Department of Energy
Washington, DC 20585

MAR 29 1993

Mr. Joseph J. Holonich, Director
Repository Licensing & Quality Assurance
Project Directorate
Division of High-Level Waste Management
Office of Nuclear Material Safety
and Safeguards
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Holonich:

Enclosed (enclosures 1-3) are a series of U.S. Department of Energy (DOE) response packages to State of Nevada comments on Site Characterization Plan study plans.

DOE will transmit future study plan response packages to the U.S. Nuclear Regulatory Commission as part of routine transmittals of Yucca Mountain Site Characterization Project participant monthly status reports.

If you have any questions, please contact Mr. Chris Einberg of my office at 202-586-8869.

Sincerely,

Dwight E. Shelor
Associate Director for
Systems and Compliance
Office of Civilian Radioactive
Waste Management

Enclosures: on the shelf
1. DOE Responses to State Comments in 1990-1991 (Not Record Material)
2. DOE Responses to State Comments in 1992 (Not Record Material)
3. DOE Responses to State Comments in 1993 (Not Record Material)

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NH03

cc: (w\ enclosures)
C. Gertz, YMPO (w\o encl.s)
T. J. Hickey, Nevada Legislative Committee
R. Loux, State of Nevada
D. Bechtel, Las Vegas, NV
Eureka County, NV
Lander County, Battle Mountain, NV
P. Niedzielski-Eichner, Nye County, NV
W. Offutt, Nye County, NV
C. Schank, Churchill County, NV
F. Mariani, White Pine County, NV
V. Poe, Mineral County, NV
J. Pitts, Lincoln County, NV
J. Hayes, Esmeralda County, NV
B. Mettam, Inyo County, CA
C. Abrams, NRC

Rec'd with letter dtd 3/29/93

ENCLOSURE 3

Responses to State of Nevada Comments on Study Plans:

1. 8.3.1.2.2.7 (HYDROCHEMICAL CHARACTERIZATION OF THE UNSATURATED ZONE)
2. 8.3.1.3.2.1 (MINERALOGY, PETROLOGY, AND CHEMISTRY OF TRANSPORT PATHWAYS)
3. 8.3.1.17.4.6 (QUATERNARY FAULTING WITHIN THE SITE AREA)

102.8

Department of Energy
Yucca Mountain Site Characterization
Project Office
P. O. Box 98608
Las Vegas, NV 89193-8608

WBS 1.2.5.2.5
QA: N/A

FEB 18 1993

Robert R. Loux
Agency for Nuclear Projects
State of Nevada
Evergreen Center, Suite 252
1802 North Carson Street
Carson City, NV 89710

U.S. DEPARTMENT OF ENERGY (DOE) RESPONSES TO STATE OF NEVADA COMMENTS ON APPROVED STUDY PLAN 8.3.1.2.2.7 (HYDROCHEMICAL CHARACTERIZATION OF THE UNSATURATED ZONE)

Enclosed are responses to 27 comments made by the State of Nevada on the subject study plan in a letter dated December 22, 1992 (enclosure 1). Enclosure 2 contains DOE's responses.

For comments on DOE-approved study plans, the Yucca Mountain Site Characterization Project Office asks the responsible participant organization (in this case, the U.S. Geological Survey [USGS]) and principal investigator to perform a review and assess their impact on the planned study. The assessment includes a determination as to whether or not a revision is warranted. If a revision is warranted, DOE's intention is stated in responses. If a revision is not warranted, additional information is provided on how the comment is being addressed, why it is inappropriate, or where the concern is being addressed if another study plan is at issue.

Revision 1 to the study plan that was sent to DOE for review in November 1992 addresses some of the concerns expressed by the state. The state's comments express the need for clarification of relatively minor points, and we will make these revisions in a future USGS revision, the timing for which is still to be determined.

If you have any questions, please contact Thomas W. Bjerstedt at (702) 794-7590.

Carl P. Gertz
Project Manager

RSED:TWB-2314

Enclosures:
1. State of Nevada Comments on Study Plan 8.3.1.2.2.7
2. DOE Responses to State Comments

YMP-5

cc w/encls:
S. J. Brocoum, HQ (RW-22) FORS
L. J. Desell, HQ (RW-331) FORS
Allen Benson, HQ, (RW-5.2) FORS
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BOB MILLER
Governor

STATE OF NEVADA

ROBERT R. LOUX
Executive Director

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December 22, 1992

John W. Bartlett, Director
Office of Civilian Radioactive
Waste Management
U.S. Department of Energy
1000 Independence Avenue
Washington, D.C. 20585

Dear Dr. Bartlett:

The State of Nevada has reviewed the DOE Study Plan "Hydrochemical Characterization of the Unsaturated Zone" (Study Plan 8.3.1.2.2.7, Revision 0) and is providing its comments in this letter and attachment. The State's comments address the adequacy, completeness, and technical accuracy of the Study Plan to meet the Department's objective in site characterization.

The Study Plan describes the plans for gaseous - and aqueous - phase chemical investigations at Yucca Mountain. The activities involve the collection of water and gas samples from surface-based boreholes, preparation of the samples for analysis, and methods of hydrochemical analyses to be employed.

General comments relative to the Study Plan are as follows:

1. Although there appears to be a reasonable amount of time (7 years) to perform the proposed activities and the analytical methodologies and techniques appear solid (at least for those specified), this Study Plan will not achieve its objectives for a number of reasons, most of which are related to its sampling philosophy.

   For gas samples, although wells will be shut-in most of the time, if individual geohydrologic units are not isolated most if not all the time, cross-contamination and mixing of gas will occur in the units around the borehole. An unknown amount of time will be needed to

ENCLOSURE 1

draw a pristine gas sample if units within a particular borehole are packed off only during sampling. Multiple samples will be needed to determine when and if a representative sample has been collected. Additionally, what effect will the gas phase circulation study (Study Plan 8.3.1.2.2.6) have on this plan (boreholes will be left open for a time). The Study Plan presents insufficient information to fully evaluate this concern and therefore the State must assume the gas phase portion of this Study Plan will fail to satisfy its objectives.

Aqueous phase samples apparently will be almost exclusively from the rock matrix and not fractures in the vadose zone. Too much emphasis has been placed on extraction of water from cores, which is predominately matrix water. If predominantly matrix waters are analyzed, a biased and non-conservative result will be obtained for travel times and flow paths in the unsaturated zone. The ultimate objective must be to characterize hydrochemistry along the transport pathways. The methodology for extraction of water from fractures in core or rubble is doubtful and the amount of water uncoverable extremely small - too small to satisfy all analytical requirements. An insufficient number of samples are planned from perched water zones (if any are encountered) in the vadose zone and there is no provision for sampling the free water of perched zones during drilling or for collecting water samples from dripping fractures underground.

As proposed, this Study Plan will obtain its cores by air drilling. It appears the air drilling technique described incorporates no provision for detecting moisture i.e. free water in fractures or perched water during the drilling process. This is a serious oversight if the objective of the study is to sample all occurrences of moisture in each borehole.

2. What strategy is there to resolve the possible conflict among data obtained from several studies, each of which has an objective to define flux and flow times in the unsaturated zone? Specifically, there could be inconsistencies among data obtained during the unsaturated zone infiltration study (Study Plan 8.3.1.2.2.1) and the results of the geochemistry sampling described in this Study Plan.

3. Will the geochemistry of fluids obtained at Yucca Mountain from this study be compared to other Nevada Test Site data such as that from Rainier Mesa and the Tunnels to compare and contrast possible recharge and flow mechanism? Will that analysis be performed within this

Study Plan or within Study Plan 8.3.1.2.3.1.1 "Characterization of the Yucca Mountain Regional - Ground - Water Flow System", or some other Study Plan?

Should you have questions, this Office is available to meet with the Department to discuss the State's comments at any time.

Sincerely,

Robert R. Loux
Executive Director

RRL:cs
Attachment

cc: Carl Gertz, YMPO
Joe Youngblood, NRC
Dade Moeller, NRC-ACNW
Steve Kraft, EEI
John Cantlon, NWTRB
Dwayne Wiegel, GAO

ATTACHMENT

State of Nevada specific comments on Study Plan 8.3.1.2.2.7 "Hydrochemical Characterization of the Unsaturated Zone".

1. On page 1.1-3, the State agrees with the need for prototype testing and development of procedures but with the following reservations:

   (1) Is the prototype testing to be performed at Yucca Mountain, elsewhere on the Nevada Test Site, or some other analog site?

4. (2) The nature of the published reports in which the result will be presented should be specified, such as publication in peer-reviewed journals, U.S.G.S. open-file reports, or some form of DOE publication?

   (3) Will these published reports or prototype testing be available for review by the State of Nevada and others in a timely fashion before the actual characterization work begins?

2. Table 1.2-1 (page 1.2-5) lists chemical and isotopic analyses for the hydrochemical tests. Why are specific rare-earths and/or other trace elements not listed? Certainly some

5.

thought went into this item for it to be listed, but the result is not apparent.

The exact organic compounds to be analyzed are not specified either. Why not? There must be some literature information as to which organic compounds might be expected in thick vadose zones of arid regions.

5. Under "Contamination Check", certain species such as NO2 and BO3 may occur naturally and perhaps in measurable concentrations. For these to indicate contamination, background (i.e. uncontaminated levels) must first be established.

Sulfur and nitrogen isotopic analyses of the vadose-zone ground water are not mentioned and there is no discussion of the omission. If compounds containing these elements are at significant concentrations in the water, isotopic analyses can provide information on their sources and thus indirectly on potential flow paths.

3. On page 1.3-3 under Performance Issue 1.6 (Pre-waste emplacement ground water travel time), the "performance goal

6. for ground water travel time for all geohydrologic units between the disturbed zone and the accessible environment is 1,000 years or more at a very high confidence level." There

are at least a couple of problems with this statement:

(1) The <u>fastest path</u>, not, for example 100% of the flow paths at 95% confidence level, must have ground water travel time greater than 1,000 years.

6. (2) The word <u>goal</u> has been misused in the past and continues to be misused (see the State of Nevada comments on the DOE Site Characterization Plan for the Yucca Mountain). The phrase "performance goal" containing the word goal implies that man can control and obtain an objective. In reality, all engineering occurs in the disturbed zone of the repository and thus there are no engineered barrier systems, only natural ones, between the disturbed zone and the accessible environment. A different term and phrase should be used that does not imply any engineering capabilities.

4. On page 1.3-4 under Design Issue 4.4, what exactly is meant by the phrase "waste-package liner"? The State presumes that the authors mean the waste-package canister. The State is not aware that the canister is lined with any material, except for those that contain defense waste glass. Defense waste glass is poured into a 304L stainless steel can which will then be placed inside the waste-package canister. This phrase is ambiguous and requires clarification.

7.

5. Page 2.1-5 contains the following statement: "The δD values would not have been affected even if there were high-temperature events (200 to 300 °C) in the past because the tuff contains no hydrogen atoms." The tuff may have a low water content, but doubtful that it contains no hydrogen atoms. This statement is incorrect and misleading; it should be corrected or supported by a reference.

