" (p. I.6-2).

- A consistent set of coordinate axis should be used to avoid confusion over left- and right-handed axes. (See, for example, Appendix B-4 of Title I design).

REFERENCES

Bauer, S. J., L. S. Costin and J. F. Holland. "Preliminary Analyses in Support of In Situ Thermomechanical Investigations," Sandia National Laboratory, SAND88-2785, December 1988.

Ehgartner, B. L. "Free Field Load Calculations for ESF Drifts," manuscript dated 9/30/88.

Gleser, H. "Design of Shaft Liner," Fenix and Scission, FS-CA-0004, 1988.

Hustrulid, W. "Preliminary Stability Analysis for the Exploratory Shaft," Contractor Report, Sandia National Laboratories, SAND83-7069, 1984.

Mrugala, M. J. "Seismic Design Analysis," Fenix and Scisson, TI-ST-0053, 1988a.

Mrugala, M. J. "Pillar Stability Analysis," Fenix and Scisson, TI-ST-0054, 1988b.

COMMENT 6

The requirements of 10 CFR 60.21(c)(1)(ii)(D) [i.e., consideration of major design features], in particular, have not been adequately addressed in evaluating the acceptability of ESF Title I design.

BASIS

- In considering the requirement of 10 CFR 60.21 (c)(1)(ii)(D) DOE has limited the analysis primarily to comparative evaluation of five alternative ESF locations. Comparative evaluation of alternatives to the major design features could include such evaluations as comparison between ES-1 shaft and a ramp, between drilling and blasting excavation method and mechanical excavation method, and between several possible layouts for main test level. Beall (1984) concluded that "The clear recommendation is to design and construct the 16 ft. diameter exploratory shaft and the 19 ft. diameter muck handling ramp."

- Conclusion (No. 1) on p. 4-6 of Appendix J states that "Differences among the alternative shaft locations for currently expected conditions are not significant to waste isolation. This is because all the locations are expected to have conditions that would allow regulatory requirements to be met by wide margins." The evidence for this conclusion is not convincing, as the supporting analyses are based largely on assumptions of vertical matrix flow, average fluxes, ambient conditions, etc. which are not shown to lead to conservative conclusions with respect to waste isolation.

- Appendix J includes discussion that indicates that the northeast part of the repository has the poorest waste isolation performance and, therefore, requires characterization. Appendix J does not provide convincing arguments that indicate that a shaft at the present location is the only possible way to characterize this area.

- Conclusion (No. 3) on p. 4-6 of Appendix J states that "The presence of a shaft at any of the locations is not expected to affect significantly the waste isolation capability of a repository." This conclusion, derived from Section 3, is questionable, as topography, which was addressed for Conclusion (No. 1) was not considered in Section 3. In addition, the location of the shaft with respect to emplaced waste was not evaluated in the context of fracture flow.

- The interpreted fault near ESF shown on SCP Figure 1-40 does not appear to have been considered in evaluation the requirements of 10 CFR 60.21(c)(1)(ii)(D).

- In the analysis by Nimick et al (1988), the data from borehole USW G-4 along with four other boreholes were used to evaluate representativeness of the ESF location. Only one out of seven categories of data from USW G-4 was determined to be representative; others were determined to be inconclusive or non-representative.

- Surface uplift/subsidence induced by waste emplacement surrounding the shafts has not been sufficiently considered.

- Potential geochemical changes (SCP page 8.4.3-58) that could lead to blockage of drainage capacity of the shaft sump do not appear to have been considered.

RECOMMENDATION

- Title II design should be expanded to fully address 10 CFR 60.21 requirements.

REFERENCES

10 CFR 60.21

Nimick, F. B., L. E. Shepard, and T. E. Blejwas, 1988. Preliminary Evaluation of the Exploratory Shaft Representativeness for the NNWSI Project, Draft, SAND88-1685, Sandia National Laboratories, Albuquerque, N. Mex.

Beall, G. K., 1984. Recommendation for a Second Access for the Yucca Mountain Exploratory Shaft Facility, SAND84-1261, Sandia National Laboratories, Albuquerque, N. Mex.

COMMENT 7

To examine the thoroughness of the DAA, the NRC staff has reviewed the adequacy of one of the documents used in Title I design as an example. The document selected by the staff was Appendix B-4 of ESF Title I design report, Free Field Seismic Calculations. This document was not reviewed by the TAR team. This appendix has errors and raises concerns as to whether the calculations were checked.

BASIS

As an example, on page 4 of the Appendix:

(1) In Section 4, for $\theta=30°$, Combination 1, Case 2, $\sigma_{crown}=0.44$, $\sigma_{wall}=5.69$ (not 4.69).

(2) In Section 4, for $\theta=30°$, Combination 2, Case 2, M_2 =1.10/2.34 (not 1.10/2.64), = 0.47 (not 0.42).

Related boundary stresses are $\sigma_{crown}=5.92$ and $\sigma_{wall}=0.96$ (not 6.81 and 0.69).

and on page 5 of the Appendix:

In the conclusions, the combination expression should be $1.0\ S_V + 0.4(P + S_H)$, not $1.0\ S_V - 0.4(P + S_H)$.

RECOMMENDATION

Design calculations for the ESF Title II design should be thoroughly checked.

QUESTION 1

What is the justification for certifying (Appendix C.3 of DAA) that all TAR reviewers were not principal contributors to ESF Title I Design or the Subsystem Design Requirements Document which was used for ESF Title I Design in view of the documentation in the DAA showing that some of the TAR reviewers worked on the ESF Title I Design and/or SDRD?

BASIS

- Documentation in the ESF Title I Design Acceptability Analysis (DAA) indicates that some of the same people participated in both Exploratory Shaft Facility (ESF) Title I Design and the DAA process. This raises concerns of conflict of interest, where reviewers may not be independent of the preparation.

- There are five (5) individuals listed on both Table 5 of the ESF Title I Design Control Process Review Report and on pages C.2-1 or C.2-2 of DAA Vol. 1. Some of the individuals are given different titles for the different volumes (e.g., geotechnical engineer vs. mechanical engineer).

  The following listing provides a summary of what each individual is credited for on the ESF Title I Design.

  W. Wilson - Hydrologist

  - prepared "Subsystem Design Requirements Document (SDRD)"

  - prepared and reviewed "Test Requirements"

  - prepared and reviewed "Identification of Interfaces Among Different Aspects of the ESF Program"

  R. Harig - Civil Engineer

  - prepared "ES Location and Diameter"

  - provided analysis and consultation on "second shaft need"

  Note: Harig is listed as mining engineer on C.2, DAA Vol. 1, but his questionnaire does not appear in C.5 of DAA Vol. 1.

  J. Tillerson - Mechanical Engineer

  - prepared and reviewed "Shaft Separation"

  - prepared and reviewed "Identification of Interfaces Among Different Aspects of the ESF Program"

Note: Tillerson is listed as Performance Assessment Specialist and Geotechnical Engineer in C.2. of DAA Vol. 1.

In addition, Tillerson reviewed the following principal support documents:

Costin, L. S. and E. P. Chen, 1988. An Analysis of the G-Tunnel Heated Block Thermomechanical Response Using a Complaint-Joint Rock-Mass Model, SAND87-2699, Sandia National Laboratories, Albuquerque, NM.

Baur, S. J., L. S. Costin, and J. F. Holland, 1988. Preliminary Analysis in Support of In Situ Thermomechanical Investigations, SAND88-2785, Sandia National Laboratories, Albuquerque, NM.

Costin, L. S. and S. J. Bauer, 1988. Preliminary Analysis of the Excavation Investigation Experiments Proposed for the Exploratory Shaft at Yucca Mountain, Nevada Test Site, SAND87-1575, Sandia National Laboratories, Albuquerque, NM.

Hill, J., 1985. Structural Analysis of the NNWSI Exploratory Shaft, SAND84-2354, Sandia National Laboratories, Albuquerque, NM.

Johnson, R. L. and S. J. Bauer, 1987. Unit Evaluation at Yucca Mountain Nevada Test Site: Near-Field Thermal and Mechanical Calculations Using the SANDIA-ADINA Code, SAND83-0030, Sandia National Laboratories, Albuquerque, NM.

Johnstone, J. K., R. R. Peters, and P. F. Gnirk, 1984. Unit Evaluation at Yucca Mountain Nevada Test Site: Summary Report and Recommendation, SAND83-0372, Sandia National Laboratories, Albuquerque, NM.

St. John, C. M., 1987. Interaction of Nuclear Waste Panels with Shafts and Assess Ramps for a Potential Repository at Yucca Mountain, SAND84-7213, Sandia National Laboratories, Albuquerque, NM.

Tillerson had previously reviewed these same documents in his capacity as supervisor of the underground design activities for the repository. (See p. C.5-43 and C.5-45 of the DAA).

L. Costin - Mechanical Engineer

- prepared and reviewed "Shaft Separation"

- prepared and reviewed "Identification of Interfaces Among Different Aspects of the ESF Program"

Note: Costin is listed as Geotechnical Engineer in C.2 and states that he authoried Sections 8.4.2.3.1 and 8.4.2.3.6 of the Site Characterization Plan (SCP).

D. Ross-Brown - Geotechnical Engineer

- reviewed "Title I Design"

Note: Ross-Brown is listed as Mining Engineer in C.2 and claims review of the following:

Technical Assessment Review (TAR), of ESF Title I Design (50%)

Technical Assessment Review (TAR), of ESF Title I Design (100%)

ESF-SDRD Licensing Review

RECOMMENDATION

- DOE should justify why these individuals were selected despite apparent conflict of interest and/or provide rationale for not considering the issue of conflict of interest during the development of ESF Title I Design and DAA, or ensure there is no conflict of interest for the development and review process.

APPENDIX A

RESOLVED CDSCP POINT PAPERS

Section 8.3.1.2.2.4.6 Calico Hills Test in the Exploratory Shaft Facility
Section 8.4.2.1 Exploratory Shaft 1, page 8.4-23, paragraph 4 and 5

OBJECTION 2

The NRC staff considers that the need for extending the Exploratory shaft 1 (ES-1) approximately 400 ft below the proposed repository horizon into the zeolitic zone of the Calico Hills unit has not been established in the CDSCP, nor has the need been established for tests requiring drifting (horizontal excavation) through the Calico Hills unit. It has not been demonstrated that the proposed shaft (ES-1) penetration into the Calico Hills unit (an important barrier between the repository horizon and the underlying groundwater table) or the proposed drifting through it will not have potential adverse impacts on the waste isolation capability of the site.

BASIS

- 10 CFR 60.17(a)(2)(iv) requires that, "The SCP shall contain plans to control any adverse impacts from such site characterization activities that are important to waste isolation." .

- The last tentative goal on page 8.3.2.5-21 indicates that high confidence is needed that ES-1 shaft will terminate no less than 150 m above groundwater table. It does not appear that this goal would be reached under the present ES-1 design.

- The CDSCP has not identified associated site characterization activities whose benefits would outweigh potential adverse impacts of penetrating the Calico Hills unit, an important barrier below the proposed repository horizon. The CDSCP has not provided a detailed discussion of the need for conducting the identified activities from within the Calico Hills rather than obtaining the necessary data by alternate means that meet isolation constraints.

- Sections 8.3.5.13 (Total System Performance) and Sections 8.3.5.12 (Groundwater Travel Time) identify the Calico Hills unit as a primary barrier. Section 8.3.1.2.2.4.6 (Calico Hills Test In The Exploratory Shaft Facility, page 8.3.1.2-242) states that "it is critical to have high confidence in the understanding of these aspects of the unit" (Calico Hills), but "on the other hand exterior penetration or excavation of the unit for testing purposes may jeopardize the integrity of the unit as a barrier." This section also states that the preferred approach to testing in the Calico Hills unit is to drift horizontally from the shaft in the up-dip direction, through the Ghost Dance fault. However, the CDSCP does not consider the effects of drifting on the Calico Hills unit, nor does it consider alternate means of obtaining the necessary data that meet isolation constraints.

- The CDSCP does not consider potential connection of flow-paths from underneath the repository waste emplacement areas to the proposed ES-1 excavation below the repository horizon or to the proposed drifts in the Calico Hills unit.

EVALUATION OF DOE RESPONSE

- In response to this objection, the SCP (page 8.4.2-167, fourth paragraph) states that the ES-1 shaft will be sunk to a total depth of approximately 1,105 ft. from the surface. Thus, the ES-1 shaft will not penetrate into the Calico Hills unit. In addition, the ESF design has been modified so that there will be no drifting through the Calico Hills unit.

- The response further states that the DOE will defer the decision on penetrating and drifting in the Calico Hills unit from ES-1 pending completion of analyses for the need for this penetration.

- The NRC staff finds DOE's approach to be reasonable and acceptable. We will review DOE's justification provided they decide to penetrate into Calico Hills unit at a later date.

- The SCP contains numerous references to penetration of Calico Hills, for example:

  Figure 8.3.1.2-16 (page 8,3.1.2-283)
  Table 8.3.3.2-3 (page 8.3.3.2-18)
  Section 8.3.1.15.2.1.2 (page 8.3.1.15-80)
  and elsewhere

  The NRC staff assumes that these Figures, Tables and Text were overlooked in revising the CDSCP. The NRC staff considers that DOE's position is as stated in the response to this objection.

- Based on our review of the response to this objection and the corresponding modifications made to the ESF design, the objection is considered resolved.

Section 8.4.2 Underground Test Facilities, pages 8.4-14 to 8.4-22

OBJECTION 4

The CDSCP does not sufficiently consider the potentially adverse impacts resulting from the proposed locations of ES-1, ES-2, other shafts and ramp portals in areas which may be susceptible to surface water infiltration, sheet flow, and lateral and vertical erosion (Refs. 1 and 2). For the proposed locations, there is a possibility of (a) potentially significant and unmitigable long-term adverse impacts on the waste isolation capability of the site and/or (b) affecting the ability to adequately characterize the site.

BASIS

- The planned shaft locations may be susceptible to surface water infiltration. The DOE has proposed a seal design concept that would encourage the surface water entering the shafts to drain through the exploratory shaft (ES-1) bottom below the repository horizon (Ref. 3). The NRC staff considers that it is important to minimize/avoid infiltration or intrusion of surface water into the shafts because of the uncertainties about the planned drainage system to remain effective for a long period of time during the postclosure phase.

- With particular reference to ES-1, although the exact location of the shaft is not indicated on the map showing the flood potential, it is evident from Section 6.1.2.6 that the shaft location will be outside the channel area for the probable maximum flood. However, according to the flood potential map presented in Reference 4, large areas of the east side of Yucca Mountain are subject to sheet flow. Such flow could cause flooding of the shaft and adjacent areas.

- Potential for fracturing of rock around a shaft due to construction, lateral erosion, vertical erosion, and the possibility of the shaft's exposure below the ground surface have not been sufficiently considered.

- The likelihood of these processes being modified by tectonic events during the postclosure period and by surface uplift/subsidence induced by waste emplacement has also not been sufficiently considered.

EVALUATION OF DOE RESPONSE

- In response ~~to~~ this Objection, the DOE has evaluated the potential effects of locating ES-1 and ES-2 near Coyote Wash on long-term performance and the ability to characterize the site. Although the data used in the evaluation are preliminary in nature, we concur with the DOE that the shaft locations will be outside the channel area for the calculated probable maximum flood. This objection is considered resolved.

Section 8.3.1.4.1.1.1 Activity: Develop a position on drilling within the boundaries of the repository perimeter drift, pg. 8.3.1.4-24

Section 8.3.1.4.1.1.3 Activity: Evaluation of drillhole and other subsurface data for the purpose of siting additional drill holes, pg. 8.3.1.4-27

Section 8.3.1.4.1.2 Study: Integration of the drilling proposed during the first year of site characterization, pg. 8.3.1.4-28

Section 8.3.1.4.1.3 Study: Ongoing integration of the NNWSI drilling, pg. 8.3.1.4-29

Section 8.4.1.1: Preparation for Surface-based Testing, pg. 8.4-2

Section 8.4.2.5.1: Exploratory Shaft facility studies, pg. 8.4-37

COMMENT 27

The CDSCP (Section 8.4.1.1) states that current plans call for drilling approximately 300 to 350 shallow holes (50 ft to 150 ft deep), and 45 to 80 exploratory holes (presumably deep). Several trenches are also planned to be excavated for site characterization. In addition, Section 8.4.2.5.1 includes a summary of proposed numerous activities that would involve drilling from or very close to ES-1. The individual, the cumulative, and the synergistic effects of these holes have not been considered in the evaluation of the potential impacts of exploratory shaft construction and testing on the waste isolation integrity of the site (Section 8.4.2.6, and supporting references, in particular Fernandez et al., 1987; Case and Kelsall, 1987).

BASIS

- The number of shallow and deep exploratory boreholes is sufficiently large to require analysis of their impact on enhancing water inflow/outflow or air outflow from the repository directly or through interconnected faults.

- The proposed trenches, particularly along or across washes could become sources of enhanced water infiltration (e.g., along faults or fractures), especially with excavated material stored next to the trench.

- The large number of holes located at least partially within the zone mechanically influenced by the shaft raises numerous concerns that need to be addressed. Some examples:

  - Potential exists for development of preferential air flow or waterflow channels, e.g., partially along the shaft/shaft liner interface/joints/holes.

  - Given the presently preferred shaft seal design of a simple shaft backfill, shaft deformations are to be expected over the time period of interest. Given the present preferred borehole seal design with cement grouts, such seals for boreholes near ES-1 are likely to fracture.'

- Horizontal holes are known to be difficult to seal.
- Air drilled holes are likely to require extensive preparation in order to obtain satisfactory hydraulic bond between hole wall dust coat and cementitious seals.

EVALUATION OF DOE RESPONSE

In response to the CDSCP Comment 27, Table 8.4.2-4 of the SCP shows a much smaller number of planned shallow and deep surface holes. Based on an evaluation of the analyses of potential impacts of surface and subsurface testing presented in Sections 8.4.2 and 8.4.3, the DOE has concluded that the cumulative or synergistic effects of these tests are unlikely to have potential adverse impact on the isolation potential of the site. The NRC staff considers that the DOE has adequately responded to this comment and considers this comment resolved.

REFERENCES

Fernandez et al., 1987. Technical Basis for Performance Goals, Design Requirements, and Material Recommendations for the NNWSI Repository Sealing Program, SAND 84-1895, Sandia National Laboratories, Albuquerque, NM.

Case, J.B., and Kelsall, P.C., 1987. Modification of Rock Mass Permeability in the Zone Surrounding a Shaft in Fractured, Welded Tuff, SAND 86-7001, Sandia National Laboratories, Albuquerque, NM.

Section 8.3.1.4.2.2.2 Activity: Surface-Fracture Network Studies (p. 8.3.1.4-71)

Section 8.3.1.4.2.2.4 Activity: Geologic Mapping of the Exploratory Shaft and Drifts (p. 8.3.1.4-75/76)

COMMENT 29

CDSCP's approach to characterizing the complex three-dimensional nature of fracture systems in the repository block appears to rely on fractal analysis of outcrop exposures and geologic mapping of ES-1, drifts and boreholes (excluding floors and working faces). Also, the CDSCP limits the objectives of fracture network studies to providing fracture parameters and analyses to supporting hydrologic modeling. The approach and objective to characterization described in the CDSCP may not lead to sufficient descriptions of the fracture networks.

BASIS

- Characterization of fracture networks, including persistence and/or fracture geometry, is necessary to understand and model geomechanical behavior. It may also be useful in assessing the radiation shielding capacity in the vicinity of waste packages.

- Three-dimensional descriptions of fracture systems can be evaluated by systematic mapping of ES-1 and drifts, including mapping of some reaches of shaft floor and drift faces. Such mapping or photography evaluation permits direct characterization of in situ fracture networks instead of being inferred from fractal analyses of surface data.

- The CDSCP emphasizes the desirability of obtaining a three-dimensional description of fracture systems (p. 8.3.1.4-70/71) and presents the shortcomings of borehole and shaft wall mapping (p. 8.3.1.4-70 and 8.3.1.4-74).

- Fractal analysis is identified as "the best available technique," as stated on pg. 8.3.1.4-71, yet it is not included in the section on shaft and drift mapping (Section 8.3.1.4.2.2.4).

EVALUATION OF DOE RESPONSE

- The DOE has broadened the objectives for Section 8.3.1.4.2.2, study: characterization of the structural features within the site area. This alleviates the concern that fracture studies may be intended for hydrological purposes only.

- The DOE has also clarified its description of the planned fracture characterization and analysis activities.

- The DOE has presented a rational plan for characterizing fracture systems at the Yucca Mountain site. Based on the DOE response and the referenced supporting SCP sections, comment 29 is considered resolved.

Section 8.3.1.15 Overview of thermal and mechanical rock properties program, pg. 8.3.1.15-1

COMMENT 42

This table, which summarizes the requests for thermal and mechanical rock properties, appears to be far from complete.

BASIS

- Several Issues that require thermal and mechanical rock properties are not listed on page 8.3.1.15-1. For example:

  Issue 1.4 Waste Package Containment Performance, pg. 8.2-73 3rd paragraph

  Issue 1.7 Performance Confirmation Program pg. 8.2-84, last paragraph

  Issue 1.9 Post closure Siting Guidelines, pg. 8.2-91

  Issue 1.10 Waste Package Characteristics pg. 8.3.1.15-1
  Issue 2.2 Worker Radiological Safety: Normal Conditions pg. 8.2-119, 2nd sentence of first paragraph

  Issue 2.4 Retrievability Sections 8.2.2.2.1.4 (pgs. 8.2-125/130) and 8.3.5.2

EVALUATION OF DOE RESPONSE

- The DOE has provided clarification regarding the indirect linkage between some issues and data requirements as summarized in SCP Section 8.3.1.15. The tie in for Issue 2.4 is clear and unambiguous. The tie in for Issue 1.10 remains less explicit, but the required parameters appear to be addressed adequately in Section 8.3.4.2.4.3.

- The comment is considered resolved, in light of the satisfactory guidance provided in the SCP with regard to indirectly supported issues.

Section 8.3.1.15.1.6.2 Activity: Canister-scale heater experiment
pg. 8.3.1.15-52

COMMENT 46

In order to examine the margin of safety engineered into the stability of emplacement holes from the standpoint of retrievability, the canister-scale heater experiment needs to be run beyond the average design heat load. The CDSCP does not include provisions for such testing. Also, no mention is made of testing of lined versus unlined holes, backfilled holes, etc.

BASIS

- The degree of conservatism in design cannot be assessed without examining behavior outside of "average" conditions.

EVALUATION OF DOE RESPONSE

- The DOE has included a commitment to a thermal overdrive experiment on the canister-scale heater experiment, as well as to multi-year (e.g. performance confirmation) heater tests on a similar scale.

- The DOE response leaves the planning for heater testing of lined holes as uncertain. A decision on lined hole testing can be deferred until an emplacement configuration is final. This question may need to be raised/ clarified if horizontal emplacement in long lined holes is ultimately selected.

- The comment is considered resolved in light of the DOE commitment to thermal overdrive testing and long term testing on the canister scale.

Section 8.3.1.15.1.6.5 Activity: Heated room experiment, pg. 8.3.1.15-58

COMMENT 47

This experiment is one of the more important rock mechanics experiments proposed; yet, virtually no detail is given regarding it. There seems to be a lack of integration between this experiment and the modeling activities and design.

BASIS

- See the comment on Section 8.3.1.15, Overview of Thermal and Mechanical Rock Properties Program, p. 8.3.1.15-1/14.

EVALUATION OF DOE RESPONSE

- DOE has provided additional information about the heated room experiment in Section 8.3.1.15.1.6.5 of the SCP. In the description of the test, it is pointed out that the objectives of the test are to evaluate the thermomechanical response of the tuff, collect thermomechanical data and predict drift response presumably through the use of numerical models.

- DOE states that the design of the test is in a preliminary stage and thus details are not currently available. However, information has been presented in the SCP regarding the parameters to be obtained and the method of collection to gain limited insight into the heated room test plan. The staff finds this information to be sufficient for review at this time.

- The staff considers this comment to be resolved.

Section 8.3.1.15.1.7.1 Activity: Plate-Loading Tests, pg. 8.3.1.15-61

COMMENT 48

Plate-load tests do not necessarily provide a means of determining in-situ (i.e., undisturbed) rock mass deformational properties. Data obtained from such tests may be useful in assessing spatial variability, effects of different excavation procedures, etc. as part of the overall program to characterize deformational relations of the rock mass adjacent to underground openings but may not be useful in thermomechanical calculations.

BASIS

- The analysis of plate-loading tests normally assumes that the rock mass properties are isotropic in nature; however, because of the influence of fracturing, the rock mass may not exhibit isotropic deformation properties. Therefore, calculation of response with a single extensometer may be misleading. The conduct of multiple plate-loading tests may provide a false statistical importance. Also, the test only determines the characteristics of the fractured skin.of the opening.

- Plate-loading tests consist of reloading the rock mass (rock and discontinuities) which has been unloaded, disturbed and possibly fractured by excavation. The modulus of deformation obtained during loading from such tests is a function of the elastic modulus of intact rock, discontinuity closure, and discontinuity sliding, whereas the in-situ elastic modulus of an initially-stressed rock mass is a function only of the elastic modulus of intact rock and discontinuity stiffnesses.

- In performing continuum thermomechanical analyses, the largest thermally-induced stresses result from using upper-bound (rather than lower-bound, as implied by the statement on p. 8.3.1.15-62) estimates of rock modulus.

EVALUATION OF DOE RESPONSE

- In response to this comment, the DOE has made changes to the description of the plate loading tests in Section 8.3.1.15.1.7.1. In this discussion, the DOE has eluded to the possible anisotropic nature of the rock mass.

- DOE has recognized the limited value of the data obtained from the plate-loading tests.

- The staff considers this comment to be resolved.

Section 8.3.2.1.4.1.1 Geomechanical Analyses, p. 8.3.2.1-21

COMMENT 54

CDSCP has limited its consideration of how jointed tuff can be treated to equivalent continuum models. Although several possible models are described in Chapter 2 (pp. 2-19 and -20), representation of jointed tuff by equivalent continuum models only and disreading of other models such as quasi-discrete or distinct element models has not be justified.

BASIS

- o Equivalent continuum models may be misleadingly simple and miss essential behavior features even if one or two calculated results match. For example, these models may adequately represent the behavior of a block of jointed rock subject to low stress gradients but may not yield representative results when high stress gradients are introduced (Singh, 1973). If validation testing does not include tests with a stress gradient boundary condition, then an important deformation mechanism may be overlooked.

- o Another limitation of equivalent continuum material models concerns the issue of intersecting joints. For a rock mass cut by two intersecting joint sets, relative movement on one joint set produces a stepped surface on the second set. The shear strength is then a function of applied shear direction. The initial shearing does not involve dilation but subsequent shearing does. Most current continuum models do not adequately account for this behavior. Equivalent continuum models must either be restricted to slip motion on a particular joint set or assume very small joint spacing (Gerrard, 1983).

- o Other models, such as quasi-discrete or distinct element models, may be equally valid. For example, the CDSCP states that equivalent continuum models do not address block failure and that distinct element models may be required (p. 8.3.2.2-82). Blanford and KEY (1987) demonstrated that a quasi-discrete approach of isolating joints from the rock matrix can be appropriate, particularly near areas of high stress gradient.

EVALUATION OF DOE RESPONSE

- o In response to this comment, the DOE has revised Section 8.3.2.1.4.1 of the CDSCP to include a discussion on the use of discrete element models and quasi-discrete models in the development of constitutive models.

- o The staff finds DOE's response to be adequate and therefore considers the comment to be resolved.

REFERENCES

Blanford, Mark L., and Samuel W. Key (1987). "An Example of Continuum versus Quasi-Discrete Modelling of a Jointed Rock Mass," in Proceedings of the Conference on Constitutive Laws for Engineering Materials: Theory and Practice (C. S. Desia et al,. Eds.) pp. 1003-1010.

Gerrard, C. (1983). "Rock Balting in Theory -- A keynote Lecture," in Proceedings of the International Symposium on Rock Bolting (Abisko, Sweden) pp. 3-32. Singh, B. (1973). "Continum Charcterization of Jointed Rock Masses: Part I--Constitutive Equations," Int. J. Rock Mech. Min. Sci. & Geomech. Abst., 10,311-335.

Section 8.3.2.1.4.1 Geomechanical Analyses, pg. 8.3.2.1-21

COMMENT 55

Geomechanical analyses do not consider the effects of emplaced support components or the effect of elevated temperature on the support system components.

BASIS

- Emphasis is placed on the function of rock reinforcement in limiting deleterious rock movement. Only empirical approaches are discussed in relation to selection of rock reinforcement components.

- System element 1.2.12, drift construction, recognizes the need for designing ground support to accommodate the long-term thermal considerations. However, consideration of thermal effects is limited to thermally-induced stresses in the rock mass, not in support components.

EVALUATION OF DOE RESPONSE

- In response to this comment, the DOE has revised Section 8.3.2.1.4.1 of the CDSCP to include a discussion on the use of finite element models to evaluate the rock-support interactions. DOE states that the thermal effects on the support system will be considered.

- The staff finds DOE's discussion on the use of finite element models to be adequate and considers this comment to be resolved.

Section 8.3.2.2.3 Information Need 1.11.3, Product 1.11.3-5: Criteria for contingency plan, pg. 8.3.2.2.-55

COMMENT 56

The first section of the next last paragraph on pg. 8.3.2.2-55 express the anticipation that contingency measures might strongly emphasize contractibility based on sem-empirical rock mass classifications. These classifications bear no direct relation to the primary long-term repository performance requirements of containment and isolation. It is not clear, therefore, whether the selected criteria re appropriate for guiding emplacement decisions, and, specifically to perform system performance studies for off-normal conditions, as proposed in the first sentence of the last paragraph on pg. 8.3.2.2-55.

BASIS

o Contrary to the second sentence of the last paragraph on pg. 8.3.2.2-55, product 1.11.3-3 does not site data required to perform such assessments.

EVALUATION OF DOE RESPONSE

o In response to this comment, the DOE has revised Section 8.3.2.2.3 of the CDSCP to indicate that total system performance concerns will be ~~factored~~ f into the contingency procedures.

o DOE's response identifies methods that can be used for system performance studies for off-normal conditions, with particular attention to the primary long term repository performance requirements.

o Section 8.3.2.2.3 (pp. 8.3.2.2-52/53) identifies the site data required by reference to product 1.11.3.1.

o The DOE response and referenced SCP sections provide the information requested by the NRC. The staff considers the comment to be resolved.

Section 8.3.2.2.6 Information Need 1.11.6 Drift scale analyses, pg. 8.3.2.2-81 Related to comment 60

COMMENT 57

The CDSCP states that the potential for the development of new paths to the accessible environment for for an extension of the disturbed zone will be mitigated by backfilling the emplacement drifts.

BASIS

- o Backfill design presently allows for a 1 to 5 ft. void between backfill and roof (CDSP-CDR Section 5.1.2.2, page 5-3). Hence, considerable rock fall can take place, with creation of voids above the drifts, before the backfill can resist the rock mass displacements.

EVALUATION OF DOE RESPONSE

- o DOE states in the response to this comment, as well as in SCP Table 8.3.2.2-5, that the mechanical effects of backfill are not relied on for postclosure performance.

- o Since, DOE has stated that the mechanical effects of backfill will not relied upon to meet postclosure performance, this comment is considered resolved.

Section 8.3.2.2.6 Information Need 1.11.6: Repository thermal loading and predicted thermal and thermomechanical response of the host rock, Container Scale Analyses, pg. 8.3.2.2-81, Next to last sentence

COMMENT 58

The proposed wedge analysis and key block analysis are not capable of including the effects of thermal loading or stress gradients on the host rock.

BASIS

o Both wedge analysis and key block analysis methods are based on limit equilibrium. These analyses are based on fracture orientation and properties relative to postulated transactional failure modes. It is fundamentally not possible to include the effects of stress state without making simplifying assumptions. These methods, therefore, are not capable of considering induced thermal stresses without input from other thermomechanical calculations.

EVALUATION OF DOE RESPONSE

o In response to this comment, the DOE has revised Section 8.3.2.2.6 of the CDSCP to state that the thermal loading history used in the key block will be obtained through independent thermomechanical analyses.

o The SCP has been adequately revised to address the NRC comment. Therefore, the staff considers the comment to be resolved.

Section 8.3.2.2.6 Information Need 1.11.6, Far-Field Analyses, pg. 8.3.2.2.2-82

COMMENT 59

The description of far field analysis in the CDSCP does not address potential for thermally induced movement along faults or fractures.

BASIS

- Heat sources in the repository will induce perturbations to the in situ stress field. If faults are presently at limiting equilibrium, thermally or excavation induced stresses may cause slip on some sections of the fault. Heating may also increase pore pressure and decrease effective stress on fault. Similar effects may be induced on fractures.

EVALUATION OF DOE RESPONSE

- In response to this comment, the DOE has revised Section 8.3.2.2.6 of the CDSCP to indicate that thermally induced movement along fractures and faults will be considered in the Far Field analysis.

- DOE has also indicated in Tables 8.3.2.2-5 and 8.3.2.2-14 that fault locations are required as parameters for thermal modeling and far field thermemechanical analyses.

- The staff considers the SCP revisions and DOE's response to be adequate, and considers the comment to be resolved.

Section 8.3.2.2.7 Information Need 1.11.7 logic, pg. 8.3.2.2-89

COMMENT 60

The comment that "...drifts will not be relied on to be open. They may have caved in or settled on the backfill" raises concerns because it is formulated as a very broad option.

BASIS

- If drifts through faults or fault-zones are allowed to cave in, it could extend considerably the potential for connections between potential flowpaths and the repository. It could also enhance permeability at larger distances than calculated for stable conditions.

  Examples:

  - cavities above drifts could greatly reduce resistance to airflow, and link the repository to preferential air flow channels along a fault, hence facilitating upward flow of airborne radionuclides.

  - large open space above failed drifts could become preferential condensation locations for water vapor, thus enhancing water flow down faults.

EVALUATION OF DOE RESPONSE

In response to this CDSCP comment, it has been acknowledged that the role of backfill and the consequences of caving require further evaluation. This comment is considered resolved.

Section 8.3.2.4.1.2 Design activity to verify air quality and ventilation (pg. 8.3.2.4-30)

COMMENT 61

Systematic studies or calculations may be needed to determine the heat and moisture transfer from the rock to the ventilation air.

BASIS

- o Some aspects of the transfer are mentioned (e.g., in situ moisture), but the most difficult parameters to determine usually are the ones governing transfer to the air.

EVALUATION OF DOE RESPONSE

- o In response to this comment, the DOE has revised Section 8.3.2.4.1.2 of the CDSCP to explicitly identify that heat and moisture transfer in the ventilation system will be evaluated in the ventilation system design.

- o The DOE has also revised Section 8.3.1.15.1.8.4 of the CDSCP to identify the activity which will evaluate parameters needed for the ventilation system design.

- o The DOE response and SCP revisions adequately respond to the NRC comment and thus the comment is considered resolved.

Section 8.3.2.5 Table 8.3.2.5-3 Preliminary performance allocation for system element 1.2.1.1, pg. 8.3.2.5-21

COMMENT 63

The last tentative goal on pg. 8.3.2.5-21 indicates that high confidence is needed that ES-1 shaft will terminate no less than 150 m above ground-water table.

It does not appear that this goal is reached under the present ES-1 design.

BASIS

- According to the last sentence on pg. 81 of the CDSCP Overview volume: "The (first exploratory) shaft..., leaving about 280 feet of the Calico Hills tuff undisturbed above the static water table."

- According to Section 8.4.2.6.1 (pg. 8.4-66, first paragraph), "...would still provide almost 85 m to the water table."

EVALUATION OF DOE RESPONSE

- In response to this comment, the DOE has stated that the current ESF design requires the ES-1 shaft to terminate at a distance of about 200 m above the water table.

- The response further states that the DOE's tentative design goal in the CDSCP should have read "The thickness between the bottom of ES-1 or any drifting and the ground-water table should be greater than the minimum thickness of the Calico Hills unit above the water table anywhere else within the repository boundary."

- In view of the modification to the ESF design changing the depth of ES-1 below the ground surface, we find that the comment is no longer applicable.

- The CDSCP comment # 63 is considered resolved because it is no longer applicable to the revised ESF design configuration.

Section 8.3.3.1.2 Seal Components, page 8.3.3.1-4, next to last paragraph

COMMENT 67

The statement near the end of the next to the last paragraph on pg. 8.3.3.1-4 that "boreholes that are upgradient or long distances from the repository may not require sealing" appears to be driven largely by considerations of the vertical downward flow in the pre-repository rock environment, and does not represent a conservative sealing approach.

BASIS

- Thermally induced gas flow is likely to be upward.
- Thermally induced (or disturbed) water vapor/steam flow may be upward.
- Repository induced flow may not be one dimensional.

EVALUATION OF DOE RESPONSE

- In response to this comment, the DOE has stated that the SCP Sections 8.3.3.1 and 8.3.3.2 have been modified to indicate that both liquid and gaseous flow concerns are part of decision making strategy for sealing. The staff concludes that these revisions adequately responds to NRC CDSCP comment 67.
- The SCP has satisfactorily responded to this comment and therefore, the comment is considered resolved.

Section 8.3.3.2 Step D: Performance and Design Goals, page 8.3.3.2-24 and Figure 8.3.3.2-3, page 8.3.3.2-25

COMMENT 68

It is stated in the second paragraph on pg. 8.3.3.2-24 that "more conservatism has been added by the selection of the design - basis performance goals to be substantially less than the maximum allowable values." Although this is true immediately after closure, the two curves (Fig. 8.3.3.2-3) do converge relatively rapidly. Although no time scale is included, it can be inferred from Fernandez et al, 1987, Fig 3-2, that the breakpoint in the Design Basis Performance Goals is at about 1,000 years. Beyond that point the two curves are so close together as to leave very little safety margin.

BASIS

- Table 3-2 of Fernandez et al. (1987) compares the maximum-allowable performance goals and design-basis performance goals. In the period from 1,000 to 10,000 years following repository closure, the ratio of "maximum allowable" to "design-basis" decreases from 2.8 to 1.0, leaving little or no safety margin.

- In usual engineering practice, one would allow for uncertainties by providing a safety margin between "Maximum Allowable" and "Design Basis" performance goals. This would be particularly true for structures that require a very long life, and hence are subject to considerable uncertainty.

EVALUATION OF DOE RESPONSE

In response to this comment, the SCP text has been changed to clarify the evaluations shown on the two curves in Figure 8.3.3.2-3 related to maximum allowable and design basis performance goals. Based on these clarifications, the comment is considered resolved.

REFERENCE

Fernandez et al., 1987. Technical Basis for Performance Goals, Design Requirements and Material Recommendations for the NNWSI Repository Sealing Program, SAND84-1895, Sandia National Laboratories, Albuquerque, New Mexico.

Section 8.4.2: Underground Test Facility, page 8.4-21, paragraph 2
Section 8.4.2.2: Exploratory Shaft 2, pg. 8.4-31, para. 2

COMMENT 97

Plans should be made to correlate persistence of geologic features from ES-1 to ES-2 which might provide preferential pathways and to develop a photographic record of ES-2 for possible future use.

BASIS

- If interconnection of ES-1 and ES-2 occurs during construction (i.e., drill water), mapping in each shaft will aid in interpretation of flow paths and flow mechanisms in unsaturated rock.

- The CDSCP states (pg. 8.4-21) that "Unanticipated structural or hydrological features and stratigraphic contacts will be mapped as they are encountered in ES-2." It appears that unless special provisions are made, the concept of "mapping when needed" could be difficult to implement.

- The CDSCP also states (pg. 8.4-31) that "significant structural or hydrologic features and stratigraphic contacts may be mapped if encountered or as needed to verify data obtained in ES-1." Verification of data obtained in ES-1 may be difficult, at least for the lower section of the shafts, given that ES-2 is planned to be completed before ES-1.

EVALUATION OF DOE RESPONSE

- In response to this comment, the DOE has accepted NRC staff recommendation to develop a photographic record of both exploratory shafts (ES-1 and ES-2).

- The response also states that onsite geologists will determine whether additional, detailed geologic mapping of specific features in ES-2 may be required.

- We find DOE's response to our CDSCP comment # 97 to be reasonable and acceptable.

- The comment is considered resolved as the DOE has accepted the recommendation to photo log the shaft ES-2 and to provide for additional geologic mapping in this shaft.

CDSCP Section 8.4.2: Underground Test Facilities, page 8.4-21, para 3

COMMENT 98

A reasonable assurance that the shafts are adequately separated so that construction in ES-2 does not adversely affect the ability to obtain required data in ES-1 and adjacent test areas has not been provided.

BASIS

- The CDSCP discusses only the potential mechanical interference of the shafts. Potential hydrologic interferences along intersecting fractures has not been discussed. No analysis of possible interference is presented or referenced.

- The effects of presence of faults, high density of fractures in the area, possibility of creation of blast-induced radial fractures, or extension of existing fractures have not been accounted for.

- Relevant locations and distances between sensitive instruments (installed in long boreholes from ES-1) and ES-2 are not given. Also, locations of radial core holes from ES-1 are not provided.

- Interaction effects resulting from drill and blast excavation (e.g., contamination of some of the test samples by drill water, blasting fumes and blast vibrations) are not adequately addressed.

- Past experience at Yucca Mountain suggests that hydrological interference between holes may have occurred (e.g., Ref. 1)

- Consequences of ES-2 failure have not been considered.

EVALUATION OF DOE RESPONSE

In response to this CDSCP comment, SCP Sections 8.4.2.3 and 8.4.3.2 have provided discussions and evaluations to show that separation between the exploratory shafts (ES-1 and ES-2) is adequate to avoid adverse effects. The NRC staff considers these evaluations to be reasonable and sufficient to resolve this comment.

REFERENCE

NRC comments on the DOE's Draft Environmental Assessment for the Yucca Mountain Site, March 20, 1985.

Section 8.4.2.1.1 Smooth Wall Blasting in Shafts (p. 8.4-24, first paragraph)

8.4.2.1.2 Construction of the Upper Demonstration Breakout Room and Stations (p. 8.4-27, third paragraph)

COMMENT 99

The CDSCP does not present appropriate information on blasting to reflect the most recent strategy for minimizing shaft wall damage as outlined in DOE's "Response to NRC Information Requests from the April 14-15 1987 Meeting Between DOE and NRC" (Ref. 1).

BASIS

- The design criteria for rock excavation [10CFR60.133(f)] require that "the design of underground facility shall incorporate excavation methods that will limit the potential for creating a preferential pathway for groundwater to contact the waste packages or radionuclide migration to the accessible environment."

- 10 CFR 60.17(a)(2)(iv) requires that "The site characterization plan shall contain plans to control any adverse impacts from such site characterization activities that are important to safety or that are important to waste isolation."

- The NRC guidance about shaft construction requirements is contained in its Borehole and Shaft Sealing GTP (NRC, 1986, especially Sections 3.2 and 4.4).

- Statements in the CDSCP (Sections 8.4.2.1.1 and 8.4.2.1.2) imply the possibility of a strictly conventional, highly empirical approach and give little or no indication of a tightly controlled and supervised approach to blasting, with emphasis on the need to minimize the shaft wall damage as the prime objective.

EVALUATION OF DOE RESPONSE

- In response to this comment, the DOE has stated that smooth blasting will be used to minimize shaft wall damage during excavation.

- The response further states that drilling agent, blasting materials, and water, which could interfere with gathering uncontaminated in-situ data will be closely monitored.

- We find DOE's commitment to minimize shaft wall damage to be reasonable and acceptable.

- The CDSCP comment # 99 is considered resolved on the basis of DOE's commitment to minimize shaft wall damage and to monitor drilling agents, blasting materials and water, as appropriate.

REFERENCES

- Letter from C. P. Gertz, DOE, to J. J. Linehan, NRC, dated October 29, 1987, on the subject "Response to Information Requests From the April 14-15, 1987, Meeting Between DOE and NRC."

CDSCP Section 8.4.2.4 Exploratory Drifts, pages 8.4-35 and 36

COMMENT 101

Plans for remedial measures that may be required to minimize potentially adverse impacts of penetrating the target features are not given.

BASIS

- Details of remedial measures are needed to evaluate potential adverse impacts of penetrating target structures (i.e., Ghost Dance fault, Imbricate Normal Fault Zone and Drill Hole Wash) on long-term isolation capability of the geologic repository. These structures could become air or water flowpaths.

EVALUATION OF DOE RESPONSE

- In response to this comment, the SCP has been modified to discuss potential remedial measures to isolate and stabilize target structures. This comment is considered to be resolved.

CDSCP Section 8.4.2.5.1 Exploratory shaft facility studies, pages 8.4-37 to 8.4-55

COMMENT 102

In several activity descriptions, it is proposed that air coring will be used to drill holes to be used for permeability testing (e.g., Infiltration test, pg. 8.4-52; bulk-permeability test, pg. 8.4-53; radial borehole tests, pg. 8.4-53; Calico Hills tests, pg. 8.4-54; diffusion tests, pg. 8.4-54).

