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STATE OF NEVADA

AGENCY FOR NUCLEAR PROJECTS/ NUCLEAR WASTE PROJECT OFFICE

STATE OF NEVADA COMMENTS

ON THE

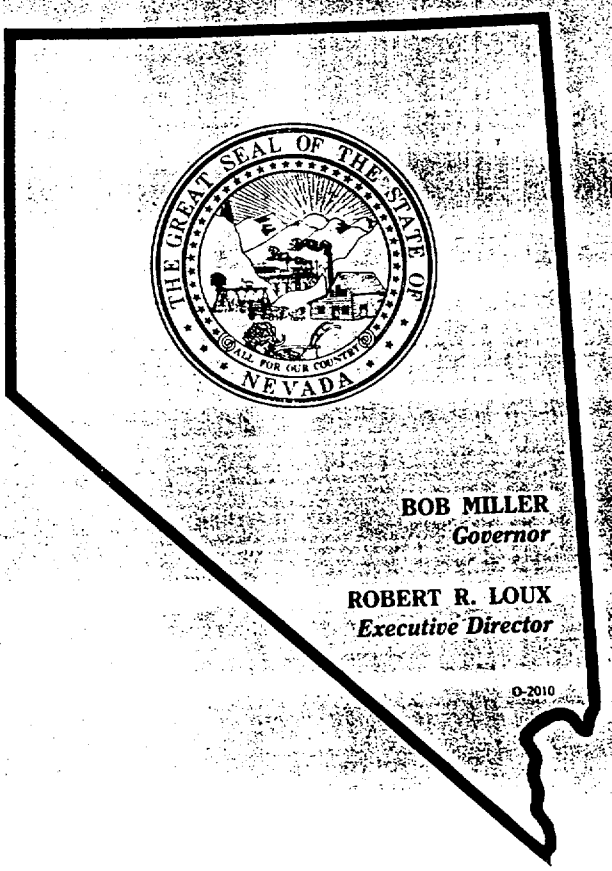
U.S. DEPARTMENT OF ENERGY

SITE CHARACTERIZATION PLAN

YUCCA MOUNTAIN SITE

NEVADA

VOLUME II



BOB MILLER
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STATE OF NEVADA COMMENTS

ON THE

U.S. DEPARTMENT OF ENERGY

SITE CHARACTERIZATION PLAN

YUCCA MOUNTAIN SITE

NEVADA

VOLUME II

PREPARED BY

NEVADA AGENCY FOR NUCLEAR PROJECTS/
NUCLEAR WASTE PROJECT OFFICE

SEPTEMBER 1989

COMMENTS OF

MIFFLIN AND ASSOCIATES

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Review of:

Site Characterization Plan
Yucca Mountain Site, Nevada Research and Development Area, Nevada
DOE/RW-0160, December 1988.

for

State of Nevada
Nuclear Waste Project Office
Agency for Nuclear Projects
Carson City, Nevada

by

Mifflin & Associates, Inc.

June 1989

Approved by (Project Manager or Designee) : _____ Date: July 3, 1989

Accepted by (Administrator of Technical Programs or Designee): _____ Date: _____

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SUMMARY STATEMENT

"What you see depends mainly on what you look for."

We find the Site Characterization Plan: Yucca Mountain Site, Nevada Research and Development Area (DOE/RW-0160) seriously deficient, in terms of establishing an investigative program to confidently characterize hydrogeologic and closely-related aspects of the proposed repository, in the vadose zone at Yucca Mountain. Most hydrogeological licensing criteria indirectly measure waste isolation provided by the geologic environment during pre- and postclosure conditions. We believe the Site Characterization Plan (SCP) generally fails to establish scientifically sound and feasible programs of investigation that will, in a timely and confident manner, resolve most of the hydrogeologic and geochemical licensing issues that have been recognized since the vadose-zone repository was first proposed at this location in 1982.

The SCP generally fails in its responsibility because it does not objectively set aside the DOE conceptual model of a "dry" repository environment with extremely slow flow of water confined to the rock matrix. In the SCP, the DOE fails to establish a scientifically sound investigative program that seriously tests for hydrogeologic conditions based on the range of existing data and general knowledge. Rather, the DOE builds a probabilistic program upon a preconceived conceptual model, without designing a field-data collection program with the power to test the validity of the conceptual model. This is unacceptable in that the DOE program, as described in the SCP, plans to build numerical model after numerical model upon untested conceptual models, in attempts to "resolve" the fundamental licensing issues of waste isolation by the geologic barrier. If executed as planned, these analyses will have only a series of assumptions for their foundation and, therefore, can not resolve licensing issues. In unkind words, the SCP is a document that generally lays a plan of information management for the hydrogeological and geochemical issues, instead of a plan for scientifically valid site characterization.