8.

6. On page 2.1-4, the following statement is made: "All these evidences of profile inversions of tritium concentration with depth point to the fact that vertical percolation was not occurring at Yucca Mountain, while either fractures or bedded units were transporting moisture laterally." Quite to the contrary, all evidences of profile inversions of tritium concentration points towards a strong vertical component of movement of water in the vadose zone. How else are these modern waters able to reach the bedded tuff units where they are able to travel with a more lateral component? Fractures and fault zones with more of a vertical than lateral orientation provide infiltrating water of percolation an avenue to reach the bedded tuff units. These bedded tuff units then allow more of a lateral component to the flow paths. The original statement which can be traced to the Environment Assessment for Yucca Mountain that "vertical percolation was not occurring at Yucca Mountain" seems to be more of a policy statement than one that is based on

9.

9. reasonable geologic sense and the meager scientific data available.

7. Page 2.1-6 contains three provisional conclusions which are drawn from the Section 2.1.2 Interpretation Discussion. The first provisional conclusion drawn by the authors ["there is no significant recharge from the unsaturated zone to the saturated zone beneath Yucca Mountain"] appears to be rather dogmatic given the available scientific data presented in the Study Plan for the following reasons:

(1) Tritium concentration profiles show reversals that suggest significant vertical movement of infiltrating precipitation [see previous comment, #6].

10. (2) The stable isotope data for ground water, Fortymile wash, and the unsaturated zone (UE-25) are within the range for precipitation on Yucca Mountain and surrounding areas. Partial evaporation (Raleigh fractionation) of precipitated waters in the soil zone or by gas circulation (caused by barometric pressure changes) in the vadose zone could cause depletion of infiltrating waters in oxygen-18 and δD.

(3) Los Alamos scientists have found evidence of bomb-derived chlorine-36 at a depth of several hundred feet in a

borehole. The authors have made no mention of this discovery nor the rapid filtration, probably along fractures, that this implies. The authors should review Study Plan 8.3.1.2.2.2 "Water Movement Tests" for a discussion of chlorine-36 in the unsaturated zone.

10.

8. The State is supportive of the statement at the bottom of page 2.1-6: "In order that the study produces valid conclusions, it is essential that (1) there be a sufficient number of moisture samples obtained as a function of both depth and spatial distance to represent a statistical sampling of tuff moisture, (2) the chemical composition of the moisture be accurately known, and (3) the effects of air introduced to the system (natural or man-made) can be evaluated." The key point for drawing valid conclusions is that samples be obtained from all environments at the site which may provide a path for rapid flow within the unsaturated zone. The sampling must be spatially representative.

11.

9. At the top of page 2.1-7, the text still refers to an exploratory shaft (ES-1), an outdated underground exploratory concept. The Study Plan should be revised to reflect the present concept of exploratory studies facility ramps and drifts.

12.

Given that the access to the underground has changed, will

there now exist additional opportunities to sample fracture water? How has the change in access location and method impacted the unsaturated-zone geochemistry sampling? The Study Plan should be revised to reflect changes.

12.

10. Section 2.1.-3 (page 2.1-7) discusses parameters and testing strategies. The authors make the statement that "a common requirement of the parameters is that sufficient confidence can be placed in their numerical values to permit the construction of hydrologic modeling and hypotheses testing." The flow paths are considered to be parameters and thus according to the quoted statement should have numerical values. This bit of apparent terminology needs some explanation. Normally flow paths are not directly measurable unless one can inject a tracer at the surface of the mountain and detect its presence somewhere else (underground in the exploratory study facility?) on the flow path in one's lifetime. The State presumes that the flow paths determined by this study result from interpretation of the data obtained by analyses of samples collected.

13.

11. Relative to Table 2.1-1 <u>Activity Parameters Derived From This Study</u>, all entries within the second and within the third columns are the same [within each column]. Therefore, the State fails to see that the table serves much of a purpose. Site parameters such as flow paths are not generally directly

14.

determinable but are interpreted entities from other quantities measured from collected samples. A similar reasoning applies to travel times; these are interpreted from other directly measured data (such as hydrochemistry and isotopes). The question is why are interpreted results such as flow paths and travel times included with directly measurable quantities and called site parameters?

14.

12. On page 2.1-11 the following statement is made: "If the numerical models do not prove adequate to provide the information required by the performance and design issues, then the original conceptual model will be revised or expanded."

15.

If the models do not provide the information required for performance and design issues, is there a provision to collect additional data as well as revise the model(s)?

13. Also on page 2.1-11, the statement is made that: "Because input parameters for modeling cannot be known explicitly everywhere throughout the modeled area, the parameters must be expressed as statistical distribution functions." Where is a discussion, procedure, or reference to the construction of statistical distribution functions from parameters? The same question may be asked of the "calibration of the model to observed conditions..." in the same paragraph.

16.

14. Given that under the new ESF underground configuration, no radial boreholes are planned (opposite of what is stated on page 2.1-12), how has the new access configuration and methods affected the proposed radial borehole concept and subsequent gas sampling presented in this Study plan? What provisions have been made to obtain that data with the ramp access?

17.

15. On page 2.1-12, regarding the collection of gas samples twice a year from isolated intervals, are these intervals isolated at all times or only during sampling? If the intervals are not isolated at all times but only during sampling, the possibility exists for mixing and flow of gas within the shut-in borehole. Gas from one geohydrologic unit may flow from the borehole into another unit. Results arising from analyses of such samples may be dubious if there has not been sufficient pumping and sampling to establish lack of contamination. Otherwise, how might this cross-contamination and mixing be handled?

18.

16. Again on page 2.1-13, planned tests focus on boreholes in an exploratory shaft. Has the proposed change in access using ramps and the additional drifting, resulted in changes in the boreholes to be sampled? Has this also changed the proposed sampling of the Calico Hills units from the surface now that there is a proposed Calico Hills drift?

19.

17. Reference to Table 2.1-2 <u>Sampling Scheme From Different Lithologic Units For Each Borehole</u> on page 2.1.-14. Sample frequency appears inadequate for the Topopah Springs units (only 20 samples, one every 50 feet); a higher sampling frequency is needed for this unit. What rationale determined sampling frequency?

Perched water zones are very important and only one sample per zone is planned. This is totally inadequate as at least two or three per zone are needed and more realistically perhaps many samples should be taken to define the size of the zone. Water levels should be measured between samples. Because these zones represent free water most likely from fracture flow, multiple samples are needed for replicate determinations and to prevent against the loss or destruction of the "only" sample.

20.

Furthermore, there appears to be no provision for the sampling of free flowing seeps in the underground workings. If the authors are truly interested in obtaining fracture water, provision must be made to sample flowing seeps (fractures) underground.

18. Page 2.1-15 discusses a methodology for collection of fracture water. Regarding the sampling of small fractures by chiseling away material from both sides and collection of water by

21.

centrifugation, there are a number of important questions left unanswered by the plan:

(1) Is there any precedence for this procedure?

21. (2) How will one ensure only fracture water is collected?

(3) From the standpoint of the volume/mass of water sample needed for analyses, has there been a calculation of the size of rock sample needed?

Without supporting information to justify its use, this procedure appears unscientific and doomed to failure.

19. Relative to Table 2.2-1 <u>Summary Of Procedures For Analysis Of Parameters For The Unsaturated-Zone Hydrochemistry Tests</u> on page 2.2-2. Table entries are incomplete, specifically those for Cl-36, Ar-39, and He-3/He-4.

22.

20. Reference to Section 3.2.2 <u>Rationale For Activity Selection</u> on page 3.2-1. How data will be interpreted to obtain information such as flow paths and travel times is only touched upon very briefly in this section yet these items are the major objective of all the data collection efforts of this Study Plan. A more detailed explanation of the derivation of interpreted parameters (flow paths and travel times) is

23.

needed.

21. In Section 3.1.3.1 on page 3.1-4, the statement is made that: "Available information suggests that this does not cause a problem with interpretation, however, there are plans to test the validity of this assumption using tracer gases applied to surrounding intervals."

24. What "information suggests that this [drilling effort and equilibration time] does not cause a problem with interpretation..."? Statements such as this should be tied to a reference, i.e. a published document.

22. The following statement is made at the top of page 3.1-7: "Also, sample sizes will be large enough to use nonstandard procedures during degassing."

25. What is implied by "sample sizes will be large enough to use nonstandard procedures during degassing."? Usually very small samples require so-called nonstandard procedures.

23. In Section 3.2.3 on page 3.2-3, the approach is to obtain pore water extracted from unsaturated-zone drill cores of rock matrix and near fractures. It is difficult to imagine how

26. fracture and/or near-fracture water will be collected from 4 inch cores without contamination from the surrounding matrix.

The State would propose that the testing of cores for extraction of water by uniaxial and triaxial compression only applies to matrix water, unless the core is from a perched water zone. The Study Plan is silent on how the authors will determine from a drill core when one is "near a fracture" appropriate for sampling. Fracture water must be obtained in the field either as perched water samples or collected underground from seeps in the exploratory study facility. An insufficient number of samples is assigned to perched water zones and there is no mention anywhere in this Study Plan for the collection of free-flowing water samples from fractures underground. This omission is a very serious defect in this Study Plan and its omission suggests that the DOE authors are not concerned with the collection of water samples from fractures.

26.

Cores from perched water zones, samples of perched water from a borehole, and the sampling of seeps are samples of opportunity and as such require immediate decisions in the field by a responsible geoscientist. The sampling of perched water requires pumping. None of these activities appears to be covered by any quality assurance or technical procedures mentioned in this Study Plan document.

24. The Study Plan on page 3.2-4 indicates that the preparation of samples for triaxial compression tests is in a nitrogen-

27.

27. atmosphere glove box to prevent atmospheric contamination. The question is will the low-humidity atmosphere cause some drying out of the sample prior to testing? Has this possibility been considered and evaluated?

RESPONSES TO STATE OF NEVADA COMMENTS ON STUDY PLAN 8.3.1.2.2.7
(HYDROCHEMICAL CHARACTERIZATION OF THE UNSATURATED ZONE)

GENERAL COMMENTS

General Comment 1

Although there appears to be a reasonable amount of time (7 years) to perform the proposed activities and the analytical methodologies and techniques appear solid (at least for those specified), this Study Plan will not achieve its objectives for a number of reasons, most of which are related to its sampling philosophy.

For gas samples, although wells will be shut-in most of the time, if individual geohydrologic units are not isolated most if not all the time, cross-contamination and mixing of gas will occur in the units around the borehole. An unknown amount of time will be needed to draw a pristine gas sample if units within a particular borehole are packed off only during sampling. Multiple samples will be needed to determine when and if a representative sample has been collected. Additionally, what effect will the gas phase circulation study (Study Plan 8.3.1.2.2.6) have on this plan (boreholes will be left open for a time). The Study Plan presents insufficient information to fully evaluate this concern and therefore the State must assume the gas phase portion of this Study Plan will fail to satisfy its objectives.