BASIS

- The large volumes of pressurized air injected into the holes for bit cooling and cutting removal are likely to change the degree of saturation, hence permeability, of the surrounding rock.

- Dust particles are likely to be injected into fractures and pores, thus changing the permeability.

- A significant dust coat is likely to be blown onto the hole walls, affecting measured permeability.

- If major difficulties are encountered in completing these holes, it could cause a significant delay or reduction in data available for License Application.

EVALUATION OF DOE RESPONSE

- In response to this comment, the DOE has clarified that the effects of air coring compared with conventional coring methods using water circulation are being investigated. The NRC staff considers this comment to be resolved.

Section 8.3.1.4
Rock Characteristics Figure 8.3.1.4-1, pg. 8.3.1.4-3; also next to last paragraph on pg. 8.3.1.4-16; also Sections 8.3.1.4.2.2.2, 8.3.1.4.2.2.3, and 8.3.1.4.2.2.4

QUESTION 12

What are the definitions of the terms fracture "aperture" and "length"?

BASIS

- "Aperture" could refer to an equivalent hydraulic aperture, or to a true physical aperture, and is a function of stress. It is less of a purely geometrical property than orientation, distribution, or frequency. "Length" of a two-dimensional feature such as a joint is not a well defined parameter.

EVALUATION OF DOE RESPONSE

- The DOE has responded to the question and has provided the definitions of the terms fracture "aperture" and "length".

- The DOE response satisfactorily answers the NRC question. Question 12 is considered resolved.

Section 8.3.1.4.1 Investigation: Development of an integrated drilling program (pg. 8.3.1.4-18/24)

QUESTION 14

Does this program include all drilling or only surface based drilling?

BASIS

- Only surface-based drillholes are listed in Table 8.3.1.4-2 (pg. 8.3.1.4-19/22).
- Drilling from the ESF is mentioned in Sections 8.3.1.4.2.2.4 (Table, pg. 8.3.1.4-79) and 8.3.1.4.2.2.5 (second paragraph, pg. 8.3.1.4-81).
- Extensive additional drilling from the ESF is planned, according to other sections (e.g., 8.3.1.15, Thermal and Mechanical Properties).
- In the analysis of "Potential impacts of exploratory shaft construction and testing on the waste isolation integrity of the site "(SCP Section 8.4.2.6) only holes already completed are discussed.
- 10 CFR 60.17(a)(2)(iv) requires that the site characterization plan shall contain plans to control any adverse impacts from such site characterization activities that are important to waste isolation.

EVALUATION OF DOE RESPONSE

- The DOE has clarified that section 8.3.1.4.1 addresses surface-based drilling only. This clarification adequately answers the question.
- The DOE has stated that section 8.3.1.4.1 has been revised to indicate the focus on surface-based drilling.
- The question has been adequately answered and is considered resolved.

REFERENCE

10 CFR 60

Section 8.3.1.4.2.2.3 Activity: Borehole evaluation of faults and fractures, pg. 8.3.1.4-72

QUESTION 16

How is the roughness coefficient parameter measured in a borehole? What is the difference between roughness coefficient listed here and "roughness" discussed elsewhere in Section 8.3.1.4.2.2.3?

BASIS

- On page 8.3.1.4-74 it is stated in Item 4 that roughness cannot be measured in a borehole. Geometric descriptions of fracture geometries are central to developing some joint constitutive relations. Roughness relates to dilation angles and shear displacement required to reduce asperities.

EVALUATION OF DOE RESPONSE

- The DOE has modified the SCP to differentiate between the terms "roughness" and "roughness co-efficient."

- The DOE has also clarified its objectives for roughness measurements in a borehole which are found to be reasonable.

- The CDSCP question 16 has been answered satisfactorily and is considered resolved.

Section 8.3.1.4.3 Investigation: Development of three-dimensional models of rock characteristics at the repository site (Also Section 8.3.1.4.3.3), pg. 8.3.1.4-87

QUESTION 17

What role, if any, will the data presented in Chapter 2 play in the proposed model development and in scoping the amount of planned site specific in situ testing?

BASIS

- The list of CDSCP sections given in the lower half of pg. 8.3.1.4-87 does not appear to be complete. This raises concerns about the adequacy of the information transfer mechanism proposed on pg. 8.3.1.4-88 (first paragraph of purpose and objectives), and of the information integration itself. As an example, not a single section from Chapter 2, Geoengineering, is included, in the list. According to the first paragraph on pg. 8.3.1.4-88 "Contour maps or cross sections will show the spatial distribution of such parameters as rock compressive strength, thermal conductivity,..." Information on these parameters is given in the CDSCP Sections 2.1.2.3.1 and 2.4.2.1, which apparently belong on the list on pg. 8.3.1.4-87.

EVALUATION OF DOE RESPONSE

- The DOE has revised section 8.3.1.4 of the SCP to reference the data presented in chapter 2.

- The DOE has stated that the Chapter 2 data will be used for planning future sampling requirements and for preliminary analyses and evaluations.

- The DOE has adequately addressed the CDSCP question 17. The question is considered resolved.

Section 8.3.1.15.1.6.3 Activity: Yucca Mountain heated block, p. 8.3.1.15-53

QUESTION 26

How will the heated block experiment be used for model validation if there are no imposed stress gradients or temperature gradients inside the block?

BASIS

- The heated block test is designed to allow application of constant stresses to a large block so that shear may be minimized. However, for model validation, stress and temperature conditions need to exist which may result in shearing of discontinuities.

EVALUATION OF DOE RESPONSE

- The DOE has adequately addressed this question by addressing the application of normal and shear stresses across the joints. In addition, DOE has stated that the effects of temperature gradients will be evaluated in other tests.

- The DOE has adequately address this question and thus the staff considers this question to be resolved.

Section 8.3.1.15.7.2 Activity: Rock-mass strength experiment (pg. 8.3.1.15-64

QUESTION 27

What are the parameters and the strength model for which the strength experiment(s) are designed, and how will a substantial volume of rock be driven to failure?

BASIS

- The term "strength" has not been defined rigorously. It is not clear if it refers to strength of joints in direct shear or some large-scale mass strength as implied by the Hoek-Brown criteria.

- Attempting to load a substantial volume of "randomly" jointed rock to failure by mechanical means would require extremely large loads.

- The definitions of "field scale" joint length (actually, area) and "representative volume" are not given. Shearing a large joint surface in situ could be an extremely difficult test,

EVALUATION OF DOE RESPONSE

- The DOE has adequately addressed this question by revising the strength experiment to focus on deformation of the rock mass rather than failure. DOE has also removed reference to "representative volume."

- The staff finds the DOE response to be adquate and thus considers this question resolved.

Section 8.3.2.2.3 Information Need 1.11.3, Product 1.11.3-4: Drainage and moisture control plan (pg. 8.3.2..2-54

QUESTION 34

Why is there no link (other than that indicated in Figure 8.3.2.1-1) established between this plan and Issue 1.12 - Repository Sealing?

BASIS

- The sealing requirements determination relies heavily on controlled water flow, and moisture migration, in combination with (long term) drainage. (SCP Section 8.3.3).

EVALUATION OF DOE RESPONSE

- DOE has adequately identified the Sections (SCP Sections 8.3.2.2 and 8.3.3.2) which link the Information need 1.11.3 and Issue 1.12.

- DOE has adequately responded to this question and therefore the question is considered resolved.

Section 8.3.2.2.3.4 Design Activity 1.11.3.4: Drainage and moisture control plan (pg. 8.3.2.2-56/57)

QUESTION 35

According to the last sentence of this section, the approach to develop this plan is given in Section 8.3.2.3, and the data requirements for this plan are given in Section 8.3.2.2.1. Both of these referenced sections cover extremely broad topics. What are the relevant items for this section?

BASIS

- The drainage and moisture control plan is discussed briefly on pg. 8.3.2.2-37/38, where it is clearly stated that the plan for drainage and moisture control plan is still under development. This section (pg. 8.3.2.2.2-37, last paragraph) also states that "This approach would require the same site data as the used for Information Need 1.11.6 (SCP Section 8.3.2.2.6)." While the information from this latter section (Repository thermal loading and predicted thermal and thermomechanical response of the host rock) may indeed provide necessary data, it is not obvious that it would provide sufficient data (e.g., with respect to flow properties in particular).

EVALUATION OF DOE RESPONSE

- DOE's response includes references to sections 8.3.5.13 and 8.3.5.9 for the definition of data requirements for moisture migration models.

- DOE has corrected the reference to Section 8.3.2.2.1.

- DOE has adequately responded to the NRC question and therefore the question is considered resolved.

Section 8.3.2.2.5.1 Design Activity 1.11.5.1: Excavation methods criteria (pg. 8.3.2.2-71)

QUESTION 36

Where in Section 8.3.2.2.1 are the data requirements for this activity discussed?

BASIS

- The last sentence in this Section 8.3.2.2.5.1 states that the data requirements for this activity are discussed in Section 8.3.2.2.1. Section 8.3.2.2.1 does list a broad range of rock mass properties, but does not directly address the rock mass response to excavation, e.g., blasting.

EVALUATION OF DOE RESPONSE

In response to this CDSCP question, data requirements for excavation method criteria have been identified to be in SCP Table 8.3.2.2-11. The question is considered resolved.

Section 8.3.2.4.1.1 Design activity to verify access and drift usability, pg. 8.3.2.4-27/30

QUESTION 38

Use of mechanical excavation is considered not feasible in some parts of the document and plausible in other parts. The next to last paragraph on pg. 8.3.2.4-28 mentions the possibility that mechanical excavation may be used. Does this contradict other implications in the CDSCP (e.g., pg. 8.3.2.2-70) that mechanical excavation is not feasible?

BASIS

- Second paragraph of Product 1.11.5-1 Section on pg. 8.3.2.2-70: "continuous mining has not yet been proved practical for welded tuff." Within the context of this product section, it appears that mechanical excavation will receive no further consideration.

EVALUATION OF DOE RESPONSE

- In response to this question, the DOE has revised Section 8.3.2.2.5 of the CDSCP to indicate that mechanical excavation is still being considered feasible, although it has not yet been proven to be practical.

- DOE has removed the inconsistency regarding the feasibility of mechanical excavation techniques. The question is considered resolved.

Section 8.3.2.5 Table 8.3.2.5-4 Preliminary performance allocation for System Element 1.2.1.2, drift construction, pg 8.3.2.5-23

QUESTION 39

Why are the requirements for some items on pg. 8.3.2.5-23 different from the requirements for System Element 1.2.1.2 identified in Table 8.3.2.4-2, nonradiological health and safety?

BASIS

- o Pg. 8.3.2.4-13 limits air velocities to less than 1,500 ft/min (supply) and less than 2,500 ft/min (return). On the other hand, pg. 8.3.2.5-23 limits air velocities to less than 2,00 ft/min (both supply and return).

- o According to pg. 8.3.2.5-23 no site characterization data is required for ventilation routing. However, according to Section 8.3.2.4.1.2, Design activity to verify air quality and ventilation system include wall roughness, in situ moisture, formation gas, dust generation, etc.

EVALUATION OF DOE RESPONSE

- o DOE has adequately revised Tables 8.3.2.4-2 and 8.3.2.5-4 to remove inconsistencies between various section of the SCP.

- o DOE has adequately resolved the inconsistencies and therefore the question is considered resolved.

Section 8.3.2.5 Table 8.3.2.5-5 Preliminary performance allocation for System Element 1.2.1.4, borehole construction, pg. 8.3.2.5-24

QUESTION 40

What is the justification for the statement on pg. 8.3.2.5-24 that "no site characterization data is required to develop the high level of confidence needed for installation of borehole liners."

BASIS

- o Inserting a steel liner in a borehole (in particular, a 350 ft long horizontal hole), will require that the hole not deform excessively. Close tolerances are needed on the straightness of the hole that may be difficult to achieve. Providing assurance that a straight hole can be drilled that will remain stable may involve analyses of mechanical response of the structure (i.e., the hole) using site-specific rock properties and parameters.

EVALUATION OF DOE RESPONSE

- o DOE has responded by revising Table 8.3.2.5-5 to indicate that no additional site characterization data, beyond that already planned, is required for installation of borehole liners.

- o DOE has adequately addressed the NRC question and therefore it is considered resolved.

Section 8.3.3.2 - Table 8.3.3.2-1 Sealing Components and Associated Functions, Processes, Material Properties, Performance Measures, and Goals, pages 8.3.3.2-8 to 8.3.3.2-11

QUESTION 42

Description of items included in Table 8.3.3.2-1 need further clarification in several areas. Why have not all the seal components been included in the list?

BASIS

- The list of sealing components seems to be incomplete and inconsistent with the description in the CDSCP text. For example, the list does not include the following:

  In shaft and ramp sealing components - ramp flow where ramp drainage is relied on, ES-1 base rock (Calico Hills) which is the present design in the CDSCP, and drift and room floors where drainage is relied on.

  In Underground facility sealing components - fault seals.

  In exploratory borehole sealing components - borehole seals above repository horizon to control gaseous radionuclide release and to minimize water flow into repository.

- Many "functions" (in step B of the Table 8.3.3.2-1) for certain components are not listed. For example, no air flow control function is assigned to either the anchor-to-bedrock plug/seal or the station plugs.

- Many important "material properties" (in step C of the Table 8.3.3.2-1) for certain components are not listed. For example, the anchor-to-bedrock plug/seal must have strength degradation parameters and the general fill must have some porosity.

EVALUATION OF DOE RESPONSE

- In response to this question, the SCP has satisfactorily modified Section 8.3.3.2 to address the points raised in this question.

- Because SCP has adequately responded to various points, the question is considered resolved.

Section 8.4: Planned Site Preparation Activities

QUESTION 48

There are many apparent inconsistencies in the write-up of the proposed activities presented in this section when compared with the details given in other sections of the CDSCP and reference documents. What are the impacts of such inconsistencies?

BASIS

A few examples of inconsistencies are as follows:

- CDSCP page 8.4-58, last paragraph states that "averaged (matrix) percolation flux (will) not exceed 0.5mm/yr," while Fernandez et al. (Ref. 1), bases sealing requirement calculations on an average matrix inflow magnitude of 0.1 mm/yr (e.g., Fernandez et al., 1987, pg. 2-10; pg. 4-5). The draft EA used an influx of 1 mm/yr, and that value was considered to be potentially too low by the NRC staff (NRC 1985, pg. 5; Comment 3-11, pg 10-11; Comment 6-43, 6-45, pg. 61-63).

- CDSCP page 8.4-61, first paragraph states that "Fernandez et al., (1987) also described methods to remove the liner." The said description of the methods to remove the liner cannot be found in the referenced document.

- CDSCP page 8.4-73, second paragraph, 4th sentence states that "Analyses presented in Fernandez et al., (1987) indicate that these precipitates will be deposited very near to the point of their nucleation so that these effects will be very localized."

  It is not clear where in Fernandez et al., (1987) the analyses of precipitates showing only very localized effects are given.

- CDSCP Section 8.4.2.5.1; Activity: Heated Room Experiment, pg. 8.4-50, second sentence states that "Either a preexisting drift will be used or a drift will be constructed specifically for this experiment." Figure 8.4-11 suggests that the heated room test is planned to be conducted in the central drift of the sequential drift mining test.

- CDSCP Section 8.4.2.5.1; Activity: Excavation effects test in the ESF, pg. 8.4-53, first sentence states that "six vertical, small diameter holes will be drilled parallel to the unexcavated shaft wall." The referenced Section 8.3.1.2.2.4.5 (pg. 8.3.1.2-236) indicates that 18 vertical and 9 inclined holes will be drilled.

- CDSCP Section 8.4.2.6.1, potential impacts on the pre-waste-emplacement ground-water travel time post closure performance objective, pg. 8.4-66, continuing paragraph states that "..activities described in Section 8.3.5.12.5 will justify a definition for the disturbed zone as a boundary 10 m or less below any underground opening...." Description in Section 8.3.5.12.5 does not seem to justify the stated definition for the disturbed zone. Page 8.3.5.12-62, 3rd paragraph states that "..The NNWSI

Project believes that the distance to a contour of minimal changes in permeability is more likely to be two to three diameters...." This would result (page 8.3.5.12-61, last paragraph) in a disturbed zone to some 14 m to 24 m below the lowest opening.

EVALUATION OF DOE RESPONSE

- This question is considered resolved because the DOE has rewritten section 8.4 in its entirety and the discrepancies identified in the CDSCP question # 48 are no longer directly applicable.

Section 8.3.1.4.3.1.1 Activity: Systematic Drilling Program, pp. 8.3.1.4-89 to 8.3.1.4-95

QUESTION 50

It is difficult to tell from various depictions in the CDSCP what are the actual boundaries of the area that may be involved in repository development and that therefore may need to be characterized intensively. What are these actual boundaries?

BASIS

Figure 6-88 presents an outline of the "revised usable portion of the primary area and expansion areas." Figure 8.3.1.4-2, Figure 1-71, and others depict the "repository perimeter drift." The outlines of the figures do not appear to be the same.

EVALUATION OF DOE RESPONSE

In response to this CDSCP question, it has been clarified that the current conceptual perimeter boundary (CPDB) is shown in SCP Section 8.4.2.2, in figures 8.4.2-1a and 8.4.2-2a. The question is considered resolved.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

May 1, 1989

Note to: Ronald Ballard, Chief
Geosciences and Systems Performance Branch

From: Seth M. Coplan, Section Leader
Systems Performance Section

Subject: Repository Performance Assessment Section Draft Point Papers

Attached are the SPS Section Draft Point Papers. Included are 6 draft objections, 30 draft comments, and 4 draft questions. Based on its review of the CDSCP, the section had 1 objection, 7 comments and 5 questions. None of these were resolved by the SCP.

I would note that we are still expecting input from RES that will be added to the package when it finally arrives.

Seth M. Coplan

Seth M. Coplan, Section Leader
Systems Performance Section

Attachment:
As stated

cc: N.K. Stablein, HLPD

OBJECTION NAE 20

Performance assessment, which is a methodology used to integrate and to focus the analyses, data acquisition, and evaluations of the many scientific and engineering disciplines involved in the Yucca Mountain Project and then apply the resulting information to resolution of regulatory issues, has apparently not played an effective and central role in the development of the SCP; an important consequence is that absent this central role, it cannot be determined (1) whether conducting one investigation would interfere with, possibly to the point of precluding, conducting another investigation needed to obtain information for licensing or (2) that the proposed investigations will not have potential adverse impacts on the waste isolation capability of the site.

BASIS

- There are five essential types of information the site characterization program must acquire:

  1. Data, parameters, and information required to perform the requisite scenario analysis, including: (1) scenario definition, (2) scenario screening, (3) quantification of scenario probabilities;

  2. Data, parameters, and information required as input to qualitative and semiquantitative conceptual models of the site, the geological (including hydrologic, geochemical, tectonic, seismic, climatologic, etc.) processes

and events affecting it, and the repository (including all the engineered systems and their interaction with natural systems);

3. Data and parameters required as input to quantitative models used to predict performance of the total repository system or of its subsystems;

4. Data, parameters, and information required to develop and establish the validity of the models (qualitative, semiquantitative, and quantitative) used to predict performance;

5. Data, parameters, and information required to support design of the waste package, repository, and other engineered facilities.

- The need for type 1 data and information must be established in a systematic, comprehensive way to assure that relevant data about the ongoing geological processes and events at Yucca Mountain are obtained and that acquisition of essential data is not precluded by disruption of existing conditions at the site by previous site characterization activities and tests. As indicated in Objection NAE 4 the underlying logic and their application used in the SCP for scenario analysis, are not adequate to assure that acquisition of essential data will not be precluded.

- Given an identification of models important to estimating performance, one can evaluate the need to acquire type 2 data to discriminate between significant alternative conceptual models. Objection NAE 7 on the inadequacy of the hypothesis testing tables in identifying important alternative conceptual models and tests to discriminate between them indicates that this has not been done sufficiently well to plan a program to resolve the issue.

- The need for type 3 data is routinely obtained by performing sensitivity and uncertainty analyses on the quantitative models of performance. These analyses can define: (1) which data are the most important determinants of performance, (2) how much data are needed to reduce uncertainty (from this source) to a specified level, and (3) at what physical locations additional data should be obtained. In developing the SCP the DOE did not use these available methods to assist in defining the site characterization program. In lieu of a quantitative analysis, the performance allocation process was used. However, as described in Objection PPB3, this substitute method was not implemented in an effective manner. The NRC staff believes that had appropriate use of the available quantitative methods been made, the performance allocation process would have been effective.

- To establish the full program of investigations needed for site characterization it is essential that the models important to estimating performance be identified. Given this identification, one can evaluate the need to conduct validation studies which gather type 4 data to evaluate the degree of correctness of the models and identify and plan the investigations to accomplish such studies. Objection DJF 1 on the apparent inadequacy of the proposed validation program indicates that this has not been done.

- (Additional detail on data type 5). NRC Objections 2 and 4 on the CDSCP and some of the residual engineering concerns on the SCP (Objection 3; Comments 1, 7, 8, 9, 10, 14, 17, 18, 19, 21, 29, 30 and WPC 3, WPC 6, WPC 10) and the lack of evidence in the DAA that any significant performance assessment considerations were integrated with the ESF design indicates that the design process for the YMP has not been integrated with performance assessment.

- Performance assessment is given a prominent role in integrating and steering the issue resolution process as it is described in Sections 8.3.5.8 and 8.1; nevertheless, an appropriate degree of integration across disciplinary lines through performance assessment considerations is apparently lacking at the investigation level. Individual investigations and plans for the several disciplines seem to be plausible and have an appropriate degree of internal consistency (although the NRC has provided numerous comments on a lack of integration and internal consistency within particular subject areas). For example, there is no table or text that purports to show that the set of tests proposed for any one discipline will not interfere with those proposed for another (except in the limited context of the ESF); such a consideration needs to be performed in a comprehensive, consistent manner. It has not been demonstrated that the hypothesis testing tables developed according to the various disciplines will assure that all important alternative conceptual models are identified and that the tests to evaluate such alternatives are planned and there is no hypothesis testing table for total system performance.

- The text in Section 8.1 (e.g. Figure 8.1.2) indicates that the issue resolution strategy requires iteration of analyses after acquisition of some data to determine the need for further site characterization. For example, page 8.1-16 states:

  "Periodic performance assessments will be conducted to evaluate the performance measures for the issue on the basis of the available information (step 10c). This evaluation will involve sensitivity and uncertainty analysis of the parameters of the models and analysis of the validity of the models. Alternative conceptual models will also be evaluated."

However, elsewhere the text asserts:

  "While many of the critical elements needed for the full performance assessments will be completed early, others that will be needed will not be completed until much later, and some not until the end of site characterization. To wait until the complete set of information is available to evaluate the testing is not prudent. Therefore, elements of this program will be evaluated individually with respect to adequacy of the information obtained without resorting to full performance assessments."

These statements appear to be contradictory, or at least inconsistent. It is unclear how elements of the program can be evaluated individually when the goal of the repository is to provide reasonable assurance that it will, acting as a system, adequately isolate waste.

° Although the text is equivocal the schedules in Sections 8.2 (Figure 8.2-6) and 8.3.5.13 (Figure 8.3.5.13-7) are clear. No intermediate performance assessments are scheduled until the near the end of site characterization. In Section 8.3.5.13, Table 8.3.5.13-19, Major Event "E" - Complete interim probabilistic analysis of performance of the total system, July 1993. Note that the Total system performance assessment calculations available for the DEIS, Major Event "F" is scheduled for August 1993. This is insufficient review and reaction time for the first time availability of this analysis. The Updated total system performance assessment calculations available, Major Event "G" is scheduled for May 1994 for inclusion in the License Application in early 1995.

RECOMMENDATION

° Integrate performance assessment considerations into the site characterization program using the total system performance assessments, performed in an interactive fashion, to evaluate and guide site characterization activities, so that: (1) the information required for licensing will be obtained, (2) the information required for licensing will not be precluded from being obtained, and (3) the site characterization activities will not irreparably damage the ability of the site to isolate waste.

° Considering that the DOE has prepared several preliminary performance assessments (in general for expected conditions; Sinnock et al. 1984, Sinnock et al. 1986, Thompson et al. 1984, DOE 1986 - Environmental Assessment) it is not clear why more use was not made of these analyses and sensitivity and uncertainty analyses performed on the quantitative methods used for them in the development of the site characterization program and as an aid to implementing the performance allocation process.

Section 8.3.5.13 Total System Performance

OBJECTION NAE4

The underlying methodological logic that is used to develop and screen scenarios and its implementation in the SCP is not correct for the generation of a CCDF representative of total system performance; therefore, this approach is unsuitable for guiding the site characterization program, even if allowances are made for the current lack of knowledge about the site and the expediences required to develop the site characterization program.

BASIS

- Comment 94 on the CDSCP was addressed by providing more detail in additional text. However, as discussed in the points below, the new text does resolve the comment. Although Question 46 on the CDSCP was answered in part, the text fails to address important issues of mathematical robustness and fails to provide confidence that site characterization will obtain data needed to analyze all the scenarios that need to be treated in the CCDF.

- With regard to the recommendaton in CDSCP Comment 94: (1) the scenario selection and screening procedures articulated in the SCP do not contain explicit criteria or the justification for them; (2) the scenario selection and screening procedures are not systematic, nor do they provide assurance of completeness, (3) the inappropriate formal use of expert judgment is discussed in Objection PPB6.

° The five scenario classes listed in Table 8.3.5.13-3 are used to develop the performance allocation for total system performance (Table 8.3.5.13-8) that guides the site characterization program for resolution of Issue 1.1. Table 8.3.5.13-2 correlates the five scenario classes with 49 other scenario classes of unspecified origin (in column 2 of the Table), some of the 99 Ross scenario sequences, and some of the scenarios considered in the Decision Aiding Methodology. Neither the Tables nor the accompanying text provide a suitable relationship among the various sets of scenarios and scenario classes to show: (1) how these scenario classes relate to the discussions of constructing the CCDF and (2) how the particular set chosen is adequate for the purposes of site characterization.

° The "scenario classes" listed in Table 8.3.5.13-3 are used as the basis for performance allocation; however, because one scenario may fit into more than one of these groupings, they are not mutually exclusive and, therefore, not appropriate for development of a CCDF. Also, it is not clear that these groupings include all significant scenarios (another requirement of the CCDF). For example, Table 8.3.5.13-2 does not map all Ross sequences into the five groupings (Ross sequences 17-22, for example).

° As defined in the SCP, the "nominal scenario class" is so improbable as to be of marginal significance. It does not seem appropriate to plan site characterization based on a set of "scenarios" which are unlikely to even occur.

- As a practical matter it does not appear that the DOE will be able to generate the joint distribution function F(1), or that the site characterization program will provide any input given that the five "scenario classes" (A-E) which form the basis of performance allocation are defined in a manner inconsistent with the mathematical definitions of this text. Equation 8.3.5.13-6 defines the conditional CCDF for a "scenario." Equation 8.3.5.13-4 defines the basis of calculating the CCDF as the expectation integral given by equation 8.3.5.13-3. The expectation integral is defined in terms of the joint distribution function F(dv), which is defined as the distribution over the entire set of state variables and their range for all eventualities. It does not appear that the use of the expectation integral as implied in equation 8.3.5.13-6 has a precise mathematical meaning, since the expectation integral has not been explicitly defined for a "scenario."

- The approach to defining scenarios used in the Ross report is to begin with a comprehensive list of external events and processes that could affect the repository performance and screen these entities and their combinations for significance for Yucca Mountain. An alternative approach is to look at the Yucca Mountain repository, to determine which subsystems are critical to waste isolation, and to define conditions or events that will compromise these subsystems; this is the central focus of most PRA. At the bottom of page 8.3.5.13-25 and in Table 8.3.5.13-2 the idea is articulated that some combination of these two approaches is being used to define scenarios for the purpose of guiding the site characterization effort. (Table 8.3.5.13-2 attempts to relate the Ross scenarios to scenarios defined on the basis of major barrier affected.) It is not clear how consistency, completeness, and mutual exclusivity of scenarios is achieved where a combination of approaches is used since this is conventionally assured by consistent use of one approach or another.

RECOMMENDATIONS

- The approach to scenario analysis and how it is being employed to guide the site characterization program must be clarified or redone.
First Recommendation from CDSCP

- In particular, the following aspects require correction:

  - Performance allocation and consideration of alternative conceptual models must be performed in the context of a reasonable number of real, mutually exclusive, important scenarios or scenario classes - not the objects listed in Table 8.3.5.13-3.

  - Consideration of sets of scenarios, sets of scenario classes, and sets of other objects derived in various references and other sources must be rationalized rather than merging them without consideration of their derivation and logical consistency, as is apparently the case in the SCP.

Section 8.3.1 Site Program (8.3.1 through 8.3.1.17)

OBJECTION NAE 7

The hypothesis testing (alternative conceptual model) tables included in Sections 8.3.1 (The Site Program), 8.3.2. (Repository Program), 8.3.3 (Seal Program, 8.3.4 (Waste Package) represent an improvement over the CDSCP in assuring the adequacy of the site program to provide data to distinguish between alternative conceptual models of site performance. However, the alternative conceptual model tables are, in part, logically inconsistent, incomplete and in a number of instances cite studies that do not address distinguishing between the alternative conceptual models listed. Accordingly, it is not clear as presently planned the site investigations will provide the needed data.

BASIS

- The Objection 1 to the CDSCP stands.

- The Objection concerned inadequate attention to articulating and differentiating between alternative conceptual models in planning the site characterization program. The SCP provides considerable discussion of alternative conceptual models and site investigations to evaluate them; however, the information provided in the hypothesis testing tables appears to be insufficient to resolve the concerns in that: (1) significant alternatives to those conceptual models used to generate the performance allocation are not listed in the hypothesis testing tables; (2) the "Need to Reduce Uncertainty" entry (essentially the importance of a particular alternative conceptual model) does not appear to be derived in a logical fashion from the other entries in the table for that alternative conceptual model; (3) the rationale for the table entries in columns 2 through 7 (see page 8.3.1.2-51) does not always appear to be logical and supportable and; (4) the studies cited to provide the information required to distinguish between the current conceptual model and the stated alternative do not appear to do so in a number of instances.

- When viewed as an entity the internal logic of the hypothesis testing tables appears to be flawed. The SCP states that the judgement entered in the eighth column of the hypothesis testing tables (need to reduce uncertainty in the selection of hypotheses (i.e., the need to gather site data of a particular type) is based upon the judgements entered in columns 3 (uncertainty and rationale); 7, (sensitivity of the performance parameters to alternative hypotheses); 6, (the significance and needed confidence of affected performance parameters), and the likelihood that feasible data-gathering activities could significantly reduce uncertainty (which is not entered in the tables). There are several instances where all the entries in two different rows are the same, but the column eight entries are different (e.g., p. 8.3.1.2-52, rows 1 and 2; p. 8.3.1.2-55, rows 1 and 2); this seems to violate rules of internal logical consistency.

In other cases (e.g., p. 8.3.1.2-54, rows 1 and 2) all entries are the same except for column 3, uncertainty in current conceptual models; it seems inconsistent that for this condition the need to reduce uncertainty is the same.

- Other comments support the concern that the treatment of alternative conceptual models in the hypothesis testing tables of the SCP will not assure that: (1) the site characterization program will explore all significant alternatives, and therefore (2) the gathering of certain kinds of essential data will not be precluded.

EXAMPLES

- Column 3, (Uncertainty and rationale). The rationale provided for the level of uncertainty stated is questionable; p. 8.3.1.2-60, row 2; p. 8.3.1.2-61, row 3; p. 8.3.1.2-65, row 3.

- Column 4, (Alternative hypothesis). The stated entry does not appear to be an acceptable alternative to the current concept stated in column 2, p. 8.3.1.2-54, row 1; p. 8.3.1.2-55, row 2; p. 8.3.1.2-56, row 3; p. 8.3.1.2-64, row 3; p. 8.3.1.2-65, row 1.

- Column 7, (Sensitivity of parameter of performance measure to hypothesis). The rationale provided for the stated level of sensitivity seems questionable, p. 8.3.1.2-55, row 3; p. 8.3.1.2-61, row 3.

- Column 8, (Need to reduce uncertainty). "Need to reduce uncertainty" logic may be faulty, p. 8.3.1.2-56, row 3; p. 8.3.1.2-57, row 2; p. 8.3.1.2-58, row 1; p. 8.3.1.2-61, row 3; p. 8.3.1.2-62, rows 1, 2 & 3; p. 8.3.1.2-63, row 1; p. 8.3.1.2-66, row 2; p. 8.3.1.2-66, row 3; p. 8.3.1.2-67, row 1.

- Column 9, (Studies or activities to reduce uncertainty). Studies cited do not appear to address clearly distinguishing between the current concept and the alternative, p. 8.3.1.2-56, row 1; p. 8.3.1.2-59, row 1.

RECOMMENDATION

- The hypothesis testing tables should be redone and appropriate modifications made to the site characterization program. Until a firmer, logical, rational basis for the treatment of alternative conceptual models is achieved and articulated, site characterization activities should be postponed.

Section 8.1 Rationale for the Site Program.

OBJECTION PPB3

The initial performance allocation contains gaps between identified performance parameters and the parameters that would actually be determined by the investigations. As a consequence, all potentially significant information needs may not be identified and it cannot be determined whether conducting one investigation would interfere with, possibly to the point of precluding, another investigation needed to obtain information for licensing.

BASIS

- In response to CDSCP Question 52, discussions of how performance allocation was used to identify the information needed to resolve each performance and design issue are in Section 8.3.1.1, Site Overview. The general principles described there, however, are not consistently followed in the SCP.

- In describing the performance allocation process on p.8.3.1.1-5, it is stated that the information needs are expressed in terms of design and performance parameters. Then, to establish the values of the performance parameters, more detailed characterization parameters which have associated goals and levels of confidence are defined. Characterization parameters, in turn, can be established by scientific investigation. Activity parameters, those parameters to be generated empirically, (e.g., hydraulic gradient for two-dimensional models) are also used. They do not have associated goals and levels of confidence.

- In response to CDSCP Question 87 the SCP has added Activity Tables which relate performance parameters to activity parameters at a general level of detail. This does not provide the explicit linkage between the performance parameters and site investigations that is needed to assure that the right information will be available to do performance assessments. In fact, this need is acknowledged in the Response Document (U.S. Department of Energy, 1988, page c-115) where it is indicated that more explicit linkages between the performance parameters needed for issue resolution and information from the testing program than given in the activity parameters tables will be provided during site characterization rather than in the initial performance allocation.

- Examples of insufficient correlation of studies and activities with performance parameters and characterization parameters and specific hypotheses are presented in bullet 3 of the basis of Comment JAP1, which points out that the lack of such correlation for coupled interaction tests calls into question the testing program for evaluating the thermal response of the hydrogeologic system.

- Until such linkages are provided the initial performance allocation and performance assessment is not fully integrated into site characterization.

RECOMMENDATION

- The highest priority should be given to completing the performance allocation so that site characterization activities can be fully integrated into the issue resolution process and interim performance assessments.

- Detailed characterization parameters and associated goals and levels of confidence should be defined as part of each performance allocation.

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.

NRC/DOE Meeting on Performance Allocation, April 17, 1985, Silver Spring, Md.

Section 8.3.5.20 Analytical Techniques Requiring Significant Development

OBJECTION DJF 1

The SCP correctly notes the importance of model and code validation for evaluating repository acceptability, but lacks an adequate description of the plans for completing such validation. Many potential validation studies require long lead times for planning and execution, and some may be impossible to carry out after the site has been disturbed by characterization and development activities. After DOE has identified a full range of alternative conceptual models, DOE should ensure that adequate plans have been developed for validating the models and the codes associated with them.

BASIS

- SCP correctly notes the importance of model and code validation for evaluating repository acceptability.

- Many potential validation studies require long lead times for planning and execution, and some may be impossible to carry out if not planned for before the site is disturbed by characterization and development activities.

- Failure to properly plan for model and code validation could cause a potential significant disruption to characterization schedules or sequencing of studies that would substantially reduce the ability of DOE to obtain information necessary for licensing.

- This objection is a direct corollary of Objection NAE 7 regarding identification of alternative conceptual models. Until a complete set of alternative models has been identified, it is impossible to be assured that all necessary model validation studies have been included in the site characterization plans.

RECOMMENDATIONS

- Develop plans for model and code validation prior to initiating site characterization activities. Validation plans should focus on validation of models used to demonstrate compliance with the four quantitative performance standards, to ensure coordination of validation and site characterization activities.

Section 8.3 Planned Tests, Analyses, and Studies

OBJECTION PPB6

The SCP describes a program that appears to rely too heavily on the Formal Use of Expert Judgement (Expert Elicitations) to supply licensing information and data. It is not acceptable to rely on subjective methods of resolving specific issues when objective methods are available. To the extent that an application of expert elicitation is planned when an empirical approach is available, investigations that should be considered in the SCP are not and the SCP does not lay out a full program of investigations needed for the license application. Therefore, it cannot be determined whether one investigation might preclude a potentially significant investigation.

BASIS

- As noted in CDSCP Comment 4, the use of expert elicitation will be examined to determine whether the subjective approach was necessary because objective approaches were unavailable.

- One way in which expert elicitation would be will be inappropriately relied on is noted in Comment NAE 1. Weighting alternative conceptual models according to the judgement that they are likely to be correct is, at best, a poor substitute for field studies to determine which model is correct.

RECOMMENDATION

- Reevaluate the plan to assure that empirical methods are incorporated in preference to expert elicitation wherever possible.

Section 8.3.5.13 Total System Performance

COMMENT NAE 1

Weighting alternative conceptual models according to the judgement that they are likely to be correct and using such "probabilities" to weight consequences in the construction of the CCDF is not a conservative estimate of repository performance, nor is it an advisable approach for demonstrating compliance.

BASIS

- Comment 91 on the CDSCP has been responded to by adding explanatory text, but the stated approach does not resolve the NRC staff's concern.

- Important objectives of site characterization are (1) to provide the basis for the analysis of a set of sufficiently complete, mutually exclusive scenarios (or scenario classes) and (2) to provide the basis for choosing between significant alternative conceptual models. If site characterization fails to establish a sufficient information base to distinguish between significant alternative conceptual models, expert judgement per se cannot add anything more. A site characterization plan that presumes recourse to a strategy of relying on expert judgement to substitute for missing data may be substantially flawed (see objection PPB2).

* 10 CFR 60.122(a) requires, in part:

"In order to show that a potentially adverse condition does not so compromise the performance of the geologic repository the following must be demonstrated:

(i) The potentially adverse human activity or natural condition has been adequately investigated, including the adequately investigated, including the extent to which the condition may be present and still be undetected taking into account the degree of resolution achieved by the investigations; and

(ii) The effect of the potentially adverse human activity or natural condition on the site has been adequately evaluated using analyses which are sensitive to the potentially adverse human activity or natural condition and assumptions which are not likely to underestimate its effect;..."

The analytical approach stated in the SCP has the potential to underestimate the effects of potentially adverse conditions and, because alternative concepts are averaged, may not be sensitive to such conditions. Further, this approach does not indicate that criteria will be set to determine whether various potentially present conditions have been adequately investigated. Neither does the approach indicate how "the extent to which the condition may be present and still be undetected" will be incorporated into the weighting factors for various alternative conceptual models.

- In discussions of the strategy to show compliance with the EPA standard, alternative conceptual models of site behavior are still considered to be in the same category as "scenarios" as used in the context of the EPA HLW standard. Such a rendering misconstrues the intent of the EPA standard and the NRC interpretation of it, in which only uncertainties related to future states of nature (scenarios) and variation in model parameters are encorporated in the CCDF. The approach is suspect because the subjective probability that a particular conceptual model is correct is a different type or meaning of probability from the occurrence probability of future events and from the possible system realizations based on spatial variability of geologic parameters. Although the approach may be mathematically satisfactory from a purely theoretical perspective, from a decision theoretic viewpoint it is undesireable, because it mixes uncertainties rather than segregating them so decision-makers can more readily evaluate their import.

- Page 8.3.5.13-7. Item 7 in the list of "highly aggregated state variables for the Yucca Mountain system" is "The effective weights assigned by professional judgment to alternative conceptual models of some site phenomenon or the response of the system to a known site phenomenon." Unlike the occurrence or non-occurrence of some future event or the realization of certain parameter values, the correctness of a conceptual model is not a "state variable."

° Page 8.3.5.13-13 and Figure 8.3.5.13-2. Alternative conceptual models of recharge are treated in the same fashion as event occurrences. Site characterization should be conducted to distinguish between important alternative conceptual models or to calculate the CCDF in a conservative fashion given insufficient evidence from site characterization to eliminate alternative conceptual models.

° Page 8.3.5.13-44. Five "undetected features" are included in the set of "agents" used to estimate how many independent scenario classes must be considered. Undetected features should not be treated as scenarios.

RECOMMENDATIONS

° The SCP should recognize that the approach of incorporating alternative conceptual model likelihoods into the computation of the CCDF of cumulative releases of radionuclides may not provide information about repository performance in a format acceptable to the NRC staff or Licensing Board, because uncertainties are not delineated distinctly.

° Plan to incorporate consideration of unresolved alternative conceptual models into the CCDF in a conservative fashion by choosing the alternative that gives the poorest performance (greatest releases of radionuclides) or by some combination of the two alternatives that overestimates releases and develop the site characterization program accordingly.

Section 8.3.5.13 Total System Performance

COMMENT NAE 2

For some scenario classes in which a particular release mode is thought to dominate or, at least, dominate for a particular time period, the consequences that are calculated may not be adequately represented unless all the release modes are quantified, especially the residual part of the inventory continuing to participate in the nominal or undisturbed mode(s) of release. Premature and inappropriate limiting of the consequence analysis in this way may distort the performance allocation process so that insufficient priority is placed on some data or important data acquisition activities may be omitted from site characterization.

BASIS

° Page 8.3.5.13-25 (first paragraph) states "... for some scenario classes, such as drilling scenarios, the direct-pathways mode may be considered to dominate." Although the direct pathway mode may dominate at the time of excavation of some waste during drilling, the remainder of the waste not excavated by drilling will continue to release radionuclides to the accessible environment in a manner that prevailed prior to drilling, as modified by the effects on liquid and gas pathways by the drilling. Although the excavated waste may provide a substantial "spike" of releases at the time of excavation, the waste released in a less disturbed fashion may still be considerable and make a substantial contribution to the CCDF.

- Page 8.3.5.13-53. "Some of the scenario classes result in direct discharge of radionuclides to the surface. Others result in indirect releases; that is they produce movement of radionuclides through the barriers of the repository system to the accessible environment. The table labels the scenario classes according to these modes of release." In fact, virtually all scenarios produce releases by several modes. If the intention is to classify scenarios by the "featured" mode of release that may be appropriate for certain applications. Recognize, however, that the "featured" mode of release may not be the same as the dominant mode of release because without a calculation to support the assertion it is not clear that specifically a particular featured mode of release, such as direct exposure to a small fraction of the emplaced waste, may be smaller than the ongoing mode(s) of release from the unaffected waste. Therefore, use of a single mode of release to calculate consequences for a given scenario is acceptable only when calculations show that the releases by modes that have been omitted do not contribute to the CCDF in a substantial fashion, either individually or aggregated over the entire range of scenarios.

RECOMMENDATIONS

- Plan to include all appropriate modes of release in calculating the consequences of every scenario class; these modes should not be eliminated unless an analysis is provided that shows that leaving them out of the analysis has no significant effect on the CCDF.

- In calculating consequences of a scenario it is acceptable to partition the waste inventory according to the mode of release, but the release from all modes should be calculated. It is not acceptable to partition the waste and not account for the ultimate fate of part of the waste.

- The confidence and goals in the performance allocation process should be determined by considering all modes of release from each scenario with appropriate consideration of the magnitudes of release from different modes.

NAEisenberg 4/27/89

Section 8.3.5.13 Total System Performance

COMMENT NAE3

There are two problems with the sequences for faulty waste emplacement (pp. 8.35.13-32 to 33): (1) sequences for faulty waste emplacement establish the initial condition for the repository at time of closure and should not be included in the set of scenarios and (2) the sequences are so limited, it is not clear that the site characterization program will acquire the data to analyze the likelihood and consequences of such initial defects.

BASIS

- Sequences related to faulty waste emplacement establish the initial condition of the repository at the time of closure. The likelihood of such sequences could be used to establish the "most likely" configuration of the ensemble of waste packages in the repository or to establish a set of initial repository configurations with their associated probabilities. In either case such configurations would be acted upon by all postclosure scenarios, so a treatment of the initial repository configuration(s) as a separate scenario(s) is incorrect, because such combinations would be precluded.

- There is no clear indication that the sequences cited in this part of the SCP are sufficiently complete to assure that the data required to analyze the given examples and other sequences related to human error will be acquired during site characterization.