In our judgment, the sparse database currently available raises very serious questions as to whether or not the Yucca Mountain site offers sufficient waste isolation to meet licensing criteria. There is no site-specific evidence which convincingly indicates the site meets site-selection criteria in terms of ground-water travel time. Clearly, the site is complex due to the highly-fractured volcanic formations and the generally undocumented behavior of gases and liquid transport in the vadose-zone environment. Therefore, carefully-designed comprehensive field investigations are required to resolve the complexity of hydrogeologic licensing issues. We believe that the site could be confidently characterized in terms of most, if not all, geochemical and hydrogeologically-related waste isolation issues, if the DOE would set aside its site-advocacy approach and seriously enter the realm of site characterization on the basis of open and objective scientific inquiry.

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INTRODUCTION

"Science is a first rate piece of furniture for a man's upper chamber, If he has common sense on the ground floor."
- Oliver Wendell Holmes, 1872 -

The Nuclear Waste Policy Act of 1982 (NWPA) and 10 CFR 60 require the U. S. Department of Energy (DOE) to submit a Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada, DOE/RW-0199 (SCP) to the U. S. Nuclear Regulatory Commission (NRC), affected States and Indian Tribes, and the general public for review and comments prior to the construction of the test shaft at Yucca Mountain. Early in 1988, the DOE provided the NRC and the State of Nevada with the Consultation Draft of the Site Characterization Plan, DOE/RW-0160 (CD-SCP). Mifflin & Associates, Inc. (MAI) has reviewed that document from the hydrogeologic and closely-related perspectives for the Nuclear Waste Project Office of the State of Nevada. In December 1988, the DOE provided the NRC and the State of Nevada with the SCP. MAI is providing a review of the SCP, again from the hydrogeologic and closely-related perspectives for the Nuclear Waste Project Office of the State of Nevada.

> "As defined in 10 CFR Part 60 **site characterization** means the program of exploration and research, both in the laboratory and in the field, undertaken to establish the geologic conditions and the ranges of those parameters of a particular site relevant to the procedures under Part 60. Site characterization includes borings, surface excavations, excavation of exploratory shafts, limited subsurface lateral excavations and borings and in-site testing at depth needed to determine the suitability of the site for a geologic repository. It does not include preliminary borings and geophysical testing needed to decide whether site characterization will be undertaken." (DOE, OGR/B-5, 1987).

Part A of the SCP, consisting of Chapters 1 through 7, describes the DOE mined geologic-disposal system in terms of what is known at the present time:

Chapter 1 - Geology
Chapter 2 - Geoengineering
Chapter 3 - Hydrology
Chapter 4 - Geochemistry
Chapter 5 - Climatology and Meteorology
Chapter 6 - Conceptual Design of a Repository
Chapter 7 - Waste Package

Part B is the DOE site-characterization program, which has been devoted to discussions of issues, issue-resolution strategies, informational needs, etc., and based on these considerations, the planned programs and investigations to accomplish site characterization.

The working elements of the SCP are structured as follows: program, investigation, study, activity, and subactivity, listed in descending hierarchy. Specific reviews have been established at the activity level, occasionally at the subactivity or study level, when appropriate. Each activity, in the SCP, is reviewed in terms of: 1) conceptual completeness and focus; 2) appropriateness of methodology to accomplish stated objectives; 3) availability of supportive technology; and 4) probability of success and/or feasibility. The following SCP programs have been reviewed:

8.3.1.2	Geohydrology Program
8.3.1.3	Geochemistry Program
8.3.1.4	Rock Characteristics Program
8.3.1.5	Climate Program
8.3.1.7	Rock Dissolution Program

8.3.1.12	Meteorology Program
8.3.4.2	Waste Package Program
8.3.5.10	Performance Assessment Program - Engineered Barrier System Release Rates
8.3.5.12	Performance Assessment Program - Ground-water Travel Time
8.3.5.13	Performance Assessment Program - Total System Performance
8.3.5.15	Performance Assessment Program - Ground-water Protection
8.3.5.20	Performance Assessment Program - Analytical Techniques Requiring Development

We find the SCP little changed from the CD-SCP in terms of activity substance. Where appropriate, we therefore have repeated some of what we believe were key comments made by MAI on the CD-SCP. However, we suggest that both MAI comment documents be considered for the most comprehensive technical evaluation of the DOE site characterization plan.