Aqueous phase samples apparently will be almost exclusively from the rock matrix and not fractures in the vadose zone. Too much emphasis has been placed on extraction of water from cores, which is predominantly matrix water. If predominantly matrix waters are analyzed, a biased and non-conservative result will be obtained for travel times and flow paths in the unsaturated zone. The ultimate objective must be to characterize hydrochemistry along the transport pathways. The methodology for extraction of water from fractures in core or rubble is doubtful and the amount of water uncoverable extremely small - too small to satisfy all analytical requirements. An insufficient number of samples are planned from perched water zones (if any are encountered) in the vadose zone and there is no provision for sampling the free water of perched zones during drilling or for collecting water samples from dripping fractures underground.

As proposed, this Study Plan will obtain its cores by air drilling. It appears the air drilling technique described incorporates no provision for detecting moisture i.e. free water in fractures or perched water during the drilling process. This is a serious oversight if the objective of the study is to sample all occurrences of moisture in each borehole.

ENCLOSURE 2

Response

(1) Each UZ borehole will be permanently stemmed, and from 10 to 15 zones isolated. After the borehole is drilled, drilling air will be evacuated until disappearance of the tracer gas, SF_6, in the evacuated air. This will assure the complete removal of the drilling air. The gas phase circulation study, 8.3.1.2.2.6, is fully integrated with this study. At the time this study plan was written, little data from the gas-phase circulation study was available. However, five to six years of gas-phase data are available now. Interpretation of this data will be discussed at the proceedings of the Fourth International High-Level Radioactive Waste Management meeting in Las Vegas, April 26-30, 1993. The title of the paper in the proceedings volume is "Carbon Isotopic Data from Test Hole USW UZ-1, Yucca Mountain, Nevada", by A. Yang and others. This paper will specifically address many concerns raised by the State of Nevada in this and other comments. This reference will be added to the Study Plan.

(2) The USGS recognizes the need to sample fast pathways. The approach to UZ hydrochemistry aqueous sampling will be: (1) extraction of matrix water from cores by one-dimensional compression; (2) extraction of near fracture water by chipping and one-dimensional compression; (3) collection of fracture water when available using the "seamist" system primarily from the ESF; and (4) collection of perched water when detected or observed.

There is no plan to extract water from fractures in core, but rather from near fractures observed in core samples. The water retrieved by this method should be enough for at least one of the following analyses: (1) major cations and anions; (2) tritium; (3) oxygen 18/16 and Deuterium/Hydrogen; or (4) Carbon 14 analysis if new methods prove adequate.

Perched water zones will be sampled whenever encountered. This includes during surface-based drilling and during underground drilling or from fracture seeps underground in the ESF. The underground work is addressed in the ESF Study Plan, 8.3.1.2.2.4 (Percolation in the Unsaturated-Zone - Exploratory Studies Facility).

A revision to the Study Plan will clarify the sampling approach outlined above.

(3) If wet zones are encountered during borehole drilling, they will be apparent in the core that is recovered.

General Comment 2

What strategy is there to resolve the possible conflict among data obtained from several studies, each of which has an objective to define flux and flow times in the unsaturated zone? Specifically, there could be inconsistencies among data obtained during the unsaturated zone infiltration study (Study Plan 8.3.1.2.2.1) and the results of the geochemistry sampling described in this Study Plan.

Response

As stated in item 10 of the specific responses that follow, several methods are available to study hydrochemical questions. For example, questions regarding fast flow paths can be investigated through studies of ^{36}CL, ^{3}H, or ^{14}C in pore water at depth. The infiltration, matrix properties, deep UZ, air permeability, gas phase circulation and UZ hydrochemistry studies will all collect data that will be used in an integrated UZ model to examine the flux and flow paths at Yucca Mountain. Integrated modeling will be helpful in establishing data ranges and increasing the confidence level. The more consistent the data remains among various methods, the narrower the range, and the higher the confidence level. Clarifying statements will be added to the Study Plan where they are apparently needed.

General Comment 3

Will the geochemistry of fluids obtained at Yucca Mountain from this study be compared to other Nevada Test Site data such as that from Rainier Mesa and the tunnels to compare and contrast possible recharge and flow mechanism? Will that analysis be performed within this Study Plan or within Study Plan 8.3.1.2.3.1.1 "Characterization of the Yucca Mountain Regional - Ground-Water Flow System", or some other Study Plan?

Response

The information available from other analog sites, such as the Apache Leap site in Arizona, will be compared to this study and used in interpreting data collected at Yucca Mountain. No new work is planned within the scope of this study to compare Ranier Mesa or G-Tunnel hydrochemical samples with Yucca Mountain UZ samples. There is existing literature on this subject, for example -

Daniels, W.R. et al., 1982, Summary Report on the Geochemistry of Yucca Mountain and Environs, Los Alamos National Laboratory, LA-9328-MS, Los Alamos, NM

Ogard, A.E., and Kerrisk J.F., 1984, Groundwater Chemistry along Flow Paths Between a Proposed Resposity Site and the Accessible Environment, Los Alamos National Laboratory, LA-10188-MS, Los Alamos, NM

White, A,F., Claassen, H.C. and Benson, L.V., 1980, The Effect of Dissolution of Volcanic Glass on the Water Chemistry in a Tuffaceous Aquifer, Rainier Mesa, Nevada, U.S. Geological Survey Water Supply Paper 1535-Q

RESPONSES TO COMMENTS FROM ENCLOSURE TO THE STATE'S LETTER

Comment 4

On page 1.1-3, the State agrees with the need for prototype testing and development of procedures but with the following reservations:

(1) Is the prototype testing to be performed at Yucca Mountain, elsewhere on the Nevada Test Site, or some other analog site?

(2) The nature of the published reports in which the result will be presented should be specified, such as publication in peer-reviewed journals, U.S.G.S. open-file reports, or some form of DOE publication?

(3) Will these published reports or prototype testing be available for review by the State of Nevada and others in a timely fashion before the actual characterization work begins?

Response

(1) The prototype testing has been done in or with geologic materials collected from G-tunnel at Rainier Mesa, Yucca Mountain, and Apache Leap, Arizona. Studies have also been performed in the laboratory.

(2) The results have been and will continue to be published in a combination of the outlets described. To date, reports have been written for conference proceedings, peer-reviewed journals and USGS outlets. The release mechanism will be decided as reports are prepared using maximum visibility as a primary consideration. Site Characterization Progress Reports should be consulted to determine what past work has been done as well as the latest research products from this study (and the outlets for this work).

(3) Before reports are published, many technical interactions are held among DOE, NRC, the State of Nevada, and the Nuclear Waste Technical Review Board. Technical information from this study is presented at various conferences, especially the International High-Level Radioactive Waste Management Conference in Las Vegas, where many State of Nevada scientists attend and participate. Study 8.3.1.2.2.7 is an ongoing study where, unlike new studies, work and prototype testing could continue in parallel with development of the Study Plan.

Comment 5

Table 1.2-1 (page 1.2-5) lists chemical and isotopic analyses for the hydrochemical tests. Why are specific rare-earths and/or other trace elements not listed? Certainly some thought went into this item for it to be listed, but the result is not apparent.

The exact organic compounds to be analyzed are not specified either. Why not? There must be some literature information as to which organic compounds might be expected in thick vadose zones of arid regions.

Under "Contamination Check", certain species such as NO2 and BO3 may occur naturally and perhaps in measurable concentrations. For these to indicate contamination, background (i.e. uncontaminated levels) must first be established.

Sulfur and nitrogen isotopic analyses of the vadose-zone ground water are not mentioned and there is no discussion of the omission. If compounds containing these elements are at significant concentrations in the water, isotopic analyses can provide information on their sources and thus indirectly on potential flow paths.

Response

Revision 1 of the Study Plan, dated November 19, 1992, includes rare earth elements in Table 1.2-1. Preliminary analyses show the rare earth elements Dy, Er, Yb, Tm and Lu, and Mn, Cu, Zn, and Mo to be present in concentrations above detection levels. In general, the trace elements and organic compounds are lower priority than the major inorganic and isotopic analyses listed elsewhere in the table. An occasional analysis of trace elements and/or dissolved organic compounds will be attempted when sufficient water is available. Clarifying statements will be added to the Study Plan where they are apparently needed.

The background level of NO_3 and BO_3 are below 1 ppm in Yucca Mountain pore water as analyzed from cores of UE-25 UZ 4 and 5. the need for background analyses of any chemical that will be used as a tracer was sufficiently self-evident that it was not explicitly stated. The statement will be added.

Sulfur and nitrogen isotopes might indeed be useful, but are (like trace elements and organics) of lower priority than the major inorganic and isotopic analyses.

Comment 6

On page 1.3-3 under Performance Issue 1.6 (Pre-waste emplacement ground water travel time), the "performance goal for ground water travel time for all geohydrologic units between the disturbed zone and the accessible environment is 1,000 years or more at a very high confidence level." There are at least a couple of problems with this statement:

(1) The fastest path, not, for example 100% of the flow paths at 95% confidence level, must have ground water travel time greater than 1,000 years.

(2) The word goal has been misused in the past and continues to be misused (see the State of Nevada comments on the DOE Site Characterization Plan for the Yucca Mountain). The phrase "performance goal" containing the word goal implies that man can control and obtain an objective. In reality, all engineering occurs in the disturbed zone of the repository and thus there are no engineered barrier systems, only natural ones, between the disturbed zone and the accessible environment. A different term and phrase should be used that does not imply any engineering capabilities.

Response

On page 1.3-3, Performance Issue 1.6, the phrase "along the fastest path of radionuclide travel" would be added after "travel time," per SCP P-8.3.5.12-1 in a revision to the Study Plan. The performance goal is taken directly from SCP Table 8.3.5.12-1 (Summary of performance allocation for Issue 1.6).

The state's comment regarding the GWTT requirement is understood. The interpretation of the GWTT subsystem performance objective from 10 CFR Part 60 bridges the entire UZ geohydrology program, not just this study. DOE is preparing a position on GWTT as part of the issue resolution initiative. For determining GWTT, see the DOE response to the State of Nevada comment 941 on the SCP. With respect to the SCP's use of "performance goals", see the DOE response to comment 220 from the State of Nevada's review of the SCP.

Comment 7

On page 1.3-4 under Design Issue 4.4, what exactly is meant by the phrase "waste-package liner"? The State presumes that the authors mean the waste-package canister. The State is not aware that the canister is lined with any material, except for those that contain defense waste glass. Defense waste glass is poured into a 304L stainless steel can which will then be placed inside the waste-package canister. This phrase is ambiguous and requires clarification.

Response

On page 1.3-4, under Design Issue 4.4, change "waste package" to "borehole" in line 5. In line 6, add "(access to waste package)" after "performance measure" for the revision to the Study Plan These changes are per SCP Table 8.3.2.5-10 (Preliminary performance allocation for System Element 1.2.2.5, Retrieval), SCP page 8.3.2.5-30.