° Human reliability analyses have been performed for the repository system, but are not cited here as the basis for the set of sequences listed. (e.g., Harris, 1985)

° Clearly some important sequences are omitted, e.g.: (1) canisters are emplaced in such a way that the air gap which is an integral part of the design for the package is eliminated by drilling the hole too small, tilting the canister in the hole, or placing the canister in the hole off-center; (2) extraneous materials may be introduced into the repository during construction or operation which will help to mobilize the radionuclides, enhance corrosion, or otherwise adversely affect performance.

RECOMMENDATION

° Use these sequences to establish (by modeling) the initial configuration for the repository; do not use these sequences as objects parallel to scenarios. Prudent engineering practice would dictate instituting design, operational, and QA controls sufficient to reduce the occurrence of this type of sequence to a level sufficiently low so as not to affect materially the performance of the repository.

- Systematically analyze human reliability in terms of the effect on postclosure performance to assure that all required data are obtained during site characterization. This could be provided in a periodic update.

References

Harris, P.A. et al., "High-Level Waste Preclosure Systems Safety Analysis Phase 1, Final Report," NUREG/CR 4303 (July 1985).

Section 8.3.5.13 Total System Performance

COMMENT NAE 5

The presence of the term r sub i in equation 8.3.5.13-21 in the denominator and in the argument of an exponential term implies that the fractional release rate is constant in time and that the quantity of radionuclide released from the EBS decreases exponentially, as does the remaining waste inventory; such a view is inconsistent with the basis for the numerical value of r sub i, where it is assumed that the solubility limit determines the value.

BASIS

- Equation 8.3.5.13-21 indicates that r sub i is responsible for an exponential decay of the source term dependent on the "fractional mass release rate" in the liquid phase. Equation 8.31.5.13-22 assumes that the quantity of mass transferred from the EBS equals the flux of water past the EBS multiplied by the solubility limit of the radionuclide in question. As long as any undissolved waste remains, the solubility limit will be the radionuclide concentration in the water flowing past the repository. As a simple analysis for purposes of the site characterization program, assuming that the radionuclide concentration is the solubility limit is acceptable. However, such an assumption leads to the conclusion that the quantity of a radionuclide released per unit time is constant from the time the waste is available for dissolution until the time that all the waste is dissolved. Thus the fractional release rate given by equation 8.3.5.13-22 increases exponentially in time.

- By assuming that the source term decays exponentially in time with the coefficient of release fraction (assumed to be constant in time), the release of radionuclides to the accessible environment is underestimated. This occurs because the assumed affect of the natural system is to delay the arrival of the radionuclides at the accessible environment thereby allowing radioactive decay to reduce the cumulative release. The effectiveness of the natural system in reducing cumulative releases is enhanced if the source term is spread out in time as with the exponentially decaying source term assumed.

RECOMMENDATION

- Do not use this analysis to screen scenarios or estimate EPPM's for the site characterization program.

- Do not use this analysis in a simplified systems model to calculate the CCDF in the LA.

- If mass transfer from the EBS is considered to be controlled by the solubility limit of the waste in the fluid surrounding the package, a constant release rate should be used for a time period equal in duration to the time required to dissolve all the waste at that constant rate; if mass transfer in the EBS is considered to be controlled by the amount of waste remaining and available for dissolution, then a rate dependent on mass present should be derived and used.

- The various release rate models for the EBS are important alternatives that should be evaluated by site characterization investigations.

Section 8.3.5.13

COMMENT NAE 6

The model for Ross sequences number 10 (p. 8.3.5.13-29), 14 and 15 (p. 8.3.5.13-30) seems to be at variance with the hydrologic model of flow at Yucca Mountain because the basis for developing scenarios to guide the site characterization program appears to be inconsistent (as in this case), site characterization may fail to provide to information needed for licensing.

BASIS

- In discussing conceptual models for the site p. 8.3.5.8-7 states, "The most probable water flow path from the repository to the accessible environment is currently thought to be vertically downward through the unsaturated Topopah Spring, Calico Hills, and Crater Flat units to the water table, and then horizontal below the water table."

- In discussing Ross sequence number 10 the text states, "Occasional major floods provide sufficient infiltration to overcome the capillary barrier that usually diverts flow laterally,..."

- In discussing Ross sequence number 14 the text states, "...The fault thus forms a 'trap' for laterally moving moisture in the Tiva Canyon welded unit..."

- In discussing Ross sequence number 15 the text states, "Fracturing along a newly mobilized fault creates a permeable pathway through the flow barrier north of the repository block. The magnitude of the resulting change in the flow system is sufficient to raise the water table under the repository..." This assumes a significant horizontal groundwater gradient and induced lateral flow.

RECOMMENDATION

- Events in scenarios can certainly change the prevailing conceptual model of the site; however, the effect of events should not be predicated on differing conceptual models, except in an exhaustive and systematic fashion.

- The discussion of Ross sequences should be consistent with the current conceptual model of site hydrology or, if non-vertical flow is anticipated near the ground surface, the description of Ross sequence number 10 should be clarified; any added text in 8.3.5.8 and the hydrology chapter should be cross-referenced.

F

Section 8.3.5.13 Total System Performance

COMMENT NAE 8

Ross sequence numbers 59-62 and 64-69 appear to characterize either anticipated conditions or alternative conceptual models, rather than scenarios.

BASIS

- Ross sequences 59-62 characterize the effect of heat from the emplaced waste on the hydrologic environment (the movement and chemistry of the water) near the repository.

- Ross sequences 64-69 characterize different types of corrosion or different manifestations of corrosion.

RECOMMENDATION

- Such effects should be included in the model of repository behavior or proposed as alternative conceptual models and investigated during site characterization.

- These should not be classed as scenarios or sequences.

Section 8.3.5.13 Total Sytem Performance

COMMENT NAE 9

The Ross sequences appear to be based entirely on spent fuel as the waste form; since these sequences presumably form a basis for the site characterization program, it is not clear that important scenarios that may be peculiar to vitrified HLW have not been omitted.

BASIS

- Sequences 68, 72, and 83 specifically mention "cladding" or "Zircalloy cladding," which is characteristic of spent fuel.

- No sequences specifically for vitrified HLW were identified.

RECOMMENDATION

- Reconsider scenario analysis for the site characterization program with the likelihood that a significant amount of vitrified HLW will be deposited in the repository.

- Augment or modify the site characterization program, performance allocation, and hypothesis testing strategy as necessary to effectively treat vitrified HLW.

Section 8.3.5.13 Total System Performance

COMMENT NAE 10

In Ross sequence 70 it is proposed that water in contact with the waste contains ions that simultaneously cause precipitation of uranium and increase the rate of fuel dissolution.

BASIS

- This appears to be inconsistent with the principles of geochemistry.

- If ions present in the groundwater cause precipitation of uranium, then the concentration of uranium in the water near the fuel will decrease. All other things being equal a decrease in uranium concentration in the water in contact with the waste will cause an increase in the rate of waste dissolution. However, the same ion content that causes the dissolved uranium to precipitate will lower the solubility of uranium in the groundwater. In fact, it may not be possible to distinguish between ionic content that causes lower solubility and ionic content that causes precipitation.

RECOMMENDATION

- This sequence should be eliminated from consideration or better explained, since it appears to be spurious.

Section 8.3.5.13 Total System Performance

COMMENT NAE 11

Scenarios, screened out as part of developing the site characterization strategy and program or as part of some other NWPA activity pursued by DOE, but not under review by NRC, may need to be revisited and discussed as part of the license application, since decisions made outside the NRC licensing process cannot automatically be accorded standing.

BASIS

- Page 8.3.5.13-46, 2nd paragraph states: "In general, the scenarios eliminated by Ross (1987) and those scenarios screened out as part of the DOE decision-aiding methodology (1986a) are assumed to be inapplicable at Yucca Mountain."

- 10 CFR 60.21(c)(1)(ii)(C) requires that the SAR contain an evaluation of postclosure performance of the repository; this requirement mandates a justification of the anticipated and unanticipated processes and events (scenarios) used as the basis for estimating performance.

- 10 CFR 60.23 allows incorporation of material by reference in the license application; such incorporation by reference does not mean the conclusions of the references are exempt from challenge, review, and litigation during the licensing hearing.

- Elimination of certain scenarios, as in the cited references, may be appropriate for the purposes of site characterization; however, the justification for such eliminations must be included in the documentation for the SAR.

RECOMMENDATION

- The DOE is cautioned to bear in mind that, although substantial technical evidence will be amassed, documentation provided, and tentative agreement on issue resolution reached with the NRC staff, resolution of issues key to licensing and the technical basis supporting the resolution cannot be concluded prior to licensing, except by rulemaking.

Section 8.3.5.13 Total System Performance

COMMENT NAE 12

There appears to be a missing coupling term in equation 8.3.5.13-12B; this equation is the primary basis for calculating liquid-phase radionuclide transport to the accessible environment.

BASIS

- The matrix/fracture coupling terms represented by lambda sub 1 for the advective coupling constant and by lambda sub 2 super i for the diffusive coupling constant both appear in equation 8.3.5.13-12A but only the diffusive coupling constant appears in equation 8.3.5.13-12B. This lack of reciprocity in coupling could be inadvertent or it could be deliberate, based on unstated assumptions about the size of these terms. If deliberate, the basis should be stated.

- Equation 25 of the cited reference (Wilson and Dudley, 1987), which appears parallel to equation 8.3.5.13-12B of the SCP contains both coupling terms.

- The importance of these coupling terms in determining system performance is cited repeatedly, pp. 8.3.5.13-62, -71, and -75.

RECOMMENDATION

- DOE should clarify equations 8.3.5.13-12 and make any adjustments necessary in the plans for site characterization that could result from changing these fundamental equations describing radionuclide transport through the primary geologic barrier.

Section 8.3.5.13 Total System Performance

COMMENT NAE 13

Although the introduction of a waiting time in equation 8.3.5.13-24 may, in general, be acceptable from a theoretical viewpoint, care must be taken to assure a correct implementation of the concept, both in generating an empirical CCDF and in approximating performance for purposes of guiding site characterization.

BASIS

- Comment 93 on the CDSCP has been responded to by adding clarifying text. some of the important caveats cited in the "Responses to NRC Point Papers" documents are not captured in the SCP text. Many facets of the comment still stand, but concerns are now more focussed.

- On page 8.3.5.13-70 "waiting time" is defined as the "time, after closure, before the first occurrence of an initiating event or process that may lead to a release (yr)."

- Clearly this definition of "waiting time" presumes a random variable; it is not clear from the discussion of the use of waiting time to calculate performance, as in equation 8.3.5.13-21, that a random variable, rather than a fixed value (perhaps the mean) is intended. Because of the way that time enters these equations, use of the mean waiting time will virtually never yield the average performance.

- The time frame from which waiting time is reckoned is implied to be t=0; for many, if not most, geological processes a weighting time measured from closure of the repository rather than last occurrence of event will introduce considerable error.

- For example, evidence appears to indicate that the site is in a state of incipient faulting, so the appropriate waiting time for these events is zero.

- The use of the waiting time concept could preclude accurate representation of certain events and processes, like tectonic activity, known to occur in clusters. Use of waiting times based on data where event occurrence is rare may underestimate true waiting time over the period of performance of the repository, estimation of waiting time based on data where occurrences are frequent may be too pessimistic. In either case this may be an unnecessary limitation in how to treat such occurrences.

- Since alternative conceptual models, undetected features, and scenarios are put on an equal footing, how is it proposed to define waiting times for alternative conceptual models and undetected features?

RECOMMENDATIONS

- At an early opportunity the DOE should clarify the limitations on the use of "waiting times" and discuss how these limitations will be reflected in the proposed DOE use of the concept.

- In the event that an inappropriate or incorrect use of the waiting time concept has led to the premature removal from consideration of a scenario or an incorrect performance allocation, the DOE should amend the site characterization program at an early opportunity.

Section 8.3.5.14 Total System Performance

COMMENT NAE 14

The strategy for issue 1.2, Chapter 8.3.5.14, assumes that if there is no significant source of groundwater at the Yucca Mountain site, then all environmental pathways for individual exposure related to radionuclide borne by groundwater are precluded.

BASIS

- The logic diagram for resolution of Issue 1.2 (Figure 8.3.5.14-1) indicates that if there is no "significant source of groundwater" (as defined in the EPA standards) at the Yucca Mountain site, then positive resolution of the Issue depends only on gaseous release of carbon-14. If there is a significant source of groundwater, only consumption of drinking water is considered as an environmental pathway.

- The EPA standard requires limiting individual dose at 1000 years after closure. Although guidance is provided by EPA for daily consumption of groundwater, individual dose is not limited to this pathway. Other pathways could include: (1) use of groundwater for irrigation, (2) rapid transport by groundwater to the surface followed by air dispersion of dusts and evaporites, (3) contamination without irrigation of soil used to grow crops.

- The proposed resolution strategy does not include DOE spelling out its proposed §60.121 controls and evaluation of their efficiency as part of the evaluation of which pathways to include.

RECOMMENDATION

- Change the resolution strategy for this issue.

- There are two points: (1) if there is no "significant source of drinking water," pathways other than drinking water need to be included in the demonstration of compliance and (2) if there is not a "significant source of drinking water," exposure of one or more individuals may still be plausible via drinking water and other liquid pathways.

- Change performance allocation to conform to a modified issue resolution strategy.

Section 8.3.5.14 Individual Protection

COMMENT NAE 15

The discussion of individual exposure through the gaseous pathway indicates that "residence time" of carbon-14 in the overburden is required, but the discussion of planned activities and information needs does not indicate that the advective and diffusive flow rates of radionuclides transport will be obtained; without these fundamental quantities, information on retardation will be of no use and calculation of residence time will be impossible.

BASIS

The discussion on page 8.3.5.14-11 does not indicate that the diffusive and advective transport of gaseous radionuclides will be obtained specifically to resolve Issue 1.2, nor is it indicated how this information will be imported from activities to resolve other issues.

RECOMMENDATION

- Amend the performance allocation table for this Issue and, if necessary, modify the site characterization program.

SCP/NAE/COM/16

F

Section 8.3.5.13 Total System Performance

COMMENT NAE 16

The use of the EPPM (expected partial performance measure) to screen scenarios and to establish goals for the performance allocation used to guide site characterization may be justified on a theoretical basis, but appears to be flawed as implemented in the SCP.

BASIS

- DOE has responded to NRC Comment #92 on the CDSCP by providing further explanation of the mathematical substantiation for the use of the EPPM (expected partial performance measure). Pages 8.3.5.13-16 to 18 provide an expanded mathematical basis for the use of EPPM's in screening scenarios.

- Although equation 8.3.5.13-9 provides a sufficient condition (sum of EPPM's over all scenario classes is less than or equal to 0.01) for compliance with the EPA standard, the performance allocation table for Issue 1.1 (Table 8.3.5.13-8) erroneously departs from the more-or-less well founded mathematical basis by: (1) stating goals in terms of individual EPPM's instead of the sum; (2) setting goals as high as 0.2 for individual EPPM's; (3) stating goal for EPPM's for objects (release scenario classes) that are not scenarios or scenario classes in the sense used to derive the mathematical substantiation for the use of EPPM's. As a consequence meeting the goals stated in this performance allocation table will not assure compliance with the regulation and resolution of the issue.

- Page 8.3.5.13-18 (first paragraph). DOE discusses how an upper bound for an EPPM can be constructed and then used to screen out potentially disruptive agents. However, the discussion does not consider the possibility that many individually insignificant EPPMs could be screened out but whose sum might be significant. For example, if the screening criteria is that an EPPM be less than 10^6, and if 10,000 EPPMs are screened out, their sum might conceivably be as large as 0.01 (the limit in Equation 8.3.5.13-9).

RECOMMENDATION

- Reconsider the performance allocation for Issue 1.1 with the proper use of EPPM's or some other valid mathematical approach and adjust the site characterization program accordingly.

- State that, in applying the screening methodology, it is necessary to check that the sum of <u>all</u> EPPMs screened out must be much less than 0.01.

F

Section 8.3.5.13 Total System Performance

COMMENT NAE 17

Coupling times for the transfer of mass (radionuclides) between matrix and fracture flow is repeatedly cited as a key factor in determining the appropriate model for radionuclide transport at Yucca Mountain, yet alternative models depending on the nature of the coupling do not appear to be treated in the hypothesis testing tables.

BASIS

- o Page 8.3.5.13-62 cites three "possible cases of transport of dissolved radionuclides through Yucca Mountain rocks" depending on the nature and speed of coupling between the flow in fractures and the flow in the rock matrix.

- o Page 8.3.5.13-71 states that if the coupling between the matrix and fracture flow is strong in the UZ, then equation 8.3.5.13-25 may be used to estimate the effective transport velocity for a given radionuclide.

- o Page 8.3.5.13-75 states how important the "coupling times" are in determining the nature of radionuclide transport in the saturated zone.

° The issue of coupling times and mechanisms does not appear to be treated in the hypothesis testing tables of either hydrology or geochemistry, but is treated in the performance allocation Table 8.3.5.13-17 (p. 8.3.5.13-110), where the need to determine the matrix-fracture interface permeability and constrictivity is cited. Given the importance of this issue (as evidenced by repeated discussion of the point in the SCP), it seems inappropriate to treat these substantially different cases by parameter determination (in the Performance Allocation Table), rather than by alternative conceptual models in the hypothesis testing tables. Although this is just one example, it points to the possibility that in producing the SCP not clear distinction was made between alternative conceptual models and verifying that a performance parameter goal was met. No general guideline or rule seems to have been stated, further contributing to the lack of demonstration that the SCP is complete and logically consistent.

° Discussions on pages 8.3.5.13-64 to -65 indicate that there are at least three different conceptual models for the coupling coefficients (Wilson-Dudley, Rasmussen-Neretnieks, Sudicky-Frind), while the entries (especially the parameter goals) in Table 8.3.5.13-17 (p. 8.3.5.13-110) assume that the Wilson-Dudley model is correct and will be used to interpret the test data. This appears to be another example of designing the test program to support current representations, rather than allowing for alternative concepts.

- The tests proposed in SCP section 8.3.1.3.6 to determine the coupling constants are to be performed on cores in the laboratory. It is not clear how such tests will be able to determine coupling constants on the spatial and temporal scales indicated by equations 8.3.5.13-12, -25, and -26.

RECOMMENDATION

- Redesign the testing program to determine the correct models for radionuclide transport in the saturated and unsaturated zone.

F

SCP/NAE/COM/18

Section 8.3.5.13 Total System Performance

COMMENT NAE 18

CDSCP Comment #90 appears not to have been adequately resolved; human intrusion is intended to be left out of the calculation of the CCDF, but the SCP text makes the omission less obvious.

BASIS

° On page 8.3.5.13-24 in discussing "The U.S. Department of Energy approach to constructing the complementary cumulative distribution function" the SCP states: "Disruptive scenario classes will also be developed for the analysis... These scenario classes would also include those developed for human interference activities discussed earlier (sic). Many, if not most, readers would conclude that some human intrusion scenarios would be used to calculate the CCDF.

° Contrary to the SCP, the DOE Responses to NRC Point Papers document clearly states: "Releases initiated by human activities will be considered separately. A CCDF accounting for human activities must be separate from a CCDF for natural processes and events because the scenario classes associated with human activities are likely to be highly speculative and would easily dominate a single CCDF.

RECOMMENDATION

- Include human initiated scenarios in the construction of the CCDF.

- Reconsider the Site Characterization Program in light of the data required to estimate the probabilities and consequences of such scenarios and modify the program accordingly; do not start until this is done.

F

Section 8.3.5.13 Total System Performance

COMMENT NAE 19

Numerous minor mathematical errors indicate that insufficient management control and quality assurance was in place for the development of the SCP.

BASIS

- page 8.3.5.13-45 "2" is raised to the exponent "13" and the result given is an odd number.

- Page 8.3.5.13-74, equation 8.3.5.13-28 uses the subscript "s" in two senses; as the index for geohydrologic units and to denote the saturated zone.

RECOMMENDATION

- Institute sufficient management control and quality assurance procedures to assure that the appearance of minor technical errors is not symptomatic of deeper technical problems and/or a lack of concern the quality of work submitted to the NRC pursuant to an Act of Congress.

Section 8.3.5.13 Total System Performance

COMMENT LRA 1

There is a gap in the discussion of the treatment of state variables as constants or as random variables.

BASIS

- Page 8.3.5.13-8 (third paragraph). DOE states that a state variable can be treated as a constant if its coefficient of variation (the ratio of the standard deviation to the mean) is "very small" but may have to be treated as a random variable if its coefficient of variation is "nearly one or larger." There is no discussion of the case where the coefficient of variation is not small but is less than one (e.g., 0.5).

RECOMMENDATIONS

- Introduce the term "coefficient of variation" for the ratio discussed in the paragraph. This is standard statistical nomenclature.

- Be more explicit about the conditions for treating a state variable as a constant.

- State that a state variable must be treated as a random variable whenever it fails to satisfy the conditions for treating it as a constant.

Section 8.3.5.13 Total System Performance

COMMENT LRA 2

The definition of the unit step function is not consistent with the definition of the CCDF.

BASIS

- On page 8.3.5.13-5, the CCDF Is defined as

  $G(m) = Pr\ (M > m)$

  This implies that there is no contribution to the CCDF if $M=m$.

  On page 8.3.5.13-9, $G(m)$ is represented as

  $G(m) = E[u(M-m)]$, where $u(x)$ is the unit step function defined by

$$u(x) = \begin{cases} 0 & \text{if } x < 0 \\ 1 & \text{if } x \geq 0 \end{cases}$$

  This implies that there might be a contribution to $G(m)$ if $M = m$ (if $Pr\{M = m\} > 0$).

RECOMMENDATION

- Change the definition of the unit step function to

$$u(x) = \begin{cases} 0 & \text{if } x \leq 0 \\ 1 & \text{if } x > 0 \end{cases}$$

Section 8.3.5.13 Total System Performance

COMMENT LRA 3

There is an incorrect statement about the conditions for determining whether the containment standard is satisfied.

BASIS

- Page 8.3.5.13-10 (last paragraph). DOE states that "the entire CCDF would have to be constructed to see whether Equation 8.3.5.13-2 is satisfied" in the case where

$$E[M] \geqslant 0.01$$

In fact, it is only necessary to check the CCDF at two points, i.e., m = 1.0 and m = 10.0.

RECOMMENDATION

- State that, if $E[M] \geqslant 0.01$, it is necessary to check only that G(1.0) and G(10.0) satisfy the containment standard stated in Equation 8.3.5.13-2.

Section 8.3.5.13 Total System Performance

COMMENT LRA 4

The term "independent" is incorrectly used instead of the term "mutually exclusive."

BASIS

- Page 8.3.5.13-11 (third paragraph). DOE equates the terms "statistically independent entities" and "mutually exclusive events." Instead of being equivalent, these two terms are in fact opposites. If events A and B are independent, then the occurrence of A implies nothing about the occurrence of B. If, on the other hand, they are mutually exclusive, then the occurrence of A implies that B cannot occur.

- There are numerous other places in Section 8.3.5.13 where this mistake is made.

RECOMMENDATION

- Replace the term "independent" by "mutually exclusive" throughout Section 8.3.5.13 whenever the concept of mutual exclusivity is meant.

F

Section 8.3.5.13 Total System Performance

COMMENT LRA 5

There is an incorrect statement that the CCDF can be expanded in terms of scenario classes as in Figure 8.3.5.13-2 only if the entities are statistically independent.

BASIS

- Page 8.3.5.13-13 (last paragraph). DOE states that "the formalism for expanding the CCDF in mutually exclusive* scenario classes is nevertheless capable of being generalized to any number of such objects, provided that they are statistically independent entities ..." In fact, the formalism can also be applied to dependent entities, with the products of probabilities replaced by the products of conditional probabilities.

RECOMMENDATION

- State that the expansion of Figure 8.3.5.13-2 can be extended to any number of dependent events, with the probabilities being replaced by conditional probabilities. Discuss the problems involved in estimating or modeling the conditional probabilities.

* Replaces "independent" in accordance with Comment LRA 4.

F

SCP/LRA/COM/6

Section 8.3.5.13 Total System Performance

COMMENT LRA 7

There is a gap in the discussion of human-activity related scenarios.

BASIS

- Page 8.3.5.13-23 (last paragraph). DOE states: "The scenarios and scenario classes associated with human activities are often highly speculative and often do not involve significant impacts n the variables important to waste isolation. Therefore, the specification of highly speculative, low-impact human activity-related scenarios and scenario classes ... will not be allowed to dominate the testing program".

  There is no discussion of how to deal with human activities which might involve significant impacts.

RECOMMENDATION

- State that any human activity which might have a significant impact must be evaluated, if it is sufficiently credible to warrant consideration. Discuss the role of the formal use of expert judgment.

Section 8.3.5.13 Total System Performance

COMMENT LRA 8

The tentative EPPM goals for the preliminary performance allocation for Issue 1.1 appear to be inconsistent with the containment standard.

BASIS

- Pages 8.3.5.13-90,91. The tentative goals for the EPPMs in Table 8.3.5.13-8 are all greater than or equal to 0.01. Consequently, even if all of the goals were met, there would be no assurance that Equation 8.3.5.13-9 would be satisfied.

RECOMMENDATION

- Clarify the connection between the satisfaction of the tentative goals listed in Table 8.3.5.13-8 and the conditions for satisfying the containment standard.

F

Section 8.3.5.13 Total System Performance

COMMENT LRA 9

There are a number of typos to be corrected and points of clarification to be made.

RECOMMENDATIONS

- Page 8.3.5.13-10 (line 3). Change "sample size (*)" to "sample size S".

- Page 8.3.5.13-12 (second paragraph, third line from bottom, Change "G(0) = 0 and " to "G(0) = 1, ".

- Page 8.3.5.13-13 (second paragraph, line 7). Insert the following sentence: "Furthermore, the occurrence of E1 and E2 are assumed to be independent of the presence of F1."

- Page 8.3.5.13-17 (second paragraph).
  (a) Supply a derivation or a reference for the first inequality.
  (b) Replace "K" in Equation 8.3.5.13-7 and immediately following it by "L".

- Page 8.3.5.13-21 (second paragraph). The impression given by the first sentence of this paragraph is that expert judgment will not be used to assign probability measures to geologic events. Insert a statement clarifying that expert judgment may be used to assess geologic events when the data base is inadequate.

Section 8.3.1.1, p.8.3.1.1-6,7,8 Overview of the Site Program: Role of Alternative Conceptual Models

Tables 8.3.1.2-2a,b, 8.3.1.3-2, 8.3.1.4-2,..Current Representative and Alternative Hypotheses....

COMMENT PPB1

Expert judgment used in developing the hypothesis testing tables does not appear to have been based on a consistent logic and thus may not be traceable and defensible.

BASIS

- NRC's CDSCP Comment #4 pointed out that the facts and reasoning used by experts to reach conclusions will be examined independently to determine not only whether the approach of using expert judgment is necessary, but also whether expert judgment was used in a traceable, defensible manner .

- DOE has explicitly stated (Section 8.3.1.1) that expert judgment was used to evaluate the alternative conceptual models to be used in describing site behavior. However, examination of the hypothesis testing tables (e.g. 8.3.1.2) indicates that the logical pattern for drawing conclusions is not consistent and thus not clearly evident. Examples of inconsistency are given in the basis of Comment NAE 7.

- Contrary to the statement in paragraph 3, page 8.3.1.2-353 that conceptual model development, being largely a mental exercise, does not lend itself to the establishment of formalized procedure, a mental exercise can be based on formalized procedures. There exists a body of literature on systematic procedures for using expert judgment. An example cited in the SCP is Loudon, 1979.

° The potential effect on site characterization of the apparent logical deficiencies in hypothesis testing tables is a failure to assign proper priority to investigation(s) to discriminate among alternative conceptual models.

RECOMMENDATION

° Applying the principle cited in bullet 3 above, reevaluate the final four columns of all hypothesis testing tables to assure that they are based on a consistent logic pattern.

Section 8.3: Planned Tests, Analyses, and Studies

COMMENT PPB2

The clarified role of subjective methods (e.g. formal use of judgment) in site characterization has not been applied to all segments of site characterization to determine when it is best to use experts in the analysis itself and when it is best to call for peer review of investigations, calculations or judgments.

BASIS

- In response to CDSCP Comment 4 (and CDSCP Question 2), overview sections have been revised to describe generally the need for using expert judgment in some aspects of site characterization. Examples of such general sections are Sections 8.1.2, Issue Resolution Strategy; 8.3.1.1, Overview of the Site Program: Role of Alternative Conceptual Models: and 8.3.5.8, Strategy for Post-closure Performance Assessment:

- In the description of many of the specific activities, the need for using expert judgment or peer review has been properly identified. An example is the use of peer review in the activity: Studies of calcite and opaline silica vein deposits (p 8.3.1.5-111)

- However, the "subjective weighting of alternatives (conceptual models) based on peer review" (p 8.3.5.12-17, 3rd paragraph) is an example of two kinds of misapplication of expert judgment. The first is described in Comment NAE 1; the second misapplication is the use of peer review to make an initial judgment. Peer review should be reserved for review of information or judgments reached by other means.

RECOMMENDATION

- In further developing and implementing the site characterization program, the DOE should assess the activities to ensure that problems to be addressed by experts are clearly identified, and that appropriate uses of peer review and initial application of expert judgment are distinguished from each other.

Section 8.3.5 Performance Assessment Program

COMMENT PPB5

It is inappropriate to rely on NRC staff reviews of DOE's work as peer reviews.

BASIS

- In several instances, the SCP calls for a peer review that involves NRC staff review. An example is to be found on page 8.3.5.8-6 in the last paragraph.

- NRC staff agrees that peer review in accordance with the guidelines of NUREG-1297 is an acceptable technique for increasing confidence in analyses, arguments and lines of evidence presented in the license application.

- However, it is inappropriate to imply that the regulatory agency participates in preparing the license application itself.

RECOMMENDATION

- Eliminate NRC review in plans to incorporate peer review into the program.

REFERENCE

NUREG-1297 (1988)

Section 8.5.6.1 Presentation of summary schedule for the Yucca Mountain site.
page 8.5-112

COMMENT JST7

According to the scheduling information presented within the SCP, the DOE has not allowed sufficient time between site characterization and submittal of the license application to meet all the requirements of the Nuclear Waste Policy Act.

BASIS

- The schedules presented in Section 8.5, along with the schedules presented in the individual sections, indicate that many site characterization activities will not be completed until late 1994. In some cases the activities will not be completed until January 1995.

- Section 114(a)(1) of the Nuclear Waste Policy Act (NWPA) states that, if upon the completion of public hearings and site characterization activities the Secretary of DOE decides to recommend the Yucca Mountain site to the President for a repository, that the Secretary shall notify the Governor and Legislature of the State of Nevada.

- The Secretary may not provide a recommendation to the President prior to 30 days following such notification. This is to include preliminary comments by the Commission concerning the extent to which the in-depth site characterization analysis and the waste form proposed seem sufficient for inclusion in any application for licensing.

- Section 115(b) of NWPA states that the designation of a site as suitable for application for a construction authorization shall be effective at the end of the 60 day period beginning on the date that the President recommends such site to the Congress, unless the State has submitted a notice of disapproval.

- If site characterization is completed in January of 1995, the Secretary cannot recommend the site to the President until February, 1995.

- If the President does not receive the recommendation of the site until February, 1995, the designation of the site as suitable for submittal for a license for construction authorization does not become effective until, at least, April 1995.

- If the Commission is to provide preliminary comments concerning the extent to which in-depth site characterization activities and the waste form proposed seem to be sufficient for inclusion in a license application, the Commission must be able to review the results of site characterization. While preliminary information would be available prior to this time, many of the comments and concerns of the Commission may not be available until all the site characterization information is available. The schedule presented does not appear to allow time for the Commission to perform a review of the information which would be comming available at the end of site charactierization.

RESOLUTION

- The schedules should be reviewed and revised, as necessary, to account for the requirements of NWPA and to allow the Commission sufficient time to perform a review of the information from site characterization necessary to determine if preliminary concerns exist.

REVIEW GUIDES

3.2.6

Section 8.3.5.3 Issue resolution strategy for Issue 2.1: During repository operation, closure and decommissioning (a) will the expected average radiation does received by members of the public within any highly populated area be less than a small fraction of the allowable limits and (b) will the expected radiation does received by any member of the public in an unrestricted area be less than the allowable limits as required by 10 CFR 60.111, 40 CFR 191 Subpart A, and 10 CFR Part 20?

Regulatory basis for the issue, Page 8.3.5.3-3

COMMENT JST 8

It does not appear that all the requirements of 10 CFR Part 20, specifically those in 20.105(b)(1) and 20.105.(b))2), are being considered in the design requirements for the preclosure.

BASIS

- 10 CFR 20.105(b) requires that "Except as authorized by the Commission pursuant to paragraph(a) of this section, no licensee shall possess, use or transfer licensed material in such a manner as to create in any unrestricted area from radioactive material and other sources of radiation in his possession:

    (1) Radiation levels which, if an individual were continuously present in the area, could result in receiving a radiation does in excess of two millirems in any one hour, or (2) Radiation levels which, if an individual were continuously present in the area, could

result in his receiving a dose in excess of 100 millirems in any seven consecutive days.

- While the requirements of 10 CFR 20.105(a) are based on assuring that the actual exposure is maintained below the level of 500 millirems per year, the requirements of 10 CFR 20.105(b) are based on radiation levels in the unrestricted area, not actual exposure.

- While this section of the SCP appears to commit to meeting all requirements of 10 CFR 20, the staff can find no place within either the SCP or SCP-CDR which displays that the requirements of 10 CFR 20.105(b) have been directly incorporated into the design requirements.

RESOLUTION

- DOE should review the various design requirements to assure that all the applicable provisions of 10 CFR 20 are being considered in design.

REVIEW GUIDES

3.2.3, 3.2.4.10

Section 8.1.2.4 Issue Resolution Documentation

QUESTION PPB4

It is not clear that the "multiple-barrier" concept is being implemented in the issue resolution strategies for all issues.

BASIS

- On page 8.1-16, in describing step 10a, the following words are used: "... if it were found that one barrier were to perform so well that less information about another barrier would be necessary..."

- These words are used in connection with developing a position on an "issue" before obtaining all the information originally envisioned to be necessary. In the context of the Issue Resolution Strategy, an "issue" is stated in terms of system or subsystem barriers such as waste package or engineered barrier system or natural barrier system.

- Thus, the multiple barrier approach described in the supplementary information for 10CFR60, 48FR28196 may be subverted if this distinction is not clearly made.

RECOMMENDATION

- If it is intended to refer to subsystem components rather than subsystems in the above statement, it should be so stated. Otherwise any plans based on the concept of obtaining less information about one barrier if another performs well should be revised.

Section 8.3.5.5.1 Information Need 2.3.1: Determination of credible accident sequences and their respective frequencies applicable to the repository

QUESTION RBN 1

The magnitude of the dose to members of the public during accident conditions (and consequently the Q-list) is highly dependent upon the numbers of fuel assemblies (or waste canisters) assumed to be breached in those accidents. What are the bases for the assumed numbers of breached assemblies or canisters?

BASIS

- This question, which was originally posed in the CDSCP, is repeated here since it was not adequately addressed in the SCP.

- As indicated in paragraph 2, page 5-16, Section 5.1.3 of the CDR, Fuel Pellet and HLW Glass Pulverization Factors: "Estimating the airborne source term from impact accidents is a major requirement in performing realistic dose assessment calculations."

- As indicated in equations 5.18 and 5.22, pages 5-48 and 5-49, Section 5.3 of the CDR, Approach for Event Tree Scenario Quantifications, the magnitude of the dose (to both workers and to the public) is directly proportional to the number of fuel assemblies and high-level waste canisters that are assumed to be breached.

- Dose is also used to determine those structures, systems and components important to safety in accordance with 10 CFR Part 60.2

RECOMMENDATION

- The SCP should have provided a rationale for the numbers of fuel assemblies (or waste canisters) breached in the accidents considered.

REFERENCE

H.R. MacDougall, L.W. Scully, and J.R. Tillerson, "Nevada Nuclear Waste Storage Investigations Project, Site Characterization Plan Conceptual Design Report", SAND84-2641, Volume 4, Appendix F, September 1987:

Section 8.3.5.5.1 Information Need 2.3.1: Determination of credible accident sequences and their respective frequencies applicable to the repository

QUESTION RBN 2

The SCP does not identify whether additional data are needed to establish particulate source terms for the waste package, particulate retention factors by containing vessels, or plateout or gravitational settlement factors for the geologic repository operations area during accident conditions in the preclosure phase. What investigations are planned?

BASIS

- This question, which was originally posed in the CDSCP, is repeated here since it was not adequately addressed in the SCP.

- Several statements in Sections 5.1.2-5.1.5 of the CDR seem to indicate that better bases for waste package source terms and releases from the geologic repository operations area are needed.

- The CDSCP does not discuss the need for investigations to characterize the magnitude (or particle sizes) of radionuclides that could be released from the waste package when subjected to impacts (such as a crane falling on a fuel assembly) nor does it discuss the need for investigations to develop realistic radionuclide retention fractions for containment systems and structures

RECOMMENDATIONS

- The SCP should have addressed existing information on the source terms for the waste package and plateout and retention factors for the geologic repository operations area in the preclosure phase in terms of the need for additional information (e.g. data gathering, models, etc.) to be obtained during site characterization.

- If new information is to be obtained, the investigations should have been discussed.

REFERENCES

H.R. MacDougall, L.W. Scully, and J.R. Tillerson, "Nevada Nuclear Waste Storage Investigations Project, Site Characterization Plan Conceptual Design Report", SAND84-2641, Volume 4, Appendix F, September 1987: Section 5.1.5 Release Factors for Gap Radioactivity; Section 5.1.3 Fuel Pellet and HLW Glass Pulverization Factors; Section 5.1.4 Particulate Retention Factors for Fuel Cladding, Casks, DHLW Canister, and Waste Disposal Containers; Section 5.1.5 Particulate Retention Factors by Building and Hot Cells.

P.A. Haris, D.M. Ligon, and M.G. Stamatelatos, GA Technologies, Inc., "High-Level Waste Preclosure Systems Safety Analysis, Phase I, Final Report," USNRC Report NUREG/CR-4303 (July 1985)

Section 8.3.5.3.1 Information need 2.1.1: Site and design information needed to assess preclosure radiological safety; page 8.3.5.3-20 to 8.3.5.3-23 Table 8.3.5.3-2. Parameters required for issue 2.1 (public radiological exposure--normal conditions Section 8.3.5.4.1 Information need 2.2.1: Determination of radiation environment in surface and subsurface facilities due to natural and manmade radioactivity. Table 8.3.5.4-2. Parameters required for issues 2.2 (worker radiological safety--normal conditions)

QUESTION JST 1

Are Anticipated Operational Occurrences being considered as part of normal conditions in the preclosure design and analysis?

BASIS

- Appendix A to 10 CFR Part 50, defines "Anticipated Operational Occurrences" to mean "those conditions of normal operation which are expected to occur one or more times during the life of the nuclear power unit and include, but are not limited to, loss of power to all recirculating pumps, tripping of the turbine generator set, isolation of the main condenser, and loss of all offsite power."

- The NRC staff considers that a similar usage of the term is applicable for the repository and that Anticipated Operational Occurrences would include those conditions of normal operation which are expected to occur one or more times during the preclosure period.

- Neither Table 8.3.5.4-2 nor Table 8.3.5.3-2 appear to consider such things as the effects from weapons testing and natural seismic events, which the staff consider should be evaluated under normal and anticipated operational occurrences.

- Review of Section 4.0 of Appendix F of the Site Characterization Plan conceptual Design Report lists many internal and external events which have a frequency such that they would be expected to occur one or more times during the preclosure period. While these events are being considered under accident analysis, the staff is unsure that these events are also being considered under normal operations.

- Review of Section 8.3.5.5, in general however, appears to indicate that the type of information needed for evaluations of the various external events which are not specifically listed in section 8.3.5.3 and 8.3.5.4 will be gathered under different programs of site characterization.

RESOLUTION

- DOE should assure that the design and analysis for normal conditions includes anticipated operational occurrences, both internal and external.

REVIEW GUIDES

3.S.3, 3.2.4.10

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

APR 28 1989

NOTE TO: Joseph O. Bunting, Chief
Engineering Branch

FROM: Richard A. Weller, Section Leader
Materials Section
Engineering Branch

SUBJECT: MATERIALS SECTION DRAFT SCP POINT PAPERS FOR MANAGEMENT IQA REVIEW

Enclosed for your review are the draft SCP point papers from the Materials Section for the management IQA review. To summarize, the Materials Section review of the SCP resulted in the development of 39 point papers consisting of 21 comments and 18 questions. Included in these numbers are 7 comments from the CDSCP review, which the staff determined were not satisfactorily resolved by the DOE in the SCP. Out of the original Materials Section 16 CDSCP comments and 2 questions, 9 comments and 2 questions were satisfactorily resolved by the DOE in the SCP. The staff's discussion of resolved CDSCP comments is intended to go into an appendix in the SCA. The Materials Section input to the appendix is in preparation in the format requested by the Yucca Mountain project manager (K. Stablein) and will be provided to you by a separate note. If you have any questions, please advise.

Rick

Richard A. Weller, Section Leader
Materials Section

Enclosure: As stated

cc: K. Stablein
K. Chang
D. Chery
P. Justus
J. Kennedy
S. Coplan

SCP/YUCCA/KCC/COM/1

Section 7.4.2.6.4 Activities to determine transgranular stress corrosion cracking susceptibility

COMMENT

Investigations into the stress corrosion cracking behavior of the container alloys assume that the container surface will be either homogeneously dry or homogeneously wet, but in the corrosion model (7.4.5.4.6), it is stated that "the waste package will most likely not be uniformly wet."

BASIS

* While it is obvious why assuming a homogeneous environment is desirable from a modeling standpoint, it is not clear that this is a valid assumption.

* Since the rock and the placement of the container in the borehole will not be expected to be a homogeneous environment over the entire surface of the container at all times, inhomogeneous exposure conditions are expected.

RECOMMENDATIONS

* Evaluate effects of inhomogeneous exposure conditions on the stress corrosion cracking behavior of waste package components.

REGULATORY UNCERTAINTY

No

SCP/YUCCA/KCC/COM/2

Section 7.4.3.2 Glass waste form performance research

COMMENT

* Grouts, cements, and organic materials used in the repository may change the local pH of the repository and affect the corrosion of the metal waste containers and the local leach rates of radionuclides from the glass.

BASIS

* Grouts and cements, as well as organic materials, may be used during the digging and construction of the repository. These materials may have a significant effect on the local pH of the repository.

RECOMMENDATION

* Consider the effect of pH changes resulting from building materials in the repository on the corrosion of the metal waste containers and the leach rates of radionuclides from the glass.

REGULATORY UNCERTAINTY

No

SCP/YUCCA/KCC/COM/3

Section 7.4.5.2	<u>Processes affecting waste package performance</u>
Section 7.4.5.4	<u>Yucca Mountain Project waste package system model description</u>
Section 8.3.5.9	<u>Issue resolution stragety for Issue 1.4: Will the waste package meet the performance objective for containment as required by 10 CFR 60.113?</u>
Section 8.3.5.10	<u>Issue resolution strategy for Issue 1.5: Will the waste package and repository engineered barrier systems meet the performance objective for radionuclide release rates as required by 10 CFR 60.113?</u>

COMMENT

There is inadequate discussion on how performance of the waste package may be verified at the time of license application, envisioned construction authorization, and at the expected time of issuance of a licence to receive and possess waste.

BASIS

* Section 7.4.5.4 discusses how the YMP plans to model the step processes affecting waste package performance (Section 7.4.5.2) to resolve issues 2.2 and 1.4. These issues are: Issue 2.2 (Section 8.3.5.4); Can the repository be designed, constructed, operated, closed, and decommissioned in a manner that ensures the radiological safety of workers under normal operations as required by 10 CFR 60.111, and 10 CFR Part 20? and, Issue 1.4 (Section 8.3.5.9); Will the waste package meet the performance objective for containment as required by 10 CFR 60.113?

* Sections 8.3.5.9 and 8.3.5.10 include discussions of laboratory tests to obtain information for waste package performance assessment models but no discussion on how well the models represent what actually might happen in the repository environment or how the models will be validated at repository depth in the host rock environment. If in situ test data are not obtained during site characterization, the needed information may not be available at the time of licence application, envisioned construction authorization, or even at the expected time for issuance of the licence to receive waste.

* 10 CFR 60.140 (a) requires that performance confirmation be started during site characterization.

* It is not clear how the full scale coupled effects of prolonged thermal, radiation, and geochemical phenomena are planned to be investigated for waste package in the current test plan.

* It is not clear how DOE plans to investigate stress related effects for container base metal as well as the weld-affected region after long-term thermal and radiation exposure without a full scale waste package test under repository conditions.

* DOE has not demonstrated that the potential effect of container coming in contact with dissimilar metals, resulting in galvanic corrosion, can be sufficiently investigated without a full scale waste package test under repository conditions.

RECOMMENDATION

The SCP should be modified to include in situ waste package tests to obtain the data needed to verify waste package performance during site sharacterization. Alternatively, DOE should demonstrate that the plan laid out in the SCP is sufficient to obtain the needed waste package behavior information during site characterization.