Authorship

The following have provided input for review:

Dr. O. A. Adenle
Dr. Atef Elzeftawy
Dr. M. D. Mifflin
Dr. M. E. Morgenstein
Dr. D. L. Shettel, Jr.

OVERVIEW COMMENTS

**"Study without reflection is a waste of time,
Reflection without study is dangerous."**

GENERAL COMMENTS

The following SCP objectives are stated in the Annotated Outline for Site Characterization Plans (DOE, February 1987, pp. xii to xiv):

"The purpose of the SCP is to provide a document in which the DOE:

- **Describes** the **site**, **design** of a repository **and engineered barriers** appropriate to the site, waste packages, emplacement environment, and performance analysis **in sufficient detail** so that the planned site characterization program may be understood.

- **Identifies** the uncertainties and **limitations** on site- and design-related information developed during site screening, including **issues** that need further investigation or for which additional assurance is needed.

- **Describes** the detailed programs for additional work, including **performance confirmation**, to (1) resolve outstanding **issues**, (2) reduce uncertainties in the data, and (3) make site suitability findings relative to DOE siting guidelines, 10 CFR 960.

The SCP will provide a vehicle for early NRC, State, Indian tribal, and public input on the DOE's data-gathering and development work so as to avoid postponing **issues** to the point where modifications would involve major delays or disruptions in the program. Early review of the DOE's site characterization plans as presented in the SCP will provide an opportunity for the NRC to evaluate whether the DOE's proposed program is likely to generate data suitable to support a license application." (OGR/B-5, p. xiii).

We find that in the SCP, the DOE substantially, but not completely, meets the first objective. We find that the DOE does not consistently meet the second and third objectives. The DOE **does not consistently describe the detailed programs** to: 1) resolve outstanding **issues**; 2) reduce uncertainties in the data; and 3) make site-suitability findings relative to the DOE siting guidelines, 10 CFR 960.

We find that the DOE **does not entirely** establish what is known about Yucca Mountain from site-exploration activities to date. Many, if not most, aspects and findings are freely and fully discussed, but key findings, such as evidence of perched water within the vadose zone and important observations of gas-circulation gradients within the vadose zone are omitted. These omissions could prove to be the **most fundamental findings** to date with respect to the site's ability to isolate waste.

With respect to the second objective, a major issue of fracture flow in the vadose zone has been deemed so unimportant by the DOE that the resolution activity is to be primarily laboratory experiments. Therefore, we judge the DOE program plan **to be fundamentally deficient** with respect to resolving this issue by reducing or eliminating the uncertainties about fracture flow in the vadose zone.

With respect to the third objective, the DOE frequently fails to provide enough details in the activity plans to confidently judge the plans. This is a very serious deficiency, because a large number of the activities are of an applied research nature with no precedent methodologies established.

The following questions are intended to be addressed by the DOE in the SCP (DOE, OGR/B-5, February 1987):

"• Have the important information needs and unresolved issues been identified?

- Does the SCP specifically address these information needs and present program plans to obtain the needed information?
- Are the methods of testing and analysis proposed for the planned site characterization program appropriate?
- Have alternative methods of testing and analysis been identified and evaluated, and has an adequate basis been provided for the selection of the methods to be used?
- Will the data to be collected and the reliability of the collection methods and analysis be of adequate quality to support site selection and a future license application?
- Have the testing plans been based on the performance requirements of the Mined Geologic Disposal System (MGDS) components, and are the tests adequate to enable evaluation of whether or not the MGDS components will perform as required?"

We recognize aspects where the SCP is seriously deficient in all of the above points of question. We think that important negative answers can be given for the first five questions, when aspects of vadose-zone hydrology are considered. Point six, discussion of whether tests are adequate to enable evaluation of the expected performance of the MGDS, is not recognized in the SCP. We assume that such testing requires characterizing a combination of dynamic thermal loading and unloading, multiphase water transport, and dissolution processes based on in-situ geochemistry, all acting upon the engineered barriers.