Comment 8

Page 2.1-5 contains the following statement: "The delta D values would not have been affected even if there were high-temperature events (200 to 300 degrees C) in the past because the tuff contains no hydrogen atoms." The tuff may have a low water content, but doubtful that it contains no hydrogen atoms. This statement is incorrect and misleading; it should be corrected or supported by a reference.

Response

Even at the low water contents observed in the tuffs, the molar ratio of H_2O to any hydrogen atoms contained in the tuff should be sufficiently high that even if reaction occurs, isotopic effects will be negligible. The clause, "...because the tuff contains no hydrogen atoms", will be deleted in the Study Plan revision.

Comment 9

On page 2.1-4, the following statement is made: "All these evidences of profile inversions of tritium concentration with depth point to the fact that vertical percolation was not occurring at Yucca Mountain, while either fractures or bedded units were transporting moisture laterally." Quite to the contrary, all evidences of profile inversions of tritium concentration points towards a strong vertical component of movement of water in the vadose zone. How else are these modern waters able to reach the bedded tuff units where they are able to travel with a more lateral component? Fractures and fault zones with more of a vertical than lateral orientation provide infiltrating water of percolation an avenue to reach the bedded tuff units. These bedded tuff units then allow more of a lateral component to the flow paths. The original statement which can be traced to the Environment Assessment for Yucca Mountain that "vertical percolation was not occurring at Yucca Mountain" seems to be more of a policy statement than one that is based on reasonable geologic sense and the meager scientific data available.

Response

In the revision to the Study Plan the sentence will be amended to read that "...point to the fact that both vertical flow and lateral flow occur in shallow fractures or bedded units at Yucca Mountain."

Comment 10

Page 2.1-6 contains three provisional conclusions which are drawn from the Section 2.1.2 Interpretation Discussion. The first provisional conclusion drawn by the authors ["there is no significant recharge from the unsaturated zone to the saturated zone beneath Yucca Mountain"] appears to be rather dogmatic given the available scientific data presented in the Study Plan for the following reasons:

(1) Tritium concentration profiles show reversals that suggest significant vertical movement of infiltrating precipitation [see previous comment, #6].

(2) The stable isotope data for ground water, Fortymile wash, and the unsaturated zone (UE-25) are within the range for precipitation on Yucca Mountain and surrounding areas. Partial evaporation (Raleigh fractionation) of precipitated waters in the soil zone or by gas circulation (caused by barometric pressure changes) in the vadose zone could cause depletion of infiltrating waters in oxygen-18 and delta D.

(3) Los Alamos scientists have found evidence of bomb-derived chlorine-36 at a depth of several hundred feet in a borehole. The authors have made no mention of this discovery nor the rapid filtration, probably along fractures, that this implies. The authors should review Study Plan 8.3.1.2.2.2 "Water Movement Tests" for a discussion of chlorine-36 in the unsaturated zone.

Response

(1) Tritium reversals indicate modern water to the depth of the bedded unit only, not to the water table.

(2) The USGS disagrees with this item. All of the data cited by the State refers to the unsaturated zone, not the saturated zone. Significant Rayleigh distillation would appear to be unlikely, given that the unsaturated zone is saturated with water vapor below the alluvium, thus rendering significant evaporation unlikely. There is no evidence to indicate any significant modern-water component beneath Yucca Mountain, and the absence of recharge appears to be the best working hypothesis. the phrase "provisional working hypothesis" will be added to the text to emphasize the tentative nature of this hypothesis.

(3) Study Plan 8.3.1.2.2.2, Revision 1, (Water Movement Tests), page 15, first paragraph, stated that isotopic signal at 364 m, indicating a young value, may have been contaminated by drilling fluid lost during the drilling of USW G-1 nearby and unambiguously detected in USW UZ-1. The USGS analyses of USW-UZ-1 fluid encountered at this depth shows the same chemical compositions as the drilling fluid used in USW-G-1.

Comment 11

The State is supportive of the statement at the bottom of page 2.1-6: "In order that the study produces valid conclusions, it is essential that (1) there be a sufficient number of moisture samples obtained as a function of both depth and spatial distance to represent a statistical sampling of tuff moisture, (2) the chemical composition of the moisture be accurately known, and (3) the effects of air introduced to the system (natural or man-made) can be evaluated." The key point for drawing valid conclusions is that samples be obtained from all environments at the site which may provide a path for rapid flow within the unsaturated zone. The sampling must be spatially representative.

Response

The USGS notes the comment.

Comment 12

At the top of page 2.1-7, the text still refers to an exploratory shaft (ES-1), an outdated underground exploratory concept. The Study Plan should be revised to reflect the present concept of exploratory studies facility ramps and drifts.

Given that the access to the underground has changed, will there now exist additional opportunities to sample fracture water? How has the change in access location and method impacted the unsaturated-zone geochemistry sampling? The Study Plan should be revised to reflect changes.

Response

Study Plan 8.3.1.2.2.7, Revision 1, has been revised to refer to Exploratory Studies Facility. Moreover, the change in access locations have led the USGS to revise sampling locations. Details are described in Study Plan 8.3.1.2.2.4, Revision 1, Section 3.8. Clarifying statements will be added to the revision to the Study Plan where they are apparently needed.

Comment 13

Section 2.1.-3 (page 2.1-7) discusses parameters and testing strategies. The authors make the statement that "a common requirement of the parameters is that sufficient confidence can be placed in their numerical values to permit the construction of hydrologic modeling and hypotheses testing." The flow paths are considered to be parameters and thus according to the quoted statement should have numerical values. This bit of apparent terminology needs some explanation. Normally flow paths are not directly measurable unless one can inject a tracer at the surface of the mountain and detect its presence somewhere else (underground in the exploratory study facility?) on the flow path in one's lifetime. The State presumes that the flow paths determined by this study result from interpretation of the data obtained by analyses of samples collected.

Response

The flow paths to be determined by this study result from interpretation of the data obtained by analyses of samples collected. The tracers measured in this study are environmental tracers which occur naturally. The same interpretation of the data may be needed when mixing occurs. The phrase "their numerical values" will be replaced with "their interpreted characteristics" in the appropriate sentence in the revision to the Study Plan.

Comment 14

Relative to Table 2.1-1 Activity Parameters Derived From This Study, all entries within the second and within the third columns are the same [within each column]. Therefore, the State fails to see that the table serves much of a purpose. Site parameters such as flow paths are not generally directly determinable but are interpreted entities from other quantities measured from collected samples. A similar reasoning applies to travel times; these are interpreted from other directly measured data (such as hydrochemistry and isotopes). The question is why are interpreted results such as flow paths and travel times included with directly measurable quantities and called site parameters?

Response

In order to clarify that the purpose of Table 2.1-1 is to present measurable activity parameters to be collected in this study, the following changes are appropriate for the revision to the Study Plan, 1) change "Site parameter" to "Activity parameter" in the heading, 2) on the Study Plan, page 2.1-8, delete the parameter category "Unsaturated-zone fluid flux" and its parameters "gas flow paths, hydrochemical determination" and "Gas travel times, hydrochemical determination"; and 3) on page 2.1-9, delete the parameter category "Unsaturated-zone fluid flux" and its parameters "Water flow paths (180/160 D/H), pore waters" and "Water travel times (14C and 3H).

Comment 15

On page 2.1-11 the following statement is made: "If the numerical models do not prove adequate to provide the information required by the performance and design issues, then the original conceptual model will be revised or expanded."

If the models do not provide the information required for performance and design issues, is there a provision to collect additional data as well as revise the model(s)?

Response

In the revision to this Study Plan, the sentence will be modified to read, "...the original conceptual model will be revised or expanded to include observed conditions. Additional testing will be undertaken if warranted."

Comment 16

Also on page 2.1-11, the statement is made that: "Because input parameters for modeling cannot be known explicitly everywhere throughout the modeled area, the parameters must be expressed as statistical distribution functions." Where is a discussion, procedure, or reference to the construction of statistical distribution functions from parameters? The same question may be asked of the "calibration of the model to observed conditions..." in the same paragraph.

Response

In the revision to this Study Plan, the sentence in question will be modified to read, "...the parameters must be expressed as statistical distribution functions, or the models must be run for limiting cases."

Discussion of statistical distribution functions are in various pertinent Study Plans, such as 8.3.1.2.2.8, 8.3.1.2.2.1, 8.3.1.2.2.9, and 8.3.1.2.2.3. The USGS does not discuss it in this Study Plan because it does not relate to modeling for this study, but rather to the hydrologic modeling. Discussion on model calibration can be found in Study Plan 8.3.1.2.2.9 (Site Unsaturated-zone Modeling and Synthesis).

Comment 17

Given that under the new ESF underground configuration, no radial boreholes are planned (opposite of what is stated on page 2.1-12), how has the new access configuration and methods affected the proposed radial borehole concept and subsequent gas sampling presented in this Study plan? What provisions have been made to obtain that data with the ramp access?

Response

Radial boreholes are still planned in the ESF. The effect of the new configuration is discussed in ESF Study Plan 8.3.1.2.2.4 (Percolation in the Unsaturated-zone - Exploratory Studies Facility).

Comment 18

On page 2.1-12, regarding the collection of gas samples twice a year from isolated intervals, are these intervals isolated at all times or only during sampling? If the intervals are not isolated at all times but only during sampling, the possibility exists for mixing and flow of gas within the shut-in borehole. Gas from one geohydrologic unit may flow from the borehole into another unit. Results arising from analyses of such samples may be dubious if there has not been sufficient pumping and sampling to establish lack of contamination. Otherwise, how might this cross-contamination and mixing be handled?

Response

Yes, the UZ borehole sampling intervals are permanently isolated. In the revision to the Study Plan, clarifying statements will be added to the text where they are apparently needed.

Comment 19

Again on page 2.1-13, planned tests focus on boreholes in an exploratory shaft. Has the proposed change in access using ramps and the additional drifting, resulted in changes in the boreholes to be sampled? Has this also changed the proposed sampling of the Calico Hills units from the surface now that there is a proposed Calico Hills drift?

Response

In the revision to the Study Plan, reference to the ESF "shaft" concept is deleted. Sampling in ESF boreholes are detailed in Study Plan 8.3.1.2.2.4, Revision 1. No change in surface-based studies of the Calico Hills unit is currently planned.

Comment 20

Reference to Table 2.1-2 Sampling Scheme From Different Lithologic Units For Each Borehole on page 2.1.-14. Sample frequency appears inadequate for the Topopah Springs units (only 20 samples, one every 50 feet); a higher sampling frequency is needed for this unit. What rationale determined sampling frequency?

Perched water zones are very important and only one sample per zone is planned. This is totally inadequate as at least two or three per zone are needed and more realistically perhaps many samples should be taken to define the size of the zone. Water levels should be measured between samples. Because these zones represent free water most likely from fracture flow, multiple samples are needed for replicate determinations and to prevent against the loss or destruction of the "only" sample.

Furthermore, there appears to be no provision for the sampling of free flowing seeps in the underground workings. If the authors are truly interested in obtaining fracture water, provision must be made to sample flowing seeps (fractures) underground.