REGULATORY UNCERTAINTY

No

SCP/YUCCA/KCC/COM/4

Section 7.4.5.4.5 Waste package environment model

COMMENT

* The effects of air infiltration on the corrosion of the metal canisters are not considered.

BASIS

* Oxygen in air is the major oxidizing species that drives the corrosion process. Thus, the rate of air infiltration through tuff is important to the corrosion process.

* Heating of the tuff to the temperatures expected near the waste package, can cause dramatic decreases in rock permeability of up to three orders of magnitude (Lin and Daily, 1984).

* It is reported that the transition from alpha to beta-cristobalite causes a 5% volume increase in the rock matrix (see p. 7-40).

* The above two processes could lead to sealing of cracks in the rock and to the formation of an almost airtight envelope around the metal containers.

* An airtight envelope would starve the corrosion process of oxygen and this would drastically alter the requirements for a container in this system.

* On the other hand, heating of the rock caused by radioactive decay could generate a stream of air and water vapor, which, flowing by the metal canisters, could significantly accelerate the degradation processes over and above the air flow caused by atmospheric pressure variations.

RECOMMENDATION

* Determine the effect of air infiltration on the processes affecting the corrosion of the metal waste container.

REGULATORY UNCERTAINTY

No

REFERENCE

Lin, W., and W. Daily, 1984. Transport Properties of Topopah Spring Tuff, UCRL-53602, Larence Livermore National Laboratory, Livermore, Calif.

SCP/YUCCA/KCC/COM/5

Section 7.4.5.4.6 Corrosion model
7.5.4.6 Metal barriers

COMMENT

* The term "uniform corrosion" is misleading.

BASIS

* "Uniform corrosion" implies the same corrosion rate over the entire surface of the canister.

* In the SCP, there is no information on the degree of surface roughness. Surface roughness develops gradually on an originally smooth metal surface undergoing general corrosion.

* The amplitude of the various frequency components of the roughness (and their conceivable variations as a function of the orientation of the metal surface with respect to the gravitational field) will contribute to the ultimate determination of when the metal container will be breached.

* Other factors, such as macroscopic inhomogeneities of any component undergoing corrosion, can contribute to the uniformity or lack thereof in the corrosion process.

RECOMMENDATIONSs

* Use the term "general corrosion".

* Define the variability of corrosion over the container surface and explain how the variability will be factored into the assessment of expected container lifetime.

REGULATORY UNCERTAINTY

No

SCP/YUCCA/KCC/COM/6

Section 8.3.1.8 Overview of the postclosure tectonics programs: Description of future tectonic processes and events required by the performance and design issues

COMMENT

The overall goal for waste package performance stated in this section of the SCP is not consistent with the interpretation of substantially complete containment discussed in Section 8.3.5.9.

BASIS

* The first paragraph of page 8.3.1.8-27 states that " Section 8.3.4.2 sets design goals for rock-induced loads to the waste package. One goal states that less than 0.5% of the waste packages will be breached by anticipated tectonic processes and events that may occur during the first 1,000 yr." and that "This level is designed to be compatible with the overall goal for waste package performance from all modes of failure of less than 5 percent in 300 yr and less than 20 percent in 1,000 yr."

* Section 8.3.5.9 (p. 8.3.5.9-1) states that "The DOE understands substantially complete containment to mean that the set of waste packages will fully contain the total radionuclide inventory closure, allowing for recognized technological limitations."

RECOMMENDATION

Reexamine design goals for different componets of the repository system to ensure that they are compatible with one another.

REGULATORY UNCERTAINTY

No

SCP/YUCCA/KCC/COM/7

Section 8.3.4.2.C. Emplacement hole drainage
Design goal for drainage of emplacement boreholes.
p.8.3.4.2-27 para 3.

COMMENT

It is stated (design goal #1) that the borehole and its engineered components, such as liners, shall be designed and constructed so that for anticipated processes and events the borehole will not fill with standing water at any time up to 10,000 yr following repository closure. Further it is stated that this condition/design goal for drainage of boreholes will be met with a high level of confidence.

It is not clear what the design goal ia or how the high level of confidence will be demonstrated.

BASIS

* It is not clear if "fill with standing water" means a completely filled borehole or one partially filled with standing water.

* It is not stated how the high level of confidence will be determined nor is the basis for an acceptable "high level" provided. High level of confidence for a design could have a quite different meaning from the high level of confidence that needs to be demonstrated for licensing purposes.

RECOMMENDATIONS

* Explain what is meant by "fill with standing water".

* Definition of "high level" of confidence should be provided. Method(s) of determination of the level of confidence should be given. If determined quantitatively, the basis for the acceptable level of confidence should be provided.

REGULATORY UNCERTAINTY

No

SCP/YUCCA/KCC/COM/8

Section 8.3.4.2.C <u>Emplacement hole drainage</u>
<u>Design goal for drainage of emplacement boreholes</u>.
p. 8.3.4.2-27

<u>COMMENT</u>

The design goal (#2) states that for the first 1,000 yr following repository closure, no more than 5L of standing water per waste package will accumulate in emplacement boreholes. This design goal conflicts with another design goal (#3) in the section on water flux control.

<u>BASIS</u>

* The stated goal implies that less than 5L of standing water per waste package borehole is <u>acceptable</u>, e.g. 4.99L per borehole. This design goal conflicts with the design goal for water flux control (goal #3) (p. 8.3.4.2-26) which states that during the period from 300 to 1,000 yr after repository closure, <u>no liquid water will contact</u> <u>90% of the waste packages</u>, and less than 5L per package per year will contact the remaining 10%.

<u>RECOMMENDATION</u>

* Inconsistency between the two stated design goals (and other related goals) should be resolved.

<u>REGULATORY UNCERTAINTY</u>

No

Section 8.3.4.2.E. Thermal loading of the waste package and the repository layout
Design goal for thermal loading.
p. 8.3.4.2-28 para. 5.

COMMENT

One of the two design goals (#1) for thermal loading states that the repository layout will be designed so that the thermal loading characteristics will assist in keeping liquid water from contacting the waste packages for the first 300 yr after closure. There is an inconsistency in this design goal and another design goal (#2) in the section on water flux control.

BASIS

* The design goal (#2) for water flux control (p. 8.3.4.2-26) allows 5% of the waste packages to be contacted by less than 5L of water per year during the first 300 yr after repository closure. However, the design goal (#1) for thermal loading does not allow any package to be contacted by water during the first 300 yr after repository closure.

* If the emplacement hole is constructed to meet the requirement of the design goal for water flux control, it may not meet the design goal established for the thermal loading. On the other hand, if the borehole is constructed to meet the design goal for thermal loading, it will also meet the design goal for the water flux control during the first 300 yr after repository closure, making the design goal #2 for the water flux control redundant.

RECOMMENDATION

* The inconsistency in the stated two design goals should be resolved. Satisfying one design goal should not conflict with another design goal.

REGULATORY UNCERTAINTY

No

SCP/YUCCA/KCC/COM/10

Section 8.3.5.9 <u>Issue resolution strategy for Issue 1.4: Will the waste package meet the performance objective for containment as required by 10 CFR 60.113 ?</u>

COMMENT

It has not been demonstrated that leach solutions used in waste package corrosion tests are indeed those resulting from realistic repository failure scenarios.

BASIS

* None of the studies described in this section (e.g. Section 8.3.5.9.2.3.2) mentions the use of solutions directly from integrated waste package tests. Leached products and corrosion products in the solutions can alter the results of the studies and consequently the validity of the performance models for the degradation modes.

* Contaminated solutions migrating from the vicinity of the waste package (which may have been breached) may have inherited characteristics that do not respond to postulated equilibrium controls. It is not clear for example if "composition of water" in the list of container degradation model inputs (Table 8.3.5.9-5, p. 8.3.5.9-42) includes leached products from failed waste packages.

RECOMMENDATION

* Determine the composition of contaminated solutions migrating from the vicinity of failed waste package and use such solutions in waste package studies.

* Use leach solutions in waste package corrosion studies with compositions which would conservatively bound the range and variance of the constituents and products expected from all anticipated failure scenarios.

REGULATORY UNCERTAINTY

No

Section 8.3.5.9.1 Information Need 1.4.1: Waste package design features that affect the performance of the container

COMMENT

* There is no description of the development and use of standardized test methods.

BASIS

* This comment was presented as CDSCP Comment 74. The DOE response was not sufficient. While much useful information can be gained from the use of existing ASTM standards and from interactions with ASTM committees, the DOE response was not broad enough and did not address the use of other standardized test methods (e.g., test methods developed by DOE, the Materials Characterization Center or professional societies). The comment stands as originally stated.

* The DOE has included a very few standardized test methods and procedures. For the most part, the basis for considering their appropriateness for use in HLW canister or waste forms testing has not been provided. Only one MCC test has been referenced (for the glass waste form).

* There is no description of the development and use of standardized test methods that have undergone peer review.

* Test methods are needed for determining the stability and durability of the nuclear waste and the waste package materials.

* The tests must be acceptable in terms of validation, reliability and reproducibility.

* The appropriateness of the referenced test (28-day leaching test in deionized water) in detecting variability in the glass waste form product that could affect the release rates in the water that might be encountered in the repository is questionable.

* In Section 8.3.5.9-23 para 2, it is stated that breaches in the canister that would allow air flow less than 1×10^{-4} atm-cm^3/s may not constitute failure. It is further stated that this criterion is a general standard accepted by the nuclear industry. No information is provided as to where this "general standard" is from and why it is considered appropriate for HLW canisters.

RECOMMENDATIONS

* The site characterization plan should contain a section explaining the development, approval, reliability, and use of the test methods, and statements regarding precision and accuracy of data.

REGULATORY UNCERTAINTY

No

SPC/YUCCA/KCC/COM/12

Section 8.3.5.9.1.1.4 Subactivity 1.4.11.4: State of stress in the container

COMMENT

The SCP does not take into account temporal changes in the state of stress due to corrosion of the container.

BASIS

* This comment was presented as CDSCP comment (#77). In response, the DOE has pointed out that all candidate canister materials are corrosion resistant (as opposed to corrosion allowance); therefore the increase in state of stress resulting from oxidation and aqueous corrosion will be low. It also states that DOE will consider the effects of pits and other localized corrosion phenomena as stress risers and potential sites for crack nucleation. However, DOE neglected general corrosion in their calculations and the justification given for neglecting general corrosion is insufficient. As a result, DOE should reconsider the CDSCP comment.

* Corrosion resistant materials corrode at a finite rate. While the wall thinning due to this corrosion may be insignificant over a few years, it could be significant for the design lifetime of the container.

* The maximum allowable wall thinning before failure by mechanical loads will determine the maximum allowable corrosion rate.

* General corrosion is not truly uniform and irregular surface features may evolve with continued corrosion particularly at welds.

* To avoid tensile residual stresses at welds, it has been proposed that the weld and weld heat-affected zone be treated such that the surface layer is in compression (7.4.2.7, 7.4.2.5.5 and 8.3.5.9). However removal of this layer may alter the state of stress.

RECOMMENDATION

When analyzing the state of stress at different locations, consider the influence of corrosion on wall thickness and surface flaw geometry particularly at the weld and weld heat-affected zone.

REGULATORY UNCERTAINTY

No

Section 8.3.5.9.2.2.1 Subactivity 1.4.2.2.1: Assessment of degradation modes in copper-based materials

Comment

The basis for degradation modes of copper-base alloys given in the scp does not appear to agree with scientific literature. Future testing plans may therefore be improperly designed.

Basis

* This comment was paresented as CDSCP Comment #80. DOE indicates that it has accepted the comment. However, the text in Section 8.3.5.9.2.2.1 has not been changed. Our comments stated here are limited to the major discrepancies between the description of the corrosion behavior of Cu-base materials on p. 8.3.5.9.-71, as well as in section 8.3.5.9.3.1.6 (p. 8.3.5.9-95 to -97) and our understanding of the corrosion behavior of Cu-base materials.

* It is not true that the role of NH_3 is to dissolve protective films. Cracking occurs in the so-called tarnishing solutions, where Cu_2O forms a film on the metal, as well as in conditions where no film is ever present because the aqueous ammonia solution is unsaturated with respect to Cu_2O. In the case of pure copper, cracking has been observed only when an oxide film was present.

* Cracking is not usually transgranular. Intergranular SCC is at least as common as T-SCC, and is prevalent in the case of certain alloys.

* Oxidizing conditions are not a universal requirement. T-SCC has been observed in cuprous ammonia solutions in equilibrium with Cu metal. For this reason the search for a critical potential below which SCC does not occur is of very questionable value.

* The lack of familiarity with the published literature shown in these sections leads to concern that future testing plans may also be very poorly conceived.

RECOMMENDATION

Evaluate the corrosion of Cu-based alloys using accepted thermodynamic and kinetic arguments.

REGULATORY UNCERTAINTY

No

SCP/YUCCA/KCC/COM/14

Section 8.3.5.9.3.2.7 Subactivity 1.4.3.2.7: Transgranular stress corrosion cracking

COMMENT

In the SCP, the implication is made that by going from the saturated zone to the unsaturated zone of the repository, the uncertainties with respect to corrosion are reduced.

BASIS

* The corrosion of stainless steels in aqueous solutions is probably the most thoroughly studied alloy/environment system. Hence, one must ask how can the scientific uncertainty be less in the environment where there is less scientific data and empirical experience.

* The discussion in Section 7.4.2.6.4 demonstrates the difficulty of predicting SCC behavior in unsaturated conditions as illustrated by the discussion in Westerman's U-bend experiment (p.7-95, third paragraph). It was discussed that among 40 specimens of 304 and 304L stainless steel, both in the solution-annealed and sensitization-treated conditions and exposed to unirradiated well J-13 water at 200 degree C in an autoclave. After 50 cycles (1yr) of alternate wetting and drying, only the sensitization-treated 304 specimens had cracked, and that these had cracked intergranularly, even though the experiment was planned primarily for investingating and accelerating transgranular cracking.

RECOMMENDATIONS

* Thorough and unbiased scientific investigation of the potential problems in the unsaturated zone should be studied and the uncertainties regarding corrosion processes should not be assumed to be less than those in the saturated zone.

REGULATORY UNCERTAINTY

No

Section 8.3.5.10. Issue resolution strategy for Issue 1.5: Will the waste package and repository engineered barrier systems meet the performance objective for radionuclide release rates as required by 10 CFR 60.113?
Waste form definition
p. 8.3.5.10-34 para. 4.

COMMENT

The specifications listed for the characterization of the glass waste forms do not include any specification on cooling rate of the waste form.

BASIS

* Cooling rate of glass can significantly affect fracturing of the monolith and the production of fissures prior to emplacement, which can substantially increase the surface area of the glass waste form available to water in the event of a canister breach.

* Cooling rate of glass can influence the level of residual stresses in the pour canister, and could also have an effect on the sensitization of the 304L pour stainless steel canister.

RECOMMENDATION

* An appropriate specification should be developed and presented for controlling the cooling rate of the glass waste form.

* The basis for such a specification should be developed and presented, as well as any plans for testing to establish the basis and/or specification.

REGULATORY UNCERTAINTY

No

SCP/YUCCA/KCC/COM/16

Section 8.3.5.9. <u>Issue resolution strategy for Issue 1.4: Will the waste package meet the performance objective for containment as required by 10 CFR 60.113?</u>
(Tentative goals for release from the waste packages)
P. 8.3.5.9-19 PARA 3.

<u>COMMENT</u>

As tentative goals to address substantially complete containment, the SCP states that DOE considers it appropriate to require that release of isotopes with long half-lives from the waste packages be controlled at a stricter standard during containment period than during post-containment period. Accordingly, the DOE has established the tentative criterion that release of these isotopes (listed in Table 8.3.5.10-3b) from the waste packages will be controlled such that their annual rates of release are less than 1 part in 1,000,000 for those isotopes present in sufficient quantity in 1,000-year inventory. It further states that the DOE has elected to limit releases of all other radioactive isotopes to an annual release rate of less than 1 part in 100,000 of the current inventory of that isotope in the waste packages.

The tentative goals set here may not be consistent with NRC intent for "substantially complete containment".

<u>BASIS</u>

* While the first goal stated above is a stringet one for controlled release; it may not be consistent with NRC's interpretation of "substantially complete containment" because the NRC has not set numerical limits on the release of radionuclides during the containment period.

* The second goal is identical to the requirement for controlled release after the no release containment life of 300 to 1,000 year. This permits the rate of release during containment period to be the same as post containment period.

<u>RECOMMENDATION</u>

* Relate the goals set to the interpretation of "substantially complete containment" to examine if they are conservative. While the first goal may be adequate, the second goal is judged to be non-consevative by NRC.

* Establish agreement with NRC on recognized technological limitation and uncertainties which determine "substantially complete containment" and set goals compatible with the limitation and uncertainties.

<u>REGULATORY UNCERTAINTY</u>

Yes, a rule interpretation is required of the NRC to clarify what is meant by "substantially complete containment" for waste package performance.

SCP/YUCCA/KCC/COM17

Section 8.2.2.1.1.4 Summary of waste package containment. Issue 1.4: Will the waste package meet the performance objective for containment as required by 10 CFR 60.113?

Section 8.3.5.9 Issue resolution strategy for Issue 1.4: Will the waste package meet the performance objective for containment as required by 10 CFR 60.113?

COMMENT

The performance goals and related tests described in the SCP to address the requirement for "substantially complete containment" of high-level waste within the waste package do not appear to be consistent with DOE's interpretation of the term.

BASIS

* This comment was presented as Comment 3 on the CDSCP. In response, the DOE extensively revised Section 8.3.5.9. The revised interpretation is that "substantially complete containment" means that the waste packages will fully contain the radionuclide inventory for 300 to 1,000 years following permanent closure, allowing for recognized technological limitations and uncertainties.

* The Staff is largely in agreement with DOE's revised interpretation of the containment requirement. However, further discussions between DOE and NRC must be initiated to establish agreement and understanding regarding the "recognized technological limitations and uncertainties".

* The DOE has established goals for waste package performance and related tests. However, there appear to be inconsistencies in these goals with DOE's revised interpretatin of the containment requirement. Examples of such inconsistencies are discussed in Comment 20.

RECOMMENDATION

* Establish goals for waste package performance that are consistent with the revised interpretation of the containment requirement.

* Explain in more detail what is meant by "recognized technological limitations and uncertainties", including YMP's plans for research and testing which will monimize the uncertainties related to waste package performance.

REGULATORY UNCERTAINTY

Yes. There is regulatory uncertainty regarding the meaning of "substantially complete containment".

SCP/YUCCA/KCC/COM/18

Section 8.3.5.9 Containment by Waste Package.
Section 8.3.5.10 Engineered Barrier System Release Rates.

COMMENT

The issue resolution strategies and testing programs for design of the waste package (Section 8.3.5.9 of the CDSCP) and engineered barrier system (Section 8.3.5.10 of the CDSCP) do not take into account the full range of reasonably likely natural conditions ("anticipated processes and events") that, with current understanding of the site, might be expected to affect performance of these barriers.

BASIS

* This comment was presented as CDSCP Comment 73. In response to the comment, the DOE has revised sections ofthe SCP to "explain the interaction between the scenarios developed in Section 8.3.5.13 (Issue 1.1) and those developed to resolve Issues 1.4 and 1.5 (Sections 8.3.5.9 and 8.3.5.10). Section 8.3.5.10.3.1 has been expanded to include four closely linked subactivities that are designed to develop appropriate scenario identifications, separate the scenarios into anticipated and unanticipated categories, develop the parameters of the near-field environment that describe the scenarios, and determine the adequacy of the design envelope resulting from those parameters."

* The NRC considers that while section 8.3.5.10.3 of the SCP commits to consideration of anticipated processes and events in analyzing release from the engineered barrier system, the program of testing and analysis for the waste package and engineered barrier system does not appear to reflect this philosophy. As is stated inchapter 7, page 7-8 for example, the DOE is assuming that the waste package will not be subject to any lithostatic loading. The site is bracketed by the Solitaro Canyon fault on the west and the Paintbrush canyon fault on the east, both of which have demonstrated evidence of Quaternary movement. There are numerous other faults in the site vicinity which have not yet been explored to a sufficient degree to show that Quaternary movement has not occurred. In addition, as is stated on page 1-145 of the SCP, the measured magnitudes of the smaller component of horizontal stress are near and perhaps even below the minimal values required to provide the lateral support necessary to prevent expansional failure on moderately dipping faults trending parallel to the larger component of horizontal stress. In other words, favorably oriented faults at Yucca Mountain may be in a state of incipient failure.

RECOMMENDATION

* It is recommended that Yucca Mountain faulting be considered as one of the "anticipated processes and events". This position is in agreement with the draft generic technical position "Guidance for Determination of Anticipated Processes and Events and Unanticipated Processes and Events" which was published for public comment in February, 1988, and which represents the NRC's present position on this subject.

REGULATORY UNCERTAINTY

No

SCP/YUCCA/KCC/COM/19

Section 8.3.5.9.2.3 Subactivities 1.4.2.3.2. - 1.4.2.3.9. Laboratory Test Plan for Austenitic Materials.

COMMENT

The possibility that the container may come into contact with dissimilar metals (resulting in galvanic corrosion) is not addressed adequately in this section.

BASIS

* This comment was presented as CDSCP Comment #82. The response to this comment states that DOE plans to select materials that will minimize galvanic effects. However, the approach that DOE will use to accomplish this is not stated.

* In all instances the choice of materials is limited. For example, for the spent fuel canister the DOE is considering austenitic stainless steels and copper/copper-base alloys, and the fuel is clad in Zircaloy. Does DOE plan to select the canister material to minimize the potential of galvanic corrosion on the inside of the canister? What if the material selected on this basis is not suitable or less suitable than another material from external canister corrosion point of view? Again, for the glass wasteform the only material that DOE considering for the pour canister is Type 304L stainless steel. What if copper/copper-base alloy is found to be more suitable for the outer canister from corrosion in the repository environment? How does DOE plan to minimize the the galvanic corrosion effects in such a situation?

* The SCP states that the borehole liner will be fabricated from the same family of material as the canister. However, no mention is made of the material selection criteria for the bottom support plate (for vertical borehole option) and the waste package dolly (for horizontal borehole option).

* Based on the response to CDSCP Comment 82, it is concluded that possibility of galvanic corrosion due to dissimilar metals in the waste package and the various parts of the emplacement structure/substructure has not been fully considered.

RECOMMENDATION

* Discuss the approach that YMP will take to select materials to minimize galvanic effects addressing the constraint of limited material choice.

* Discuss how the approach chosen will be applied to the design of different parts of the canister; outer and inner canister, bottom support plate and waste package dolly.

REGULATORY UNCERTAINTY

No

SCP/YUCCA/KCC/COM/20

Section 8.3.5.9 Performance Allocation, Waste Package and Engineered Barrier System.

The performance allocation and associated performance measures and goals for waste package containment are inconsistent with the Commission's intent in 10 CFR 60.113 for "substantially complete containment" of high level waste within the waste package during the containment period.

BASIS

* This comment was presented as CDSCP Comment #109. In response to this comment (which is closely related to CDSCP Comment #3), the DOE extensively revised Section 8.3.5.9 with respect to the allocations of performance to components and the associated quantitative goals for these components.
  The DOE also revised its interpretation of "substantially complete containment". The revised DOE interpretation is in substantial agreement with NRC's intent in 10 CFR 60.113. However, there appear to be inconsistencies among the tentative goals. For examples: A. The SCP states that DOE understands substantially complete containment to mean that the waste package will fully containment the total radionuclide inventory. Nevertheless, the stated overall goal for waste package performance is for all failures to be less than 5 percent in 300 yr or less 20 percent in 1,000 yr (see Comment # 6); B. the SCP allows some standing water in the borehole but no liquid contack with the waste package (see Comment # 8). Other inconsistencies are discussed in Comment # 9 and Questions # 3,4,5,8 and 9.

RECOMMENDATION

* As stated in the recomenedation for Comment 17, further agreement between DOE and NRC must be obtained to establish the recognized technological limitation and uncertainties in regard to substantially complete containment. The original comment and recommendations remain valid.

* Examine the tentative goals established for consistency.

REGULATORY UNCERTAINTY

No

Section 8.3.5.10. Issue resolution strategy for Issue 1.5: Will the waste package and repository engineered barrier systems meet the performance objective for radionuclide release rates as required by 10 CFR 60.113 ?

P.8.3.5.20-14 (Alternative approaches to be used if the reference approach proves inadequate to contain gas release)

COMMENT

Figure 8.3.5.10-3 outlines the various alternatives to be used if the reference approach proves inadequate to contain radionuclide releases. Two approches are proposed. The first approach proposes alternatives on what can be done on the spent fuel waste form and release rates. One of the alternatives proposed (Alternative 1, gas release) would alter the release rate limit of carbon-14 from EBS under 10 CFR 60.113(b). The second approach proposes alternative container designs as discussed in Section 8.3.5.9.
The SCP does not include discussion or consideration regarding how the alternative containers (e.g. the ceramic-metal system, the bi-metal system and the coating and filler system) can also reduce the gas release rate of carbon-14 from the EBS.

BASIS

* As stated in p.8.3.5.9-34, carbon-14 present in the spent fuel wast form both in the fuel and on or near the exterior surfaces of the fuel cladding and assembly hardware can be released rapidly as carbon-14 in dioxide form when air contacts the waste form at elevated temperature.

* The presence of liquid is not required for transport of gases to the environment.

RECOMMENDATION

* Provide discussions to address how the proposed alternative container designs may contribute to mitigating the release of gaseous carbon-14 from the EBS.

* Waste package design improvements should be attemped to satisfy the controlled release requirements of 10 CFR 60.113(a) before considering variation in allowed release of carbon-14 from EBS under 10 CFR 60.113(b)

SCP/YUCCA/KCC/QUE/1

Section 7.3.1.1.2 High-level waste
Section 7.4.3.2 Glass Waste form performance research

QUESTION 1

Has the DOE considered the impacts related to high-level wastes from INEL and Hanford?

BASIS

* Section 7.3.1.1.2 discusses receipt of high-level wastes from the West Valley Demonstration Project (WV) and from the Defense Waste Processing Facility (DWPF). High-level wastes from INEL and Hanford are not mentioned.

* Section 7.4.1.1.2 discusses waste form research addressing wastes from WV and DWPF but does not mention research addressing INEL and Hanford wastes.

* High-level liquid waste generated at INEL by the processing of spent fuel from the national defense (naval propulsion nuclear reactors) and reactor testing programs and by the reprocessing of fuel from nondefense research reactors is stored in large, doubly contained, underground stainless steel tanks. The liquid waste is converted to a calcine, then stored retrievably underground in stainless steel bins housed in reinforced concrete vaults. The INEL wastes are acidic.

* The Hanford waste was generated by reprocessing of production reactor fuel for recovery of plutonium, uranium, and neptunium for defense and other federal programs. Most of the high-heat-emitting isotopes (90Sr and 137Cs) have been removed from the waste, converted to solid strontium floride and cesium chloride, placed in double-walled capsules, and stored in water basins. The liquid sludge, slurry, and salt cake are stored in underground concrete tanks with carbon-steel liners. The Hanford wastes are alkaline.

* The total volume of wates from INEL and Hanford is approximately 500 thousand cubic meters which is much larger than the 115 thousand cubic meters of DWPF and WV wastes.

RECOMMENDATIONS

* Include discussions of INEL and Hanford wastes in the SCP.

* Examine the quantity and characteristics of wastes from INEL and Hanford and plans for alternate disposition, consider their impact on SCP planning and tests, and make appropriate changes to plans and tests.

REGULATORY UNCERTAINTY

No

SCP/YUCCA/KCC/QUE/2

Section 8.3.4.1.2 Waste package components.
p. 8.3.4.1-5 para 3.

QUESTION

It is stated that the borosilicate glass waste form inside a stainless steel pour canister will be placed in a metal container similar to that to be used for spent fuel.

What is meant by "similar"?

BASIS

* Similar can mean nearly identical shape and size, design, wall thickness, or same class/family of materials.

* In the context, the SCP seems to imply that the container will be fabricated from the same family of materials, i.e. austenitic stainless steels (304L, 316L, alloy 825) or copper/copper-base alloys (CDA102, CDA 613, CDA 715).

* An assumed use of "similar" materials minimizes concerns with regard to corrosion, such as galvanic corrosion, and may significantly alter the scope of testing.

* If "similar" means "of the same family of materials", then it is not clear how DOE is considering copper/copper-base alloys and any other alternative canister materials (candidates for 1000+ yr design life canisters) since Type 304L austenitic stainless steel is the only pour canister material under consideration for the borosilicate glass waste form.

RECOMMENDATION

* What is meant by similar should be clearly stated in the section cited to avoid any incorrect interpretation.

* Explanation should be provided to describe what DOE would do if dissimilar materials were selected for these containers and how this selection would affect or alter the site characterization program and waste package testing.

REGULATORY UNCERTAINTY

No

SCP/YUCCA/KCC/QUE/3

Section 8.3.4.2.C. Emplacement hole drainage
Design goal for drainage of emplacement boreholes.
p.8.3.4.2-27 para. 3.

QUESTION

It is stated that the accumulation of standing water in boreholes would lead to deleterious effects on the waste package performance. For that reason, as part of the performance allocation process, a design goal (#2) for drainage from boreholes is to allow no more than 5L of standing water per package to accumulate in the emplacement hole for the first 1,000 yr following repository closure.

How can the presence of standing water during the first 1,000 yr be justified? What is the basis for 5L of standing water per canister being acceptable?

BASIS

* During the early period of HLW canister burial (up to 1,000 yrs following repository closure), the temperature of the canister is expected to be greater than the boiling point of water. As such, any water coming in contact with the canister will presumably vaporize. A finite volume of the tuff surrounding the borehole is also expected to be dehydrated during the first 1,000 yr after the repository closure.

* Should there be any possibility of an accumulation of standing water in the borehole, the waste container design should take it into consideration.

* Since the design goal allows accumulation of the standing water, there is a possibility of a localized accelerated (crevice) corrosion on the bottom end of the HLW canister due to the existence of a crevice between the canister & the base support plate. The SCP neither provides any plans to investigate this mode of canister failure nor addresses the possibility of galvanic corrosion between the canister and the base support plate.

* It is well-known that when a metal is partially immersed in water there is much higher corrosion at the water-vapor interface than on the parts in water or in the vapor phase. This phenomena is sometimes referred to as the "water-line" corrosion. The SCP does not provide any test plans to study "water-line" corrosion in the candidate canister materials.

RECOMMENDATIONS

* Higher corrosion on the part of the canister that may be submerged in standing water during the first 1,000 yr after repository closure must be considered in canister design.

* The likelihood of an accelerated localized corrosion rate on the bottom of the canister due to the existence of a crevice, and also galvanic corrosion between the base support plate and the canister should be addressed.

* The possibility of accelerated "water-line" corrosion of the canister at the water-vapor interface needs to be investigated.

REGULATORY UNCERTAINTY

No

SCP/YUCCA/KCC/QUE/4

Section 8.3.4.2.6. Waste package fabrication and handling before emplacement
Design goal for closure.
p. 8.3.4.2-30 para. 6.

QUESTION

It is stated that the level of undetected defective closures will be shown to be less than 1%.

What is meant by undetected defective closures? Does it mean undetected defects? What is the rationale for 1%? If the "defects" are "undetected" how can it possibly be shown conclusively that the number of "defective closures" is anything other than 0%? Furthermore, if the defects are "undetected", it is reasonable to assume that their characteristics/features and precise location cannot be determined with certainty, hence they cannot be repaired. Under such circumstances what assurance is there that these defects will not get any larger or increase in number prior to emplacement or during the period requiring "substantially complete containment" of radionuclides?

BASIS

* If the defects are "undetectable", how can it be demonstrated/proven that they are below a certain limit.

* Existence of "undetectable" defects raises concerns about their nature and if and/or when they will increase in number or size, making the task of repair/rework difficult or impossible and raising further concerns about these "undetectable" defects leading to premature failures of closure joints.

RECOMMENDATIONS

* Provide a more precise definition of a "defect", and explanation about "undetectable" defects. Give examples of "undetectable" defects.

* The acceptable level of defects (detectable & undetectable) should have a rationale which relates to the performance objective for "substantially complete containment" by the waste package during the first 300 to 1,000 yrs after closure of the repository.

* Techniques should be referenced and/or development plans provided for assuring that, in the aggregate, closures with an acceptable level of "undetectable" defects and defect-free closures will meet all pre-closure and post-closure requirements regarding containment and isolation of waste.

REGULATORY UNCERTAINTY

No

SCP/YUCCA/KCC/QUE/5

Section 8.3.4.2.G. Waste package fabrication and handling before emplacement
Design goal for closure.
p. 8.3.4.2-30 para. 6.

QUESTION

It is stated that the closure process will be capable of being performed and inspected under remote conditions with a reliability such that the containment would be capable of passing a standard helium leak test at the level of 1 x 10^{-7} atm-cm^3/sec.

What is the basis for the helium leak test acceptance criteria?

BASIS

* 10 CFR Part 60.113 includes requirements for the performance of the engineered barrier system and it is not clear if the criteria are consistent with these requirements.

RECOMMENDATION

* Provide the basis for the helium leak test acceptance criteria and demonstrate that the criteria are consistent with the performance requirements of 10 CFR Part 60.113 for the engineered barrier system.

REGULATORY UNCERTAINTY

No

SCP/YUCCA/KCC/QUE/6

Section 8.3.4.2.G. Waste package fabrication and handling before emplacement
Design goal for handling.
p. 8.3.4.2-30 para. 9.

QUESTION

It is stated that containers will not be allowed to contact corrosive chemicals during surface-handling and emplacement operations except as needed for surface finishing.

What kind of surface finishing would be anticipated or required for the HLW canisters prior to emplacement? Would any corrosive chemicals be necessary or allowed for surface finishing of the canisters? What chemicals would be allowed/prohibited? How long will they be in contact with the canister surface? What techniques will be used to verify that they have been completely removed prior to emplacement in the repository and that they have has no adverse impact on the containers?

BASIS

* Bases for the need to surface finish HLW canisters, using corrosive chemicals are not given in the SCP.

* Testing of the effects of such surface finishing techniques on waste package performance are not included in the SCP.

RECOMMENDATIONS

* Need for any specific surface finishing/conditioning of HLW canisters should be justified.

* Need for using corrosive chemicals for surface finishing/conditioning of canisters should be justified.

* Plans for evaluating the long-term effects of using corrosive chemicals on HLW canisters should be provided.

REGULATORY UNCERTAINTY

No

SCP/YUCCA/KCC/QUE/7

Section 8.3.4.2.G. Waste package fabrication and handling before emplacement.
Design goal for handling.
p. 8.3.4.2-30 para. 9.

QUESTION

One of the design goals (#2) to avoid damage from handling that affects performance is not to emplace any container that is subjected to an impact load equivalent to a free-fall of 10-cm or more during handling.

What is the basis for the 10-cm free-fall acceptance criterion? Is this criterion based on the damage to the canister and/or its contents?

BASIS

* Damage will be a function of several factors including: container material and thickness, package weight, location of impact, and rigidity of surface upon which it falls.

* Calculations and/or test results were not provided which would establish 10-cm as "conservative" for all anticipated container drop scenarios.

* Internal and/or external damage may affect waste package container performance.

* It would be impractical to verify the equivalent free-fall distance after an accidental drop.

RECOMMENDATION

* The 10-cm free-fall acceptance criterion should be based on appropriate testing and assessment of external and internal damage to the canister and/or its contents.

* Techniques to be used for determining the suitability/ unsuitability of a canister for emplacement after a drop should be provided.

* Plans should be provided for testing that will be performed in establishing the free-fall acceptance criterion.

REGULATORY UNCERTAINTY

No

SCP/YUCCA/KCC/QUE/8

Section 8.3.4.2.G. Waste package fabrication and handling before emplacement
Design goal for handling.
p. 8.3.4.2-31 para.1.

QUESTION

One of the design goals (#3) to avoid damage from handling that affects performance is not to emplace any container that is scratched so that the metal is thinned by 1-mm or more.

What is the basis for the 1-mm thinning criteria? How does this relate to the variation/tolerance in the nominal wall thickness of the canister material? What is the allowed variation in canister wall thickness? Is the scratch design goal of 1-mm depth independent of the canister material? Would a scratch depth of a mm or less create a potential location for crevice corrosion?

BASIS

* Corrosion response of a scratch/scratched region will depend upon the characteristics of the scratch, e.g., its width, depth, root radius, scratch density, any chemical contamination of the scratched region with the object that produced the scratch, etc. The SCP does not provide any characteristics of the scratch other than its depth.

* Techniques that will be used to measure the wall thinning at the location of the scratch are not given in the SCP.

RECOMMENDATIONS

* Provide a more complete definition of the pertinent characteristics of a scratch.

* Scratch acceptance criteria should provide the maximum acceptable scratch length, depth, width, areal density, total number of scratches per canister, total length of scratches per canister, and other features of a scratch that could affect the performance of the canister.

* Criteria for evaluation of the suitability of a scratched canister should be supported by experimental evidence of material performance of a scratched region.

* Techniques that will be used to detect scratches and measure wall thinning at the location of the scratch should be provided.

REGULATORY UNCERTAINTY

No

SCP/YUCCA/KCC/QUE/9

Section 8.3.4.2G. Waste package fabrication and handling before emplacement
Design goal for handling.
p. 8.3.4.2-31 para. 1.

QUESTION

One of the design goals (#4) to avoid damage from handling that affects performance is not to emplace any container that has experienced an unusual process history that would cause new corrosion considerations to arise.

What is an "unusual process history"? What kinds of new corrosion considerations can arise? Give examples over the range of anticipated or potential process histories. What are DOE's plans for disposition of this kind of waste?

BASIS

* There is little discussion in the SCP about what constitutes an "unusual process history".

* In the absence of a clear definition and discussion of "unusual process history" there is difficulty in judging what constitutes such a history for the purpose of developing plans to address the problem.

* Simply stating that this kind of waste will not be emplaced does not solve the problem of dealing with this waste which will require eventual disposal.

RECOMMENDATION

* "Unusual process history" should be defined clearly.

* New corrosion considerations that would arise from "unusual process history" should be explained.

* Plans should be described for the eventual disposition of this kind of waste.

REGULATORY UNCERTAINTY

No

SCP/YUCCA/KCC/QUE/10

Section 8.3.4.2.H <u>Alteration to the environment caused by nonwaste package components</u>
<u>Design goals for the borehole liner</u>.
p. 8.3.4.2-31 para. 5.

QUESTION

One of the design goals (#1) for the liner is that the corrosion rate of the borehole liner by uniform corrosion will be within a factor of 2 of that for the container material.

What is the basis of the factor of 2? Is it two times greater or half the corrosion rate of the canister material? Since the borehole liner will be in contact with the geologic formation of the region, what testing plans have been developed to test the corrosion behavior of the candidate liner materials in the presence of tuff geologic formations? What will be the effects of the water containing liner corrosion products on the materials response of the HLW canister?

BASIS

* Corrosion products from the borehole liner would change the chemistry of water coming in contact with the canister. This could have an impact on the long-term corrosion behavior or other life-limiting canister degradation mechanisms. The SCP does not address this issue.

RECOMMENDATION

* Explain the basis for the "factor of 2" corrosion rate design goal for the liner.

* Provide information on the studies/tests to address liner corrosion.

* Provide information on the studies/tests to address the issue of possible deleterious effects of liner corrosion products on the performance of the canister.

REGULATORY UNCERTAINTY

No

SCP/YUCCA/KCC/QUE/11

Section 8.3.4. <u>WASTE PACKAGE PROGRAM</u>.
(Waste package postclosure compliance strategy)
p. 8.3.4-3 para. 4.

<u>QUESTION</u>

It is stated that the expected quality of the water is such that it will have little impact on the long-term integrity of the waste packages.

What is the expected quality of the water and how might this quality vary over the lifetime of the repository?

<u>BASIS</u>

* Some field tests have shown a wide variation in the chemical species found in the waters from different locations in the vicinity of the Yucca Mountain. Little information is available on water from the unsaturated zone.

* There is a distinct potential for concentrated salt solutions to form due to vaporization of the groundwater. These could lead to enhanced corrosion.

<u>RECOMMENDATION</u>

* Provide justification for the expectation of the quality of water in the unsaturated zone and an assessment regarding how the quality of the waster might vary during the repository lifetime.

* Provide information concerning the potential effects of concentrated solutions on waste package performance.

<u>REGULATORY UNCERTAINTY</u>

No

SCP/YUCCA/KCC/QUE/12

Section 8.3.5.9. Issue resolution strategy for Issue 1.4: Will the waste package meet the performance objective for containment as required by 10 CFR 60.113?
(Tentative goals for release from the waste packages)
P. 8.3.5.9-19 PARA 3.

QUESTION

It is stated that DOE considers it appropriate to require that release of isotopes with long half-lives from the waste packages be controlled at a stricter standard during the containment period than during post-containment period.

What is the basis of this statement?

BASIS

* Isotopes with long half-lives will have practically the same inventory during the containment period (300 to 1,000 yr) as at the beginning of the post-containment period. On the other hand, strictly controlling the release of shorter-lived isotopes during the containment period will assure (safe) substantial reduction in the inventory of the short-lived isotopes (through radioactive decay) prior to the beginning of the post-containment period.

RECOMMENDATION

* Justification for requiring stricter control on the release of long-lived isotopes during the containment period should be provided.

REGULATORY UNCERTAINTY

No

REWRITTEN

SCP/YUCCA/KCC/QUE/13

Section 8.3.5.9. <u>Issue resolution strategy for Issue 1.4: Will the waste package meet the performance objectives for containment as required by 10 CFR 60.113?</u>
(Performance allocation)
P. 8.3.5.9-23 para. 2.

QUESTION

It is stated that some preclosure container breaches will escape detection and that a very small fraction of containers will breach during containment. Further, it is stated that these breaches may not constitute failure since failure is defined as a breach large enough to allow significant air flow (1 x 10^{-4} atm-cm^3/s into the container. It is, also, stated that this test is a general standard accepted by the nuclear industry.

What is the origin of the stated definition of a failure? What is the basis for its applicability for canisters containing HLW? What segment of the nuclear industry accepts it as a general standard? For which component(s) is this standard used?

BASIS

* All breaches constitute failure of the containment. Such breaches and their effect on performance must be known to judge whether containment is "substantially complete".

RECOMMENDATIONS

* Present plans for testing and demonstrating that canisters with breaches of the size stated will meet all preclosure radioactive release requirements imposed on canisters with no breaches.

* Present plans for testing and demonstrating that the composite of canisters with and without breaches of the size stated will meet the postclosure radioactive release requirements ("substantially complete containment" and "gradual release").

* Present plans for testing and demonstrating that breaches of the size stated will not propagate or increase in time during the containment and post containment periods.

REGULATORY UNCERTAINTY

No

SCP/YUCCA/KCC/QUE/14

Section 8.3.5.9.2.1.1 Subactivity 1.4.2.1.1: Establishment of selection criteria and their weighting factors

QUESTION

The composition of the peer review panel is very important. These seven individuals should be recognized as being among the top experts in metallurgy and materials science in the United States. How are these individuals selected?

BASIS

* A peer review conducted by the expert panel would serve to put to use the best knowledge available on the given subject.

* Peer review would be for the purpose of sanctioning, improving, passing judgement and commenting on the given subject.

* Peer review indicates a strict and knowledgeable review, and this can best be accomplished by a recognized panel of experts.

RECOMMENDATIONS

* Select individuals for peer review from a cross section of leading experts representing academia, industry, government and other individuals or establishments.

* Include in the SCP discussions of criteria used for selecting peer review panel members.

REGULATORY UNCERTAINTY

No

SCP/YUCCA/KCC/QUE/15

Section 8.3.5.9.2.3.2. Subactivities 1.4.2.3.2 through 1.4.2.3.9:
Laboratory test plan for austenitic materials.
<u>Description</u>
p. 8.3.5.9-78 para. 1.

<u>QUESTION</u>

It is stated that long-term, low temperature oxidation is expected to condition the surface of the container and will influence all the other subsequent degradation modes. It is also stated that these points are taken into account in the modeling activities.

What is meant by "condition the surface"? What tests/analyses have been performed to understand the conditioning effects of low temperature oxidation? How have the surface conditioning effects been factored into the canister materials selection process?
How have the surface conditioning effects been taken into account in the modeling activities?

<u>BASIS</u>

* Plans for testing of the effects of surface conditioning of HLW canisters as a result of long-term, low temperature oxidation on the performance of the waste package are not discussed in the SCP.

* The role of this presumed protective mechanism in material selection is not stated.

<u>RECOMMENDATION</u>

* Plans for evaluating the effects of surface conditioning of the HLW canisters due to long-term, low temperature oxidation should be provided in the SCP.

<u>REGULATORY UNCERTAINTY</u>

No

SCP/YUCCA/KCC/QUE/16

Section 8.3.5.9.3.2.7 Subactivity 1.4.3.2.7: Transgranular Stress Corrosion Cracking

Section 7.4.2.6 Pitting Corrosion, Crevice Corrosion, and Transgranular Stress Corrosion Cracking

QUESTION

In this section and throughout the SCP is there an assumption that stress corrosion crack propagation results from anodic dissolution and removal of metal from the crack tip?