We find the SCP, when judged by the data development/analyses activities is unlikely to create a technical program that will establish viable databases to resolve or answer several of the important issues. The basis for this statement can be further examined in activity reviews. Many DOE activities are poorly designed and/or focused with respect to available technology. Many others are not feasible with respect to combinations of time, financial resources, and human and laboratory resources. Idealistic approaches, with much modeling in the face of little or no data and marked uncertainties with respect to processes operating, characterize the DOE planned technical program. In the SCP, DOE is very consistent in utilizing numerical models (using existing, or newly-developed, and/or to be developed codes) for the resolution of the characterization issues created by the complexity of the site and the very limited databases.

In our opinion, all the DOE programs and activities, as described in the SCP, need to be carefully screened, focused, and modified into feasible, well-coordinated activity programs that could be completed in five or six years. Each program (investigation, study, and activity) **needs the benefit of peer review by experts** experienced in both theory and field investigation.

Further, in an appropriate SCP, DOE would clearly identify and rank the most likely fatal flaws (issues) of the geologic-barrier system of the site, to **prioritize** and coordinate site-characterization studies. This has not been done. In the SCP, DOE generally fails to establish a vadose-zone fracture flow/travel time issue-resolution program that will work, and does not address the need for a research program to establish the impacts of the thermal envelope and the associated extent of the disturbed zone, caused by the heat-induced hydrothermal system. Such a disturbed system has major potential to impact waste isolation.

Additionally, we find that the DOE has almost totally failed to address alternative hypotheses in the SCP. Alternative hypotheses have been tabled in their respective SCP sections; however, no

constructive additions or deletions have been made to the activities themselves to indicate that alternative hypotheses are in fact being considered any more so than they were in the CD-SCP. In the CD-SCP, alternative hypotheses are totally ignored.

DOE GOALS

"You can't make a silk purse out of a sow's ear."

A very disquieting presentation characteristic of the SCP is the apparent DOE perception that the proposed Yucca Mountain site can be made better or worse, in terms of geologic-barrier performance, just as an engineered system can be made better or worse by design changes. This conceptual approach has flavored the DOE selection process (Draft Environmental Assessment [DEA], Environmental Assessment [EA], and CD-SCP documents) and continues in the SCP. Explicit examples occur throughout the SCP discussions and in tables, such as Table 8.3.1.5-1 on pages 8.3.1.5-4 and 5. This table, dealing with site performance during a climate change, shows a column of initiating events or processes, and another correlating column entitled "tentative goal," which gives the currently perceived extreme values that would be acceptable. The title "tentative goal" would be appropriate for an engineered barrier, where engineered design determines performance. **A natural system, the geologic barrier, can not be altered once the site has been selected.** There is no goal; therefore, there is only performance characterization. Geologic and hydrogeologic aspects can only be **characterized** to varying degrees of accuracy as to how they will perform in waste isolation. Therefore, if the DOE correctly perceives that its mission is to characterize the site and to establish whether the repository should be built, the many "tentative goal" columns would be more appropriately termed "performance requirement" or "tentative performance requirement." The term "goal" is widely used in the SCP, and should not be used in the SCP for uncontrollable geologic and hydrologic aspects of the specific site. Performance goals are fine for engineered aspects.

TIME PERIOD FOR SITE CHARACTERIZATION

It is unlikely that the DOE site-characterization program, depicted in the SCP, will produce a diagnostic picture of performance, based upon real world data collection and analysis, in the limited time period available for study. Further, it is doubtful whether the majority of the results obtained from the site-characterization efforts described in the SCP will be made public prior to licensing application. We view the tabled schedules associated with most investigations as extremely unrealistic goals. With Quality Assurance/Quality Control (QA/QC) programs and numerous technical procedures (apparently both untried and undeveloped) required for the majority of the activities in the hydrogeologic studies, we judge that at least double, and perhaps triple, the scheduled five (5) years will be required to attempt to execute the activities, as conceptually described in the SCP. In our opinion, the general approach adopted by the DOE is extremely unrealistic and unprecedented. This gives us real pause, because costs will be more or less proportional to time spent on the characterization study.