Response

(1) The USGS determined sampling frequency for the units based on consistency of the unit, and was also based on the difficulty of extracting water from the densely welded tuffs of the Topopah Spring. However, these numbers are subject to change as: (a) more information becomes available, or (b) when relevant sampling zones are determined by features seen during coring.

(2) Perched water, if encountered, will be sampled as quickly and efficiently as permitted by drilling operations. The one sample from a perched water zone is a misnomer in the sense that the zone will be sampled as long as it persists and drilling operations allow. Based on past drilling experience in the UZ, perched water zones that are encountered during drilling may not be persistent.

(3) Sampling of free flowing seeps in the underground workings are stated in the ESF Study Plan 8.3.1.2.2.4, Revision 1. It is in the ESF that the potential for sampling free water is greatest.

Comment 21

Page 2.1-15 discusses a methodology for collection of fracture water. Regarding the sampling of small fractures by chiseling away material from both sides and collection of water by centrifugation, there are a number of important questions left unanswered by the plan:

(1) Is there any precedence for this procedure?

(2) How will one ensure only fracture water is collected?

(3) From the standpoint of the volume/mass of water sample needed for analyses, has there been a calculation of the size of rock sample needed?

Without supporting information to justify its use, this procedure appears unscientific and doomed to failure.

Response

(1) The USGS has been able to collect cores that are fractured, and has been able to isolate the near fracture rock by chipping a sample away, and has been able to remove water from chip samples by one-dimensional compression. Revision 1 of this Study Plan abandoned centrifugation for 1-d compression of chips. However, there is no precedent in the literature for this procedure.

(2) There is no clear basis to distinguish the fracture water from the matrix water in a non-flowing fracture. The fracture water will transport or diffuse into the matrix by matrix suction. There will be a gradual transition from fracture water to matrix water with distance away from the fracture walls. If this perception is correct, then the near-fracture tuffs collected compared to tuffs further away from the fracture walls could show differences in the chemistry and isotopic composition. There is no precedent in the literature for this procedure. In the revision to this Study Plan, the near-fracture and free-fracture water sampling distinction will be clarified.

(3) If tuffs near the fracture are near saturation, about 25 cm^3 volume is needed to obtain a 3-ml pore water sample which can be used for analyses of major cations and anions. For other isotopic analyses, more water is needed.

Comment 22

Relative to Table 2.2-1 Summary Of Procedures For Analysis Of Parameters For The Unsaturated-Zone Hydrochemistry Tests on page 2.2-2. Table entries are incomplete, specifically those for Cl-36, AR-39, and He-3/He-4.

Response

CL-36 in the table is complete in the revised Study Plan 8.3.1.2.2.7, Revision 1. AR-39 and He-3/He-4 are still incomplete. This is because not enough Ar or He gas has been extracted from pore water for the analyses. The reason for listing them in the table is to show that we have considered the methods. The table will be updated as appropriate.

Comment 23

Reference to Section 3.2.2 Rationale for Activity Selection on page 3.2-1. How data will be interpreted to obtain information such as flow paths and travel times is only touched upon very briefly in this section yet these items are the major objective of all the data collection efforts of this Study Plan. A more detailed explanation of the derivation of interpreted parameters (flow paths and travel times) is needed.

Response

The radioactive isotope data can provide a time framework for travel times, within which different flow paths, if they exist, can be delineated by chemical reaction modeling. These are standard modeling approaches and do not need to be elaborated in this Study Plan. See for example -

Plummer, L.N., Parkhurst, D.L. and Thorstenson, D.C., 1983, Development of Reaction Models for Groundwater Systems; Geochemica Cosmochimica Acta, v. 47, (p. 665-686).

Plummer, L. N., Prestemon, E. C., and Parkhurst, D. L., 1991, An Interactive Code (NETPATH) for Modeling NET Geochemical Reactions along a flow Path; U.S. Geological Survey Water-Resources Investigations Report 91-4087.

These references will be added in the revision to the Study Plan.

Comment 24

In Section 3.1.3.1 on page 3.1-4, the statement is made that: "Available information suggests that this does not cause a problem with interpretation, however, there are plans to test the validity of this assumption using tracer gases applied to surrounding intervals."

What "information suggests that this [drilling effort and equilibration time] does not cause a problem with interpretation..."? Statements such as this should be tied to a reference, i.e. a published document.

Response

The information in question is the following. The calculated ^{14}C age of rock CO_2 gas was measured as a function of depth (up to 1200 feet). The calculated ^{14}C age was contemporary near the surface and increased to about 9,000 years at a depth of 1,200 feet, with a smooth trend. The ^{14}C data are consistent for the last five years. Also, the $^{13}C/^{12}C$ ratios indicate a biogenic source (delta ^{13}C = -7%). Details are published in the paper entitled

Yang, A., Peters, C.A., and Thorstenson, D.C., 1993, Carbon Isotopic Data From Test Hole USW UZ-1, Yucca Mountain, Nevada; Proceedings, Fourth Annual International High Level Radioactive Waste Management Conference, Las Vegas, Nevada, April 26-30, 1993.

This reference will be added in the revision to the Study Plan.

Comment 25

The following statement is made at the top of page 3.1-7: "Also, sample sizes will be large enough to use nonstandard procedures during degassing."

What is implied by "sample sizes will be large enough to use nonstandard procedures during degassing"? Usually very small samples require so-called nonstandard procedures.

Response

The sentence will be deleted in the revision to the Study Plan.

Comment 26

In Section 3.2.3 on page 3.2-3, the approach is to obtain pore water extracted from unsaturated-zone drill cores of rock matrix and near fractures. It is difficult to imagine how fracture and/or near-fracture water will be collected from 4 inch cores without contamination from the surrounding matrix.

The State would propose that the testing of cores for extraction of water by uniaxial and triaxial compression only applies to matrix water, unless the core is from a perched water zone. The Study Plan is silent on how the authors will determine from a drill core when one is "near a fracture" appropriate for sampling. Fracture water must be obtained in the field either as perched water samples or collected underground from seeps in the exploratory study facility. An insufficient number of samples is assigned to perched water zones and there is no mention anywhere in this Study Plan for the collection of free-flowing water samples from fractures underground. This omission is a very serious defect in this Study Plan and its omission suggests that the DOE authors are not concerned with the collection of water samples from fractures.

Cores from perched water zones, samples of perched water from a borehole, and the sampling of seeps are samples of opportunity and as such require immediate decisions in the field by a responsible geoscientist. The sampling of perched water requires pumping. None of these activities appears to be covered by any quality assurance or technical procedures mentioned in this Study Plan document.

Response

The basis for the State's suggestion that perched water would represent fracture water is not clear to the USGS. The free-flowing fracture water will be collected using "Seamist" (a commercial product developed by Science and Engineering Associates of Santa Fe, New Mexico) for surface-based boreholes. Direct collection in a bottle or "Seamist" will be used in the ESF. Perched water and fracture water (free-flowing seep water) sampling are discussed in UZ-ESF Study Plan 8.3.1.2.2.4; in Section 3.7 of the Perched Water Test, and pages 3.8-26 to 3.8-27 of the Hydrochemistry Test. Collections of fracture and matrix water from cores is discussed in the response to comment 18.

Comment 27

The Study Plan on page 3.2-4 indicates that the preparation of samples for triaxial compression tests is in a nitrogen-atmosphere glove box to prevent atmospheric contamination. The question is will the low-humidity atmosphere cause some drying out of the sample prior to testing? Has this possibility been considered and evaluated?

Response

All procedures during core sealing, core transportation, core storage, and core preparation, are designed to prevent evaporation and limit the potential for the core to dry out. The effects of core sealing, storing, and transportation are discussed briefly in the proceedings of the 7th International Symposium on Water Rock Interaction, Park City, Utah, July 13-18, 1992. This reference will be added to the Study Plan in the revision.

Some effects of core preparation were studied during the G-tunnel work. A paper that will discuss that work is in preparation by USGS staff.

The potential for evaporation is being minimized at all points during curation. The USGS knows how critical evaporation is in studying rocks from the UZ and is doing everything practicable to minimize it. Evaporation has no discernable effect on water chemistry.

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WBS 1.2.5.2
QA: N/A

FEB 2 4 1993

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U.S. DEPARTMENT OF ENERGY (DOE) RESPONSES TO STATE OF NEVADA COMMENTS ON STUDY PLAN 8.3.1.3.2.1, "MINERALOGY, PETROLOGY, AND CHEMISTRY OF TRANSPORT PATHWAYS"

Enclosed are responses to 12 comments made by the State of Nevada on the subject study plan in a letter dated December 23, 1992 (enclosure 1). Enclosure 2 contains DOE's responses.

For comments on DOE-approved study plans, the Yucca Mountain Site Characterization Project Office asks the responsible participant organization (in this case, Los Alamos National Laboratory [Los Alamos]) and principal investigator to perform a review and assess the impact of the State's comments on the planned study. The assessment includes a determination as to whether or not a revision is warranted. If a revision is warranted, DOE's intention is stated in responses. If a revision is not warranted, additional information is provided on how the comment is being addressed, why it is inappropriate, or where the concern is being addressed if another study plan is at issue.

The State of Nevada's comments are generally concerned with how well the study plan defines the scope of the study and concern as to how well the study plan develops a well-focused sampling strategy which will characterize rock and fracture flow pathways using mineralogic, petrologic, and chemical data. In general, these comments indicate a lack of understanding of the study plan which may be due to a lack of clarity in the study plan or the inherent flexibility built into the scientific design. The study plan is now under revision by Los Alamos. Appropriate aspects of the State's concerns will be addressed in Revision 1 of the study plan.

If you have any questions, please contact Thomas W. Bjerstedt at (702) 794-7590.

for Maxwell Blanchard
Carl P. Gertz
Project Manager

RSED:TWB-2542

Enclosures:
1. State Comments on Study Plan 8.3.1.3.2.1
2. DOE Responses

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December 23, 1992

Dr. John W. Bartlett, Director
Office of Civilian Radioactive
Waste Management, RW-1
U.S. Department of Energy
1000 Independence Ave. S.W.
Washington, DC 20585

Dear Dr. Bartlett:

The State of Nevada has reviewed the DOE Study Plan "Study Plan for Mineralogy, Petrology, and Chemistry of Transport Pathways" (Study Plan 8.3.1.3.2.1, revision 0) and is providing its comments in this letter and attachment. The State's comments address the adequacy, completeness, and technical accuracy of the Study Plan to meet the Department's objective in site characterization.

The State has the following general comments relative to the subject Study Plan.

1. The purpose of this study is to characterize the mineralogy and associated parameters along ground-water flowpaths leading from the repository to the accessible environment. This study recognizes vadose and saturated-zone matrix and fracture flow pathways and accurately states that at Yucca Mountain, they are not well-defined. Due to this lack of definition, this study will investigate all possible flowpaths between the repository and the accessible environment. Given that the Study has the lofty goal of investigating all possible flowpaths, the study provides little confidence that scientifically the goal is achievable. It is doubtful that the Study can obtain conservative data representative of pre-emplacement behavior along critical pathways required for licensing.