BASIS

* Not all viable mechanisms will require a liquid phase at the crack tip. For example, three alternative mechanisms for T-SCC of stainless steels have been proposed: hydrogen embrittlement, film-induced cleavage and surface diffusion. These mechanisms may not require liquid phase water at the crack tip.

* If a liquid phase is not required at the crack tip for environmentally induced cracking, then cracking may be possible in the unsaturated zone during the containment period and should be evaluated.

* The assumption that SCC propagation results from anodic dissolution and removal of metal from the crack tip is not generally accepted throughout the corrosion research community and is contrary to recent research results, particularly for transgranular stress corrosion cracking (T-SCC).

* The mechanism of SCC is not thoroughly established and more than one mechanism may be capable of causing crack propagation.

* Since the mechanism of SCC is not known, then all viable mechanisms should be evaluated.

RECOMMENDATIONS

* Modeling efforts should include all viable mechanisms of SCC and testing should include evaluation of cracking resistance in vapor phase environments.

REGULATORY UNCERTAINTY

No

SCP/YUCCA/KCC/QUE/17

Section 8.3.5.10. Issue resolution strategy for Issue 1.5: Will the waste package and repository engineered barrier systems meet the performance objective for radionuclide release rates as required by 10 CFR 60.113 ?
A. Waste form definition. Specification 1.3. Leaching properties.
p. 8.3.5.10-34 para. 4.

QUESTION

It is stated that the leaching properties specification will require the producer to control the leaching characteristics of the glass waste form such that the release rates in a 28-day MCC-1 leach test in deionized water do not exceed certain specified limits.

Why is the specification based on release rates in deionized water when the specific water chemistry of the repository may produce different and, certainly, more representative results?

BASIS

* Leach testing in deionized water may not be able to detect some variability in the glass waste form production which might significantly affect the waste form response to leaching in a solution representative of the repository environment.

RECOMMENDATION

* A leach test specification to detect any variability in the glass waste form production that might have a significant effect on the leaching behavior of the waste form in the repository environment should be based on testing in simulated repository water.

REGULATORY UNCERTAINTY

No

SCP/YUCCA/KCC/QUE/18

Section 8.3.5.10.2.1.1 Subactivity 1.5.2.1.1: Dissolution and leaching of spent fuel

QUESTION

* Does the proposed SCP test for rate of release of radionuclides from spent fuel in J-13 water take into consideration the effect of ground water contamination by container metal ions, or the possible concentration of J-13 salts in the repository?

BASIS

* The SCP proposes to investigate release rates of radionuclides from spent UO_2 fuel in reference J-13 water. If the waste containers fail through some corrosion related phenomenon, the J-13 water will, very likely, be contaminated by the container metal ions (Fe, Ni, Cu, etc.). These charged ions will affect the chemical reactions in the container and the dissolution of the radionuclides in J-13 water. Furthermore, the evaporation of J-13 water may increase the concentration of J-13 water above its proposed reference level.

RECOMMENDATION

* Testing of release rates in J-13 water should include water that contains the various metal ions that will be made available from the corrosion of the metal container. The solute concentrations should include those found at and above the concentration levels in reference J-13 water.

REGULATORY UNCERTAINTY

No

SCP/YUCCA/KCC/QUE/19

Section 8.3.4 WASTE PACKAGE PROGRAM
p. 8.3.4-4 (Waste Package Postclosure Compliance Strategy)

QUESTION

It is stated that, for spent fuel, reliance (i.e., performance allocation) is placed on the cladding during the early years to limit the release of the radionuclides with short half lives. How can performance allocation or reliance be placed on the cladding of those spent fuel elements which fail or "leak" during reactor operation? Will spent fuel "leakers" be identified and fixed prior to packaging for emplacement in the repository?

BASIS

* During normal reactor operation, the cladding of a small percentage of the fuel elements can be expected to fail or leak, exposing the fuel elements to leaching conditions.

* Existing spent fuel rod consolidation technology appears to damage the cladding of an additional small percentage of those fuel assembies undergoing rod consolidation

* The spent fuel of those elements with damaged or failed cladding will be directly exposed to the leaching conditions of any water which may collect or develop in the repository horizon.

RECOMMENDATION

* Provide justification for allocating performance to spent fuel cladding, given the knowledge that a small percentage of the spent fuel will have failed cladding on emplacement, and identify any plans to repair fuel with damaged cladding prior to emplacement.

REGULATORY UNCERTAINTY

No

SCP/YUCCA/KCC/QUE/20

Section 8.3.5.9.2.3.2 Subactivities 1.4.2.3.2. - 1.4.2.3.9. Laboratory Test Plan for Austenitic Materials.

The experimental approach for each possible degradation mode to be tested should be designed and evaluated prior to testing. How will "more severe" environments be identified and proven to be "more severe" for a given failure mode?

BASIS

* This question was presented as CDSCP Question #45. In response to this question, the DOE has added text to Sections 8.3.5.9.2.2.2 and 8.3.5.9.2.3.2 to provide for review of test plans and procedures to ensure adequacy of the range of test conditions in metal barrier degradation mode tests. However, no description is provided of any procedures that have been established for conducting the reviews and who will conduct the reviews. It is not mentioned if/how/when the NRC input will be factored into the reviews. No schedule for the reviews are provided.

RECOMENDATION

* Provide copies and details of reviews and schedules of test procedures and tests plans for the metal barrier degradation mode tests.

* State how NRC inputs will be factored into the reviews.

REGULATORY UNCERTAINTY

No

too much details for SCP?

MAY 12 1989

NOTE TO: J. Bunting, Chief
Engineering Branch

FROM: R. Weller, Section Leader
Materials Section

SUBJECT: RESOLVED CDSCP COMMENTS FOR INCLUSION IN THE APPENDIX TO THE STAFF'S SITE CHARACTERIZATION ANALYSIS (SCA)

As stated in my April 28, 1989 note to you which forwarded the Materials Section draft SCP point papers, the Materials Section discussion of resolved CDSCP comments would be provided by separate note. Resolved CDSCP comments are intended to go into an appendix in the SCA. Enclosed is the Materials Section input for that appendix in the format requested by the Yucca Mountain project manager (K. Stablein). If you have any questions, please advise.

Rick

R. Weller, Section Leader
Materials Section

Enclosure: As stated

cc: K. Stablein
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SCP/YUCCA/KCC/CDSCP/COM/75

CDSCP COMMENT #75

Section 8.3.5.9.1.1.2 Microstructural Properties.

Metallographic and microscopic characterization techniques given in this section (Section 8.3.5.9.1.1.2) for copper, copper-based alloys, and austenitic stainless steels are insufficiently described.

BASIS

* Some microstructures cannot be observed using conventional metallographic techniques.

* Grain boundary structure, precipitate formation, and dislocation structures affect material properties and stability, and these features should be viewed at high magnifications using electron microscopy.

* Advanced analytical techniques are needed to analyze for oxygen, hydrogen, or other elemental diffusion into metals.

EVALUATION OF THE DOE RESPONSE

* In response to this comment, the DOE has accepted the NRC recommendation to use advanced techniques for resolution of the microstructure and microchemical analysis of the canister materials.

* A paragraph identifying several advanced techniques for examination and characterization of the microstructure has been added to Section 8.3.5.9.1.1.2 of the SCP.

* However, the DOE believes that details on which techniques and detailed procedures that will be used are beyond the scope of the SCP.

CONCLUSION

Based on our review of the response to this comment, and the DOE's acceptance of the NRC recommendation to use more advanced techniques to resolve and characterize the fine microstructural details, the comment is resolved.

SCP/YUCCA/KCC/CDSCP/COM/76

CDSCP COMMENT #76

Section 8.3.5.9.1.1.2 Microstructural Properties.
(Phase stability in austenitic stainless steels).

Data are not presented to show that structural stability of the container will be maintained after prolonged exposure to 100 to 250°C temperature (p. 7-42).

BASIS

* Microstructures of austenitic stainless steels are unstable in terms of transformation to martensite, precipitation of sigma or other embrittling phases and sensitization.

* Small amounts of martensite increase the steel's susceptibility to stress corrosion cracking.

* Embrittling phases provide initiation sites for cracking and increase susceptibility to cracking.

* Sensitization or carbide formation may be enhanced by initial high temperatures and by extended temperatures of the repository. Beneficial effects of carbide forming alloying elements such as titanium and of specified cooling rates during manufacture could be negated by the extended time at temperature after emplacement.

* Phase precipitation causes chemical changes in the microstructure which may result in decreased resistance to localized corrosion such as pitting and stress corrosion cracking.

EVALUATION OF THE DOE RESPONSE

* In response to this comment, the DOE has added text in Section 8.3.5.9.1.1.2 to explicitly identify microstructure stability as a criteria to be evaluated in the material selection process. Specific parameters that include aspects of phase stability effects are also identified, e.g. resistance to environmentally accelerated cracking, localized corrosion attack, and mechanical embrittlement.

* DOE has also had a peer review of its canister material selection criteria. However, the report of the review panel and the reviewed criteria have not been made available as yet.

CONCLUSION

Based on our review of the response to this comment, and the corresponding additions to the appropriate sections of the SCP dealing with the canister material selection criteria, the comment is resolved.

SCP/YUCCA/KCC/CDSCP/COM/78

CDSCP COMMENT #78

Section 8.3.5.9.1.1.5 Characterization and inspection of weld integrity.

The effect of microstructure and chemistry on weld integrity has not been sufficiently treated.

BASIS

* Welds are areas of chemical inhomogeneity, and effects of this inhomogeneity under repository conditions should be established.

* Welds of austenitic stainless steels are areas subject to sensitization that may lead to failure.

* Weld solidification shrinkage can result in localized increases in stress that can promote stress corrosion cracking and other cracking.

* Weldments have the potential for contamination and local segregation, either of which may promote premature failure.

* Welded areas are potential sites for galvanic corrosion and localized corrosion.

EVALUATION OF THE DOE RESPONSE

* The DOE has agreed with the NRC's concern expressed in this comment and has included in its plans the determination of the metallurgical and microstructural properties of the welds, and also plans to conduct studies and tests to evaluate the effects of welding on residual stresses in the canister and closure joint and on the corrosion behavior of the canister.

* Discussion to reflect plans for testing and studies on welds has been added in the SCP.

CONCLUSION

Based on our review of the response to this comment, the comment is resolved.

SCP/YUCCA/KCC/CDSCP/COM/79

CDSCP COMMENT #79

Section 8.3.5.9.2.2 Degradation Modes Affecting Candidate Copper-Based Container Materials.

There is no discussion of the basis and reasons for choosing three specific copper-base alloys as candidate container materials.

BASIS

* Three materials--CDA 102, CDA 613, and CDA 715--are going to be tested.

* Other copper-based alloys could perform as well or better than the three listed.

* Except for these three materials, no tests, not even scoping tests, have been performed on other potential, or candidate copper-base alloys.

EVALUATION OF THE DOE RESPONSE

* DOE has provided references to relevant studies that were undertaken by the Yucca Mountain Project in FY-85 and FY-86 in conjunction with the copper industry.

* Additional text has been provided in Section 8.3.5.9.2.2.2 to briefly discuss the feasibility study on using copper/copper-base alloys for the HLW canister.

CONCLUSION

Based on the response to this comment, and the relevant references provided by the DOE, this comment is resolved.

SCP/YUCCA/KCC/CDSCP/COM/81

CDSCP COMMENT #81

Section 8.3.5.9.2.3.2 Subactivities 1.4.2.3.2. - 1.4.2.3.9. Laboratory Test Plan for Austenitic Materials.

Investigation of the effects on the corrosion behavior of the containers that may result from any metallurgical changes associated with fabrication in large sections is not identified as a specific topic of a test program.

BASIS

* The influence of fabrication in large sections on the corrosion behavior of the container is not identified as a specific topic of a test program.

* The size of the section and the welding procedures govern metallurgical conditions and thus alter the corrosion behavior.

* Other fabrication processes and procedures (such as surface peening) may alter the surface and metallurgical condition of the container and thereby alter the corrosion behavior of the container.

* Residual stresses present in large vessels after post-weld stress-relief heat treatment can be significant.

EVALUATION OF THE DOE RESPONSE

* The DOE has accepted the NRC's recommendation and has included plans in the SCP for testing of full-scale fabricated canisters. The testing program will include evaluation/measurement of mechanical, physical, and metallurgical properties. Characterization of metallurgical conditions in the fabricated canister will also include microchemical analyses and corrosion properties of coupons cut from the full-scale container.

* The DOE plans to conduct these investigations only on the material finally selected as the prime candidate material for the HLW canisters.

CONCLUSION

Based on our review of the response and incorporation of additional plans in the SCP for testing full-scale fabricated canisters and test coupons from such canisters, the comment is resolved.

SCP/YUCCA/KCC/CDSCP/COM/83

CDSCP COMMENT #83

Section 7.4.5.4.6 Corrosion Model.
Section 8.3.5.9.3 Information Need 1.4.3: Scenarios and models needed to predict the rate of degradation of the container material.

The corrosion models described in the CDSCP are not specific and/or adaptable to specific metals, environmental conditions, and forms of corrosion.

BASIS

* The electrode potential of a metal or a phase within an alloy and the repository environment will control initiation or absence of corrosion. Electrode potentials should be known for various possible conditions and for expected times of exposure.

* Changes in water chemistry such as pH and/or ionic content will affect the electrode potential and corrosion rate must be established.

* Localized stresses, brittle phases, precipitates, different phases and other microstructural variations will result in variations in electrode potential and corrosion processes.

* Corrosion processes expected should be correlated with the material and environment.

EVALUATION OF THE DOE RESPONSE

* In response to this comment, the DOE acknowledges the NRC's concerns, and plans to develop corrosion models only for the selected metal barrier material.

* Text has been added to Section 8.3.5.9.3 in the SCP that states that deterministic models linked to the relevant degradation models will be developed as part of the advanced design work. These models will be based on physical, chemical, metallurgical, and mechanical parameters covering the range of expected repository conditions.

CONCLUSION

Based on the DOE response, this comment is resolved.

SCP/YUCCA/KCC/CDSCP/COM84

CDSCP COMMENT #84

Section 8.3.5.9.3.2.1 Subactivities 1.4.3.2.1 Metallurgical Aging and Phase Transformations.

The resistance of an alloy to corrosion, intergranular corrosion, and stress-corrosion cracking is a function of the combined effects of radiation, temperature, stress, and time on the metallurgical stability of the alloy. These combined effects are not sufficiently discussed in the CDSCP.

BASIS

* Changes in the metallurgical condition of metastable austenitic materials can have dramatic effects on the resistance of these materials to degradation by chemical as well as mechanical processes.

EVALUATION OF THE DOE RESPONSE

* In response to this comment, the DOE has added text in Section 8.3.5.9.3.2.1 on metallurgical aging and phase transformation to address the NRC's concerns.

CONCLUSION

Based on the response to this comment, and incorporation of additional text in the SCP, the comment is resolved.

SCP/YUCCA/KCC/CDSCP/COM/85

CDSCP COMMENT #85

Section 8.3.5.10 Corrosion of Zircaloy.

The tests discussed in this section of the CDSCP are insufficient in that they do not account for the previous history of the Zircaloy, all modes of hydrogen embrittlement, and other types of localized corrosion.

BASIS

* The type of reactor exposure, the composition of the residue that collects on the fuel rods, and the manner in which the fuel rods were cleaned will affect corrosion of Zircaloy.

* Residue deposits that contain copper have especially destructive effects on Zircaloy's protective oxide film, and local corrosion or pitting may result.

* Zircaloy, in reactor service, is subject to stress corrosion cracking from the fuel side of the cladding due to fission products such as iodides.

* Examples of hydrogen embrittlement failures in Zircaloy cladding have been reported.

* Zircaloy is not immune to pitting corrosion; and pitting can occur in hydrochloric acid containing ferric or cupric ions and in the presence of all the halogens either in liquid or gaseous form.

EVALUATION OF THE DOE RESPONSE

* In response to this comment, the DOE has agreed with the NRC's CDSCP comment and has added text in Section 8.3.5.10.2.1.3 on corrosion of Zircaloy to address the NRC's major concerns.

* The DOE has included plans to perform additional experiments and failure mode investigations of Zircaloy cladding within the range of expected water and vapor chemistry in the Yucca Mountain repository site.

CONCLUSION

Based on our review of the response, and the additions made by the DOE to the testing plans in the SCP, this comment is resolved.

SCP/YUCCA/KCC/CDSCP/COM/110

CDSCP COMMENT #110

Section 8.3.5.10.2 Information need 1.5.2; material properties of the waste form. Technical basis for addressing the information need.

The effect of oxidation on the leaching of spent fuel has not been sufficiently addressed in relation to meeting the performance objectives for radionuclide releases.

BASIS

* The solubility or leachability of spent fuel will be enhanced if it is oxidized in a repository environment.

* The rate of spent fuel oxidation has not been determined.

* The leaching behavior of spent fuel has not been determined.

* The leach rate of fission products may be greatly increased depending on their distribution in the spent fuel. For example, if fission products concentrate in grain boundaries and oxidation along grain boundaries is the dominant mechanism, leach rates may be greatly increased.

* Radionuclide release, because of spent fuel oxidation, may result in an unexpectedly high source term to the engineered barrier system.

EVALUATION OF THE DOE RESPONSE

* In response to this comment, the DOE has agreed with the NRC's concerns and has recognized the need for determining spent fuel oxidation related parameters. The response references pertinent sections of the SCP dealing with the planned testing activities to generate the necessary technical data in meeting the modeling information needs.

CONCLUSION

Based on our review of the response, this comment is resolved.

SCP/YUCCA/KCC/CDSCP/QUE/1

CDSCP QUESTION #1

Section 6.2.6 Subsurface design.
Section 7.3.1.3 Reference waste package design.
Section 7.4.1.3 Figure 7-5 Example of temperature histories of thermal waste package components and host rock for a vertically emplaced spent fuel container.

Is the site characterization testing related to thermal loading for the site based on the maximum waste package and areal loading?

BASIS

* The subsurface design is using a design basis areal power density of 57 kw/acre, based on an average waste package heat input of 3.03 kw. The maximum design heat output of a waste package is 5 kw. Figure 7-5 shows typical modeled thermal histories of a vertically emplaced spent fuel waste package and its immediate surroundings with waste package average power of 3.3 kw.

* Design basis information should include the maximum design case.

* The areal power density and the maximum heat output of a waste package can be exceeded if 5 year old high burnup fuel is consolidated and placed in boreholes of close proximity to other 5 year old high burnup fuel.

8 Any analysis must consider the margins of safety under normal conditions and anticipated operational occurrences (10CFR 60.21(c)(ii)(F)(3)).

EVALUATION OF THE DOE RESPONSE

* In response to this question, the DOE has added a statement to Section 6.2.6 to clarify the basis for thermal loading conditions (p. 6-147 of the SCP). The statement indicates that: (1) the current design is based on the emplacement of reference waste packages as described in Section 7.3.1.3 and (2) development of a waste emplacement program with a thermal management strategy is planned as information becomes available.

* The DOE response has clarified that the 5 kW per package is used for waste package testing because of waste form temperature limits. This loading provides a reasonable basis for testing until further information is available.

CONCLUSION

Based on the response to this question, the question is resolved.

K- Stablein

Pg. 1 of 2

April 30, 1989

MEMO FOR: Ronald Ballard, Chief
Geosciences and Systems Performance Branch

FROM: Philip S. Justus, Section Leader
Geology-Geophysics Section

PSJ

SUBJECT: GEOLOGY-GEOPHYSICS SECTION DRAFT OF CONCERNS ABOUT SITE CHARACTERIZATION PLAN, YUCCA MOUNTAIN SITE

The Geology-Geophysics Section's draft of concerns about the SCP for Yucca Mountain, Nevada are enclosed (Attachment 1-Status of CDSCP Point Papers; Attachment 2-Summary of GGS SCP New & Unresolved Draft Point Papers). This draft constitutes the Section Leader's IQA draft developed in accordance with the IQA requirements of Section 6.1 of the SCP Review Plan (Attachment 3-GGS New & Unresolved (CDSCP) Point Papers; Attachment 4-GGS Resolved CDSCP Point Papers).

IQA requirement 2F, assure technical consistency across different disciplines, could not be completed because the final draft point papers (concerns) from the other disciplines were not available for review and comment. I recommend that 2F be completed prior to issuance of the branch draft concerns, due May 5th.

Certain background information not in the SCP Review Plan should be borne in mind when reviewing these concerns: (1) the CDSCP Response Document submitted by DOE with the SCP is not the reference of merit for NRC's evaluation of responses to our concerns about the CDSCP, the SCP is; and (2) the special requirement to identify concerns that are associated with regulatory uncertainties and correlate them to the Center report (R9), "Analysis of Regulatory Uncertainties Related to the Site Characterization Plan and the Exploratory Shaft Facility" will be completed by May 5th.

The GGS is proposing concerns about the SCP as follows (Attachments 1, 2, 3):

Objections... 2
Comments.....33
Questions....11

Of the CDSCP concerns that we had last year to be addressed by DOE, there were 16 comments, 3 are considered resolved; there were 11 questions, 7 are considered resolved (Attachment 4-GGS Resolved CDSCP Point Papers).

The draft was prepared by Geology-Geophysics Section staff with various responsibilities as described in my note to you on January 4, 1989 (Attachment 5). These contractors provided various draft point papers: Center, Bureau of Mines and Weston

Geophysical Corporation; their recommendations were fully considered. The Center provided IQA support to me in preparation of this draft. Contractor recommendations are a part of the IQA record.

The GGS concerns can be categorized as follows, for convenience and in no particular order; we consider that they are all of potential significance to DOE:

* Design control process for ESF location
* Sequencing of tests, measurements and decisions
* Integration of geophysical, geological and drilling activities
* Numerical criteria of performance
* Representativeness of site characterization activities
* Alternative conceptual tectonic/geological models
* Faulting hazard
* Volcanic hazard
* Natural resources assessments
* Mapping shafts and drifts
* Climate hazard
* Erosion hazard

We have a concern about DOE's identification and characterization of the "geologic setting" components (i.e., volcanic system, seismologic system, mineral resources system). It seems premature, however, to develop a comment on the subject because the basis will rely upon the re-definition of the term in the proposed rulemaking on "anticipated and unanticipated processes and events," not yet publicly available for discussion. Somehow, we need to identify our concern to DOE; I propose either a letter to DOE, or a special category of point paper, such as an 'anticipatory comment.' A draft of the latter will be available by May 5th.

Philip S. Justus

Philip S. Justus, Section Leader
Geology-Geophysics Section

Attachments:
1. Status of GGS CDSCP Point Papers
2. Summary of GGS SCP New & Unresolved (CDSCP) Draft Point Papers
3. GGS New & Unresolved (CDSCP) Point Papers
4. GGS Resolved CDSCP Point Papers
5. GGS SCP Review Responsibilities - Note dated 1/4/89

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ATTACHMENT 1

GGS

ATTACHMENT 1 - STATUS OF GEOLOGY-GEOPHYSICS SECTION CDSCP POINT PAPERS

CDSCP#	STATUS	APRIL 29, POINT PAPER CODE
Com 26	not resolved	scp/ai/com/4
Com 28	not resolved	scp/yucca/kim/com/30
Com 34	resolved	scp/ca/com/34/34
Com 35	not resolved	scp/ca/com/5
Com 36	not resolved	scp/yucca/jst/com/4/4
Com 37	not resolved	scp/yucca/kim/com/13, scp/yucca/kim/com/1
Com 38	not resolved	scp/ca/com/2
Com 39	not resolved	scp/ca/com/2
Com 49	not resolved	scp/ai/com/2
Com 50	not resolved	scp/yucca/jst/com/1/1, scp/yucca/jst/com/2/A, scp/yucca/jst/com/2/8, scp/yucca/jst/com/3/3
Com 51	not resolved	scp/ai/com/3
Com 52	not resolved	scp/yucca/meb/com/1
Com 53	not resolved	scp/yucca/kim/com/32
Com 62	not resolved	scp/yucca/kim/com/33
Com 69	resolved	scp/yucca/jst/com/5/5
Com 95	not resolved	scp/yucca/jst/com/4/4
Ques 13	not resolved	scp/ca/ques/13
Ques 15	resolved	scp/ai/ques/15a
Ques 18	resolved	scp/ca/ques/18
Ques 19	resolved	scp/ca/ques/19
Ques 20	not resolved	scp/yucca/kim/com/18
Ques 21	resolved	scp/yucca/meb/ques/1
Ques 22	resolved	scp/yucca/meb/ques/2
Ques 29	resolved	scp/ca/ques/29
Ques 31	resolved	scp/yucca/meb/ques/3
Ques 32*	not resolved	scp/yucca/meb/com/2
Ques 33	not resolved	scp/ai/com/4

*upgraded to Comment status

ATTACHMENT 2

GGS

ATTACHMENT 2 - SUMMARY OF GEOLOGY-GEOPHYSICS SECTION SCP NEW AND UNRESOLVED (CDSCP) DRAFT POINT PAPERS

OBJECTIONS

SCP/YUCCA/KIM/OBJ/1
The process used to integrate all available technical data into decisions regarding shaft location appears to have been flawed. As a result of the apparent lack of data integration, concerns are raised about the suitability of shaft locations and about a process that has resulted in a possible violation of the criteria specified in the Design Acceptability Analysis (DAA) for set-back distances from faults.

SCP/YUCCA/KIM/OBJ/2
The sequencing of many geophysical and geologic activities related to faulting may lead to data collection activities that are inadequate to support assessments of performance and design bases.

COMMENTS

SCP/YUCCA/KIM/COM/1
Alternative tectonic models for the site are not fully integrated into the site characterization plan and as result alternatives are apparently not considered in preliminary performance allocation and the design of the EBS. The site characterization program appears to be directed toward providing data that confirm the preferred tectonic model rather than determining what the "preferred model" should be.

SCP/YUCCA/KIM/COM/3
The technical rationale for this investigation implies that the perimeter drift defines an area of a significantly lower concentration of faults than surrounding areas. However, based on information in other parts of the SCP, this implication may not be accurate. There is no indication that studies in the SCP address the potential impact on system performance of the presence within the perimeter drift (i.e., in emplacement areas) of a significatn number of faults that may be favorably oriented for failure under the present stress regime.

SCP/YUCCA/KIM/COM/8A
Faults appear to be considered as single strands of narrow width, an approach that may underestimate the effects of faulting on the results of planned tests and on the performance of repository facilities.

SCP/YUCCA/KIM/COM/11
The program of site characterization activities related to postclosure tectonics does not appear to provide input to performance issues related to the waste package and engineered barrier system as required in 10 CFR 60.133(a). No clear line of integration of postclosure tectonics data into the issue resolution strategy for issues 1.4 and 1.5 exists.

SCP/YUCCA/KIM/COM/12
The term "parameter goal" appears to have been inconsistently defined in various parts of Chapter 8. The adequacy of site characterization plans cannot be judged without a clear definition of parameter goal.

SCP/YUCCA/KIM/COM/13
The use of fault slip rates to determine the level of hazard posed to repository facilities by faults does not appear to be a conservative approach and may result in overly optimistic predictions about the affects of faulting on system performance.

SCP/YUCCA/KIM/COM/15
The current representation of the Physical Domain for postclosure tectonics issues (i.e., brittle crust, southern Great Basin) appears to be inadequate to evaluate the full range of processes and events likely to occur at the site and should not act as a limit on conceptual tectonic models or site investigations.

SCP/YUCCA/KIM/COM/16
Reliance on volcanic rate calculations that are developed largely independent of consideration of the underlying volcano-tectonic processes appears likely to underestimate potential impacts on the performance of the respository.

SCP/YUCCA/KIM/COM/21
The characterization parameters for the identification and characterization of "significant Quaternary faults" in the area of the repository block will not fulfil the requirements in 10 CFR 60.

SCP/YUCCA/KIM/COM/22
The design and performance parameter for characterizing faults in the waste emplacement area should be reexamined based on realistic alternative tectonic models to assure that the performance objectives can be met.

SCP/YUCCA/KIM/COM/24
The use of domains to define areas of "faulting potential" does not appear to be a reasonably conservative and technically justifiable approach to assess the potential for faulting at the site area and could underestimate the fault displacement hazard to the respository.

SCP/YUCCA/KIM/COM/26
Other aspects of detachment faulting described in Section 8.3.1.17.4.5 are at least as significant to the site as those listed as key questions to be answered by this study.

SCP/YUCCA/KIM/COM/27
The SCP does not appear to integrate synthesize data resulting from the planned activities to characterize northwest-trending faults.

SCP/YUCCA/KIM/COM/30
The program of drifting in the north, combined with systematic drilling and feature sampling drilling, appears unlikely to provide the lithologic and structural information necessary to adequately investigate potentially adverse conditions at the site or insure that observations made and data collected will be representative of conditions and processes throughout the repository block.

SCP/YUCCA/KIM/COM/32
The program of activities outlined for study of northeast-trending faults in the area of Yucca Mountain appears insufficient to determine the significance of some of these features.

SCP/YUCCA/KIM/COM/33
The tentative goal, design parameter, and expected value relating faulting and performance allocation for System Element 1.1.2 are not sufficient for adequately characterizing the hazard posed by faulting in the repository.

SCP/YUCCA/JST/COM/3/3
The NRC staff does not consider that the basis and rationale for the design and performance parameters, characterization parameters, and goals proposed in the SCP for fault displacement, in particular for fault investigations for facilities important to safety, have been justified. The staff is concerned as these values appear to be used to limit the exploration program prior to having sufficient data to evaluate the site.

SPC/YUCCA/JST/COM/1/1
The program of investigations for faulting appears to assume that any future faulting will follow old faulting patterns. The NRC staff considers that this is not a reasonably conservative assumption, and does not consider that this assumption is technically justified.

SCP/YUCCA/JST/COM/2/A
The information presented for the program of investigations for study of faulting at the surface facilities does not allow the NRC staff to determine how DOE is proposing to use standoff distances in designing the program of investigations and in performing the resultant design and analysis.

SCP/YUCCA/JST/COM/2/B
The information presented for the program of investigations for study of faulting at the surface facilities does not allow the NRC staff to determine what investigation will actually be conducted. In addition, this investigation does not appear to have integrated pre-existing information, does not appear to be in a logical sequence with other proposed investigations, and makes assumptions about pre-existing information and ongoing investigations which the NRC cannot evaluate because the NRC has not seen the background information.

SCP/YUCCA/JST/COM/4/4
If the results of the investigations on direct release resulting from volcanic activity do not provide information which shows that either the probability or consequence resulting from such a scenario is much lower than the tentative parameter goals stated in Table 8.3.1.8-1b and Table 8.3.5.13-10, the Yucca Mountain site will fail to meet the requirements for overall system performance.

SCP/YUCCA/JST/COM/9
Neither the current representation of climatic conditions during the postclosure period, nor the alternative hypothesis, allows for significant increase in precipitation or for abrupt climatic changes.

SCP/YUCCA/TC/COM/1
One of the objectives of the Activity 8.3.1.4.2.2.4 is to characterize major faults and fault zones in the subsurface. There is no justification given for not characterizing minor faults and fault zones, although these features potentially present the same kinds of hazards as do major faults, even though on a smaller scale.

SCP/YUCCA/TC/COM/3
The SCP does not appear to provide a procedure to implement the performance confirmation requiring a procedure to recognize, evaluate, and document anomalous features and changed geologic conditions that may be encountered in the exploratory shaft facility.

SCP/CA/COM/2
The program of investigations for natural resources assessment as presented in the SCP appears to be unsatisfactory for consideration of potential natural resources and natural resource models at the site.

SCP/CA/COM/4
The rationale for numerical goals specified in Tables 8.3.1.17-3a, 8.3.1.17-4a and b, and 8.3.1.17-7 is poorly supported and the use of averaged values or rates for establishing acceptable limits for fault movement, rates of volcanism, and rates of erosion does not provide for conservative assessments of potential hazards.

SCP/CA/COM/6
Recent data suggests that previous criteria for delineation of surficial deposits may need to be reevaluated.

SCP/CA/COM/5
The overall erosion program still does not include an evaluation of escarpment retreat.

SCP/YUCCA/MEB/COM/1
Since the 10,000-year cumulative slip earthquake methodology assumes that average cumulative slip over 10,000 years is released in a single event, it appears that recurrence is implied to be fixed at 10,000 years. It is questionable whether such a methodology can properly characterize the fault activity, and the related seismic activity, in the site region.

SCP/YUCCA/MEB/COM/2
The data, compiled according to Activity 8.3.1.17.4.1.2, may not be sufficient to support an evaluation of the effects of local site geology on surface and subsurface motions.

SCP/AI/COM/2
Geophysical coverage as indicated in the SCP may not be sufficient to identify and characterize the deep crustal and shallow geologic features and their interrelationship.

SCP/AI/COM/3
No specific geophysical program appears to be planned to identify volcanic/igneous features and their extent under or close to the site.

SCP/AI/COM/4
The program for geophysical integration as presented in the SCP is insufficiently described. The correlation between the different geophysical investigations is not presented and, in addition, the approach that will be used to integrate the geophysical activities and how these different geophysical activities will compliment each other does not appear to be discussed.

QUESTIONS

SCP/YUCCA/KIM/QUES/9
Why has the Lunar Crater area not been considered as a possible natural analog for detailed study of the processes related to basaltic volcanism in the Death Valley-Pancake Range volcanic belt?

SCP/YUCCA/KIM/COM/18
What is the basis for statements made about the migration, structural boundaries, and stage of volcanism at Yucca Mountain? These statements appear to be unsupported by data presented in the SCP. Data in the SCP references and conclusions made in the SCP appear contradictory.

SCP/YUCCA/KIM/COM/34
What is the basis for the three thousand foot spacing for drillholes in the systematic drilling program?

SCP/YUCCA/JST/QUE/4
The work of Sass and others (1988) indicates that the site is in an area of anomalously low heat flow. How will the temperature logging described in the above sections be sufficient to evaluate the significance of this preliminary conclusion?

SCP/TC/QUES/1
Explain what is meant by the statement in the last paragrpah of page 8.3.1.4-75 that the discontinuities and other features of interest to be mapped "will be identified based in part, but not exclusively, on predetermined criteria." Also, what are the "criteria?"

SCP/CA/QUES/1
The SCP does not appear to consider historical records of claims and/or leases in its evaluation of previous drilling or excavation at Yucca Mountain. What consideration been given to historical maps and claim and lease information in establishing the position that "no further investigation of previous drilling or mining is needed" (p.1-213) in the repository area?

SCP/CQA/QUES/13
Discussions of the integrated drilling program are unclear: How will data from various drillholes be used in support of different studies; how will uncertainty in core retrieval and data analysis be handled; and how will the large volume of existing information be used to plan the drilling program?

SCP/CA/QUES/7
Measuring systems used in the SCP are inconsistant. Explain this lack of consistency.

SCP/CA/QUES/6
What consideration is being given to the use of side looking airborne radar (SLAR) at Yucca Mountain?

SCP/CA/COM/3
What is the basis for SCP statements with respect to resource exploration and resource potential? The following statements are misleading, inconsistant, and/or erroneous?

SCP/CA/COM/1/1

The SCP lists many surficial mapping projects, some of which are currently on-going or are near completion. How does the DOE plan to integrate these various mapping tasks and the resultant information?

ATTACHMENT 3

GGS

GEOLOGY-GEOPHYSICS SECTION NEW AND UNRESOLVED (CDSCP)
POINT PAPERS

April 29, 1989

Section Design Acceptability Analysis, Chapter 3: Assessment of Alternative Shaft Locations

OBJECTION 1

The process used to integrate all available technical data into decisions regarding shaft location appears to have been flawed. As a result of the apparent lack of data integration, concerns are raised about the suitability of shaft locations and about a process that has resulted in a possible violation of the criteria specified in the Design Acceptability Analysis (DAA) for set-back distances from faults.

BASIS

- The Design Acceptability Analysis cites Bertram (1984) as the basis for decisions regarding shaft set-back distance from faults and concludes that "...all five shaft locations are more than 100 feet from the nearest faults and this factor is nondiscriminating..." (DAA, p. 3-7). The DAA states that "Thus, consideration in this report of fault locations as a surrogate for performance essentially adopts the use of the same characteristic by Bertram" and "Because Bertram (1984) excluded all areas within 100 feet of faults, all five alternative locations compared by Bertram are in an acceptable zone" (DAA, pgs. 2-26, 2-29). However, the Bertram (1984) report, while publishing the results of siting activities conducted in early 1982, does not include the results of recommended activities to determine the presence of potentially adverse structures near the shaft locations. Therefore, the conclusion made in the DAA regarding faulting as a factor in shaft location is not technically supported by the analysis provided in the Bertram (1984) report.

- The activitites of DOE's shaft related Technical Integration Group conducted in 1982, and reported on by Bertram in 1984, made several recommendations regarding geologic mapping and geophysical evaluations in the vicinity of the preferred shaft locations. Some of the recommended mapping and evaluation was carried-out in the two years (1982-1984) preceeding publication of the Bertram (1984) report, however, there is no indication in either Bertram (1984) or a subsequent report on shaft location by Gnirk and others (1988) that the results of the geologic mapping and geophysical surveys were ever integrated into the decision on shaft location.

- In 1987, in response to concerns raised by the NRC staff, the locations of the exploratory shafts were moved from the center of Coyote Wash to the rock slope that bounds the wash to the north (Gnirk and others, 1988). There is no indication that data other than that presented in the outdated Bertram (1984) report was used in the decision-making process that led to the determination of the new locations.

- In 1982, the NNWSI Technical Integration Group (TIG) recommended that the sites of the shafts be re-evaluated should the recommended sites contain surface joint densities significantly higher than other sites. The SCP indicates that scientific criteria were used so that the exploratory shaft would not be constructed in areas of fractures associated with structural features (8.4.2-155). The area near the present sites on the northern slope of the wash is said to contain "fracture sets ...so intense that they are essentially breccias..." (Dixon to Vieth, 1982). Based on the recommendations made in 1982, a re-evaluation of the recommended site should have been conducted to determine the significance of the fracturing near the sites selected in 1987. While the DAA refers to the Dixon to Vieth letter and suggests that the mapping "tends to support the data set used in the original selection..." (p. I.6-8), there is no indication that the site selection process included a detailed analysis of these fracture data.

- The TIG also recommended that a geophysical evaluation be made in the washes near Yucca Mountain to explore for structures not exposed at the surface. Many of the geophysical surveys (most are regional studies) cited in the Gnirk and others' (1988) report as addressing the TIG recommendation were completed after the final decision on shaft locations was made (August, 1982). In addition, there is no indication that the results of resistivity surveys suggesting the presence of a fault at the current shaft locations (Smith and Ross, 1982) were considered in the selection of the site.

- There is no indication that the results of the geologic mapping, showing a high degree of fracturing present in rocks near the present shafts sites, were integrated and assessed with the results of the 1982, geophysical survey that suggests the possible presence of a fault in the vicinity of the mapped breccias.

RECOMMENDATION

- The DAA should reconsider whether the design process, which appears to have overlooked key information about the suitability of exploratory shaft locations, is adequate to assure that the shafts will not adversely impact waste isolation.

- The DAA should address apparent conflicts between the design criteria specified (i.e., set-back of 100 feet from faults) in Bertram (1984) and Gnirk and others (1988) and the presence of a possible fault near the exploratory shafts as suggested by the geophysical testing (Smith and Ross, 1982).

- The present shaft locations should be re-evaluated based on an assessment of available technical data.

° Consider conducting further tests (e.g., geophysical testing and trenching) in the vicinity of the proposed shafts to verify features and conditions that exist in that area.

REFERENCES

Bertram, S., 1984, NNWSI Exploratory shaft site and construction method recommendation report: Sandia National Laboratory, SAND 84-1003, 100 p.

Dixon to Vieth, 1982, letter: G.L. Dixon, (USGS/Las Vegas) to D.L. Vieth (DOE/NV-WMPO), re: "Results of detailed geologic mapping at the five potential exploratory shaft locations on Yucca Mountain," July 16, 1982.

Gnirk, P., Hardin, E., and Voegele, M., 1988, Exploratory shaft location documentation report: U.S. Department of Energy Nevada Operations Office, Las Vegas, Nevada, December 21, 1988, 127 p.

Smith, C., and Ross, H.P., 1982, Interpretation of resistivity and induced polarization profiles with severe topographic effects, Yucca Mountain area, Nevada Test Site, Nevada: U.S. Geological Survey Open-File Report 82-182, 21 p.

REVIEW GUIDE

3.3.4, 3.3.23

Section 8.3.1.17 Overview of preclosure tectonics: Description of tectonic and igneous events required by performance and design requirements

OBJECTION 2

The sequencing of many geophysical and geologic activities related to faulting may lead to data collection activities that are inadequate to support assessments of performance and design bases.

BASIS

- Many planned geophysical tests (e.g., Activity 8.3.1.17.4.7.8) must await the results of prototype testing (Decision 10/90). No alternative tests for collecting critical subsurface geologic information are presented should the planned tests prove to be infeasible.

- Table 8.3.1.17-9 and 8.3.1.4-4 provide a summary of site geophysical programs. Page 8.3.1.17-115 states however, that locations of surveys and data collection techniques will not be finalized until the review by activity 8.3.1.4.2.1.6 is complete. This also appears to be true for such activities as drilling (see SCP Section 8.3.1.4.1.1). While the SCP provides a general description of tests that may be done and locations at which they may be conducted, certain tests such as those under activity 8.3.1.4.2.1.6 must be completed before final locations or types of surveys will be determined. Until this review activity (8.3.1.4.2.1.6) is complete and a program is presented which lays out actual tests and locations, the NRC staff cannot evaluate the adequacy or appropriateness of the DOE program.

- The SCP indicates (p. 8.5-32) that logs of trenches to investigate for possible faulting in the vicinity of the surface facilities will be complete by 12/89. Completion of these logs precedes completion of geophysical testing that could possibly provide valuable input into the selection of the location of the surface facilities and in the location of trenches.

- Table 8.3.1.8-9 indicates that the calculations of the number of waste packages intersected by a fault will be completed by 9/90. This date preceeds most site characterization activities related to faulting.

- Studies related to faulting at prospective surface facilities (8.3.1.17.4.2) will be completed (6/90) prior to the determination of geophysical methods used to examine subsurface characteristics of faults (i.e., 8.3.1.17.4.7, 10/90), the mapping of surficial deposits (Activity 8.3.2.5.1.4.2, 5/91), and the results of the photogeologic investigation of Quaternary scarps (8.3.1.17.4.3, 12/90).

RECOMMENDATION

- Alternative strategies should be provided for collecting data in the event that specific geophysical tests prove to be infeasible.

- All activities should be re-examined and cross-referenced to other studies.

REFERENCES

REVIEW GUIDE

3.2.6

Section 8.3.1.1 Overview of the site Program: Role of alternative conceptual models

Section 8.3.1.17.12.2 Activity: Evaluate tectonic models

COMMENT 1

Alternative tectonic models for the site do not appear to be fully integrated into the site characterization plan and as a result alternatives are apparently not considered in in the preliminary performance allocations and the design of the EBS. The site characterization program appears to be directed toward providing data that confirm the preferred tectonic model rather than determining what the "preferred model" should be.

BASIS

- The response to CDSCP comment 37 states that it is proper to distinguish between faults within and outside the waste emplacement areas. This response does not consider alternative fault models in which faults within and outside the waste emplacement areas may be related to each other. In a model where faults are related, consideration of slip-rates on faults outside of the waste emplacement areas has a direct bearing on the the prediction of expected movements on faults within the waste emplacement areas.

- Section 8.3.1.17.2.1.2 states that the program does not expect to encounter faults in the waste emplacement areas (p. 8.3.1.17-62) even though Figs. 8.4.2-4 and 8.3.1.4-10 imply that an imbricate fault zone (in one conceptual model these faults could be associated with the Bow Ridge fault system) may occur in the waste emplacement areas.

- Tectonic models, as used in the SCP, do not form a conceptual basis from which to make conservative judgements about the likelihood and magnitude of future tectonic events. For example, Table 8.3.1.8-3b indicates that the current estimate related to the performance parameter of the probability of offset of > 2 m in 10,000 yrs is slip-rates on faults of < 0.01 mm per yr with moderate confidence in that estimate. This estimate does not consider reasonably conservative alternative fault models that suggest slip-rates may be higher than the estimate. The confidence expressed in the estimate is unsupported by statements in the text that indicate that the amount of strike-slip motion along faults is unknown (e.g., Spengler and others, 1981; Spengler and Chornack, 1984).

- North-trending normal faults are not considered in the context of a realistic conceptual tectonic model that indicates that the current stress field may be such that all favorably oriented faults, even those that do not display demonstrable Quaternary offset, are susceptible to failure (i.e., an anticipated process). The SCP appears to favor the development of imprecise categories of faults (i.e., "potentially significant Quaternary faults," Section 8.3.1.17.4.6.2) rather than use conceptual models of faulting in the performance allocation process.