SITE ASSESSMENT APPROACH

The implicit motto of the SCP is that the Yucca Mountain site can be characterized by modeling efforts. Models will even be used to verify field data, according to the SCP! This approach places the resolution of site selection and performance issues on a conceptual model/probabilistic foundation, and undermines a conservative and comprehensive data collection effort (a deterministic approach), which we view as a minimum requirement to confidently assess site characteristics and to meet licensing application standards.

In addition to an overreliance on modeling, key aspects of DOE data collection are either omitted or poorly addressed in the SCP. A serious example of this is the treatment of the Calico Hills Formation, which is a key tuff horizon for travel time and sorption credit. Figures 1 and 3 depict the number and spatial distribution of sampling locations that the DOE will use to characterize these two performance

issues. This level of effort does not represent a serious approach towards addressing these issues, hence they will remain an enigma. Figure 2 shows the locations of drillholes that have penetrated the Calico Hills Formation. Quality assurance and drilling methodology problems have limited the full extent of utility of these holes with respect to site characterization. It appears that the DOE pre-site characterization efforts are more extensive and intensive than characterization efforts proposed in the SCP. This is a critical deficiency. Unless this is corrected, the DOE-generated, site-specific data could not meet licensing requirements.

EFFICIENT APPROACH TO SITE ASSESSMENT

In our opinion, the most cost-effective and time-saving approach to site characterization is to concentrate intensive site-specific data-collection programs on the most likely fatal flaws of the site. This is in contrast to the DOE approach, which, according to the SCP, assumes there are none, and therefore mounts programs that may avoid early detection of existing fatal flaws.

The best way to put to rest a potential fatal flaw that does not exist is to attempt, in a serious and comprehensive manner, an investigative program that will identify the flaw on the basis of hard data. The following is our list of the potential fatal flaws of the site in terms of licensing criteria:

I. Fracture-flow dominant in terms of total flux from the repository horizon to the water table. Travel times are therefore short.

II. The disturbed zone is very extensive due to the hydrothermal transport/condensation fracture flow system that will be triggered by the waste heat. Extensive zones of saturated fractures will occur above and below the repository.

III. Pluvial-climate conditions will cause marked increases in fracture flow/water perching due to about a 10 fold increase in recharge. The water table may rise significantly.

IV. Retardation/sorption can only occur in the Calico Hills Formation, if the majority of flux is via the rock matrix in this unit. If fracture flow occurs in this unit, minimal to no retardation can be claimed.

V. Fracture continuity and effective soil-gas storage is such that there is very rapid gas-phase exchange between the repository horizon and the land surface.

The SCP, as presently constituted, dances around these "fatal flaw" issues, with either no program or weak programs that may not satisfy the NRC, the State of Nevada, or the scientific community in general, after execution. If one or more flaws are encountered, the rest of the characterization program can be put on hold until the DOE, the NRC, and the State of Nevada resolve whether licensing has been precluded.

REFERENCES

10 CFR 60, Code of Federal Regulations, 1987. Title 10, "Energy," Part 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories," U. S. Government Printing Office, Washington, D. C., p. 627 to 658.

10 CFR 960, Code of Federal Regulations, 1987. Title 10, "Energy," Part 960, "General Guidelines for the Recommendation of Sites for Nuclear Waste Repositories," U. S. Government Printing Office, Washington, D. C., p. 518 to 551.

Nuclear Waste Policy Act of 1982, Public Law 97-425, 42 USC 10101-10226, Washington, D. C.