ENCLOSURE 1

2. Given the indecision portrayed in the Study Plan relative to defining flowpaths for sampling, sampling techniques, quantity of samples, and the representativeness of the samples, there appears to be little value in the overall Study Plan as well as the study itself. Unless the overall unsaturated-zone program can define a focused well-planned sampling strategy that has the ability to intersect critical elements in the subsurface stratigraphy that can be used to characterize rock matrix and fracture-flow pathways between the repository and the accessible environment, characterization with respect to the performance objective as required by 10CFR60.113 will not be accomplished. Rigorous analytical efforts on poorly chosen samples will do nothing other than provide volumes of useless data. Predictive models of mineralogy and chemistry derived from such data through kriging exercises will be unconvincing. Therefore, this Study Plan demands significant revision. Improvement needs to be made on a conceptual design basis and not with respect to argumentative justification of the value of extrapolation techniques.

Should you have questions, this Office is available to meet with the Department to discuss the State's comments at any time.

Sincerely,

Robert R. Loux
Executive Director

RRL:CAJ

Attachments

✓ cc: Carl Gertz, YMPO
Joe Youngblood, NRC
Dade Moeller, NRC-ACNW
Dwayne Weigel, GAO
Steve Kraft, EEI
John Cantlon, NWTRB

ATTACHMENT

The State of Nevada comments on Study Plan 8.3.1.3.2.1 "Study Plan for Mineralogy, Petrology, and Chemistry of Transport Pathways.

1. It appears the objective of this study is to provide data for all possible flowpaths between the repository and the accessible environment. In order to provide these data, this study will characterize drill core, surface outcrops, and exploratory study facility (ESF) material. At this point in time, it is not known with certainty whether ESF drifts will penetrate the Calico Hills horizon, which has been designated as the primary barrier for waste isolation. The Calico Hills formation will be characterized by use of drillholes shown in figure 2 (a total of nine holes in the exploration block and about twelve holes outside the exploration block boundary). It is uncertain whether these drillholes are adequate to characterize all possible flowpaths. Drillholes in figure 1 (page p. 8) are not appropriately QA classed and therefore their utility is uncertain.

3.

2. Section 2.2 (page 6) discusses the types of measurements and determinations to be made. This section needs to match the types of measurements and determinations that are planned in the objectives of the study. Section 2.3 can then provide further rationale. At present, it is unclear how the measurements described in Section 2.2 will actually address the specific objectives of this study.

Textural relationships of minerals in fractures by SEM needs to be more detailed. For example, are crystal orientation studies going to be made?

4.

When abundance of minerals in fractures using X-ray diffraction are made, how will these data relate to mineral accessibility to fracture flow liquids? If a general scraping technique is being used to collect all authigenic minerals located on a fracture surface, this would presumably include authigenic minerals buried by other authigenic minerals. Knowledge of the authigenic fracture mineralogy, in part, is required for retardation studies. Minerals require accessibility to transport fluids if they are to provide sorption.

3. Section 2.4 describes the sampling program planned for this study. Subsection 2.4.1 describes the location of drillholes anticipated for sample collection. The distribution of the systematic drillholes presents the following problems:

5.

(1) Limited accessibility to zeolitic Calico Hills formation - the primary barrier.

(2) No apparent attempt towards drilling fracture-zone intersections within the Calico Hills formation to ascertain the potential retardation characteristics of the more likely paths of transport. An attempt to "investigate all possible flow paths" between the repository and the accessible environment is therefore not apparently being accomplished.

(3) Drillholes USW G-5 and USW G-6 are presumably located in the zeolitic Calico Hills formation. Only the WT-23 and WT-24 holes are located between the USW holes and the SD-1 and SD-2 holes. It is unknown what retrievable core data will be acquired from the WT holes (presumably only cuttings). Consequently, it will be difficult to establish a correlation that will be statistically valid between the SD hole and the USW holes. The utility of the USW holes will be limited with respect to characterizating flow pathways.

(4) "For purposes of characterization of potential transport pathways, the holes used need to be fully cored and extended to the first major laterally transmissive zone below the water table." (Section 2.4.1,p. 10, paragraph 3). This also has not been defined (with respect to the SD holes) as noted in the study plan. Consequently, drillholes G-5, G-6, and G-7 are to be used for characterization, neither of which is located within the exploration block boundary. There are apparently, therefore, only three drillholes that at present can be utilized to characterize transport pathways and these are outside the licensing zone.

5.

The Calico Hills formation is an ash-flow tuff which is presumably well-zeolitized in the north end of the exploration block and becomes increasingly vitric southward. Holes SD-1 and SD-2 are therefore the dominant locations for the penetration and characterizational of well-zeolitized Calico Hills formation, whereas UZ-2, UZ-3, UZ-8, UZ-7, SD-7, SD-8, SD-9, SD-10, SD-11, SD-12, and VSP-1 can be utilized to characterize the more vitric ash-flow tuff. Holes SD-3, SD-4, SD-5, and SD-6 can be used to assess the transition between the zeolitized and vitric areas. The distribution of sampling locations to obtain data characterizing the Calico Hills formation (the primary barrier) could be justifiable if the exploratory study facility would also penetrate the Calico Hills formation. As this is not known presently, a serious concern is raised as to the adequacy of sample distribution. Special concern is raised with respect to sorption characteristics within paths of most likely transport.

5. The systematic drilling program described in the SCP, indicates that the holes will be drilled to 100 feet below Static Water Level (SWL) and in this Study Plan, page 9, figure 2 hole depth is proposed to be at 200 feet below SWL. It is unknown which of the two, the Study Plan or the SCP, is correct in their notation.

4. Section 3.1.2. (page 15) discusses the required accuracy and precision for identification of minerals present in tuffs. The Plan indicates detection precision to ± 5% of the determined amount for bulk samples. There is no discussion of minerals which occur in percentages below 5%. Further the Plan is silient on whether X-Ray powder diffraction will include "unambiguous" volcanic glass determinations.

6. The section also discusses an analysis of fracture coatings and emphasizes that the primary purpose is the identification of minerals in fractures, not quantification of amount. If quantification of fracture coatings is not an objective, how will the acquired fracture mineral data be utilized for retardation-sorption studies. Further discussion is required.

5. Section 3.1.4 (page 16) addresses data reduction and analysis. Quant 5 and XRF-11 software procedures are critical with respect to defining a large portion of the study plan data. These procedures should be broken out and discussed on a more comprehensive basis.

7.

6. On page 16-17 the following statement is made:

"As outlined above, our ability to define the mineralogy along potential groundwater pathways from the repository to the accessible environment will ultimately be limited by our ability to predict the locations of these pathways, not by our ability to obtain mineralogic data for the site."

8. This statement underlines the basic issue relative to the value of this Study Plan. It appears that this Study Plan is written in a manner that attempts to justify a sampling strategy which was really not designed to locate and assess groundwater pathways. This Study Plan needs to recognize that criteria have to be set on what constitutes a pathway, to what extent it (that "pathway") can be recognized as a pathway, how well that pathway needs to be defined in a lateral and stratigraphic sense, and what mineralogical and chemical data need to be acquired in that pathway to respond to key characterization issues. A well-focused organizational framework is not evident. This problem is not unique to this Study Plan, rather it appears that this Study Plan is uniquely cognizant of these problems but is unable to resolve them with the Yucca Mountain program structure.

7. Page 21 discusses the determination of mineral and glass compositions. It should be noted that when analyzing volcanic glass, it will be important to obtain concentrations of water of hydration. The methods for these analyses need to be discussed. 9.

8. In Section 3.4 (page 23) the Plan states that isotopic data obtained on fracture-lining minerals and fluid inclusion data will be integrated with the results from this activity to interpret mineral paragenesis. The isotopic data needed for this integration should be outlined in this Section. 10.

Past-transport pathways studies are very important. It would be beneficial to discuss dating methods that might be used to ascertain the timing of various events beyond mineralogical overgrowth data.

9. Section 3.5 (page 26) describes a statistical evaluation of mineralogic, petrographic, and chemical data. The discussion fails to relate the statistical evaluation to the objective of the study: mineralogy, petrology, and chemistry of the transport pathways. Until the sampling program focuses on groundwater (transport) pathways, a statistical evaluation of the data has little or no validity. 11.

10. There is a serious attempt in this Study Plan to address the mineralogic and chemical characterization along groundwater flowpaths leading from the repository to the accessible environment. It is doubtful; however, that objectives of this study will be met given the constraints which include: 12.

(1) Poor sampling strategy;

(2) Lack of defining criteria, which provides recognition of such pathways; and

(3) An incomplete focus on analytical techniques that might be diagnostic in responding to the key objective and associated issues.

Responses to State of Nevada Comments on Study Plan 8.3.1.3.2.1, Revision 0, "Mineralogy, Petrology, and Chemistry of Transport Pathways"

Response to General Comment 1

DOE appreciates the State's concern over the ability of this study to obtain conservative data which is required for licensing, and which is representative of pre-emplacement behavior along critical pathways, and thus meet the study goal. The goal of this study, however, is to provide data on reasonable types of flow paths (fracture and matrix pathways, which may vary between stratigraphic units), not all possible flow paths as stated in the study plan. DOE is concerned with limited sampling of the Calico Hills unit and has maintained support for ESF access to this unit. The combined results of drill core and ESF-mined studies of the tuff of Calico Hills will provide sufficient information to characterize this geologic unit.

Moreover, DOE has studied supplementary sites for near-surface adit locations to host field-scale experiments in both vitric and zeolitic portions of the tuff of Calico Hills; a Los Alamos report is in preparation describing these sites.

This study plan is currently being revised, and Los Alamos will better explain the goal of the study.

Response to General Comment 2

A comprehensive and thorough program of sample analysis does not reflect indecision. Rather, Los Alamos' approach is based on the deliberate decision to investigate the already well-constrained major stratigraphic features at the Yucca Mountain site while also investigating significant discontinuities (e.g., fractures and faults). These investigations are covered in the study plan, but Los Alamos agrees with the State that the descriptions of the investigations are not as complete as they could be. Los Alamos is currently revising the study plan to address these points of clarification. In particular, text is being added to describe a future focus on transmissive discontinuities that can be recognized by using: (1) fracture mineralogy of young calcites and surface-derived deposits in the unsaturated zone, and (2) pumping-test results to define transmissive intervals in the saturated zone.

Kriging and other statistical methods will be used to test our models of stratigraphic mineralogy; it will not form the basis for these models. The stratigraphy of the Topopah Spring Member of the Paintbrush Tuff has been well established since the work of Lipman, Christiansen, and O'Connor (1966). The overlying units are thoroughly described by Scott and Bonk (1984). Our task is not to redefine these strata, but rather to evaluate the quantitative mineralogy and geochemistry of major units within this framework. This goal is well defined in the study plan. The State is correct in questioning the degree of confidence capable of being reached in understanding the deeper units, but we disagree with the conclusion that predictive reliability cannot

ENCLOSURE 2

be obtained. Since the initial drilling at Yucca Mountain began, reliable predictions have been made for the interception of the tuff of Calico Hills and the Crater Flat Tuff units in subsequent drill holes. There is no reason to assume that stratigraphic modeling will fail the test of future drilling and ESF exploration and, as stated above, quantitative data are meant to reside within this framework rather than define it or redefine it from previous work.