- The approach to the use of alternative tectonic models in the SCP deemphasizes the importance of characterizing the underlying tectonic processes for use in predicting future tectonic events at the site. For example, Table 8.3.1.8-8 (p. 8.3.1.8-41) states that it is more important to reduce uncertainties about the nature of local faulting than to resolve faulting mechanisms. This statement implies that characterizing the underlying processes responsible for faulting (i.e., anticipated process) is of secondary importance to characterizing movements on particular faults (i.e., anticipated events). In this approach, conceptual models of faulting such as fault segmentation, episodic faulting, and fault imbrication would not be adequately addressed.

- Alternative tectonic models are not adequately factored into performance allocation and design considerations. Specifically, Investigation 8.3.1.17.2 assumes that the slip-rate and recurrence interval on individual faults is an accurate and conservative method for determining hazard to surface and subsurface facilities. However, conceptual tectonic models (e.g., detachment faults) that link faults of higher slip with others displaying lower slip interjects considerable uncertainty into the future behavior of individual faults within a structural block. The current design of the EBS appears to be based on the assumptions used in 8.3.1.17.2. No contingency EBS designs, to encompass the effects of alternative tectonic models, are presented in the SCP.

- Current representations of model hypotheses do not accurately reflect the uncertainty that alternative models of fault mechanisms bring into judgements about future fault behavior. Specifically, the preferred representation listed in Table 8.3.1.17-7 concludes that slip-rates are low and that the uncertainty is medium. In addition, Section 8.3.1.8 (p. 8.3.1.8-27) states that "...faults (such as Windy Wash and Paintbrush Canyon ....) have very low slip rates..." suggesting that a conclusion about the slip rates on faults has already been made. Doubt is cast on these two assumptions about fault movement by the considerable evidence suggesting strike-slip motion may be a significant (e.g., Spengler and others, 1981; Spengler and Chornack, 1984), and as yet unassessed, component on faults near Yucca Mountain.

- There is no indication in the SCP that alternative tectonic models have been used to form the basis for prioritizing those investigations associated with tectonic features, events, or processes that could lead to the site being considered unlicensable, or to a substantial change in the site characterization program.

RECOMMENDATIONS

- Alternative tectonic models should be thoroughly integrated into preliminary performance allocations and the design of the EBS.

- Consideration should be given to prioritizing investigations giving high priority to those investigations associated with tectonic features, events, or processes that could lead to the site being considered unlicensable, or to a substantial change in the site characterization program.

REFERENCES CITED

Spengler, R.W., Byers, R.M., Jr., and Warner, J.B., 1981, Stratigraphy and structure of volcanic rocks in drill hole USW G-1, Yucca Mountain, Nye County, Nevada: U.S. Geological Survey Open-File Report 81-1349, 50 p.

Spengler, R.W., and Chornack, M.P., 1984, Stratigraphic and structural characteristics of volcanic rocks in core hole USW G-4, Yucca Mountain, Nye County, Nevada: U.S. Geological Survey Open-File Report 84-789, 77.

REVIEW GUIDE

3.3.4, 3.2.4.2, 3.2.4.4

Section 8.3.1.4.2 Investigation: Geologic framework of the Yucca Mountain site

COMMENT 3

The technical rationale for this investigation implies that the perimeter drift defines an area of a significantly lower concentration of faults than surrounding areas. However, based on other parts of the SCP, this implication may not be accurate. There is no indication that studies in the SCP address the potential impact on system performance of the presence within the perimeter drift (i.e., in emplacement areas) of a significant number of faults that may be favorably oriented for failure under the present stress regime.

BASIS

- The technical rationale for this investigation suggests that the imbricate fault zone "limits" the repository to the east.

- Section 8.3.1.2.3 indicates that "Numerous normal, west-dipping faults occur east of the block..."

- In Chapter 1 (p. 1-332), it is stated that the repository "...would be bounded...on the east and southeast by the western edge of an imbricate normal fault zone.

- Section 8.3.1.17.2.1.2 states that the program does not expect to encounter faults in the waste emplacement areas (p. 8.3.1.17-42).

- Figure 8.4.2-4 (p. 8.4.2-92) depicts the imbricate fault zone on the east side of the repository block as being well within the perimeter drift.

- Figure 8.3.1.4-10 (p. 8.3.1.4-76) depicts the imbricate fault zone on the east side of the repository as being well within the perimeter drift.

- Page 1-207 implies that consideration is being given to implacing waste in or near recognized fault zones.

- 10 CFR 60.133(h) requires that the engineered barriers be designed to assist the geologic setting in meeting the performance objectives. The apparent inclusion within the waste emplacement area of a major zone of imbricate faulting, possibly associated with faults having known Quaternary movement (e.g., Bow Ridge fault), suggests that the design of the engineered barrier may not be such that it will assist the geologic setting in meeting the performance objectives.

RECOMMENDATION

- Rectify the apparent contradict as to whether a zone of imbricate faulting is present within the perimeter drift.

- If the imbricate fault zone is present within the perimeter drift, an assessment should be made to demonstrate that the requirements of 10 CFR 60.133(h) will be met.

REFERENCES

REVIEW GUIDE

3.3.4, 3.3.23, 3.3.24

Section	Table 8.3.1.8-2b	Investigation 8.3.1.8.2 - Studies to provide information required on rupture of waste packages due to tectonic events
	Table 8.3.1.17-3b	Characterization parameters related to surface facilities and preclosure fault displacement

COMMENT

Faults appear to be considered as single strands of narrow width, an approach that may underestimate the effects of faulting on the results of planned tests and on the performance of repository facilities.

BASIS

- Table 8.3.1.8-2b indicates that the current estimate of the width of Quaternary fault zones in and near the site is < 5 m.

- Chapter 1 (p. 1-332) indicates that "Breccia zones in the Ghost Dance fault are as wide as 20 m." Cross-section A-A' of Scott and Bonk (1984), indicates that the breccia zone associated with the Solitario Canyon fault zone, the Windy Wash fault zone, and the Bow Ridge fault zone are all significantly greater than 5 m.

- Table 8.3.1.8-2b indicates that the characterization parameter for investigating faults in the repository is characteristics of faults with > 10 m of offset. Individual fault strands within a fault zone may not exhibit > 10 m of offset but the cumulative offset along faults in a fault zone may be greater than 10 m.

- Table 8.3.1.17-3b indicates that the current estimate for "potentially significant faults" within 5 km of FITS is four. This estimate appears to overlook models involving fault imbrication in which major fault zones might contain more than one "potentially significant fault."

- One model resulting from seismic studies in Midway Valley (Neal, 1986) could suggest that in the vicinity of the location of the surface facilities, the Paintbrush Canyon fault zone could represent a zone of imbricate faulting extending from the east side of Exile Hill to the main trace of the Paintbrush Canyon fault.

RECOMMENDATION

- The approach to characterization of faults in the vicinity of repository facilities should consider alternative models of faulting in which faults are not independent entities but may be parts of larger fault zones.

REFERENCES

Neal, J.T., 1986, Preliminary validation of geology at site for repository surface facilities, Yucca Mountain, Nevada: Sandia National Laboratories, Sand85-0815, 27 p.

Scott, R.B., and Bonk, J., 1984, Preliminary geologic map of Yucca Mountain Nye County, Nevada, with geologic sections: U.S. Geological Survey Open-File Report, 84-494, Scale 1:12,000.

REVIEW GUIDE

3.3.4

Section 8.3.1.8 Overview of the postclosure tectonics program: Description of future tectonic processes and events required by the performance design issues

COMMENT 11

The program of site characterization activities related to the postclosure tectonics program does not appear to provide input to performance issues related to the waste package and engineered barrier system as required in 10 CFR 60.113(a). No clear line of integration of postclosure tectonics data into the issue resolution strategy for issues 1.4 and 1.5 exists.

BASIS

- 10 CFR 60.113(a) requires that during the containment period, any release from the EBS shall be a gradual process which results in small fractional releases to the geologic setting over long times.

- Faulting in the repository during the containment period could result in releases to the geologic setting that are not small fractional releases over long times.

- SCP Section 8.3.1.8 (Figure 8.3.1.8-1) does not address performance Issues 1.4 (Will waste package meet the performance objective) and 1.5 (Will the waste package and repository engineered barrier systems meet the performance objective). Table 8.3.1.8-1 implies that Issues 1.4 and 1.5 do not call for data from section 8.3.1.8.

- Section 8.3.5.10.3 describing information need 1.5.3 (p.8.3.5.10-55) indicates information is needed from the Postclosure tectonics program.

- Scenarios developed under Information Need 1.5.3 will also be used to describe the waste package near-field environment (p. 8.3.5.9-87).

RECOMMENDATION

- Consideration should be given to establishing a clear path for the integration of data collected in the Postclosure Tectonics program into issues 1.4 (Will waste package meet the performance objective) and 1.5 (Will the waste package and repository engineered barrier system meet the performance objective).

REFERENCES

REVIEW GUIDE

3.3.4, 3.3.24, 3.3.25

Section 8.3.1.8 Overview of the postclosure tectonics program: Description of future tectonic processes and events required by the performance design issues

COMMENT 12

The term "parameter goal" appears to have been inconsistently defined in various parts of Chapter 8. The adequacy of site characterization plans cannot be judged without a clear definition of parameter goal.

BASIS

- Section 8.1.2.2 indicates that "If the results of site characterization can successfully demonstrate that the tentative goal has been met, the DOE plans for getting a license will be fulfilled as far as that parameter's contribution to the associated performance measure is concerned" (p. 8.1-9).

- Section 8.3.1.8 indicates that "...the goal provides an estimate of when the initiating event may start to become significant in performance calculations and is intended to provide guidance to the tectonics program on the level of accuracy or precision required..." and "...setting goals guides the specification of tests...to tell quantitatively what information will lead to resolution of the performance and design issues" (p. 8.3.1.8-22).

- Section 8.1.2.2 suggests that when the goal has been met then DOE's plans for getting a license are fulfilled as far as that parameter's contribution to the associated performance measure is concerned. Section 8.3.1.8 indicates that the value of the goal is the bottom line of when the parameter becomes significant in performance calculations. These two definitions seem contradictory.

RECOMMENDATION

- The definition of parameter goal should be clearly expressed.

REFERENCES

REVIEW GUIDE

3.2.2

Section 8.3.1.8 Overview of the postclosure tectonics program: Description of future tectonic processes and events required by the performance design issues (p. 8.3.1.8-27)

8.3.1.8.2.1.4 Activity: Assessment of waste package rupture due to faulting

Table 8.3.1.17-3a Design and performance parameters related to surface facilities and preclosure fault displacement

Table 8.3.1.17-2 Studies to provide required information on fault displacement that could affect repository design or performance

COMMENT 13

The use of fault slip rates to determine the level of hazard posed to repository facilities by faults does not appear to be a conservative approach and may result in overly optimistic predictions about the affects of faulting on system performance.

BASIS

- The concern expressed by this comment reiterates and expands on CDSCP comment 37.

- In the response to CDSCP comment 37, the DOE indicates that the "goals established for performance measures properly distinguish between faults within and outside the waste emplacement area, take into account for present uncertainties in slip rates." The NRC staff does not consider that the approach for distinguishing similarly oriented faults in the geologic setting based on their location is a reasonably conservative approach because it appears to overlook alternative models of faulting that could physically link faults with higher apparent slip rates with faults with lower apparent slip rates.

- Section 8.3.1.8 indicates that since faults in the area of the repository have "very low slip rates" then it can be demonstrated that offset of 5 cm in 1,000 years is a very low probability. Therefore, 5 cm was determined as a value at which displacement becomes significant over a 1,000 year period.

- Slip rates average offset along faults over a series of events and appear to obscure the episodicity of fault events and relatively high offsets that could be expected in single event. For example, the last major episode of movement (Holocene in age) on one strand of the Windy Wash fault zone (slip rate estimated to be .0015mm/yr, p. 1-133) had approximately 10 cm of vertical offset.

- The use of slip-rates is likely to obscure the uncertainty in the total offset on a fault due strike-slip motion.

- The statement made in 8.3.1.8 (p. 8.3.1.8-27) that faults in the area have "very low slip rates" suggests that fault characteristics have been pre-judged prior to the completion of site characterization. However, the SCP acknowledges that the lateral component on most faults in the area has not been assessed.

RECOMMENDATION

- Demonstrate that the use of slip rates for determining hazard does not provide overly optimistic predictions of the affects of faulting on repository performance.

- Consider alternative methods (e.g., maximum event offset) or a combination of methods (e.g., maximum event offset and slip rates) to assess the level of hazard to the surface facilities and EBS posed by faulting.

REFERENCES

REVIEW GUIDES

3.2.2, 3.3.4

Section 8.3.1.8 Overview of the postclosure tectonics program: Description of future tectonic processes and events required by the performance design issues (p. 8.3.1.8-40)

COMMENT 15

The current representation of the physical domain for postclosure tectonics issues (i.e., brittle crust, southern Great Basin) appears to be inadequate to evaluate the full range of processes and events likely to occur at the site and should not act as a limit on conceptual tectonic models or site investigations.

BASIS

- Table 8.3.1.8-8 lists the physical domain for postclosure tectonics issues as the brittle crust, southern Great Basin.

- Processes acting in the lower, ductile crust and upper mantle may be the driving force for events that occur in the upper, brittle crust.

- Physiographic subdivisions in the southern part of the Basin and Range include the southeast Great Basin, southwest Great Basin and Walker Lane belt (Fig. 1-3). Limiting the Physical Domain to the southern Great Basin would appear to either exclude the Walker Lane belt or include only the southern part of the belt.

- Major faulting activity has occurred in the central Walker Lane belt. Possible shifts in the locus of faulting within the belt would appear to necessitate that an understanding of the fault processes in central Walker Lane belt be developed in order to understand processes that might affect the site in the postclosure.

- The Death Valley Pancake Range volcanic belt extends through the site and outside of the southern Great Basin. Processes that resulted in the formation of the Lunar Crater volcanic field and Reville Range basalts are applicable to the site as possible natural analogs. These areas provide an opportunity for to characterize processes that may be active at the site.

RECOMMENDATION

- Consideration should be given to extending the area of consideration for alternative conceptual tectonic models to areas outside of the southern Great Basin including the lower crust and upper mantle.

- Areal restrictions should not be limiting factors in the consideration of alternative conceptual models.

REFERENCES

REVIEW GUIDE

3.3.4

Section 8.3.1.8 Overview of the postclosure tectonics program: Description of future tectonic processes and events required by the performance design issues

COMMENT

Reliance on volcanic rate calculations that are developed largely independent of consideration of the underlying volcano-tectonic processes appears likely to underestimate potential impacts on the performance of the repository.

BASIS

- The SCP indicates that the annual probability of a volcanic eruption penetrating the repository is not greatly dependent on the regional model (Tables 8.3.1.8-7 and 8). However, regional tectonic models of crustal and mantle processes would appear to be essential to estimating whether magma generation will be increasing or decreasing in the future and, therefore, seemingly have a significant effect on the uncertainty of probabilities of future volcanic events. Chapter 1 (p. 1-203) indicates that volcanism appears to be directly linked to tectonic processes in the region.

- Rate calculations of volcanic activity in the vicinity of the site during the Quaternary have, in the past, been based on the assumption that the events were monocyclic. Volcanic events in the vicinity of Yucca Mountain are now believed to be, at least in part, polycyclic (p. 8.3.1.8-117), but the number of cycles may still be uncertain due to imprecise age determinations. Considerable uncertainty is introduced into probability calculations by total reliance on cone counts because single cones may be the loci of multiple eruptions.

- Probability calculations appear to be based on establishing a rate of volcanic activity during the Quaternary which averages the activity over at least 1.6 million years. Probabilities calculated in this manner do not appear to be conservative in establishing the hazard to the repository in that they assume an uniform distribution of volcanism has occurred through time and require a large number of events to become significant.

RECOMMENDATION

- More consideration should be given to characterizing volcanic processes acting in the geologic setting.

- Consideration should be given to establishing alternative (i.e., deterministic) methods (e.g., expert judgement) to assess the hazard to the site from volcanism.

REFERENCES

REVIEW GUIDE

3.2.4.2, 3.3.4

Section 8.3.1.17.2 Investigation: Studies to provide required information on fault displacement that could affect repository design or performance

Table 8.3.1.17-4a Design and performance parameters related to underground facilities and preclosure fault displacement

COMMENT 21

The characterization parameters for the identification and characterization of "significant Quaternary faults" in the area of the repository block will not fulfill the requirements in 10 CFR 60.

BASIS

- Activity 8.3.1.17.4.6.2, an activity that provides input into postclosure tectonics (Fig. 8.3.1.8-4), suggests that only "potentially significant Quaternary faults" will be characterized.

- The characterization parameters for the identification and characterization of "significant faults" in the repository block limit those faults to ones with > 1 m of offset of Quaternary materials or with > 100 m of offset of Tertiary rocks.

- The NRC staff is unsure as to what is meant by the term "potentially significant fault." The NRC staff considers that until site characterization is complete, the interrelationship of faults is known, the interrelationship of site parameters to design parameters has been established, and the potential effect of the various faults on meeting the various performance objectives has been determined, the staff cannot determine what faults are significant.

- Strike-slip faults with little to no surface expression could well be overlooked by using an approach that considers only "significant Quaternary faults." For example, Swadley and others (1984, page 19) indicate that faults in the vicinity of the repository with a "few meters or less" of pure strike-slip movement in the Quaternary may be undetectable with current technology.

- Numerous shear fractures with predominately strike-slip motion have been reported in boreholes in the repository block (Spengler and others, 1981; Spengler and Chornack, 1984). No assessment of the amount of displacement along these fractures was determined.

RECOMMENDATION

- The site characterization program should be designed to investigate any fault that could have an adverse impact on waste isolation.

REFERENCES

Spengler, R.W., Byers, R.M., Jr., and Warner, J.B., 1981, Stratigraphy and structure of volcanic rocks in drill hole USW G-1, Yucca Mountain, Nye County, Nevada: U.S. Geological Survey Open-File Report 81-1349, 50 p.

Spengler, R.W., and Chornack, M.P., 1984, Stratigraphic and structural characteristics of volcanic rocks in core hole USW G-4, Yucca Mountain, Nye County, Nevada: U.S. Geological Survey Open-File Report 84-789, 77.

Swadley, W.C., Hoover, D.L., and Rosholt, J.N., 1984, Preliminary report on late Cenozoic faulting and stratigraphy in the vicinity of Yucca Mountain, Nye County, Nevada: U.S. Geological Survey Open-File Report 84-788, 42 p.

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3.3.4

Section Table 8.3.1.17-4a Design and performance parameters related to underground facilities and preclosure fault displacement

COMMENT 22

The design and performance parameter for characterizing faults in the waste emplacement area should be reexamined based on realistic alternative tectonic models to assure that the performance objectives can be met.

BASIS

- Chapter 1 (p. 1-207) suggests that waste canisters may be placed in recognized fault zones.

- The postclosure tectonics program (Section 8.3.1.8) does not address performance Issues 1.4 (Will waste package meet the performance objective) and 1.5 (Will the waste package and repository engineered barrier systems meet the performance objective) (See comment SCP/YUCCA/KIM/COM/11), and, therefore, design and performance parameters specified in the preclosure tectonics program must be assessed with respect to these two performance issues.

- Table 8.3.1.17-4a listing the design and performance parameter for characterizing faults in the waste emplacement relies on 7 cm air gap to protect the cannister. Only faults with > 1 m offset of Quaternary materials or > 100 m offset of Tertiary rocks will be considered (p. 8.3.1.17-10)

- Design configurations shown in Figure 8.3.5.9-2 indicate that the waste canister is emplaced rigidly in the waste emplacement hole and that the air gap either does not exist or is substantially less than 7 cm near the upper part of the cannister.

- Episodes of movement on faults in the vicinity of Yucca Mountain have exceeded, by substantial margins, the 7 cm protective air gap.

- Swadley and others (1984, page 19) indicate that faults in the vicinity of the repository with a "few meters or less" of pure strike-slip movement in the Quaternary may be undetectable with current technology.

- The uncertainty over the strike-slip component of movement on faults in the vicinity of the repository may not be resolvable.

RECOMMENDATION

- The design and performance parameter for the design of the underground facilities should be reconsidered based on realistic models of faulting at the site and consideration of the level of uncertainty that may exist in establishing the magnitude of offset along faults.

REFERENCES

Swadley, W.C., Hoover, D.L., and Rosholt, J.N., 1984, Preliminary report on late Cenozoic faulting and stratigraphy in the vicinity of Yucca Mountain, Nye County, Nevada: U.S. Geological Survey Open-File Report 84-788, 42 p.

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3.3.4

Section 8.3.1.17.2.1.2 Activity: Assess the potential for displacement on faults that intersect underground facilities

COMMENT 24

The use of domains to define areas of "faulting potential" does not appear to be a reasonably conservative and technically justifiable approach to assess the potential for faulting at the site area and could underestimate the fault displacement hazard to the repository.

BASIS

- The assumption that signficant faulting will, in the future, be restricted to domains is not adequately supported by existing data.

- The domainal concept of faulting potential overlooks the in-situ stress state in the vicinity of the site that indicates that, in part of the tuff section, favorably oriented faults might fail under current stress conditions (Stock and others, 1985). This condition may cross domainal boundaries near the site.

RECOMMENDATION

- Domains can be used to describe areas of similar fault characteristics but should be reconsidered as mechanisms for determining the hazard to repository systems via some artifical quantity termed fault potential.

REFERENCES

Stock, J.M., Healy, J.H., Hickman, S.H., and Zoback, M.D., 1985, Hydraulic fracturing stress measurements at Yucca Mountain, Nevada, and relationship to the regional stress field: Journal of Geophysical Research, v. 90, p. 8691-8706.

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Section 8.3.1.17.4.5 Study: Detachment faults at or proximal to Yucca Mountain

COMMENT 26

Other aspects of detachment faulting described in Section 8.3.1.17.4.5 are at least as significant to the site as those listed as key questions to be answered by this investigation.

BASIS

- Section 8.3.1.17.4.5 states that the key questions regarding detachment faults are whether they represent a significant earthquake source and whether they conceal a significant earthquake source.

- As outlined in Section 8.3.1.17.4.5, detachment faults could also be key to developing a conceptual model of faulting that could lead to conclusions about fault potential and expected magnitudes of fault events at the site. For example, if major faults (for example, the Bare Mountain and Midway Valley faults) are connected at depth, then the controlling feature of fault movement is the regional detachment surface. Recurrence intervals and offset magnitudes of faults tied to a common detachment surface should be, in a conservative view, considered as that expressed by the most active and most significant fault tied to the detachment surface.

- The characterization program related to detachment faults does not provide input into postclosure tectonics except in the digested form of tectonic models (Fig. 8.3.1.8-4) even though detachment faults may be of signficance to addressing to postclosure performance issues.

RECOMMENDATION

- The significance of detachment faulting as a key element in assessing the potential for faulting at the site needs to be readdressed giving consideration to other key concerns related to detachment faulting.

- Consideration should be given to having the results of Study 8.3.1.17.4.5 input directly into postclosure tectonics performance issues.

REFERENCES

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3.3.4

Section 8.3.1.17.4.5.5 Activity: Evaluate the age of detachment faults using radiometric ages

COMMENT 27

The SCP does not appear to integrate and synthesize data resulting from the planned activities characterizing northwest-trending faults.

BASIS

- The Walker Lane belt, a major zone of northwest-trending faults, continues through the Yucca Mountain area (p. 1-208) and may be expressed by the northwest-trending washes north of the repository (Scott and others, 1984).

- Several conceptual tectonic models for the site (i.e., continuation of the Stagecoach Road-Paintbrush Canyon breakaway zone) could involve northwest-trending faults at the site.

- Movement along northwest-trending faults could occur as subsidiary movements related to movement along differently oriented faults.

- Planned activities (e.g., northeast-trending ESF drift) will, at least in part, address northwest-trending faults.

- No specific study appears to exist to integrate investigations that will collect data on northwest-trending faults in the vicinity of the repository.

RECOMMENDATION

- Consideration should be given to specifically outlining a program of study to integrate and synthesize all activities that will collect data on northwest-trending faults.

REFERENCES

Scott, R.B., Bath, G.D., Flanigan, V.J., Hoover, D.B., Rosenbaum, J.G., and Spengler, R.W., 1984, Geological and geophysical evidence of structures in northwest-trending washes, Yucca Mountain, southern Nevada, and their possible significance to a nuclear waste repository in the unsaturated zone: U.S. Geological Survey Open-File Report 84-567, 23 p.

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3.3.4

Section 8.4.2.1 Rationale for planned testing

COMMENT 30

The program of drifting in the north, combined with systematic drilling and feature sampling drilling, appears unlikely to provide the lithologic and structural information necessary to adequately investigate potentially adverse conditions at the site or insure that observations made and data collected will be representative of conditions and processes throughout the repository block.

BASIS

- Activities described in the SCP are not sufficient to resolve the concerns expressed in NRC CDSCP comment 28. For example, the response to NRC CDSCP comment #28 on the ability of site characterization activities to adequately characterize the site indicates that additional information on rock property values will be collected during the construction phase of the repository. This response does not satisfy the requirements of 10 CFR Part 60, in that Section 60.122(a)(2) requires that potentially adverse conditions be adequately investigated during site characterization. The concern expressed by this comment reiterates and expands on CDSCP comment 28.

- Data collection activities appear to be heavily biased to the northern part of the repository and to non-welded to moderately welded tuffs, an attribute that will lead to population densities that are highly skewed to rock characteristics found in nonwelded to moderately welded tuffs in the northern part of the repository. For example, data collection in the northern third of the repository will include 5 coreholes, 2 shafts, and 3 drifts, while in the southern third of the repository, data collection will be largely restricted to several unsaturated zone test holes. Coring in most holes will be continuous in nonwelded tuffs, but due to problems in core recovery, densely welded tuffs are generally only to be spot cored.

- Barton and Scott (1987), citing Spengler (R.W. Spengler, USGS, oral communication, 1986), state that "The general depth at which abundant lithophysal cavities will be found can be interpolated from drillhole data, but the exact depth, with the precision necessary for repository construction cannot be predicted (p. 12).

- The SCP indicates that fracture and fault zone characteristics will be determined in the ESF excavation (p. 8.4.2-26). However, the SCP also indicates that faults decrease in both offset and abundance northward through Yucca Mountain (p. 1-119). For example, the Ghost Dance fault has 38 meters of vertical offset at the southeastern margin of the perimeter drift and is unmeasureable at the northeastern boundary of the perimeter drift (p. 1-128). All excavation associated with the ESF will take place in the northern part of the repository where the number of faults and amount of offset along faults do not appear to be representative of the rest of the repository block.

- Portions of two structural blocks, the Central block and the Abandoned Wash block, appear to be included within the Conceptual Perimeter Drift Boundary (CPDB). Excavations related to the ESF will test only the Central block. The Central block contains a scarcity of large-displacement faults and a uniform 5° to 10° eastward dip of beds (USGS, 1984). The Abandoned Wash block is characterized by many north-northwest-striking faults and fractures with dips of beds of the Central block steepening eastward into the Abandoned Wash block (USGS, 1984). Excavations in the the Central block may not provide representative data on the characteristics of faults and fractures in the Abandoned Wash block.

- Planned drifting to the imbricate fault zone is not sufficient to characterize the full range of conditions to be expected in an imbricate fault zone. Chapter 1 (p. 1-332) indicates that the repository would be bounded on the east by the western edge of an imbricate fault zone and Section 8.3.1.4.2 states that the perimeter drift is "limited" on its eastern extent by structural features. Both citations suggest that the main part of the imbricate fault zone is east of the perimeter drift and east of drifting related to the ESF. Figure 8.4.2-4 and other Figures and statements in the text emphasize that drifting will occur <u>to</u> the imbricate fault zone and not through that zone. Therefore, the character of imbricate fault zones will not be tested across the full range of conditions that may occur.

- Section 8.4.2 states that boreholes are unsuited for a statistical evaluation of fault and fracture characteristics and that studies in long drifts from the ESF will be used to collect data on the hydrologic and geomechanical significance of faults and fractures that are believed to be similar to those encountered in the southeastern part of the site. However, Barton and Scott (1987) state that "The presence or detailed character of faults in any one part of the repository is not predictable from studies of any other part of the repository, particularly within the older and non-exposed Topopah Spring Member of the Paintbrush Tuff (p. 4)" suggesting that observations of fault and fracture characteristics in the northern part of the repository cannot be extrapolated to other parts of the repository.

RECOMMENDATION

- Demonstrate that from a scientific perspective, the program of drifting in the northern part of the repository combined with the systematic drilling program and feature sampling program will provide the information necessary to ensure that conditions and processes encountered are representative of conditions and processes throughout the site and that potentially adverse conditions will be adequately investigated.

- Compare and evaluate the benefits and disadvantages between more extensive drifting during site characterization (including supplemental horizontal core drilling) and the surface-based systematic drilling program with respect to the data derived and effects on repository performance.

REFERENCES

Barton, C.C., and Scott, R.B., 1987, Rationale for a continuous map of geologic features in the exploratory shaft and drifts: U.S. Geological Survey Administrative Report, 15 p.

USGS, 1984, A summary of geologic studies through January 1, 1983, of a potential high-level radioactive waste repository site at Yucca Mountain, Nye County, Nevada: U.S. Geological Survey Open-File Report 84-792, 103 p.

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3.3.2, 3.3.4, 3.2.4.2

Section 8.3.1.17.4 Preclosure Tectonics Data Collection and Analysis

COMMENT 32

The program of activities outlined for study of northeast-trending faults in the area of Yucca Mountain appears insufficient to determine the significance of some of these features.

BASIS

- The concern expressed by this comment reiterates CDSCP Comment 53.

- The text of Activity 8.3.1.17.4.4.2 has been revised to note the significance of the Mine Mountain fault system to the repository including the possible association with a detachment ("low-angle extensional fault") and the possibility of Quaternary offset. The text of Activity 8.3.1.17.4.4.2 has also also been expanded to more completely describe activities that will address the possible extension of the Mine Mountain fault into Jackass Flats. These activities include possible trenching of Quaternary scarps and geophysical testing (Activity 8.3.1.17.4.7.8) in Jackass Flats. However, the program of characterization of the Mine Mountain fault system appears to be largely contingent on the actual implementation of the geophysical testing (Activity 8.3.1.17.4.7.8 is an activity to evaluate the suitability of the technique). The NRC staff can not evaluate the program to investigate the Mine Mountain fault system until Activity 8.3.1.17.4.7.8 is complete and the technique demonstrated to be suitable or an alternative method of characterization selected.

RECOMMENDATION

- Consideration should be given to developing alternative strategies to investigate the Mine Mountain fault system in the event that the techniques identified in Activity 8.3.1.17.4.7.8 are found to be unsuitable.

REFERENCES

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3.3.4

Section Table 8.3.2.5-2 Preliminary performance allocation for System Element 1.1.2, subsurface

COMMENT

The tentative goal, design parameter, and expected value relating faulting and performance allocation for System Element 1.1.2 are not sufficient for adequately characterizing the hazard posed by faulting in the repository.

BASIS

- The concern expressed by this comment is part of the concern expressed in CDSCP comment 62.

- The response to CDSCP comment 62 revises the performance measure and eliminates the term "potentially active fault." However, a new, and equally unacceptable (SCP Comment KIM/21) term, "significant Quaternary fault," is introduced. The definition of the term "significant Quaternary fault" presupposes that only faults with demonstrable Quaternary offset represent a hazard to the repository in the preclosure and that the magnitude of offset along faults that may contain a significant component of lateral movement (i.e., strike-slip) can be accurately determined. Due to the potential for large uncertainties associated with both of these assumptions, this approach does not appear to be reasonably conservative in addressing preclosure tectonics issues.

- The design parameter indicates that "significant Quaternary faults" will be identified and characterized; however, the NRC staff continues to be concerned (SCP Comment KIM/30) that the site characterization program is inadequate to characterize potentially adverse conditions in the southern part of the repository block.

- The expected value for "significant Quaternary faults" indicates that none are expected to be found. This value does not consider alternative models for faulting in the geologic setting or the implication from Figs. 8.4.2-4 and 8.3.1.4-10 that an imbricate fault zone may occur in the waste emplacement area.

RECOMMENDATION

- Consideration should be given to using alternative fault models as a conceptual basis for assessing the preclosure hazard to the repository.

- Demonstrate that from a scientific perspective, the program of drifting in the northern part of the repository combined with the systematic drilling program and feature sampling program will provide the information necessary to ensure that conditions and processes encountered are representative of conditions and processes throughout the site and that potentially adverse conditions will be adequately investigated.

REFERENCES

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3.3.4

Section 8.3.1.17 Overview of preclosure tectonics: Description of tectonic and igneous events required by performance and design requirements

Table 8.3.1.17-3(a) Design and performance parameters related to surface facilities and preclosure fault displacement

SCP COMMENT (USE AS FIRST OF SERIES)

The NRC staff does not consider that the basis and rationale for the design and performance parameters, characterization parameters, and goals proposed in the SCP for fault displacement, in particular for fault investigations for facilities important to safety, have been justified. The staff is concerned as these values appear to be used to limit the exploration program prior to having sufficient data to evaluate the site.

BASIS

- The concern expressed by this comment is part of the concern expressed in CDSCP comment 50. This comment specifically is in reference to the requested justification of the design, performance and characterization parameters.

- In the response to CDSCP comment 50 and in the tables the DOE gives the following design and performance parameters:

  Table 8.3.1.17-3a gives design and performance parameters related to surface facilities and preclosure fault displacement as "total probability of exceeding 5 cm fault displacement at locations proposed for FITS, with a goal of less than 1 chance in 100 of exceeding 5 cm displacement beneath surface FITS in 100 years"

Table 8.3.1.17-3b gives characterization parameters as "the identification and characterization of potential Quaternary faults within 5 km of FITS", Identification and characterization of faults within 100 m of FITS that have apparent Quaternary slip rates greater than .001 mm/yr or that measurably offset materials less than 100,000 years old", and "estimate of total probability for greater than 5 cm displacement beneath FITs, considering known and possible concealed faults and tectonic interrelationships among local faults"

- The NRC does not consider that DOE has presented a justifiable basis for the use of 100,000 years as a base age to determine if the offset is significant. The basis for most information within 10 CFR Part 60 is the Quaternary, and other similar nuclear facilities such as those licensed under 10 CFR 72 have used Appendix A criteria for determining the significance of fault activity (i.e., once in 35,000 years or more than once in 500,000 years).

- The DOE has presented no analysis of the proposed design to demonstrate that 5 cm of fault movement is acceptable. The DOE appears to assume that structures can be built to withstand that amount of movement, however, the staff has seen no analysis to support this assumption.

- The NRC also does not consider that the probability cut off values on the parameters and goals which are being used to limit the investigation, such as 1 chance in 100 in 100 years, have been justified. The NRC staff does not agree with the attempted justification presented in the response to CDSCP comment 50 because:

  The use of the probability cut off has not been accepted for use in determining the items on the Q-List (see SCP comment scp/yucca/kh/com/106), and

  The work of Reiter and Jackson (1983), was not intended as guidance for making a licensing decision, but rather to evaluate the relative safety of existing plants. In addition, the authors themselves state that no great confidence can be placed on the absolute probabilities.

- The SCP discusses "potentially significant faults," however the NRC staff is unsure as to what is meant by this term. It appears that DOE intends this to be related to the above probability values, age of movement or limit of movement, however, as stated above the NRC staff does not see justification for the values. Until site characterization is complete, the interrelationship of faults is known, the interrelationship of the site parameters to the design parameters has been established, and the potential effect of the various faults on meeting the various performance objectives has been determined, the staff cannot determine what faults are significant (see also SCP comment KIM/21).

- The SCP states on page 8.3.1.17-27 that probabilistic methods will be used for evaluating the adequacy of deterministic final results, however, the question of what investigations will be conducted appears to be controlled by *a priori* probabilistic assumptions. For example, the response to CDSCP comment 50 states that the total probability of faulting will be assessed prior to trenching. The NRC staff is unsure how DOE intends to assign probability values related to various features prior to completing the site characterization program. If the characterization program is overly limited by *a priori* probability assumptions, the NRC staff is unsure how a sufficient understanding of the site characteristics will ever be obtained.

- While the NRC staff recognizes that "goals" are not "criteria", when goals are set which do not appear to be justified, or which appear to unwisely limit the necessary investigations, the NRC staff does not see a rationale for the investigation which can be supported.

RECOMMENDATION

- DOE needs to strengthen its justification for the design and performance parameters, characterization parameters, and goals for preclosure fault displacement as related to FITS, or revise these values. The justification should include a discussion of the interrelationship of the characterization parameters, performance and design parameters, and goals with the design criteria and the performance objectives of 10 CFR Part 60.

REFERENCES

Reiter, L., and Jackson., R.E., 1983, Seismic Hazard Review for the Systematic Evaluation Program - A Use of Probability in Decision Making: NUREG-0967, U.S. Nuclear Regulatory Commission.

U.S. Department of Energy, 1988, Response to NRC Point Papers on Site Characterization Plan/Consultation Draft

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3.2.3, 3.2.4.10, 3.3.4

Section 8.3.1.17 Overview of preclosure tectonics: Description of tectonic and igneous events required by performance and design requirements

Table 8.3.1.17-3(a) Design and performance parameters related to surface facilities and preclosure fault displacement

SCP COMMENT

The program of investigations for faulting appears to assume that any future faulting will follow old faulting patterns. The NRC staff considers that this is not a reasonably conservative assumption, and does not consider that this assumption is technically justified.

BASIS

- In the basis for CSDCP comment 50, the NRC staff discussed surface offsets which have been observed in Nevada, and requested DOE to evaluate this information to assure that the program of investigations would be sufficient to produce a design which was safe and performance parameters for fault displacement which were reasonably conservative. The faulting investigations not only appear to be driven by criteria which the NRC staff does not feel have been justified (see comment scp/yucca/jst/com/3/3), but also by unconservative assumptions of future faulting patterns.

- In the response to CDSCP comment 50, the DOE states it expects to meet the probabilistic goal conservatively because of the expectation that future main, branch and secondary faulting will generally recur at the same location as previous faulting. As support, the DOE quotes studies of the 1983 Borah Peak earthquake and the 1932 Cedar Mountain earthquake.

- While in many cases it is true that faulting will generally follow old patterns there are many examples, some within the Basin and Range, where this was not true: For example:

  For most of the August 23, 1954, Rainbow Mountain event fault ruptures coincided with or extended the July 6 faulting patterns, but some of the new ruptures were subparrallel to the older ones (Bonilla, 1970).

  Part of the December 1954 faulting north of Fairview Peak coincided with ruptures formed about 1903, but over most of the rupture length it did not coincide. The 1954 faulting crisscrossed the earlier faulting and was located more than 1000 feet from it in some places (Bonilla, 1970).

- One of the conclusions reached by Depolo and others, (1989) in their study of fault segmentation in the Basin and Range was that "... some earthquake discontinuities may be difficult to identify and significant faulting may occur beyond postulated discontinuities."

- The pattern displayed by a fault, especially at or near the surface, will change through its developmental history. Fault patterns do not spring forth fully developed, but change through time.

- The assumption that future recurring at locations of old faulting has also been discounted in a recent report by Sandia (Subramanian and others, 1989), as it was recognized that "unknown faults" must be considered in the probabilistic evaluations of surface facilities in Midway Valley that this report was attempting to quantify.

RECOMMENDATION

- The DOE needs to review the assumptions used to plan the exploration program for FITS to assure unconservative assumptions, such as future faulting only occurring at the exact locations of past faulting, do not bias the program.

REFERENCES

dePolo, C., Clark, D.G., Slemmons, D.B., and Aymard, W.H., 1989, Historical Basin and Range Province Surface Faulting and Fault Segmentation, U.S. Geological Survey Open File Report 89-xxx (in press)

Bonilla, M.G., 1970, Surface Faulting and Related Effects, in Wiegel, R.L., Ed., Earthquake Engineering: Prentice-Hall Inc., Engelwood Cliffs, N.J.

Subramanian, C.V., Abrahamson, N., Hadjian, A.H., Jardine, L.J., Kemp, J.B., Kiciman, O.K., Ma, C.W., King, J., Andrews, W., and Kennedy, R.P., 1989, Preliminary seismic design cost-benefit assessment of the tuff repository wastehandling facilities: Sandia National Laboratories, SAND88-1600.

REVIEW GUIDES

3.2.3, 3.2.4.10, 3.3.4

Section 8.3.1.17 Overview of preclosure tectonics: Description of tectonic and igneous events required by performance and design requirements

Table 8.3.1.17-3(a) Design and performance parameters related to surface facilities and preclosure fault displacement

SCP COMMENT

The information presented for the program of investigations for study of faulting at the surface facilities does not allow the NRC staff to determine how DOE is proposing to use standoff distances in designing the program of investigations and in perform~~m~~ing the resultant design and analysis.

BASIS

- The concern expressed by this comment is a continuation of the concern expressed in CDSCP Comment 50 regarding standoff distance from faults.

- The SCP states on page 8.3.1.17-96 "Note that the 100 meter distance is not intended to represent an appropriate standoff distance for FITS from faults that have a potential for displacement. Should the faulting investigations identify a fault within 100 meters of the proposed FITS locations, the appropriate standoff distance and/or mitigative engineering measures will be assessed."

- The NRC staff is unsure what DOE is proposing for appropriate stand off distances. The statement in the SCP seems to suggest that the DOE considers less than 100m as an appropriate standoff distance for faults which have a potential for displacement. The NRC has seen no justification for such a position.

- The DOE response to CDSCP comment 50 states that trenches will likely be excavated beyond 100 meters past FITS, but does not state that trenches will be excavated past 100 meters. The NRC therefore is not sure what is the extent of trenching which is planned, and how faults greater than 100 meters from FITS will be investigated or evaluated.

- 10 CFR Part 60.122(a) requires that DOE demonstrate, among others, that:

  (i) potentially adverse conditions have been adequately investigated, including the extent to which the condition may be present and still be undetected, and

  (ii) potentially adverse conditions be adequately evaluated using analyses which are not likely to underestimate its effect, and

  (iii) the condition will not significantly effect the ability of the site to meet the performance objectives, can be compensated for, or can be remedied.

- While 10 CFR 60.122 is directed at postclosure concerns, the information used in the evaluation of FITS will be used to help evaluate the postclosure conditions, and the basic principles laid out within 10 CFR 60.122(a) will apply to all phases of the licensing process. The program laid out for evaluation of faulting near or at FITS appears to be ignoring these principles.

RECOMMENDATION

- The DOE needs to demonstrate that:

  (i) the program of investigations for faulting at or near FITS will adequately evaluate all faults which have a potential of movement, and/or

  (ii) that the evaluation of the effects of faulting, taking into account the degree of resolution of the investigation, will not underestimate the effects, and

  (iii) the effect of faulting will not compromise the ability of the FITS to meet the performance objectives

REFERENCES

Neal, James T., 1986, Preliminary Validation of Geology at site for Repository Surface Facilities, Yucca Mountain Nevada: Sandia National Laboratories, SAND85-0815.

REVIEW GUIDES

3.2.3, 3.2.4.10, 3.3.4

Section 8.3.1.17 Overview of preclosure tectonics: Description of tectonic and igneous events required by performance and design requirements

Table 8.3.1.17-3(a) Design and performance parameters related to surface facilities and preclosure fault displacement

SCP COMMENT

The information presented for the program of investigations for study of faulting at the surface facilities does not allow the NRC staff to determine what investigation will actually be conducted. In addition, this investigation does not appear to have integrated pre-existing information, does not appear to be in a logical sequence with other proposed investigations, and makes assumptions about pre-existing information and ongoing investigations which the NRC cannot evaluate because the NRC has not seen the background information.

BASIS

- The concern expressed by this comment is a continuation of the concern raised by the response to CDSCP comment 50.

- SCP Section 8.3.1.17.4.2 suggests that possible locations for trenching will be based on air photo interpretation, geologic mapping and possible use of geophysical investigations. This section also suggests that trenching would extend at least 100 meters from the FITS and extend to depths which expose materials at least 100,000 years old. In addition to the fact that the NRC staff does not consider that the parameters have been justified (See comment scp/yucca/jst/com/3/3), geologic mapping and geophysical investigations have been conducted in the area of the proposed surface facility and suggest the presence of many closely spaced normal faults and a high degree of fracturing in the subsurface. (Neal, 1986) The NRC staff is unsure as to how this information has and/or will be used to plan additional trenching, mapping, and geophysical investigations in the area of the surface facilities. Neal (1986) appears to identify many areas which have questionable geologic structure, however, there appear to be no present plans to investigate these areas.

° Table 8.3.1.17-9 and 8.3.1.4-4 provide a summary of site geophysical programs. Page 8.3.1.17-115 states however, that locations of surveys and data collection techniques will not be finalized until the review by activity 8.3.1.4.2.1.6 is complete. This also appears to be true for such things as drilling (see SCP Section 8.3.1.4.1.1). While the SCP provides a general description of tests which may be done and locations at which they may be conducted, certain tests such as those under activity 8.3.1.4.2.1.6 must be completed before any final locations or types of surveys will be determined. Until this review activity is complete and a program is presented which lays out actual tests and locations, the DOE cannot present the program which it plans on conducting. The NRC staff cannot evaluate the adequacy or appropriateness of the DOE program until the DOE states what studies, tests, investigations it actually will conduct.