U. S. Department of Energy, 1987, Annotated Outline for Site Characterization Plans, OGR/B-5, Washington, D. C.

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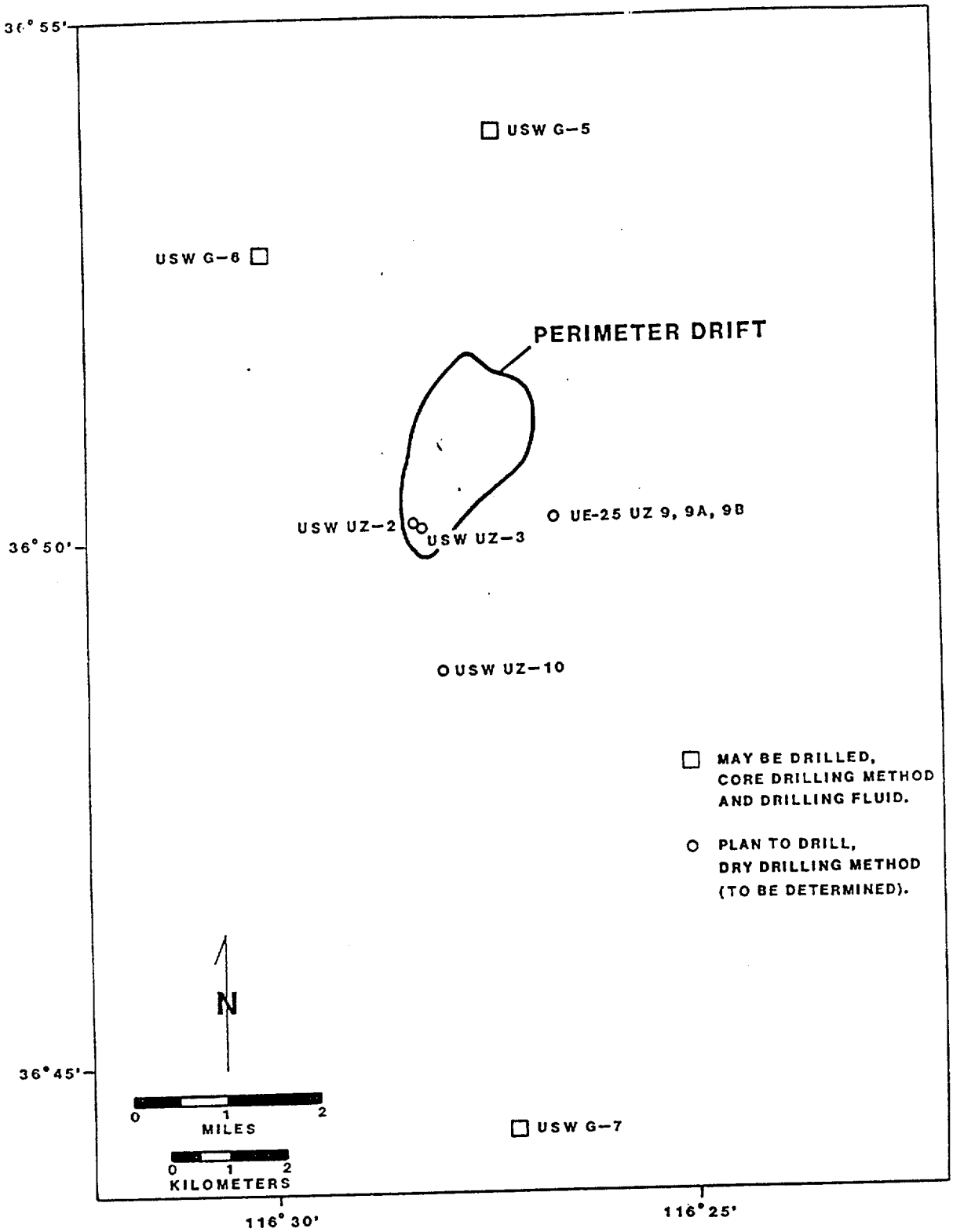

FIGURE 1: Boreholes near Yucca Mountain which may be drilled or are planned to be drilled which penetrate the tuffaceous beds of Calico Hills.