Responses to Detailed Comments in Attachment to the Letter

Response to Comment 3

The State is concerned that data for all possible flow paths be provided, when the data base will clearly not be able to sample every location of the site. This is not the intent of the study plan; rather, the goal is to provide data on all reasonable types of flow paths (fracture and matrix pathways, which may vary between stratigraphic units). The State's concern with limited sampling of the Calico Hills unit is understood, and Los Alamos supports ESF access into this unit. The combined results of drill core and ESF-mined studies of the tuff of Calico Hills will provide sufficient information to characterize this geologic unit. Moreover, supplementary sites for near-surface adit locations to host field-scale experiments in both vitric and zeolitic portions of the tuff of Calico Hills have been studied and a report describing these sites is in preparation.

The State is concerned that the utility of earlier drillhole data is uncertain; however, at a minimum these data can be and have been used to develop site concepts that will be tested by future drilling and ESF studies.

Response to Comment 4

The measurements discussed in Section 2.2 are appropriate to the objectives of this study. The purpose of this study, as stated in Section 1.1, is "to characterize the mineralogy, petrology, and chemistry along potential ground-water flow paths leading from the repository to the accessible environment." If the State were to suggest specific measurements that have not been considered, DOE would consider the suggestions.

Textural relationships have been and will be considered in this study in terms of depositional sequence and particularly of mineral distributions at fracture surfaces. Specific studies of crystal orientation are not planned because the minerals in the tuffs lack preferred orientation, although exceptions may be made if any significant orientations are observed.

The State recognizes that mineral abundances in fractures are less important than the effective distributions of minerals at fracture surfaces. It is planned to study the mineral exposures on fracture surfaces and estimate the percentages of minerals exposed in various types of fractures. Fracture surfaces are seldom uniformly sealed, and in general the fracture minerals are exposed at one point or another in a "patchwork" of mineralized surfaces along any given fracture. All fracture surfaces cannot be described, but previous work gives confidence that a useful description of distinctive types of fracture mineralization can be provided for each of the major stratigraphic units of importance at the site.

Response to Comment 5

The State is concerned that the drilling program planned for the site is inadequate for the purposes of this study. The State focuses on the surface-based drilling but does not give adequate weight to the additional information to be obtained by drilling or drifting in the ESF, information that will provide a large amount of information on the most critical faults and fracture zones at the site. It should also be noted that although core samples are required for intact fracture-mineralogy samples, a large amount of petrologic, chemical, and mineralogic data has been and can be obtained from cuttings.

The State is concerned that depths of penetration in the systematic drilling program are variably listed as either 100 or 200 feet below the static water level (SWL). Actually, the study plan cites these target depths as "100-200 feet below SWL," allowing for variable penetration.

Response to Comment 6

The State says that minerals that occur in percentages below 5% are not discussed. In fact, the State confuses detection limits and precision; the detection limits are 1-5% and future advances may provide precisions of better than +5% of the amount present. Unambiguous glass determinations are made by combined petrographic and XRD analysis.

Although a three-dimensional map of fracture-mineral abundances for all fractures and faults throughout the site cannot be provided, information will be obtained on the average types of fracture-coating mineral distributions for each of the major stratigraphic units. In addition, more detailed data will be obtained on particularly prominent or important fault and fracture zones that cross the potential repository horizon. Drifting or drilling from the ESF within the potential repository horizon will provide adequate sampling of such potentially transmissive features.

Response to Comment 7

Detailed discussions of software specifications are not appropriate within the study plan. Software implementation procedures are prepared to meet the requirements of the Yuca Mountain Site Characterization Project Quality Assurance Requirements Document, Revision 4.

Response to Comment 8

The State maintains that "this Study Plan needs to recognize that criteria have to be set on what constitutes a pathway, to what extent it (that "pathway") can be recognized as a pathway, how well that pathway needs to be defined in a lateral and stratigraphic sense, and what mineralogical and chemical data need to be acquired in that pathway to respond to key characterization issues."

Actually, all of these requirements except the last (mineralogical and chemical data) are not appropriate to this study plan but are covered instead by hydrology and paleohydrology study plans. The work performed under this study plan is not conducted in isolation from these studies, however. The work is currently conducted jointly on studies of fracture calcite ages, isotopic character, petrography, and chemistry. Determinations of young calcite deposits in fractures above the SWL by U-series dating point to some paths of relatively recent transport. Pumping data from below the SWL provide data on transmissive horizons in saturated rock. Such information provides the means of focusing studies to obtain more detailed data for demonstrated transport pathways.

Response to Comment 9

Water in volcanic glasses has been specifically analyzed by Moisture Evolution Analyzer (MEA).

Response to Comment 10

Isotopic data and radiometric data are described not in this Study Plan but in the "Study Plan for History of Mineralogic and Geochemical Alteration of Yucca Mountain" (8.3.1.3.2.2).

Response to Comment 11

This comment appears to inaccurately restate the objective of this study. The purpose is to define the mineralogy, petrology, and chemistry along potential flow paths. Inasmuch as these flow paths are not yet defined, the first-order task is to provide a description of these properties in the major rock types (devitrified, vitrophyric, vitric nonwelded, and zeolitic rocks) that comprise the volcanic stratigraphy of Yucca Mountain. The data to date suggest that this goal is attainable, and the statistical treatment of these data is both reasonable and prudent.

The State is correct in their recognition of the important task of identifying discrete transport pathways within the stratigraphic framework of various tuff rock types. This task was not adequately described in Revision 0 of the study plan, and Los Alamos will correct this inadequacy in the revision to Revision 1. However, the identification of flow paths rests principally with the U.S. Geological Survey's Hydrogeology and Paleohydrology tasks; our current studies are directed toward a more detailed mineralogic, petrologic, and chemical analysis of fractures above the SWL with relatively young minerals and of demonstrated transmissive intervals beneath the SWL.

Response to Comment 12

There are three enumerated parts to this comment. DOE responses to these are:

(1) The sampling strategy outlined in Section 2.4 of the study plan is valid. Suggestions that this strategy is too poor to meet our objectives ignore the stratigraphic nature of major rock types at Yucca Mountain - tuff is a highly variable rock type, but the variability is not chaotic. Revision of the study plan will add more discussion of additional samples to be obtained from the ESF.

(2) There are criteria to define transport pathways, such as the distributions of young calcite deposits in fractures and the distribution of transmissive intervals beneath the SWL. The study plan revision underway for the study plan will take these criteria into account and allow the flexibility to use other such criteria that may be developed as site characterization proceeds.

(3) The analytical techniques being used are quite comprehensive, considering the objectives of the task. If the State has specific techniques that they wish to be used, DOE will be glad to consider them.

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Yucca Mountain Site Characterization
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WBS 1.2.5.2
QA: N/A

MAR 0 8 1993

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U.S. DEPARTMENT OF ENERGY (DOE) RESPONSES TO STATE OF NEVADA COMMENTS ON STUDY PLAN 8.3.1.17.4.6, REVISION 0 (QUATERNARY FAULTING WITHIN THE SITE AREA)

Enclosed are responses to 14 comments made by the State of Nevada on the subject study plan in a letter dated January 4, 1993 (enclosure 1). Enclosure 2 contains DOE's responses.

For comments on DOE-approved study plans, the Yucca Mountain Site Characterization Project Office (YMPO) asks the responsible participant organization (in this case, U.S. Geological Survey) and principal investigator to perform a review and assess the impact of the state's comments on the planned study. The assessment includes a determination as to whether or not a revision is warranted. If a revision is warranted, DOE's intention is stated in the responses. If a revision is not warranted, additional information is provided on how the comment is being addressed, why it is inappropriate, or where the concern is being addressed if another study plan is at issue.

The State of Nevada's comments generally concern the perceived completeness and technical accuracy of the study plan. Most of the concerns involve inconcise wording in parts of the study plan and are rather minor. YMPO does not believe the comments alone warrant a revision. The actions identified in the responses will be undertaken if or when the study plan is revised in the future. Some of the state's concerns are also addressed in other study plans, and these are so indicated.

If you have any questions, please contact Thomas W. Bjerstedt at (702) 794-7590.

Carl P. Gertz
Project Manager

[redacted]

Enclosures:
1. State Comments on Study Plan 8.3.1.17.4.6
2. DOE Responses to State Comments

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January 4, 1993

John W. Bartlett, Director
Office of Civilian Radioactive
Waste Management
U.S. Department of Energy
Washington, D.C. 20585

Dear Dr. Bartlett:

The State of Nevada has reviewed the DOE Study Plan "Quaternary Faulting Within the Site Area", Rev. 0, (Study Plan 8.3.1.17.4.6) and is providing its comments in this letter and attachment. The State's comments address the adequacy, completeness, and technical accuracy of the Study Plan to meet the Department's purpose in site characterization.

The State has three general comments regarding the subject Study Plan:

1. The Study Plan describes plans to use a scale of 1:24,000 for the final map of Quaternary faults. The State considers this scale to be inadequate to show the necessary detail of the faulting. For example, at the scale of 1:24,000, fault segments and possible interconnections between faults would be extremely difficult to adequately illustrate. The Study Plan also states that locations of well-exposed faults would be plotted to within a few tenths of a millimeter (5 meters on the ground). At the proposed scale, these measurements would be about the width of a pencil point. We suggest that a scale of 1:6,000 as used by the USGS be the mapping scale with supplemental compilations on 1:12,000 or 1:24,000-scale for illustrative purposes, if necessary.

ENCLOSURE 1

2. In the Purpose and Objectives of the Study section, the site area for this study is defined as an area of about 240 km^2 that "encompasses the controlled area". What are the dimensions of this controlled area? To our knowledge, there has never been a consistent definition of the controlled area by the Department. Furthermore, the proposed area to be mapped does not include portions of, or, in some cases, entire Quaternary faults. For example, the Stagecoach Road fault, the northern end of the Paintbrush Canyon fault, and the southern portion of the Windy Wash fault are not included in the site area. The study area should be enlarged to include the entire tectonic package of faults at or near Yucca Mountain in order to get an accurate picture of the paleoseismic history of the site.

   In fact, the studies of the paleoseismic histories of the Quaternary faults at and near Yucca Mountain are fragmented to such a degree that it is nearly impossible to determine which study will be specifically responsible for the comprehensive characterization of the total tectonic package at Yucca Mountain. For instance, the Midway Valley Study Plan (8.3.1.17.4.2) indicates that the characterization of the Midway Valley fault will be completed by this study (8.3.1.17.4.6), yet the fault is not discussed in this study. It would be more logical to expand this study to include a comprehensive assessment of all faults at and near Yucca Mountain.

3. Given the recent seismic event at Little Skull Mountain, the Department should revise the Study Plan to include investigations into other possible blind seismic sources.

   Specific comments are listed in the attachment.

We look forward to your response to the State's comments. Should you have any questions, this Office is available to meet with the Department at any time.