- The NRC staff is also concerned as to the sequencing of the various activities. Page 8.5-32 of the SCP states that surface facilities trench logs will be complete by 12/89, however, the staff can not visualize how the location of trenches can be finalized until the site investigations have been complete. If geophysics is to play any role in the location of facilities, location of investigations, etc, activity 8.3.1.4.2.1.6 has to be complete prior to the geophysical surveys, and the geophysical surveys have to be conducted prior to finalization of the facility location and finalization of trenching and testing. The justification of the sequencing and ordering of the various processes in site characterization is not apparent.

- This work is being planned to be used in licensing, however, the NRC staff is unsure as to how much of this work is planned to be qualified, can be qualified under the Quality Assurance program, or the potential effect on schedules if some of the planned information cannot be qualified (see also QA comment scp/yucca/kh/com/106). Much of the work which forms the basis for many of the assumptions within this section has been ongoing and is considered by DOE to be substantially complete. For example, mapping of trenches on the bow ridge fault system is considered to be 50% complete (SCP page 8.3.1.17-160), a Quaternary fault map has been published and mapping of surfical geologic deposits is considered to be 25% complete (SCP page 8.3.1.17-156). The NRC has not seen any official results from the investigations.

RECOMMENDATION

- Prior to the NRC staff being able to evaluate the program of site investigations, the DOE needs to complete, at least, the planning step of integration of the site program. This should include, not only a separate integration of drilling, or a separate integration of geophysics, but a complete integration of the planned program of investigations. This integration should include, not only consideration of results of various activities, but sequencing and incorporation of ongoing activities and pre-existing information into the program with reasonably conservative assumptions on qualification of pre-existing data. While the NRC staff recognizes that there will be changes in the program, the DOE should be able to clearly state those tests, locations etc which will be initially conducted and from which decisions will be made.

REFERENCES

Neal, James T., 1986, Preliminary Validation of Geology at site for Repository Surface Facilities, Yucca Mountain Nevada: Sandia National Laboratories, SAND85-0815.

REVIEW GUIDES

3.2.3, 3.2.4.10, 3.3.4

Section 8.3.1.8 Overview of the postclosure tectonics program: Description of future tectonic processes and events required by the performance and design issues.

Table 8.3.1.8-1a, and table 8.3.1.8-1b.

Investigation 8.3.1.8.1 - Studies to provide information required on direct releases resulting from volcanic activity.

8.3.5.13 Issue Resolution strategy for issue 1.1: Will the mined geologic disposal system meet the performance objective for limiting radionuclide releases to the accessible environment as required by issue 10 CFR 60.112 and 40 CFR 191.13?, Disturbed case (A-1): direct release in basaltic volcanism.

Table 8.3.5.13-10. Performance parameters for scenario class A-1 (extrusive magmatic events)

COMMENT

If the results of the investigations on direct release resulting from volcanic activity do not provide information which shows that either the probability and/or consequence resulting from such a scenario is lower than the tentative parameter goals stated in Table 8.3.1.8-1b and Table 8.3.5.13-10, the Yucca Mountain site will fail to meet the requirements for overall system performance.

BASIS

- The concern expressed by this comment was the main basis for CDSCP comments 36 and 95.

- The tentative parameter values were not revised within the SCP. The response to CDSCP comments 36 and 95 focused primarily on what effects the expected values may have on the CCDF, and on justifying the use of the EPPM.

- The NRC agrees, with the discussion in section 8.3.1.8, 8.3.5.13, and the comment responses presented for CDSCP comments 36 and 95, that if the expected values of probability of volcanism are obtained, this scenario by itself, would not cause the site to fail the EPA standard. The goals however, are 2 orders of magnitude or more higher than the expected values.

- The annual probability of 10E-6 stated in the tentative goals, is higher than one chance in 1000 in 10,000 years, and therefore a process or event with such a probability would have to be included in the CCDF to determine compliance with the overall system performance objective if the results of such a process or event were significant.

- Disruption and release of on the order of one tenth of one percent of the repository inventory, the other tentative goal, would result in a release to the accessible environment on the order of 170 times the EPA standard ratio. Such a release, combined with the above probability would cause the site to fail the overall system performance objective, and is therefore considered significant.

- While, as stated on page 8.3.5.13-18, an EPPM of greater than .01 does not necessarily imply a violation of the EPA standard, if the EPPM were calculated in accordance with the methodology presented on page 8.3.5.13-18, the resultant value would be on the order of 1.7, which is much more than the tentative goal of less than .1 listed in Table 8.3.1.8-1a and table 8.3.5.13-8. The NRC considers that an EPPM on the order of 1.7 would imply a violation in most cases.

- Furthermore, as can be determined from the discussion on page 8.3.5.13-18, the significance of an EPPM of greater than .01 cannot be determined without performing other calculations. While the EPPM may have some use, in this specific case the goal for the EPPM is above .01, therefore by itself it provides no guidance to the persons performing the investigations. (see also comments sco/nae/com/16, scp/lra/com/3, scp/lra/com/7)

- The purpose of performance allocation is to determine what components of the natural and engineered system are significant in determining if the site can meet the various performance objectives to assure that the proper emphasis is placed on the various investigations. To assure that the investigator understands the significance of the technical finding, the goals should be set so that the performance objectives can be met if the goals are met.

- In the specific case of volcanism intersecting the repository, the consequences are sufficiently high that the probability goal should be set to assure that, if met, this scenario by itself would not cause the site to fail the performance objectives.

RECOMMENDATIONS

- DOE should review the various performance measures, performance parameters and goals presented for basaltic volcanism. Goals should be set which will assure that the performance objectives could be met.

REFERENCES

Ross, B., 1987, A First survey of Disruptive Scenarios for a High-level-Waste Repository at Yucca Mountain, Nevada: Sandia National Laboratory, SAND85-7117.

DOE, 1988, Response to NRC Point Papers on Site Characterization Plan/Consultation Draft

REVIEW GUIDES

3.2.4.9, 3.2.3, 3.3.4,

Table 8.3.1.5-3 Current representation and alternative hypotheses for regional model for climate program

COMMENT

Neither the current representation of climatic conditions during the postclosure period, nor the alternative hypothesis, allows for significant increase in precipitation or for abrupt climatic changes.

BASIS

- The Current representation of the system response/dynamics for the period after 1000 years, is stated on page 8.3.1.5-21, as a significant decrease in precipitation.

- The alternate hypothesis, stated on the same page, is no significant change in temperature or precipitation for the period after 1000 years.

- Neither the current representation, nor the alternative hypotheses, appear to consider information, such as is presented on page 8.3.1.5-36, which suggest the possibility that increased frontal activity could increase precipitation, reduce evaporation, and thus potentially increase recharge.

- Neither the current representation, nor the alternative hypothesis, appear to consider the potential for abrupt climatic changes, which could significantly change climatic patterns, in some cases in less than 1000 years. (see, for example, Crowley and North, 1988)

RECOMMENDATION

- The various hypotheses for climatic variations should consider, both, significant increase in precipitation during the postclosure period, and the potential for abrupt climatic changes.

REVIEW GUIDES

3.2.2, 3.2.3, 3.3.18

REFERENCES

Crowley, T.J., and North, G.R., 1988, Abrupt climatic change and extinction events in earth history: Science, V. 240, pp. 996-1002.

Section 8.3.1.4.2.2.4 Activity: Geologic Mapping of the Exploratory Shaft and Drifts.

COMMENT

One of the objectives of Activity 8.3.1.4.2.2.4 is to characterize major faults and fault zones in the subsurface. There is no justification given for not characterizing minor faults and fault zones, although these features potentially present the same kinds of hazards as do major faults, even though on a smaller scale.

BASES:

- Item 2 under objectives (p. 8.3.1.4-74) states that one of the objectives of this activity is to "characterize major faults and fault zones in the subsurface."

- As this item is presently written, the question arises, what are the standards and criteria by which a fault is to be judged to be major or minor, and whether or not significant to safety? Such judgments would have to be made under difficult conditions underground and in a brief time interval.

- Minor faults and fault zones may have had significant Quaternary movement (i.e., are anticipated events) or may be preferred pathways for radionuclide transport and thus affect waste isolation.

- The significance of a fault or fault zone can only be judged when its significance is integrated and analyzed on the basis of regional tectonics, stress field, its relationship with other nearby faults, and in the light of design criteria.

- There are no criteria provided for distinguishing a major from a minor fault or fault zone nor a justification for mapping one and not the other.

RECOMMENDATION:

- All faults and fault zones encountered in the shafts and drifts should be mapped in situ and characterized in detail.

REVIEW GUIDES:

3.3.2, 3.3.4

Section 8.3.1.4.2.2.4 Activity: Geologic Mapping of the Exploratory Shafts and Drifts

COMMENT:

The SCP does not appear to provide a procedure to implement the performance confirmation requiring a procedure to recognize, evaluate, and document anomalous features and changed geologic conditions that may be encountered in the exploratory shaft facility.

BASIS:

- Part 60.140(d)(3) requires that the performance confirmation program monitor and analyze changes from the baseline condition of parameters that could affect the performance of a geologic repository. The program shall have been stated during site characterization [60.140 (b)].

- SCP page 8.4.2-194 of Section 8.4.2.3.4.4 Exploratory shaft facility underground construction and operation states, "Any unforeseen, anomalous features encountered while mining these drifts will be considered for additional study."

- Activity 8.3.1.4.2.2.4 "Geologic mapping of the exploratory shaft and drifts" is silent on anomalous features, both in the objectives (page 8.3.1.4-74) and the products (page 8.3.1.4-78) of the activity.

- A baseline or nominal description is needed to provide a reference base of data and conditions against which anomalies can be identified during underground investigations and against which design can be evaluated.

RECOMMENDATION:

- Develop a systematic procedure to recognize, describe, analyse, and map in detail any anomalous features or conditions that may be encountered underground. The procedure should include a geologic description of the rock mass that was used as the basis for design of the exploratory shaft facility.

- The description should include (1) rock classification and rock quality determination, for ground support methods; and (2) maps that show inferred faults with their characteristics, inferred fracture frequencies and orientation, and rock lithologies.

- The procedure should provide for an established plan for feedback and analysis of data, and implementation of appropriate action, e.g. Part 60.140(d)(4).

REVIEW GUIDES:

3.3.2, 3.3.4

Section 8.3.1.9.2.1 Study: Natural resource assessment of Yucca Mountain, Nye County, Nevada

COMMENT

The program of investigations for natural resources assessment as presented in the SCP appears to be unsatisfactory for consideration of potential natural resources and natural resource models at the site.

BASIS

- This comment addresses concerns expressed in unresolved CDSCP Comments 38 and 39 to the CDSCP.

- Although conceptual models directed toward natural resource occurrence in tuffs have now been considered in the SCP, alternative resource models to include hosts other than tuffs appear not to be considered. For example, the resource assessment program does not specifically provide for testing structures as potential ore hosts, nor does it provide for testing of possible tactites on the margin of the hypothesized Crater Flat caldera complex.

- The suite of elements selected for analysis in the geochemical sampling program is limited to those commodities known to exist in silicic tuff (p. 8.3.1.9-30) and excludes those elements or commodities associated with resources in tactites (skarn), carbonate and other sedimentary rocks, and possible plutonic rocks that may be present beneath the site.

- Proposed investigations still appear to lack integration with other geological, geophysical, and geochemical investigations and pre-existing data. No geophysical investigations directed toward natural resources assessment and evaluation appear to be considered as recommended in CDSCP Comment 39. Results of geologic/geophysical activities planned for other purposes may provide a portion of the information to delineate areas for more detailed study.

- Drillholes proposed for other tests may not uniformly cover the controlled area and may not be directed at or intersect features favorable to mineralization such as high-angle fault zones, detachment zones, or veins. Drillholes as planned may not be favorably placed or extend to the depth necessary to provide sufficient information to assess resource potential of pre-Cenozoic rocks and volcanic rocks underlying the proposed respository. A large degree of uncertainty exists that vertical drill holes would intersect vertical to near vertical faults or mineralized zones (See SCP Question SCP/CA/Ques/13).

- Mineral and/or hydrocarbon resource potential of pre-Cenozoic rocks cannot be adequately assessed based on surface samples. Drillholes that penetrate the Paleozoic rocks, postulated detachment zone (Scott, 1986), and lowermost volcanic rocks are necessary to test for possible mineral resources in light of gold discoveries and mines near Yucca Mountain associated with low-angle faulting, Paleozoic rocks, and the lower Tram Member of the Crater Flat Tuff (Sterling Mine at Bare Mountain, Bullfrog District, and GEXA gold claims in northern Crater Flat).

° Information in Chapter 1 and Section 8.3.1.9.2.1 does not reflect recent publications, models, and discoveries (See NRC, 1986 and CDSCP Comment 38; see information in Raney, 1988 and Price, 1988). Reliance has been placed on out-of-date models, parameters (production figures in dollars rather than in tonnage and grade), and references (e.g., McKee, 1979 and Hewitt, 1968).

RECOMMENDATION

° Consider and develop a program of planned technical procedures which demonstrate integration and application of geological, geochemical, and geophysical studies in support of the resource assessment investigations, as well as those to be employed in the probability estimation of unidentified resources.

REFERENCES

Hewitt, W.P., 1968, Western Utah, eastern and central Nevada, in Ore Deposits in the United States, 1933-1967, Part 8: Utah and Nevada, J.D. Ridge ed.: American Institute of Mining Engineers, New York, N.Y., p. 857-885.

McKee, E.H., 1979, Ash-flow sheets and calderas: their genetic relationshop to ore deposits in Nevada: Geological Society of America Special Paper 180, p. 205-211.

NRC, 1986, NRC staff comments on the DOE final environmental assessments.

Price, J.G., 1988, Letter to Carl Gertz on review of Raney, 1988, dated October 25, 1988.

Raney, R.G., 1988, Ash-flow sheets and calderas: their relationship to ore deposits in Nevada, by E.H. McKee -- a review of the paper and of its application in an assessment of the resource potential at a proposed high-level waste repository, Yucca Mountain, Nye County, Nevada: document review prepared for the NRC by U.S. Bureau of Mines, FIN D1018.

Scott, R.B., 1986, Extensional tectonics at Yucca Mountain, southern Nevada: Geological Society of America Abstracts with Programs, v. 18, no. 5, p. 411.

REVIEW GUIDES

3.3.5, 3.3.6, 3.3.11

SCR/CA/COM/4

Section 8.3.1.6 Overview of the erosion program: Description of the future erosional rates required by the performance and design issues.

Section 8.3.1.8 Overview of the postclosure tectonics program: Description of future tectonic processes and events required by the performance and design issues.

Section 8.3.1.17 Overview of preclosure tectonics: Description of tectonic and igneous events required by performance and design requirements.

COMMENT

The rationale for numerical goals specified in Tables 8.3.1.17-3a, 8.3.1.17-4a and b, and 8.3.1.17-7 is poorly supported and the use of averaged values or rates for establishing acceptable limits for fault movement, rates of volcanism, and rates of erosion does not provide for conservative assessments of potential hazards.

BASIS

- 10 CFR 60.122 (a)(2)(ii) requires that the natural conditions on the site be "adequately evaluated using analyses ... and assumptions which are not likely to underestimate" the effect of those conditions.

- Regional, long-term rates of erosion averaged over time and applied to specific areas do not provide a conservative estimate of potential erosion which could occur over a short time period during a single erosive event. Failure to consider maximum conditions in predicting erosion over the next

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10,000 years may result in an underestimation of the effect of potential erosion.

- Numerical goals assigned for acceptable limits for fault movement appear to be unrealistic. The performance measure of the probability of 5 cm of fault displacement on faults in the respository area or at the location of FITS may be unattainable in light of difficulty in ascertaining lateral movement along faults in the Yucca Mountain area (See SCP Point Paper, SCP/Yucca/KIM/COM/13).

- The use of slip rates provides an average value for fault offset of a number of faulting events over time, but fails to consider the potential for single events of maximum slip or offset (see SCP Point Paper, scp/yucca/kim/com/13).

- The use of the 10,000 year cumulative slip earthquake concept normalizes and averages the amount of fault displacement over time and does not provide a conservative estimate of maximum fault movement resulting from a single episode (See SCP Point Paper, scp/yucca/meb/com/1).

- Averages of cone counts through time are likely to underestimate the rates of volcanic eruptions over a given period of time (in this case, the Quaternary or 1.6 million years, Palmer, 1983). This method of calculation does not appear to provide a process for accurately estimating the potential of volcanic activity and, therefore, the potential disruption of the repository that could occur as a result of a volcanic eruption (See SCP Point Paper, scp/yucca/kim/com/16).

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- Faulting potential based on the "average spacing of Quaternary faults that is estimated for the structural domain" (p. 8.3.1.17-62) is a nonconservative parameter which may underestimate the potential for faulting.

RECOMMENDATION

- DOE should provide goals that are not likely to underestimate maximum single-event disruptions, rather than providing estimates of cut-off values or goals which are based on averaging of established values over time.

- Alternatively, DOE should plan to demonstrate the average values are conservative values.

REFERENCE

Palmer, A.R., 1983, The decade of north American geology geologic time scale: Geological Society of America.

REVIEW GUIDES

3.3.1, 3.3.3, 3.3.4

Section 8.3.1.5 Climate

COMMENT

Recent data suggests that previous criteria for delineation of surficial deposits may need to be reevaluated.

BASIS

- Recent data (University of Neveda - Reno, 1988) suggests there may be some problems with the previously adopted Surficial Deposits units as mapped by Swadley and others (1984). These new data suggest mapping of geomorphic surfaces (vs. deposits) defined in terms of soils and stratigraphic relations is more appropriate.

- The reliability of the relative age and correlations of the Quaternary map units needs to be clearly established because of the significant role these units play in the evaluation of important geologic studies, such as fault age determinations, estimates of erosion rates, paleoclimatic reconstructions, and selection of trench location.

RECOMMENDATION

- Reevaluate the criteria for distinguishing existing surficial deposits map units. This reevaluation should be performed prior to, or in conjunction with, SCP Activities Surficial Deposits mapping of the Yucca Mountain Area (8.3.1.5.1.4.2) and Modeling of Soil properties in the Yucca Mountain Region (8.3.1.5.4.1)

REFERENCES

Swadley, W.C., Hoover, D.L., and Rosholt, J.N., 1984, Preliminary report on late Cenozoic faulting and stratigraphy in the vicinity of Yucca Mountain, Nye County, Nevada: U.S. Geological Survey Open-File Report 84-788.

University of Nevada-Reno, 1988, Evaluation of the geologic relations and seismotectonic stability of the Yucca Mountain area, Nevada Nuclear Waste Site Investigation (NNWSI): Final report from the Center for Neotectonic Studies, Mackay School of Mines, to the State of Nevada, Nuclear Projects Office.

REVIEW GUIDES

3.3.1, 3.3.4

Section 8.3.1.6 Overview of the Erosion Program

COMMENT

The overall erosion program does not include an evaluation of escarpment retreat.

BASIS

- Previous NRC comment #35 suggested that the DOE include an evaluation of valley incision, sediment yield, uplift/subsidence, and escarpment retreat.

- DOE has identified and included sections in the SCP which address hillslope erosion (which includes valley incision) and uplift and subsidence (1.1.3.1.1, 8.3.1.6.1.1 and 8.3.1.8.3).

- The DOE has also presented a justification for estimating approximate volumes of sediment eroded off hillsides instead of sediment yield studies for the short-term (8.3.1.1.6), and also expects to qualitatively estimate debris flow hazards (8.3.1.16.1.1).

- Evaluations of escarpment retreat have not been included in the SCP. DOE suggests that escarpment retreat is indirectly treated in Activity 8.3.1.6.1.1.3 (an analysis of hillslope erosion); however, no studies of escarpment retreat are described under that activity. Because of the critical relationship between the westernmost extent of the waste repository and the western face of Yucca Mountain, direct studies of escarpment retreat are necessary to provide sufficient data to evaluate the overall hazard of erosion at the proposed Yucca Mountain site (Purcell, 1986).

RECOMMENDATION

° A direct evaluation of escarpment retreat, especially as it relates to the western face of Yucca Mountain should be included in the erosion program to evaluate the overall future erosion potential required by performance and design issues.

REFERENCES

Purcell, C.R., 1986, Potential erosion at the Yucca Mountain nuclear waste site: Letter report from LLNL to NRC.

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3.3.1

Section 8.3.1.17.3.1.2 Activity: Characterize 10,000-year cumulative slip earthquakes for relevant seismogenic sources (p. 8.3.1.17-72)

COMMENT

Since the 10,000-year cumulative slip earthquake (10-kyr CSE) methodology assumes that average cumulative slip over 10,000 years is released in a single event, it appears that recurrence is implied to be fixed at 10,000 years. It is questionable whether such a methodology can properly characterize the fault activity, and the related seismic activity, in the site region.

BASIS

- The revisions to the SCP are not considered to have sufficiently addressed NRC CDSCP Comment 52.

- The general design criterion 1, §60.131(b)(1), for structures, systems, and components important to safety implies that a reasonably complete knowledge of the anticipated seismic phenomenon is required.

- In the description of the 10-kyr CSE it is stated that recurrence intervals may be on the order of 10,000 to 100,000 years for faults in the site region that have moved during the Quaternary (see page 8.3.1.17-72 and Section 1.3).

- Given that the range for recurrence intervals in the site region is on the order of 10,000 to 100,000 years, the 10,000 year recurrence interval, selected to characterize the cumulative displacement for the 10-kyr CSE, appears to be the minimum recurrence interval that is typical of the region.

- According to the 10-kyr CSE sample calculation, the 10-kyr CSE is derived from the displacement determined by multiplying the average annual displacement by 10,000 years, assuming all the displacement occurs in one 10,000-year event. The use of a 10,000 year recurrence interval, which is the minimum interval suggested by the available data (see page 8.3.1.17-72 and Section 1.3), in this manner results in a minimum cumulative displacement, which in turn, results in a minimum magnitude being estimated for the relevant earthquake source.

- The reliance on fractional fault length for the determination, or justification, of maximum magnitude, which is presented in the 10-kyr CSE sample calculation, can be very region dependent. For example, studies cited by URS/John A. Blume and Associates (1987) in their discussion of normal and strike-slip faulting in extensional environments indicate that earthquakes can rupture normal faults with rupture lengths that are not small in comparison to mapped fault lengths, and are occasionally larger. In addition, those authors indicate that ruptures occupying the entire length of strike-slip faults of the Basin and Range may be possible. Also, in another study (Matsuda, 1974), certain faults in Japan have been shown to rupture along their entire length during one earthquake.

- The methodology does not appear to constrain magnitudes in a manner that results in a design-basis ground motion for facilities important to safety that would have an annual probability of exceedence between 1 chance in 1000 and 1 chance in 10,000 per year, which is typical of nuclear power plants, according to the SCP. In addition, to assure the same level of design basis exceedence between nuclear power plants and a geologic repository, it would be necessary to have consistent methodologies and, to the extent possible, consistent inputs. This may be quite difficult because there are no nuclear power plants in the Basin and Range.

- It is apparent from a review of SCP Section 8.3.1.17, Preclosure Tectonics, that since the 10-kyr CSE is intended to be the primary means for establishing the vibratory ground motion design basis for facilities important to safety, it is very important that the methodology for determining 10-kyr CSE's is clearly understood and that it is accepted as a reasonably conservative and technically sound approach for the characterization of vibratory ground motion.

- The description of the 10-kyr CSE presented in Section 8.3.1.17.1.2 does not appear to address recurrence in a very clear manner. If one considers the hypothetical example given in the sample calculation, significantly different results could be determined if the recurrence interval is changed. In the example, the 10-kyr CSE methodology assumes that 74 very similar earthquakes have occurred since the 740,000 year old layer was initially displaced. Two alternative hypotheses immediately come to mind: first, that cumulative displacement resulted from a smaller number of similar earthquakes with magnitudes significantly larger than the 10-kyr CSE, or second, that the cumulative displacement is the result of a suite of different-sized earthquakes with recurrence intervals of different lengths. Some of these earthquakes could also be significantly larger than the 10-kyr CSE.

- It may be argued that earthquakes with recurrence intervals longer than 10,000 years may have such low probabilities of annual exceedance that they need not be considered for the preclosure design, but it is not known just where in the normal recurrence interval a particular fault may be at the present time. This critical uncertainty does not appear to be addressed in the 10-kyr CSE sample calculation.

- It must be more clearly demonstrated that there is sufficient seismic margin to conservatively withstand the larger maximum earthquake, before the rationale for accepting maximum magnitude earthquakes less than that determined by fault parameters such as length and displacement can be accepted.

RECOMMENDATION

Recurrence-rate estimates should be given special emphasis. In particular, differences between the true maximum magnitude and the 10-kyr CSE, based on evaluations of the recurrence interval associated with the maximum earthquake determined from magnitude-frequency relationships, should be thoroughly explained.

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REFERENCES

Matsuda, T., 1974, Surface Faults Associated with the Nobi (Mino-Owari) Earthquake of 1891, Japan [in Japanese]: Tokyo University Earthquake Research Institute Special Bulletin No. 13, pp. 85-126.

URS/John A. Blume & Associates, Engineers, 1987, Technical Basis and Parametric Study of Ground Motion and Surface Rupture Hazard Evaluations at Yucca Mountain, Nevada: Contractor Report, Sandia National Laboratory, SAND86-7013, 99 p.

REVIEW GUIDES

3.3.3, 3.3.4

Section 8.3.1.17.3.4 Study: Effects of local site geology on surface and subsurface motions. (p. 8.3.1.17-77)

COMMENT

The data, compiled according to Activity 8.3.1.17.4.1.2, may not be sufficient to support an evaluation of the effects of local site geology on surface and subsurface motions.

BASIS

- Changes to the SCP in response to CDSCP question 32 are insufficient.

- The provisions of §60.122(c)(14) require an investigation into the degree to which the local effects of an earthquake compare with those typical of the area in which the geologic setting is located.

- The objective of this study is to develop local correction factors for ground motion with respect to regional values by comparing ground motion parameters obtained from a more densely-spaced network of seismic instruments in the site area with those from a less densely-spaced regional network.

- The parameters listed under Activity 8.3.1.17.4.1.2 that are applicable to the determination of local correction factors, such as peak ground acceleration and velocities, durations, spectral amplitudes and so forth, will only be compiled for the larger (M greater than or equal to 5.5) earthquakes. Since earthquakes of this size are not common in the Yucca Mountain vicinity, considering the period of time allotted for characterization of the site, no regional data may be collected except for data from underground nuclear explosions.

- Current references of compiled seismic data for the Yucca Mountain vicinity such as Harmsen and Rogers (1987) include focal mechanism information for several events, none of which is greater than magnitude 3.

- The upgrading of the southern Great Basin seismograph network to digital recording, which is currently underway, should permit the routine determination of some of the parameters listed in Activity 8.3.1.17.4.1.2 that are reserved for earthquakes of magnitude greater than 5.5.

RECOMMENDATION

- The distinction between those parameters that are to be compiled for all recorded seismic events and those that are to be compiled for events greater than magnitude 5.5 should be dropped. If it is reasonable and practical, information for any of the nineteen categories of parameters listed in Activity 8.3.1.17.4.1.2 should be compiled for earthquakes in the Yucca Mountain vicinity, without regard to their size.

REFERENCE

Harmsen, S.C., and Rogers, A.M., 1987, Earthquake Location Data for the Southern Great Basin of Nevada and California: 1984 through 1986: U.S. Geological Survey Open-File Report OFR-87-596.

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3.3.3

Section 8.3.1.17 Preclosure Tectonics
Section 8.3.1.8 Postclosure Tectonics

COMMENT

Geophysical coverage as indicated in the SCP may not be sufficient to identify and characterize the deep crustal and shallow geologic features and their interrelationship.

BASIS

- In response to CDSCP comment 49, a new activity of integration was added in section 8.3.1.4.1.2. Since the subject of the CDSCP comment 49 was the insufficiency of geophysical coverage to characterize the Yucca site and the geologic setting, a response that only addresses an integration of geophysical activities is clearly not sufficient.

- A single long refraction line as noted in Figure 8.3.1.4.6 is generally inconclusive and/or no definition of an anomalous trend is possible. With a single line of investigation as planned, there is a significantly increased probability that ambiguous data and/or misleading interpretations will occur.

- Most of the proposed geophysical activities such as shown in Figure 8.3.1.4.7 (seismic reflection) and Figure 8.3.1.4.8 (gravity and magnetic) indicate coverage that is isolated and not crossed or tied to other lines.

RECOMMENDATION

- Provide a geophysical investigation program plan that is comprehensive, integrated and sufficient to identify and understand the interrelationships of the deep crustal structure and shallow geologic structural features, and to assure that no significant structural features have gone undetected.

- Consider including a gridded program of exploratory surveys and measurements that would allow for cross-line correlations and more complete spatial definition of anomalies at the site and specifically at the locations of the exploratory shafts.

REVIEW GUIDE

3.3.6

Section 8.3.1.17.1 Studies - Volcanic Activity
Section 8.3.1.8.1. Investigation - Volcanic Activity
Section 8.3.1.8.5.1 Study - Volcanic Features
Section 8.3.1.8.5.2 Study - Intrusive Features

COMMENT

No specific geophysical program appears to be planned to identify volcanic/ igneous features and their extent under or close to the site.

BASIS

- This comment restates the concern expressed in CDSCP Comment 51.

- The SCP includes a re-written Activity 8.3.1.8.1.1.3 and includes cross references between Activity 8.3.1.8.1.1.3 and 8.3.1.17.4.3.1; however, the SCP is not specific about a planned program for volcanic/igneous features identification.

- Activities 8.3.1.8.1.1.3 and 8.3.1.17.4.3.1 indicate that a number of geophysical parameters exist for the activities; however, there is no indication of a coherent plan in these two sections or elsewhere in the SCP to indicate that the volcanic/ igneous investigation will be accomplished in a consistent and coherent manner.

RECOMMENDATION

- The DOE should include and integrate into its geophysical program a subprogram designed specifically for consideration of volcanic/ igneous features.

REVIEW GUIDE

3.3.6

Section 8.3.1.4 Rock Characteristics
Section 8.3.1.17 Preclosure Tectonics

COMMENT

The program for geophysical integration as presented in the SCP is insufficiently described. The correlation between the different geophysical investigations is not presented and, in addition, the approach that will be used to integrate the geophysical activities and how these different geophysical activities will compliment each other does not appear to be discussed in the SCP.

BASIS

- This comment addresses the concerns expressed in CDSCP Comment 26 and CDSCP Question 33.

- The geophysical program proposed in the SCP is the same program proposed in the CDSCP including figures and tables. The locations and scopes of the geophysical program in the SCP are generally related only to specific geologic features or cover areas of limited extent. According to the figures presented in the SCP each geophysical investigation appears to cover a specific area of the site. For example, the seismic reflection survey proposed in the SCP mainly covers the area outside the perimeter drift (fig. 8.3.1.4-7), and only one seismic refraction line (fig. 8.3.1.4-6) is proposed for site characterization. The SCP does not address the possibility of a 3-D seismic program at the site.

- It is noted on p. 8.3.1.4-27 that the integration of geophysical activities will include "planning", "review", and "development of strategy"; the NRC staff believes that these elements should have been present in the SCP, rather than as future events. "Changes in planned activities" may be anticipated, but the planning should be much more descriptively than that presented in the SCP.

RECOMMENDATION

- Integrate and evaluate existing geologic and geophysical data and provide overlays of the existing coverage and evaluations.

- Based on this integration, provide a coherent geophysical program to be implemented in the Yucca Mountain area that would provide sufficient characterization of the site.

- Consider initiating a program to obtain a 3-D seismic image at the site.

REVIEW GUIDE

3.3.6

Section 8.3.1.8.1.1.1 Activity: Location and timing of volcanic events

QUESTION 9

Why has the Lunar Crater area not been considered as a possible natural analog for detailed study of the processes related to basaltic volcanism in the Death Valley-Pancake Range volcanic belt?

BASIS

- 10 CFR 60.21 requires that models, including tectonic models, be supported by an appropriate combination of such methods as field tests, in situ tests, laboratory tests which are representative of field conditions, monitoring data, and natural analog studies.

- Both the Crater Flat and Lunar Crater basaltic fields are part of the Death Valley-Pancake Range volcanic zone.

- The 70 km limit on volcanic activities (Section 8.3.1.8.5) excludes the Lunar Crater volcanic field from consideration.

- Section 8.3.1.8.5.1.5 implies that similar trends in geochemistry and eruptive patterns have been noted between the Yucca Mountain area and Lunar Crater.

- The Lunar Crater volcanic field has 110 volcanic centers of probable Quaternary age (Crowe and others, 1983) and provides an opportunity to study basaltic volcanism in great detail.

- Crowe and others (1986) indicate that they have completed geologic mapping in the Lunar Crater volcanic field, but the mapping apparently is unpublished.

- Recent work in the Reveille-Lunar Crater area has suggested that previous concepts relating chemical trends and the stages of volcanism are not accurate (Naumann and Smith, 1988).

RECOMMENDATION

- The 70 km limit on activities to investigate volcanic processes should should be reconsidered.

- The Lunar Crater volcanic field should be considered as a possible natural analog important to the understanding of volcanic processes in an area where numerous Quaternary volcanic events have occurred.

REFERENCES

Crowe, B.M., Vaniman, D.T., and Carr, W.J., 1983, Status of volcanic hazard studies for the Nevada Nuclear Waste Storage Investigations: Los Alamos National Laboratory, LA-9325-MS, 47 p.

Crowe, B.M., Wohletz, K.H., Vaniman, D.T., Gladney, E., and Bower, N., 1986, Status of volcanic hazard studies for the Nevada Nuclear Waste Storage Investigations: Los Alamos National Laboratory, LA-9325-MS, V. II, 101 p.

Naumann, T.R., and Smith, E.I., 1988, Compositional trends within Late-Cenozoic alkali basalts of the central Great Basin, Nevada: Geological Society of America Abstracts with Programs, 1988 Centennial Celebration, p. A114.

REVIEW GUIDE

3.3.4

Section 8.3.1.8.5.1.5 Activity: Geochemical cycles of basaltic volcanic fields

QUESTION 10

What is the basis for statements made about the migration, structural boundaries and stage of volcanism at Yucca Mountain. These statements appear to be unsupported by data presented in the SCP. Data in the SCP references and conclusions made in the SCP appear contradictory.

BASIS

- The concern expressed by this comment expands on CDSCP Question 20.

- Section 8.3.1.8.5.1.5 implies that similar trends in geochemistry and eruptive patterns have been noted between the Yucca Mountain area and Lunar Crater and that these patterns "may be" indicative of the terminal stage of basaltic activity at a volcanic field.

- No data are presented to indicate why these trends should be considered as indicative of the terminal stage of basaltic activity. Crowe and others (1986) indicate that the Lunar Crater volcanic field is the youngest and most active field in the Death Valley-Pancake Range belt and that data suggest that the field is still active. No data are presented to suggest that the field is in a terminal stage of activity.

- Naumann and Smith (1988) suggest that compositional trends of single volcanic centers are more complex than previously believed and that specific trends may not be indicative of termination of volcanism in a specific area.

- No data appear to be presented in the SCP to indicate that the tectonic processes that initiated the volcanic activity that resulted in the Lathrop Wells and Lunar Crater volcanic fields have changed or stopped.

- No data appear to be presented in the SCP to strongly support the statement made in Activity 8.3.1.8.5.1.5 that a southwestwardly migration of basaltic activity has occurred.

- Section 8.3.1.8.5.1.5 states that eruptions near Yucca Mountain were characterized by early hypersthene hawaiites with subsequent, smaller eruptions with increasing undersaturation and that similar trends have been noted at Lunar Crater. Crowe and others (1986, p.22) state that rocks of the Lunar Crater volcanic field are characterized by increasingly undersaturated basalts whose patterns are distinctly different from the volcanic patterns of the NTS region.

RECOMMENDATION

- Assumptions and preferred models of processes in the geologic setting should be fully supported by the available data.

- In cases were the data do not support a preferred model, alternatives should be presented and considered.

REFERENCES

Crowe, B.M., Wohletz, K.H., Vaniman, D.T., Gladney, E., and Bower, N., 1986, Status of volcanic hazard studies for the Nevada Nuclear Waste Storage Investigations: Los Alamos National Laboratory, LA-9325-MS, V. II, 101 p.

Naumann, T.R., and Smith, E.I., 1988, Compositional trends within Late-Cenozoic alkali basalts of the central Great Basin, Nevada: Geological Society of America Abstracts with Programs, 1988 Centennial Celebration, p. A114.

REVIEW GUIDE

3.3.4, 3.2.4.4

Section 8.3.1.4.3.1.1 Activity: Systematic drilling program

QUESTION 34

What is the basis for the three thousand foot spacing for drillholes in the systematic drilling program?

BASIS

- One of the two factors used to define the 3000 foot spacing of holes in the systematic drilling program was a correlation length for variability of physical properties.

- The SCP cites Rautman and others (1988) as the source of information on the lateral variability of physical properties in the Calico Hills unit.

- The Rautman and others (1988) reference was not provided with the SCP.

RECOMMENDATION

- Provide the basis for assuming that the 3000 foot spacing on drill holes of the systematic drilling program is sufficient to adequately characterize lateral variability in rock characteristics.

REFERENCES

REVIEW GUIDE

3.3.2

SCP/YUCCA/JST/QUE/4

former scp/yucca/jst/com/6/6

Section 8.3.1.4.2.1.3 Activity: Borehole geophysical surveys, page 8.3.1.4-57 to 8.3.1.4-58 Section 8.3.1.2.2.3.2 Activity: Site vertical borehole studies, page 8.3.1.2-200 to 8.3.1.2-221

QUESTION TEMP

The work of Sass/ and others (1988) indicates that the site is in an area of anomalously low heat flow. How will the temperature logging described in the above sections be sufficient to evaluate the significance of this preliminary conclusion?

BASIS

- The quality of the data used to prepare the above report does not permit unambiguous interpretations, however, possible reasons for the apparently anomalously low heat flow include the result of a higher downward flux of groundwater than is presently being assumed, vaporization and advective transport of heat in upward movement of air, or such things as shallow lateral flow in the saturated zone.

- To obtain unambiguous data on heatflow it would be necessary to perform temperature logging using procedures which may be substantially different from that used by standard commercial logging.

- Such heatflow data may help resolve various tectonic and hydrological questions about Yucca Mountain, such as the rate and direction of groundwater flow in both the saturated and unsaturated zone, and the characteristics of various fault zones.

- The information presented in the SCP appears to allow for only standard commercial temperature logging.

RECOMMENDATION

- The DOE should include provisions for performing temperature logging which can supplement the information obtained by Sass and others, (1988), to evaluate the significance of the anomalously low heat flow values.

REFERENCE

Sass, J.H., Lachenbruch, A.H., Dudley, W.W., Jr., Priest, S.S., and Monroe, R.J., 1988, Temperature, thermal conductivity, and heat flow near Yucca Mountain Nevada: Some tectonic and hydrologic implications: U.S. Geological Survey Open File Report 87-649.

REVIEW GUIDES

3.2.3, 3.3.4, 3.3.6

Section 8.3.1.4.2.2.4 Activity: Geologic Mapping of the Exploratory Shaft and Drifts.

Question 1:

Explain what is meant by the statement in the last paragraph of page 8.3.1.4-75 that the discontinuities and other features of interest to be mapped "will be identified based in part, but not exclusively, on predetermined criteria." Also, what are the "criteria"?

Basis:

- The above wording is vague and suggests that some discontinuities and features may or may not be identified in a consistent manner.

Recommendation:

- The "criteria" should be provided for review prior to the onset of ESF mapping.

Review Guides:

3.3.2, 3.3.4

Section 8.3.1.9 Human Intrustion

Section 1.6.1 Drilling and Excavation History

QUESTION

The SCP does not appear to consider historical records of claims and/or leases in its evaluation of previous drilling or excavation at Yucca Mountain. What consideration been given to historical maps and claim and lease information in establishing the position that "no further investigation of previous drilling or mining is needed" (p. 1-213) in the proposed repository area?

BASIS

- The statement that "all known drilling within 10 km of the perimeter drift outline has been under the control of either the Nevada Test Site Office or the Nuclear Rocket Development Station" (p. 1-213) is misleading. The crest of Yucca Mountain and the area to the west of the mountain are not under the control of those two entities.

- Excavation and/or drilling may have occurred in the Yucca Mountain area prior to the withdrawal of the land to the east of the mountain crest for establishment of the NTS in the 1940's.

- An early 1900's map of Nevada (Clason Map Company, 1906) shows a possible mining area on the east flank of Yucca Mountain.

° Mapping or surface inspection may not delineate relatively inconspicious surface disturbances (e.g., drilling).

RECOMMENDATION

° Prior to the evaluation that "no further investigation of previous drilling or mining is needed" at the Yucca Mountain site, a thorough search of historical information pertinent to the evaluation should be made.

REFERENCE

Clason Map Company, 1906, Map of Nevada and the southeastern portion of California, Denver, Colorado.

REVIEW GUIDE

3.3.5

Section 8.3.1.4.1.1 Development of an integrated drilling program

Section 8.3.1.4.2.1 Characterization of the vertical and lateral distribution of stratigraphic units within the site area

QUESTION

Discussions of the integrated drilling program are unclear: How will data from various holes be used in support of different studies; how will uncertainty in core retrieval and data analysis be handled; and how will the large volume of existing information be used to plan the drilling program?

BASIS

- Although discussions of the integrated drilling program have been explanded in the SCP to address CDSCP Question 13, the SCP still does not clarify or resolve concerns stated in CDSCP Question 13.

- It is unclear to what extent the proposed drilling program will be implemented. For example, page 8.3.1.4-33 states that "three additional continuously cored holes may be drilled."

- It is not clear whether data obtained from holes drilled for one particular investigation or discipline will be utilized as possible input into other investigations (e.g., data from water level drilling as input to geologic studies; utilization of core from proposed holes USW G5, G6 and G7, if drilled, for collection of data as input to natural resources studies in addition to the proposed stratigraphic, lithologic, and structural studies).

° Information from core may be limited with respect to mineral fillings, fractures, and faults due to the small sample size and the difficulty in recognizing certain features in core. Vertical holes may not intersect may major rock discontinuities such as near vertical faults and fractures.

° Difficulties may arise in interpretation of core, as "core recovery is typically poor in the unsaturated zone" (Page 8.3.1.4-35).

RECOMMENDATIONS

° The integrated drilling program should supply relevant data from drillholes to all investigations requiring such data and coordinate the proposed program of exploration with the information needs of planned investigations.

° Drill core may be inadequate to provide information on many parameters; the SCP should propose alternative methods for determination of parameters.

° Angled drillholes should be considered as a means to identify and characterize vertical/near vertical features.

- At an early stage in planning the drilling program, qualified existing information should be identified, integrated, and evaluated to identify information still needed.

- Planned drilling programs should be integrated with planned drifting and geophysical programs.

REVIEW GUIDES

3.3.2, 3.3.4, 3.3.5

SCP/CA/QUES/7

All Chapters

QUESTION

Measuring systems used in the SCP are inconsistant. Explain this lack of consistancy.

BASIS

° The use of English, metric and SI systems of measurement vary within the SCP (e.g., drillhole spacings in feet, proposed drillhole depth in meters, existing drillhole depths on Table 1-15 listed in feet).

RECOMMENDATION

° A single measurement system is recommended for use throughout the site characterization program. This will limit sources of error frequently experienced where various systems of measurement are employed.

REVIEW GUIDE

3.2.7

SCP/CA/QUES/6

Section 8.3.1.17 Pre-Closure Tectonics

QUESTION

What consideration is being given to the use of side looking airborne radar (SLAR) at Yucca Mountain?

BASIS

- SLAR missions have proved effective in establishing a consistent base for regional fault scarp assessment (USGS, 1966).

- Low-sun angle photography is planned for selected fault assessment, and various other remote sensing methods are scheduled for determination of a regional geologic model (Section 8.3.1.4). No mention is made regarding use of SLAR.

- SLAR missions have been planned and/or obtained by the USGS for the region (USGS, 1966), but no indication of the use of such data was found during this review.

RECOMMENDATION

- An east-look and west-look regional SLAR mission should be considered at an early date to provide a consistent remote sensing base for regional structure.

REFERENCE

U.S. Geological Survey, May 1966, SLAR-Site Looking Airborne Radar: U.S. Geological Survey, EROS Data Center

REVIEW GUIDES

3.2.7, 3.3.1, 3.3.4

Section 8.3.1.9.2.1 Study: Natural resource assessment of Yucca Mountain, Nye County, Nevada

QUESTION

What is the basis for SCP statements with respect to resource exploration and resource potential? The following statements are misleading, inconsistant, and~~/or~~ erroneous.