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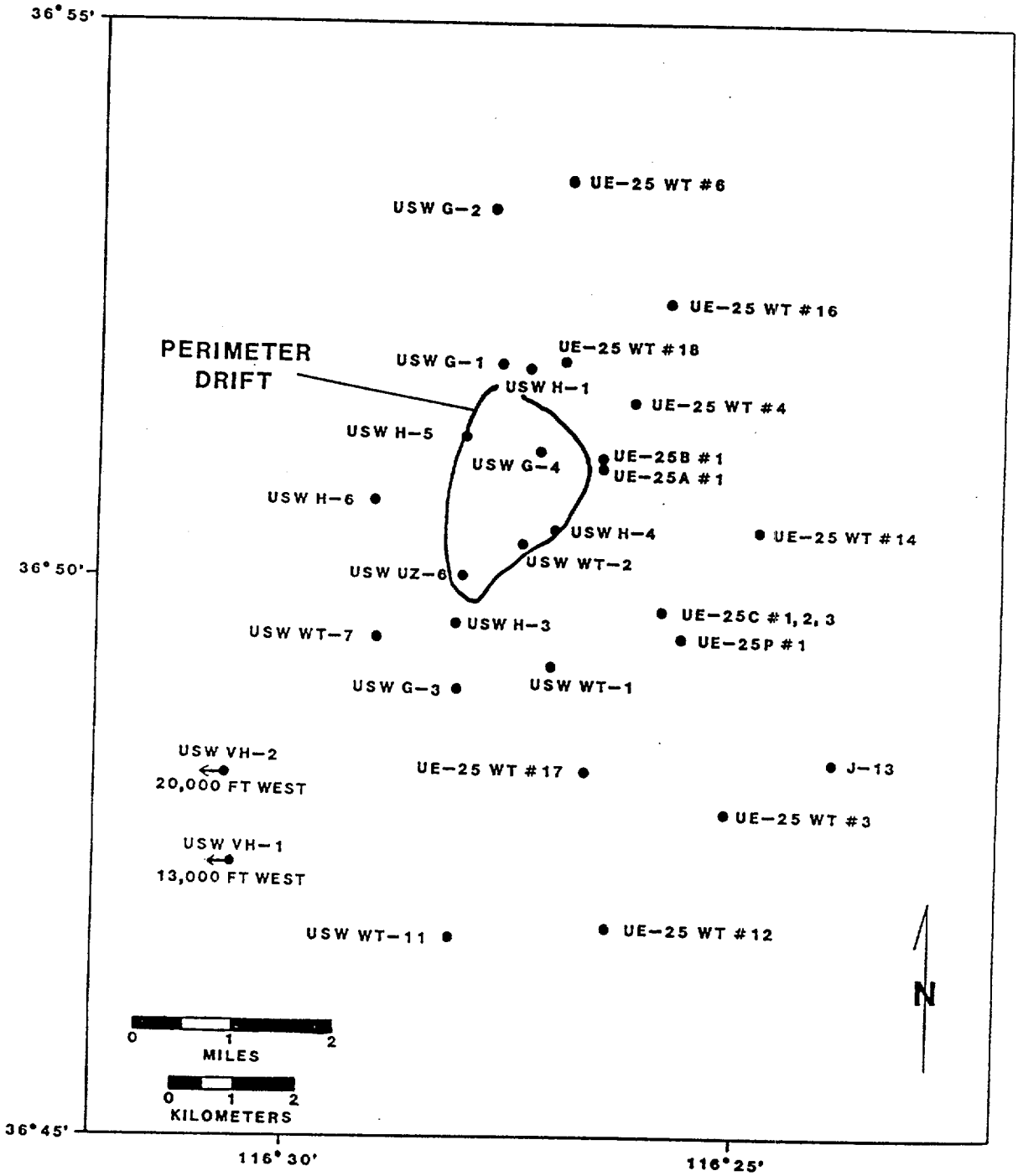

FIGURE 2: Boreholes near Yucca Mountain which penetrate the tuffaceous beds of Calico Hills.