Sincerely,

Robert R. Loux
Executive Director

RRL:cs
Attachment

cc: Carl Gertz, YMPO
Joe Youngblood, NRC
Dade Moeller, NRC-ACNW
Steve Kraft, EEI
Dwayne Weigel, GAO
John Cantlon, NWTRB

ATTACHMENT

1. On page 1-2, the statement is made that the study will identify faults within the repository block that have more than 1 meter of Quaternary offset and faults that would intersect the underground facilities that have inferred slip rates of more than 0.005 mm/yr. How were these criteria determined for selecting faults for study? The study plan fails to recognize the post-closure performance issue that would come with displacement on <u>any</u> fault, regardless of length, that in effect changes the hydrologic model. 4.

2. On page 1-3, there is the statement that "information is needed to reduce the likelihood that the underground facilities will be located in areas of potentially active faults...so that the repository and its engineered barriers will comply with 10 CFR 60 and 10 CFR 960". The DOE criteria in 10 CFR 960 for siting in areas of active faulting are exclusionary. How does this statement in the Study Plan correlate to the criteria in 10 CFR 960? 5.

3. On page 2.1-1, paragraph 1, it is suggested that, in addition to the phrase "information on faults along which Quaternary movement is known or suspected...", the words "or cannot be demonstrated not to have occurred" be added. 6.

4. On page 2.1-1, paragraph 2, the study plan states that as <u>relevant</u> (emphasis added) information becomes available, it will be updated and incorporated. What is the DOE definition of "relevant information" and how will the determination of "relevance" be made? 7.

5. On page 2.1-2, paragraph 2, the study plan indicates that DOE will identify and characterize <u>major known potentially significant</u> Quaternary faults only within 5 km of the FITS (Facilities Important to Safety). Will this area be sufficient to sufficiently characterize the potential for seismic movement that could affect the repository? Also, please define the phrase "major known potentially significant" as used in this paragraph. 8.

6. On page 3.1-5, paragraph 3, the study plan states that the information obtained will be representative of faults that have offset of more than 1 meter and/or faults that have slip rates greater that 0.005 mm/yr. It seems logical to the State that <u>any</u> fault exhibiting Quaternary offset, if they intersect or could potentially intersect the repository block, should be investigated in considerable detail. According to Wells and Coppersmith, 1991, displacement of 1 meter would be the equivalent of a Mw 6.5 earthquake. Given the recent 5.6 magnitude earthquake at Little Skull Mountain and the public interest that this event generated, it would appear that faults with smaller offsets should also be investigated. 9.

10. 7. On page 3.1-5, paragraph 5, the study plan states that some data gaps and uncertainties are likely to occur that will impose limitations on the ability to recognize and characterize Quaternary faults in the site area. Given this statement, how does DOE intend to satisfy 10 CFR 60.122 regarding the extent to which a hazardous natural condition could be present and still be undetected?

11. 8. On page 3.2-2, paragraph 2, the study plan discussed the numerical dating methods to be used in this study. Numerical age-dating of Quaternary stratigraphic datums is limited to the use of uranium-series, uranium-trend, and cation-ratio techniques and on page 2.2-1, it is stated that there are no reasonable alternatives. To the contrary, there are several additional techniques available and the study plan should incorporate as many of these as possible in order to cross-verify dating results, increase confidence, and reduce analytical uncertainty in probabilistic analyses.

12 9. On page 3.2-4, paragraph 1, mention is made of a "metric camera". Please explain what a metric camera is and its purpose.

13. 10. On page 5-1 and Figure 5-1, the State supports the issuance of interim reports on each one of the major fault systems. One element missing from the schedule is the mapping and evaluation of "other suspected and possible fault zones", as indicated in test methods and procedures on page 3.2-3.

14. 11. In the reference section, the references should include the 1:12,000 high and low angle photographic databases and the 1:6,000 high angle photos and topographic data of the USGS.

RESPONSES TO STATE OF NEVADA COMMENTS
ON STUDY PLAN 8.3.1.17.4.6,
"QUATERNARY FAULTING WITHIN THE SITE AREA"

Response to General Comment 1

The U.S. Department of Energy (DOE) appreciates the State of Nevada's comment; however, the 1:24,000 scale maps (standard topographic map bases) are entirely adequate for displaying pertinent Quaternary fault data. The location and other measurements on faults exposed in trenches will be shown on much larger scale maps as indicated in the study plan.

The primary purpose of mapping faults at 1:24,000 is to highlight their potential interconnectivity. This characteristic is made more apparent at smaller map scales. Producing fault maps at larger scales in a geologic terrain where little bedrock exposure and much alluvial cover exists will not proportionately increase the number or length of known, as opposed to inferred, fault traces that are able to be mapped. Scott and Bonk's 1984 map of the eastern part of the site area will have companion maps to the west and south that are to be published by the U.S. Geological Survey (USGS) at a scale of 1:12,000.

The fault mapping under Study Plan 8.3.1.17.4.6 is being done on 1:12,000 scale aerial photographs and, in some cases, on 1:6,000 scale low sun angle aerial photographs where these are available. This information will then be compiled onto a 1:24,000 base map. The USGS believes that there is no loss of information in mapping faults at 1:24,000. This is a pragmatic scale for the area being studied and the ratio of exposed to covered faults.

Response to General Comment 2

The controlled area is conceptual at this time. It is identified in Site Characterization Progress Reports 5, 6, and 7 in Figures 1.1 and 1.2. The term "controlled area" will be deleted in the first paragraph in Section 1 (page 1-1) in any subsequent revision of the study plan. Of primary importance to the study is the "site area," the boundaries of which are shown on Figure 1-2 and which defines the area to be studied. The site area boundaries shown on this figure were taken from the Site Characterization Plan (SCP), see Figure 8.3.1.17-11 (page 8.3.1.17-104). Quaternary faults (or fault segments) outside the site area will be studied as part of Study 8.3.1.17.4.3 (Quaternary Faulting Within 100 km of Yucca Mountain, Including the Walker Lane) and a synthesis of all faulting and other tectonic phenomena is planned in Study 8.3.1.17.4.12 (Tectonic Models and Synthesis).

Response to General Comment 3

The recent earthquake at Little Skull Mountain is outside the scope of this study because the study plan's focus is on past faulting history in the area. This is especially true for the Little Skull Mountain event insofar as no surface rupture occurred. Studies that will address recent seismic activity, such as that which took place at Little Skull Mountain on July 28, 1992, would be primarily under the purview of Study 8.3.1.17.4.1 (Historical and Current Seismicity) as well as the other studies identified in the response to Comment 2. It is uncertain to what the reference to "other possible blind seismic sources" refers.

ENCLOSURE 2

Responses to Detailed Comments in Attachment

Response to Comment 4

Parameters for the study of fault movements are established in the SCP (see SCP Tables 8.3.1.17-4a and 4b). The overall objective of the investigation is to identify and characterize (by location, orientation, length, width, recurrence interval, etc.) all known or suspected Quaternary faults that (1) intersect or project toward the surface facility, repository, or controlled area, and (2) pose a potential for future ground motions that will affect same. The study will report on the fault parameters as observed and measured, but determination of their ultimate effect on the hydrologic regime and the repository as a whole is undertaken by other studies (such as Study 8.3.1.17.4.12 [Tectonic Models and Synthesis]).

Response to Comment 5

10 CFR 960.4-2-7(d) states that "A site shall be disqualified if, based on the geologic record during the Quaternary Period, the nature and rates of fault movements or other ground motion are expected to be such that a loss of waste isolation is likely to occur." This requirement does not include all Quaternary faults as disqualifying conditions, but only those faults whose offsets and displacement rates exceed certain limits primarily established in the SCP. The statement in question (first sentence, top of page 1-3 in Study Plan 8.3.1.17.4.6) refers primarily to the overall objective of identifying all known or suspected Quaternary faults and measuring the designated fault parameters to eliminate, or at least greatly minimize, the possibility that facilities will be located in fault-prone areas.

Response to Comment 6

The wording will be added, as suggested, in any subsequent revision.

Response to Comment 7

"Relevant information" includes data from other site characterization studies (such as seismic surveys, excavation of the Exploratory Studies Facility, drilling, surficial deposit and bedrock geologic mapping, etc.) that can be used to help determine magnitude and rates of fault movement on Quaternary faults within the site area. Germane technical reports by the Nuclear Waste Project Office are considered relevant information that the principal investigators would seek to evaluate.

Response to Comment 8

Wording "major known potentially significant" is redundant and will be deleted in any subsequent revision. The term "potentially significant" is sufficient to include all those faults that are known or suspected to have been active during the Quaternary, which is the major objective of this study. With regard to the 5-km limit of the conceptual controlled area, faults that occur outside this area are the subject of Study 8.3.1.17.4.3 (Quaternary Faulting Within 100 km of Yucca Mountain, Including the Walker Lane), Study 8.3.1.17.4.4 (Quaternary Faulting Proximal to the Site Within Northeast Trending Fault Zones), and Study 8.3.1.17.3.1 (Relevant Earthquake Sources).

Response to Comment 9

As stated in Study Plan 8.3.1.17.4.6 (Section 3.1.8, page 3.1-5), the study is designed to yield comprehensive information on all known or suspected Quaternary faults, regardless of their offsets and displacement rates, and to identify and characterize as many hitherto unrecognized faults that cut Quaternary deposits in the site area as is possible from the evidence at hand. Hence, there are no limits being imposed insofar as the magnitudes of fault movements are concerned for the overall study. The term "representative" links back to the characterization parameters set forth in the SCP.

Response to Comment 10

The study plan discusses the limitations and uncertainties that may pertain to the use of the results of a Quaternary fault study and hence affect the representativeness of those results. Such a discussion at the bottom of page 3.1-5 and top of page 3.1-6 of Study Plan 8.3.1.17.4.6 recognizes the fact that field relationships cannot always be used to make unequivocal interpretations, and further, that if the relationships are obscured beyond a certain degree, a fault could possibly go undetected. A list of some of the factors that contribute to the uncertainties is presented on page 3.1-6. Such uncertainties are expected to have minimal effect on the representativeness of field relationships, even though there is no guarantee that all faults will be detected, despite the detailed mapping and related activities that are being planned.

Response to Comment 11

Although the study plan focuses on uranium-series, uranium-trend, and cation-ratio age-dating techniques, the study plan also prescribes use of any and all available methods that will provide the best information for dating fault movements. Tephrochronology based on K-Ar and fission-track techniques are also mentioned (page 2.2-1). Thermoluminescence can also be employed.

Response to Comment 12

A metric camera is especially designed to provide precise photogrammetric measurements. Many recent types of cameras may also be of comparable quality, hence the word "metric" will be deleted.

Response to Comment 13

The USGS agrees with this comment and in any subsequent revision to the study plan will include other suspected and possible fault zones in the mapping.

Response to Comment 14

It is not appropriate to include unpublished items of this nature in study plan reference lists. The aerial photographs upon which mapping in the field takes place are part of a data records package according to USGS Technical Procedure GP-01.