BASIS

- The conclusion that "on the basis of currently available data and regional comparisons, the mineral resource potential of the site is considered low" (p.8.3.1.9-31) is not justified in the SCP. It appears to be in error, because the site's mineral resource potential may be perceived as high. For example, Yucca Mountain is surrounded by mineralized areas such as Bare Mountain, Wahmonie, and Calico Hills (NRC, 1986) and is in proximity to faults, breccia zones, and veins and overlies zones that may host resources (e.g., Tram Member of the Crater Flat Tuff).

- The statement that it is "standard practice to exclude evaluation of mineral resources below 1 km" (p. 1-258) is without merit. There are precedents in the literature for resource exploration at depths greater than 1 km (Mining Ann. Rev., 1987). Deposits at depth, whether large tonnage or high-grade or not, may be economic at higher, but reasonable, values (i.e., $1,000/oz gold is not inconceivable; gold prices reached $800/oz in 1980).

° SCP (p. 1-258) states that evaluation of hypothetical resources in the Paleozoic rocks cannot be accomplished due to the "constraints" of depth. However, on page 1-280 it is stated, "Exploration for precious metals in a deeply buried Paleozoic terrain, such as at Yucca Mountain, cannot be dismissed."

RECOMMENDATION

° Resolve inconsistencies and/or misleading statements relative to the establishment of a program to address the potential for natural resources at the proposed HLW site.

REFERENCE

Mining Annual Review, 1987, Mining Journal, London, p. 389.

REVIEW GUIDES

3.3.5

Section 8.3.1.2.2.1.1	Activity: Characterization of hydrologic properties of surficial materials
Section 8.3.1.4.2.1.1	Activity: Surface and subsurface stratigraphic studies of the host rock and surrounding units
Section 8.3.1.4.2.2.1	Activity: Geologic mapping of zonal features in the Paintbrush Tuff
Section 8.3.1.5.1.4.2	Activity: Surficial deposits mapping of the Yucca Mountain area
Section 8.3.1.5.1.4.3	Activity: Eolian history of the Yucca Mountain region
Section 8.3.1.5.2.1.1	Activity: Regional paleoflood evaluation
Section 8.3.1.5.2.1.3	Activity: Evaluation of past discharge areas
Section 8.3.1.5.2.1.5	Activity: Studies of Calcite and opaline silica vein deposits
Section 8.3.1.6.1.1.1	Activity: Development of a geomorphic map of Yucca Mountain
Section 8.3.1.8.5.1.3	Activity: Field geologic studies
Section 8.3.1.8.5.2.2	Activity: Chemical and physical changes around dikes
Section 8.3.1.8.5.3.1	Activity: Evaluation of folds in Neogene rock of the region
Section 8.3.1.14.2.1.1	Activity: Site reconnaissance
Section 8.3.1.16.1.1.1	Activity: Site flood and debris hazards studies
Section 8.3.1.17.4.2	Study: Location and recency of faulting near prospective surface facilities
Section 8.3.1.17.4.3.2	Activity: Evaluate Quaternary faults within 100 km of

	Yucca Mountain
Section 8.3.1.17.4.3.4	Activity: Evaluate the Bare Mountain fault zone
Section 8.3.1.17.4.3.5	Evaluate structural domains and characterize the Yucca Mountain region with respect to regional patterns of faults and fractures
Section 8.3.1.17.4.4	Study: Quaternary faulting proximal to the site within northeast-trending fault zones
Section 8.3.1.17.4.5	Study: Detachment faults at or proximal to Yucca Mountain
Section 8.3.1.17.4.6	Study: Quaternary faulting within the site area
Section 8.3.1.17.4.9.2	Activity: Evaluate extent of areas of Quaternary uplift and subsidence at and near Yucca Mountain
Section 8.3.1.17.4.9.3	Activity: Evaluate variations in the nature and intensity of Quaternary faulting within 100 km of Yucca Mountain through morphometric and morphologic analysis
Section 8.3.1.17.4.12.1	Activity: Evaluate tectonic processes and tectonic stability at the site

QUESTION

The SCP lists many surficial mapping projects, some of which are currently on-going or are near completion. How does the DOE plan to integrate these various mapping tasks and the resultant information?

BASIS

- The SCP provides only a listing of mapping studies and provides little information as to how information obtained from one study may provide input or be integrated with each other.

- Individual mapping studies and activities will be conducted by investigators from Los Alamos National Laboratory, Sandia National Laboratories, and the U.S. Geological Survey resulting in the potential for non-integrated investigations and products.

- Map scales for studies and resultant maps do not appear to be compatable (e.g., Tectonic geomorphology, 8.3.1.17.4.9, at 1:20,000 and Surficial deposits mapping, 8.3.1.5.1.4.2, at 1:24,000).

- Many mapping studies appear to cover overlapping areas (e.g., Activities 8.3.1.5.1.4.2 and 8.3.1.16.1.1.1).

- Map scales do not appear to be appropriately detailed to provide information necessary to the study (e.g., Quaternary faulting, 8.3.1.17.1.6, at 1:24,000).

RECOMMENDATION

° Consider a program to integrate mapping studies to provide integrated products at scales appropriate in detail to fulfil the objectives of the proposed activities.

REVIEW GUIDES

3.3.1, 3.3.2, 3.3.4

ATTACHMENT 4

GGS

GEOLOGY-GEOPHYSICS SECTION RESOLVED CDSCP
POINT PAPERS

April 29, 1989

Section 8.3.1.6 Overview of Erosion Program

CDSCP COMMENT 34

The CDSCP does not specifically address the evaluation of erosion/sedimentation at the surface facility locations.

BASIS

- Overall erosion programs are likely to result in an understanding of the potential future erosion in the Yucca Mountain area, but these programs are not likely to result in satisfactory evaluation of erosion/sedimentation potential at the proposed specific surface facilities such as portals and shafts (Purcell, 1988).

EVALUATION OF SCP RESPONSE

The DOE plans site-wide studies to evaluate the overall erosion/sedimentation potential in the Yucca Mountain area (Sections 8.3.1.6 and 8.3.1.16). Although not specifically directed toward the surface facilities mentioned in NRC CDSCP Comment 34, the proposed studies should cover any presently proposed facility locations or any likely location changes. It is therefore concluded that CDSCP Comment 34 is resolved.

REFERENCES

Purcell, C.R., 1988, Geomorphic evaluation of proposed shaft and ramp locations - Yucca Mountain High Level Waste Site: Lawrence Livermore National Laboratory, LLNL/NRC-NNWSI-CRP-87/88-Y111.

Section 8.3.3.2 Issue resolution strategy for Issue 1.12: Have the characteristics and configurations of the shaft and borehole seals been adequately established to (a) show compliance with the postclosure design criteria of 10 CFR 60.134 and (b) provide information for the resolution of the performance issues, page 8.3.3.2-24 to 27 step D: Performance and design goals

CDSCP COMMENT 69

The performance and design goals for the sealing subsystem do not consider a comprehensive set of anticipated processes and events and unanticipated processes and events.

BASIS

- 60.112 requires that ..... the shaft and boreholes and their seals shall de designed ..... with respect to both anticipated processes and events and unanticipated processes and events.

- Processes and events considered in Section 8.3.3.2. for the sealing subsystem do not appear to be as complete as the scenarios and categories of processes and events considered in CDSCP Section 8.3.5.13.

- This section does not consider the effects of such anticipated processes and events and unanticipated processes and events as faulting on the performance of the sealing subsystem, on the status of the waste package and the engineered barrier system, and the interrelationship of the waste package, engineered barrier system and seal system on the total performance of the repository.

- This section does not appear to account for the effects on the natural system caused by the perturbations of waste emplacement.

- This section, and the referenced report, considers only 62 cubic meters of water per year can contact the waste under anticipated processes and events and 5600 cubic meters per year under unanticipated conditions (Fernandez and others, 1984, pages 5-4 and 5-5).

- Thordarson (1965) estimated 30 to 50 million gallons discharged over a five year period in tunnel U12e at Rainer Mesa. The very large difference in the estimated inflow values at U12e and estimated values of water that can potentially contact the waste package in Yucca Mountain do not appear justified, despite the recognized differences in the hydrological conditions at Rainer Mesa and Yucca Mountain.

- Rush and others (1984) noted 14 zones of water inflow in the unsaturated zone in borehole H-1. While the source of this water can not be identified, the possibility that the water is perched water cannot be discounted, at present.

- This section only assumes 1 mm per year infiltration even though Montazar and Wilson (1984) estimated that net infiltration, under present conditions, is between .5 and 4.5 mm per year.

- This section does not appear to account for the nonuniformity in which precipitation events occur within the Yucca Mountain geologic setting.

- This section does not consider the effects of either potential "anticipated climatic changes" or "unanticipated climatic changes" and the potential change in net infiltration such processes and events could cause.

EVALUATION

- The DOE has modified and expanded section 8.3.3.2 and in doing so has demonstrated a need to consider a broad range of information needs in designing and evaluating seal performance. This is especially evident in areas such as section 8.3.3.2.1, which discusses information needed for design of seals and their placement methods, Tables 8.3.3.2-3 and 8.3.3.2-4 which list information needed to support resolution of issue 1.12, and Table 8.3.3.2-7 which list site properties needed for issue 1.12.

- While the NRC staff is not necessarily in agreement with the "expected parameter values" assumed by DOE, the information needs required in this section appear adequate with respect to both anticipated processes and events and unanticipated processes and events and with respect to required parameters that will allow the design and performance of the seals to be evaluated.

RECOMMENDATION

- This CDSCP comment is considered to be adequately resolved.

REFERENCES

Fernandez, J.A., Kelsal, P.C., Case, J.B. and Meyer, D., 1987, Technical basis for performance goals, design requirements, and material recommendations for the NNWSI repository sealing program: Sandia National Laboratories, SAND84-1895.

Rush, F.E., Thordarson, W., and Pyles, D.G., 1984, Geohydrology of test well H-1, Yucca Mountain, Nye County, Nevada: U.S. Geological Survey Water Resources Investigation Report 84-4032.

Thordarson, W., 1965, Perched water in the zeolitized-bedded tuff, Rainer Mesa and vicinity; Nevada Test Site, Nevada: Report No. TEI-862, U.S. Geological Survey, Denver CO.

Montazer, P., and Wilson, W.E., 1984, Conceptual hydrologic model of flow in the unsaturated zone, Yucca Mountain, Nevada: U.S. Geological Survey Water Resources Investigation Report 84-4345.

REVIEW GUIDES

3.2.4.2, 3.2.2, 3.2.4.1, 3.2.4.9

Section 8.3.1.4.1.3 Ongoing Integration of the NNWSI Project Drilling

QUESTION 15

What are the types and sources of data, and what is the interpretation of geologic and geophysical data used in identifying the limits of the region of investigation around the site? Explain.

BASIS

- On page 8.3.1.4-33 it is stated that "The northern, eastern, and southern limits of a region of investigation around the site are selected primarily on the basis of differences in structural styles inferred from existing geologic and geophysical data."

- The boundary of the tectonic region/region of investigation is one of the parameters needed in calculating probabilistic seismic hazard. The response to this question will provide valuable information which will be used in the seismic hazard analysis.

EVALUATION OF SCP RESPONSE:

The DOE has revised the SCP and clarified the basis for their identification of the site area boundary to the north, east and south and has referred to the identification on the basis of geologic data, not geophysical data, therefore this question is considered to be resolved.

Section 8.3.1.5.1.4 Climate

CDSCP QUESTION 18

In addition to regional climate influences on erosion and deposition at the site, how have local variables such as uplift, subsidence, and stream piracy been considered?

BASIS

- The climatic model developed for the Yucca Mountain area should correspond/correlate well with regional models of the Great Basin, but, in addition, the model also needs to evaluate local variables in order to provide an understanding of the history of erosion and deposition at the site (Purcell, 1986).

EVALUATION OF SCP RESPONSE

The DOE has provided a detailed site specific program to evaluate the influences of tectonics and geomorphic processes on erosion (8.3.1.5, 8.3.1.6, 8.3.1.16, and 8.3.1.17). In light of the addition and clarification of these specific programs, the SCP has addressed Question 18. It is therefore concluded that this question is resolved.

REFERENCES

Purcell, C.R., 1986, Potential erosion at the Yucca Mountain nuclear waste site: Letter report from LLNL to NRC.

Section 8.3.1.6 Erosion

CDSCP QUESTION #19

What is the source for hillslope erosion rates (page 8.3.1.6-7) and attendent uncertainties? Explain.

BASIS

- Substantiation of average downwasting rates over the last 1 to 5 million years should be provided.

EVALUATION OF SCP RESPONSE

The hillslope erosion rates referred to in Section 8.3.1.6 have been cross-referenced to Section 1.1 which includes a discussion of long-term erosion rates for the southern Great Basin with references to support the data. This question is considered to be resolved.

Section 8.3.1.8.3 Investigation: Studies to provide information required on changes in unsaturated and saturated zone hydrology due to tectonic events (p. 8.3.1.8-75)

CDSCP QUESTION 21

The CDSCP states that initiating events considered in investigation 8.3.1.8.3 "probably will have no significant impact on repository performance because of the very low rates at which the related tectonic processes operate at Yucca Mountain." What is the basis for this low level of effort with respect to assessment of initiating events?

BASIS FOR CDSCP QUESTION

- Significant effects on the groundwater regime have been observed to occur during earthquakes of the size and type anticipated at the proposed Yucca Mountain HLW repository vicinity.

- These effects, which have lasted up to several months in some cases, could possibly adversely affect the capability of the underground facility to limit release of radionuclides.

EVALUATION OF SCP RESPONSE

The following sentence has been added to Section 8.3.1.8.3 (p. 8.3.1.8-75) of the SCP: "A higher level of effort will be given to those initiating events judged to have a higher probability of affecting repository performance (i.e., faulting and strain effects)." This sentence indicates that the level of effort related to initiating events involving uplift, subsidence and folding will be less than the effort devoted to potentially more significant initiating events involving faulting and strain. This CDSCP question is considered to be resolved.

Section 8.3.1.8.3.1.5 Activity: Assessment of the effects of faulting on the flux rates and Section 8.3.1.8.3.2.6 Activity: Assessment of the effect of faulting on water-table elevation (p. 8.3.1.8-85 and p. 8.3.1.8-93)

CDSCP QUESTION 22

What is the basis for considering that significantly large, or significantly cumulative, offsets are those offsets that are greater than two meters?

BASIS FOR CDSCP QUESTION

- According to studies by Bonilla and others (1984), a displacement of one meter is the equivalent of a magnitude 7 earthquake in western North America.

- Earthquakes of magnitude 7 may have a significant effect on flux rates and water-table elevation.

REFERENCE

Bonilla, M.G., Mark, R.K., and Lienkamper, J.J., 1984, Statistical Relations Among Earthquake Magnitude, Surface Rupture Length, and Surface Fault Displacement: Bulletin of the Seismological Society of America, V.74, No. 6, pp. 2379-2411.

BLACKFORD/04-28-89

EVALUATION OF SCP RESPONSE

The response to the CDSCP question correctly points out that the thrust of the particular sections of CDSCP, and equivalent sections of the SCP, is to assess the static effects of fault offsets on flux rates and water-table elevations. The reviewer is referred to other sections of the SCP, namely Sections 8.3.1.8.3.3.2 and 8.3.1.8.3.3.3, where the dynamic effects of faulting are treated. In these sections of the SCP no minimum limits on significant faulting are cited. This CDSCP comment is considered to be resolved.

BLACKFORD/04-28-89

Section 8.3.1.17

CDSCP QUESTION #29

How will studies of rock varnish dating be integrated with other data for site characterization?

BASIS

- The use of rock varnish dating is not tied to other studies in the CDSCP.

- Rock varnish dating is a viable instrument to aid in determining the age of a surface. However, it should be used in conjunction with various other parameters, such as degree of dissection, desert pavement development, and soil profile development.

EVALUATION OF SCP RESPONSE

The DOE has identified and discussed the use of rock varnish dating throughout various sections of the SCP including 8.3.1.6, 8.3.1.8, and 8.3.1.17. It is therefore concluded this question is resolved.

Section 8.3.1.17.3.1.1 Activity: Identify relevant earthquake sources (p. 8.3.1.17-69)

CDSCP QUESTION 31

What is the process used to develop the example of a conceptual approach to determining relevancy criteria and what is the basis for it?

BASIS FOR CDSCP COMMENT

- The adverse conditions described in §60.122(c) concerning earthquakes all require a consideration of which earthquakes are relevant to the condition described.

- The relevancy criteria illustrated appears to depend upon source distance and 10,000-year cumulative slip earthquake magnitude.

- If a commonly used attenuation relationship such as that of Campbell (1981) is applied to various points along the line defining the relevancy limit (Fig. 8.3.1.17-6), the resulting values of peak ground acceleration, estimated at the mean plus one standard deviation, range from nearly 0.7g at one kilometer from the site to 0.12g at one hundred kilometers distance.

° Additional parameters or a significantly different attenuation relationship apparently were incorporated into the relevancy criteria example.

REFERENCE

Campbell, K.W., 1981, Near-Source Attenuation of Peak Horizontal Acceleration: Bulletin of the Seismological Society of America, vol. 71, no. 6, p. 2039-2070

EVALUATION OF SCP RESPONSE

Several paragraphs that were added to Section 8.3.1.17.3.1.1 have clarified much of the uncertainty regarding the conceptual approach to determining relevant earthquake sources. There remains some question regarding the utility of the 10,000-year cumulative slip earthquake, however, that issue is addressed as a separate concern elsewhere in this SCA. A significant concept added to this section of the SCP addresses the anticipated variation in the frequency spectra of potential ground motion due to differences in the nature of local and more distant faults. This CDSCP question is considered to be resolved.

ATTACHMENT 5

GGS

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

JAN 4 1989

NOTE TO: Ronald L. Ballard

FROM: Philip S. Justus

SUBJECT: Geology-Geophysics Section (GGS) SCP Review Responsibilities

The attached tables indicate GGS staff members' specific technical areas of responsibility for the SCP review during the SCP comment period. The tables represent the GGS staff's primary areas of responsibility; staff are not restricted solely to those areas assigned. For assistance on sections where GGS staff has support responsibility, lead section representatives should contact the appropriate GGS staff member. These assignments supplement the SCP Review Plan. Assignees are to implement the SCP Review Plan in their respective areas of responsibility as stated here. GGS staff have been instructed to become familiar with the SCP Review Plan prior to the SCP review kick-off meeting scheduled for 01/04/89.

Philip S. Justus

Attachments:
As stated

cc: John Linehan
Joe Bunting
Don Chery
Seth Coplan
Rick Weller
King Stablein
GGS Staff

Table 3 Lead Responsibilities for DOE Issues* and Related 10 CFR Part 60 Requirements

DOE Issues (related 10 CFR Part 60 Requirement) *	Lead Section and Discipline**	GG Staff	Support Section and Discipline*
Key Issue 1 - Post-closure Performance			
1.1 Releases to Accessible Environment (60.112)	SP	JT	HT,GG,EM,EG
1.2 Individual Protection	SP		
1.3 Groundwater Protection	HT	JT	GG,HT
1.4 Waste Package Containment (60.113)	EM	JT	HT,GG,SP
1.5 EBS Release Rate (60.113)	EM	KM	HT,EG,SP,GG
1.6 Groundwater Travel Time (60.113)	HT	JT	GG,HT,SP
1.7 Performance Confirmation (60.137)	SP	JT	GG,HT,EM,EG
1.8 NRC Siting Criteria (60.122)	SP	JT	GG,HT,EM,EG
1.9 DOE Guideline Findings	X		X
1.10 Waste Package Design (60.135)	EM	JT	GG,HT,EG
1.11 Repository Design (60.133)	EG	KM	GG,HT
1.12 Seals Design (60.134)	EG	KM	GG,HT
Key Issue 2 - Pre-closure Radiological Safety			
2.1 Public Safety During Normal Operation (60.111)	SP	JT	GG,EG
2.2 Worker Safety (60.111)	SP	JT	GG,HT,EG
2.3 Public Safety During Accidents	SP		
2.4 Retrievability (60.111)	EG	JT	GG
2.5 DOE Guideline Findings	X		X
2.6 Waste Package Design (60.135)	EM		EG
2.7 Repository Design (60.131, 132, 133)	EG	KM	GG

* Key issues and issues from DOE's Issues Heirarchy. Only key issues 1 and 2 are related to 10 CFR Part 60.

** Geology-Geophysics (GG), Hydrologic Transmport (HT), Systems Performance (SP), Engineering-Geotechnical (EG), Engineering-Materials (EM), Quality Assurance (QA), Project Management (PM), Special Analysis (SA), X not NRC review responsibility

GG Staff

JT - John Trapp
KM - Keith McConnell
CA - Charlotte Abrams*
MB Michael Blackford

AI - Buck Ibrahim
TC - Tom Cardone
HL - Harold Lefevre
* Site Lead for GGS

Table 4 Responsibilities for Reviewing Chapter 8 of the SCP

Section Number and Title	Lead Section (Discipline)*	GG Staff	Support Section (Discipline) *
8.1 Rationale for Site Char. Prog.	SP	JT	GG,HT,EG,EM
8.2 Issue Resolution, Info. Req.	SP	JT	GG,HT,EG,EM
8.3 Planned Tests, Analysis, Studies			
8.3.1 Site Program			
8.3.1.1 Overview	GG,HT,EG,EM	CA, All	
8.3.1.2 Geohydrology	HT	CA/km/JT	GG,EG
8.3.1.3 Geochemistry	HT	CA	GG
8.3.1.4 Rock Characteristics	EG,GG	km/AI/TC	HT,EM
8.3.1.5 Climate	HT,GG	CA/JT	
8.3.1.6 Erosion	GG	HL/CA/TC	
8.3.1.7 Rock Dissolution	HT	CA	GG
8.3.1.8 Post-closure Tectonics	GG	km/mB/CA/JT	HT,EG
8.3.1.9 Human Interference	GG	HL/CA/JT	SA
8.3.1.10 Population	SA		
8.3.1.11 Land Ownership	SA	CA	GG,OGC
8.3.1.12 Meterology	HT		
8.3.1.13 Offsite Installations and Operations	SA	TC	GG,EG
8.3.1.14 Surface Characteristics	GG	HL/CA/TC	EG
8.3.1.15 Thermal and Mechanical Rock Prop.	EG	km/TC	GG,HT
8.3.1.16 Pre-closure Hydrology	HT	HL/CA/JT	GG,EG
8.3.1.17 Pre-closure Tectonics	GG	km/mB/CA/JT	EG
8.3.2 Repository Program			
8.3.2.1 Overview	EG		
8.3.2.2 Post-closure Repository Design IRS	EG	km/TC	GG,HT,EM,SP
8.3.2.3 Pre-closure Repository Design IRS	EG	km/TC	GG,SP
8.3.2.4 Non-radiological Health, Safety IRS	X		X
8.3.2.5 Adequate Technology IRS	EG		
8.3.3 Seal Program			
8.3.3.1 Overview	EG		
8.3.3.2 Post-Closure Shaft, Borehole Seals IRS	EG	km/TC	GG,HT,SP

Geology-Geophysics (GG), Hydrologic Transport (HT), Systems Performance (SP), Engineering-Geotechnical (EG), Engineering-Materials (EM), Quality Assurance (QA), Project Management (PM), Special Analysis (SA), X not NRC review responsibility

Table 4 Responsibilities for Reviewing Chapter 8 of the SCP (Continued)

Section Number and Title	Lead Section (Discipline)	GGSA	Support Section (Discipline)
8.3.4 Waste Package Program			
8.3.4.1 Overview	EM		
8.3.4.2 Post-closure Waste Package Design IRS	EM	JT	GG,HT,EG,SP
8.3.4.3 Pre-closure Waste Package Design IRS	EM	JT	GG,EG,SP
8.3.4.4 Adequate Technology IRS	EG		
8.3.5 Performance Assessment Program			
8.3.5.1 Strategy for Preclosure Performance Assessment	SP	JT/CA	GG,HT,EG,EM,SA
8.3.5.2 Retrievability IRS	EG	JT/TC	GG,EM
8.3.5.3 Public Safety From Normal Operations IRS	SP	JT	GG,EM,EG
8.3.5.4 Worker Radiological Safety IRS	SP	JT	GG,HT,EM,EG
8.3.5.5 Public Safety from Credible Accidents IRS	SP	JT	GG,HT,EM,EG
8.3.5.6 960 Findings	X		X
8.3.5.7 960 Findings	X		X
8.3.5.8 Strategy for Post-closure Performance Assessment	SP	JT/CA	GG,HT,EG,EM
8.3.5.9 Waste Package Containment IRS	EM	JT/KM	GG,HT,EG,SP
8.3.5.10 EBS Release Rates IRS	EM	JT/KM	GG,HT,EG,SP
8.3.5.11 Seal System Perf. IRS	EG	JT/KM/TC	SP
8.3.5.12 Groundwater Travel Time IRS	HT	JT	GG,HT,SP
8.3.5.13 Release to Access. Envir. IRS	SP	JT	GG,HT,EM,EG
8.3.5.14 Individual Protection IRS	SP	JT	GG,HT,EM,EG
8.3.5.15 Groundwater Protection IRS	HT	JT	GG
8.3.5.16 Performance Confirmation IRS	SP	JT/TC	GG,HT,EM,EG
8.3.5.17 NRC Siting Criteria IRS	SP	JT/CA	GG,HT,EM,EG
8.3.5.18 960 Findings	X		X
8.3.5.19 Sub. Complete Anal. Tech.	SP	JT	GG,HT,EM,EG
8.3.5.20 Anal. Tech-Sign. Devel.	SP	JT/TC	GG,HT,EM,EG
8.4 Potential Impacts of Site Char. Act.			
8.4.1 Introduction			
8.4.2 Description, Location of SC Operations	EG	~~[illegible]~~/TC	GG,HT
8.4.2.1 Rationale for Testing	SP	JT/TC	GG,HT,EG,EM
8.4.2.2 Surface-based Activities	GG	AI	GG,HT
8.4.2.3 Subsurface-based Activities (ESF)	EG	TC/KM	GG,HT,EM
8.4.3 Potential Impacts on Performance	SP	JT/KM/TC	GG,HT,EG,EM

Table 4 Responsibilities for Reviewing Chapter 8 of the SCP (Continued)

Section Number and Title	Lead Section (Discipline)	GG Staff	Support Section (Discipline)
8.5 Milestones, Decision Pts., Schedule	SA	CA/JT	SP,GG,HT,EG,EM,QA
8.6 Quality Assurance Program	QA	HL/JT	SP,GG,HT,EG,EM
8.7 Decontamination, Decommissioning	X		X

Table 5 Lead Responsibilities for Preparing SCA Sections

SCA Sections	Lead Section* (Discipline)	GG Staff
1.0 Introduction	PM	
2.0 Director's Comments and Recommendatins	PM	
2.1 Issue Resolution Process		
2.2 Site Program		
2.3 Repository Program		
2.4 Seal Program		
2.5 Waste Package Program		
2.6 Performance Assessment Program		
2.7 Exploratory Shaft Facility Impacts		
2.8 Quality Assurance Program		
2.9 Schedules		
2.10 Use of Radioactive Materials		
2.11 Resolution of CDSCP Concerns		
2.12 Other (topics based on concerns such as integration, conservatism)		
3.0 Summary of SCP Concerns		
3.1 Issue Resolution Process	SP	
3.2 Site Program		
3.2.1 Geohydrology and Preclosure Hydrology Programs	HT	
3.2.2 Geochemistry and Rock Dissolution Programs	HT	
3.2.3 Rock Characterisitcs and Thermal Rock Properties Programs	EG/GG(1)	KM/AI/TC
3.2.4 Climate and Meterology Programs	HT/GG	CA/JT
3.2.5 Erosion and Surface Characteristics Programs	GG	CA/HL/TC
3.2.6 Post-closure and Pre-closure Tectonics Programs	GG	KM/MB/KA/JT
3.2.7 Human Interference and Land Ownership-Mineral Rights Programs	GG/SA	HL/CA/JT
3.2.8 Population and Offsite Installations, Operations Programs	SA	
3.3 Repository Program		
3.3.1 Post-closure Repository Design	EG	
3.3.2 Pre-closure Repository Design	EG	
3.4 Seal Program	EG	

*Geology-Geophysics (GG), Hydrologic Transport (HT), Systems Performance (SP), Engineering-Geotechnical (EG), Engineering-Materials (EM), Quality Assurance (QA), Project Management (PM), Special Analysis (SA)

(1) GG coordinator of each and all sections (GG) is CA; responsibility for content preparation is as listed on Table 4.

Table 5 Lead Responsibilities for Preparing SCA Sections (Continued)

SCA Sections	Lead Section* (Discipline) GG Staff
3.5 Waste Package Program	
3.5.1 Post-closure Waste Package Design	EM
3.5.2 Pre-closure Waste Package Design	EM
3.6 Performance Assessment Program	
3.6.1 Post-closure Performance Assessment	SP
3.6.2 Pre-closure Performance Assessment	SP
3.7 Potential Impacts of Site Characterization Activities on Waste Isolation	
3.7.1 Exploratory Shaft Facility and Impacts	EG
3.7.2 Surface-based Activities and Impacts	SP
3.8 Quality Assurance Program	QA
3.9 Schedules	SA
4.0 SCP Concerns with the Site Characterization Program	All (1)
4.1 Objections	
4.2 Comments	
4.3 Questions	
Appendix A: Resolved CDSCP Concerns	All (1) (2)
1.0 Objections	
2.0 Comments	
3.0 Questions	

(2) responsibility for resolution of CDSCP Concerns is as listed in Table 6.

Table 6 Lead Responsibilities for Reviewing CDSCP Open Items

Section (Discipline)

HYDROLOGIC TRANSPORT:

Comments 5; 6; 7; 8; 9; 10; 11; 12; 13; 14; 15; 16; 17; 18; 19; 20; 21; 22; 23; 24; 25; 31; 32; 33; 40; 41; 71; 86; 87; 88; 89; 96.
Questions 3; 4; 5; 6; 7; 8; 9; 10; 11; 24; 28; 47.

GG staff

GEOLOGY/GEOPHYSICS:

AI km CA CA JT km CA AI AI JT AI MB km km JT JT
Comments 26; 28; 34; 35; 36; 37; 38; 39; 49; 50; 51; 52; 53; 62; 69; 95.
Questions 13; 15; 18; 19; 20; 21; 22; 23 (deleted); 29; 30 (deleted); 31; 32; 33.
CA AI CA CA km MB MB CA MB MB AI

SYSTEMS PERFORMANCE:

Objection 1.
Comments 2; 4; 90; 91; 92; 93; 94.
Questions 2; 43; 44; 46; 52.

QUALITY ASSURANCE:

Objection 5.
Comments 104; 105; 106; 107; 108.

ENGINEERING (GEOTECHNICAL):

Objections 2; 3; 4.
Comments 1; 27; 29; 30; 42; 43; 44; 45; 46; 47; 48; 54; 55; 56; 57; 58; 59; 60; 61; 63; 64; 65; 66; 67; 68; 70; 72; 97; 98; 99; 100; 101; 102; 103.
Questions 12; 14; 16; 17; 25; 26; 27; 34; 35; 36; 37; 38; 40; 41; 42; 48; 49; 50; 51.

ENGINEERING (MATERIALS):

Comments 3; 73; 74; 75; 76; 78; 77; 79; 80; 81; 82; 83; 84; 85; 109; 110.
Questions 1; 45.

Table 7 SCP Review Products

SCP Review Activity and Product

Notification of SCP Receipt

- *Federal Register* notice of SCP receipt and start of staff review
- Letters to State of Nevada Governor and Legislature noticing SCP receipt
- Letters to Indian Tribes noticing SCP receipt
- Letters to Nye, Clark, and Lincoln Counties noticing SCP receipt
- Letter to Director, State of Nevada Nuclear Waste Project Office (NWPO) noticing SCP receipt

Acceptance Review

- Letter to DOE with the SCP acceptance review decision and a copy to NWPO

Technical Review and Integration

- Reviewer Draft of concerns and summary

Internal QA and Management Review

- Section Draft of concerns and summary
- Branch Draft of concerns and summary
- Division Draft of SCA and transmittal letter
- Office Draft of SCA and transmittal letter

ACNW Review

- Commission Paper with Draft Final SCA and transmittal letter

Commission Review and Printing and Issuance

- Final SCA and transmittal letter

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

APR 28 1989

MEMORANDUM FOR: John J. Linehan, Director
Repository Licensing and Quality Assurance Project Directorate
Division of High-Level Waste Management

FROM: James E. Kennedy, Section Leader
Repository Licensing and Quality Assurance Project Directorate
Division of High-Level Waste Management

SUBJECT: QA SECTION DRAFT OF SCA POINT PAPERS AND RESOLVED CDSCP COMMENTS

Enclosed for your review are draft point papers and summaries of resolved CDSCP comments. The following is a summary of the enclosed:

PROPOSED COMMENTS AND OBJECTION

Objection	--	was Objection 5 to CDSCP, now rewritten to reflect current status of NRC/DOE agreements on QA.
Comment 1	--	has to do with need to revise 88-9 to reflect new project office responsibilities when WMPO became YMPO. This is a new comment.
Comment 2	--	similar to CDSCP 108 on qualifying existing data but expanded to include a request for a list of data to be qualified based on Geology's input.
Comment 3	--	similar to CDSCP 106 on the Q-list.

RESOLVED COMMENTS

CDSCP 104 on Level II and Level I
CDSCP 105 on old data
CDSCP 107 on Criteria of Appendix B at different organizations.

Kenneth R Hooks
for James E. Kennedy, Section Leader
Repository Licensing and Quality Assurance Project Directorate
Division of High-Level Waste Management

Enclosure: As stated

cc: R. Ballard
J. Bunting
D. Chery
S. Coplan
P. Justus
M. Nataraja
R. Weller
K. Stablein

OBJECTION

Section 8.6 of the SCP describes the quality assurance program to be applied to new site characterization activities and exploratory shaft construction. It commits to having a program in place for the activities which meets Subpart G of 10 CFR Part 60. Based on staff reviews to date, the program does not meet this commitment.

BASIS

- CDSCP Objection No. 5 noted that DOE's QA program for site characterization was still being developed and did not yet conform to the Commission's requirements in Subpart G of 10 CFR Part 60. It recommended that DOE submit plans and procedures for staff review, facilitate staff verification reviews such as audits, and not start new site characterization work until additional confidence was obtained in the adequacy of the program.

- In DOE's response to the CDSCP objection, it was noted that a meeting between the staff and DOE occurred on July 7, 1988, in which the DOE and NRC agreed to an approach for NRC acceptance of the DOE's QA program for site characterization. This approach and schedules for implementing it were subsequently revised in a meeting between DOE and NRC on January 25, 1989.

- DOE and NRC staffs are in the process of implementing the agreed-upon approach for qualifying and accepting the DOE QA program.

RECOMMENDATION

This objection will remain open until the agreed upon milestones for staff acceptance of the QA program are fulfilled.

SECTION 8.6.3 ORGANIZATION OF THE PROJECT WITH RESPECT TO QUALITY ASSURANCE

COMMENT 1

The organizational responsibilities and interfaces within the Yucca Mountain Project described in this section differ from the NRC accepted organizational responsibilities in the NNWSI QA Plan 88-9.

BASIS

- NRC regulations in Appendix B, 10 CFR Part 50, which are referenced in 10 CFR Part 60, Subpart G, require that the authorities and duties of persons and organizations performing activities affecting safety be clearly established and delineated in writing.
- NRC accepted the 88-9 QA Plan in a Safety Evaluation dated October 14, 1988 and Safety Evaluation Supplement dated December 30, 1988 as conforming to the above requirements.
- The accepted version of the 88-9 QA Plan (Revision 2) describes obsolete organizational responsibilities. The Waste Management Project Office has been replaced by the Yucca Mountain Project Office.

RECOMMENDATION

- DOE should revise the 88-9 QA Plan to reflect the current organizational responsibilities and to be consistent with the information presented in the SCP.
- DOE should submit the revised 88-9 QA Plan for staff review and acceptance of the changes.

REFERENCES

U. S. Nuclear Regulatory Commission, Title 10 Code of Federal Regulations, Part 50, Appendix B, Criterion I, "Organization."

SECTION 8.6.4.1 QUALITY ASSURANCE BEFORE SITE CHARACTERIZATION

COMMENT 2

This section states that data was gathered during site exploration from 1977 to 1986 which may be used for characterization and to support a license application. It further states that if any data is identified as primary information in support of items and activities important to safety or waste isolation, the data will be qualified against the current QA program on a case-by-case basis in accordance with approved administrative procedures incorporating the guidance provided in Qualification of Existing Data for High Level Nuclear Repositories (NUREG-1298).

DOE has not identified the existing data that will be used in the licensing process and needs to be qualified, nor have they submitted the procedures which will be used to qualify existing data.

BASIS

- 10 CFR Part 60, Subpart G requires that a QA program be implemented for all systems, structures and components important to safety; design and characterization of barriers important to waste isolation; and activities related thereto. These activities include the development of site characterization data which will be used in support of the license application. Data used in support of the license application and not originally collected under the QA requirements of 10 CFR Part 60, Subpart G should be qualified to meet these requirements.

  In the response to CDSCP comment 108, DOE committed to meeting the staff's guidance on qualifying existing data in NUREG-1298 and to submit a procedure for doing so.

- Section 8.3.1.4.2.1.5 of the SCP states that samples have been collected prior to the implementation of an acceptable QA program, and implies that the data will subsequently be used in the licensing process. Other sections of the SCP similarly infer that existing data will be used in licensing.

  In order for DOE to have developed a plan of studies which they consider sufficient to provide licensing information it would have been necessary for them to have made decisions and assumptions on the information which was obtained prior to the implementation of an acceptable QA program and thus needed to be qualified.

- For the NRC to be able to completely evaluate the sufficiency and viability of the proposed program, the NRC needs to understand what preexisting information the DOE is planning on qualifying.

RECOMMENDATION

DOE should submit the procedures which will be used by the Yucca Mountain Project (YMP) Office and the major participants on the YMP to qualify data which has not been gathered under a QA program which meets the requirements of Subpart G to 10 CFR Part 60.

DOE should provide a general listing by activity of existing data that will be qualified for use in licensing.

REFERENCE

U.S. Nuclear Regulatory Commission, "Generic Technical Position on Qualification of Existing Data for High-Level Nuclear Waste Repositories," NUREG-1298, 1987.

SECTION 8.6.4.2 QUALITY ASSURANCE DURING SITE CHARACTERIZATION, SECTION 8.3.5.5 PRECLOSURE PERFORMANCE

COMMENT 3

The lists of items and activities covered by the 10 CFR Part 60 Subpart G quality assurance programs are incomplete and the analysis provided for their identification is non-conservative in some areas. (This is the same as Comment 106 on the CDSCP.)

BASIS

- The seven basis statements in Comment 106 on the CDSCP involved use of a nonconservative source term for accident analyses, failure to put any mitigating features on the Q-list, lack of a basis for the probability cut-off for screening events, failure to consider a criticality event in defining Q-list items, and failure to provide a quality activities list (including design and performance assessment activities).

- The DOE has provided a "potential" Q-list (Table 6-18 of the SCP) which does not contain any mitigative items and a "preliminary" quality activities list (Section 8.6.4.2.2 of the SCP) which includes some performance assessment items. Reanalysis of the source term used in the dose consequence analyses, and criticality control, are identified as requiring further analysis. The basis for the probability cutoff is still inadequately justified.

- Numerous statements in Appendix F to the SCP-Conceptual Design Report indicate that credit is being taken for proper design, manufacture, installation/construction, testing, operation and maintenance of systems, structures and components. Such credit can only be taken if the processes are verified by an adequate quality assurance program.

- The original NRC recommendations are generally unresolved. Resolution does not appear possible without further analyses by the DOE and probably more and better input data.

RECOMMENDATIONS

- The use of probability risk assessment/preliminary radiological safety analysis techniques to eliminate items from consideration should be reevaluated particularly considering the reliability of the input data.

- Section 6.1.5 of the SCP states that only the waste "container" and not the waste form is on the proposed Q-list of items important to waste isolation; however, the analyses appear to rely on the waste form in performance allocation. The waste form (or at least the glass waste form) should be on the Q-list.

- The Q-list should be expanded to included items such as the "design" to preclude criticality, or another list should be created to identify items requiring 10 CFR 50 Appendix B QA controls which do not fit the definition of Q-list or quality activities list items.

- In general, items should be assigned Quality Level 1 (equivalent to Q-list or quality activities list QA requirements) until firm data and objective analyses demonstrate that lesser QA requirements are appropriate.

<u>REFERENCES</u>

10 CFR Part 60, Subpart G and 10 CFR Part 50, Appendix B.

U.S. NRC Review Plan for NRC Staff Review of DOE's Site Characterization Plan, December 12, 1988.

U.S. DOE Site Characterization Plan, December 1988.

U.S. DOE Responses to NRC Point Papers on Site Characterization Plan/Consultation Draft, December 1988.

SECTION 8.6.4.1 QUALITY ASSURANCE DURING SITE EXPLORATION

CDSCP COMMENT 105

The acceptance review process for data collected after August 1980 (the date when the NNWSI Project QA Plan, NVO-196-17, was first issued) appears to be insufficient.

BASIS

- NRC regulations (10 CFR 60, Subpart G) require that a QA program be implemented for all systems, structures and components important to safety, to design and characterization of barriers important to waste isolation and to activities related thereto. These activities include the development of site characterization data which will be used in support of the license application. Data used in support of the license application that are important to safety or waste isolation and not originally collected under the QA requirements of 10 CFR 60, Subpart G should be qualified to meet these requirements.

- The NNWSI QA plan (196-17) has not been found acceptable by the NRC. A number of outstanding comments remain. An unacceptable or unimplemented QA program could jeopardize the use of data collected under such a QA program in licensing.

- For example, Section 8.3.1.4.2.1.5 refers to specific drill core samples, collected after the August 1980 date, which will be used to measure magnetic properties and consequently, to make stratigraphic correlations. However, numerous concerns have been identified by the NRC staff related to the handling and logging of core collected for the NNWSI project. These data were generated under the NNWSI QA program but may not be defensible in licensing. These data must also be "qualified" to meet the requirements as described in 10 CFR 60, Subpart G.

- NNWSI procedure SOP-03-03, Rev. 0 "Acceptance of Data or Data Interpretations Not Developed Under the NNWSI QA Plan," dated January 31, 1986 describes a process for qualifying data collected after August 1980. According to this procedure, all data or data interpretations generated by the NNWSI participants after the NNWSI QA Plan implementation date (August 1980) will be processed as a nonconformance. This approach may be acceptable to the NRC staff if the proposed corrective action consists of the data qualification methods described in the NRC's "Generic Technical Position on Qualification of Existing Data for High-Level Nuclear Waste Repositories," or some other method proposed by DOE and accepted by NRC. However, to treat "unqualified data" under the traditional nonconformance system - which has less rigor than the methods in the GTP - does not appear adequate.

DOE RESPONSE

DOE has committed in Subsection 8.6.4 to meet the guidance in NUREG-1298 for the qualification of data to be used to support the license application. Based on our review of the response to this comment, the comment is resolved.

TABLE 8.6-2, QUALITY ASSURANCE PLANS AND PROCEDURES IN EFFECT DURING SITE EXPLORATION AND TABLE 8.6-3, NNWSI PROJECT PROCEDURES GENERIC TO SITE CHARACTERIZATION TASKS.

CDSCP COMMENT 107

The plans and procedures listed in Table 8.6-3 do not appear to address all of the applicable criteria of Appendix B to 10 CFR Part 50 for the NNWSI Project office and contractors.

BASIS

- In accordance with the requirement of 10 CFR 60.152, "DOE shall implement a quality assurance program based on the criteria of Appendix B of 10 CFR Part 50 as applicable...."

- The NRC staff recognizes that all of the 18 criteria of Appendix B to 10 CFR Part 50 do not apply to each participant involved in the NNWSI Project. However, in the NRC staff review of Tables 8.6-2 and 8.6-3, and the associated CDSCP descriptions for these tables, the CDSCP does not address why certain parts of the Appendix B criteria have not been covered by the quality assurance plans and procedures in Tables 8.6-2 and 8.6-3, (e.g. the USGS quality assurance plans and procedures referenced in Table 8.6-2 do not appear to address the Appendix B to 10 CFR Part 50 criteria for inspection, test control, calibration and nonconformances.) Similarly, the H&N quality assurance plans and procedures in Table 8.6-3 do not appear to address the Appendix B criteria for procurement; instructions, drawings and procedures; document control; control of purchased material; equipment and services; and test control.

DOE RESPONSE

DOE has provided a listing of procedures in the various tables of 8.6 in the SCP, which address all the applicable criteria of Appendix B 10 CFR Part 50 for the Yucca Mountain Project Office and principal contractors. There are a few areas where those procedures are listed as, "to be determined" since the applicability of particular criteria for an organization has yet to be evaluated. The latest approved and issued procedures will be used during site characterization. Based on our review of the response to this comment, the comment is resolved.