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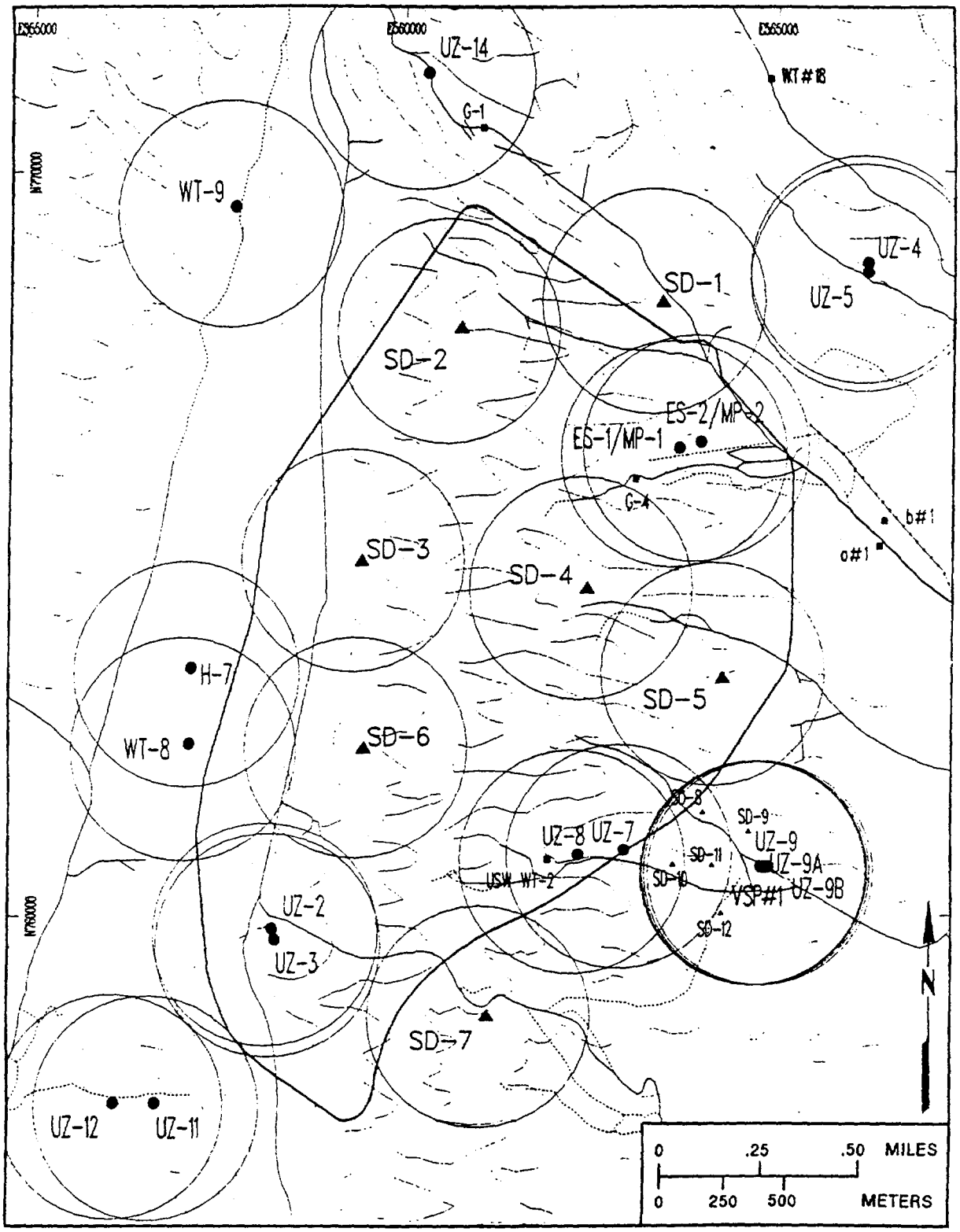

Figure 8.3.1.4-11a. Yucca Mountain systematic drilling program- areal coverage scheme. See Figure 8.3.1.4-11b for legend.

SCP CONTENTS AND TECHNICAL REVIEW

"An approximate answer to the right question is far better than an exact answer to the wrong question."

The SCP is so massive and complex, in terms of topical scope and objectives, that the reader is easily diverted from the true intent of the document. The SCP describes the DOE program of exploration and research, on Yucca Mountain, both in the laboratory and in the field. Therefore, MAI has focused review efforts, not on the very extensive organizational discussions and rationalizations, but, on the descriptions of the programs of exploration and research.

We believe that the success or failure in reaching **confident** site characterization will depend heavily on the SCP adopted by the DOE. We base this belief on the following: 1) the choice of a repository-horizon environment, that is totally unknown from a hydrogeologic perspective; 2) the ten years of effort already expended on the Nevada Test Site (NTS) and the Yucca Mountain site characterization; and 3) the continuing high degree of uncertainty, with respect to many critical performance aspects of the site. Therefore, the SCP has been reviewed in anticipation of discovering the technical program the DOE would mount to resolve the many issues and performance questions.

Activities are the DOE technical and/or scientific efforts planned for site characterization. In the SCP, DOE links activities (usually with a brief discussion of the planned objectives, methods, and associated elements), to studies (generally composed of one or more activities), to investigations (which include studies), to programs (composed of investigations). All are organized and rationalized, with respect to characterization issues from the perspective of licensing requirements. The SCP provides planning discussions at these levels. However, the **activities** are a better measure of the planned DOE site characterization, and we give, in general, very low marks for the activities.

We have reviewed each activity in our topical areas of responsibility because we recognize them as the only fundamental DOE investigative activities in the SCP. These activities, when executed, must provide the information to deal definitively with all issues and have the power to characterize the site. **Unfortunately, we have found that many activities are only at the conceptual stage at best, and would be better judged when work plans and technical procedures become available.** In response to this very real problem, we are forced to review the activities from an expert opinion mode, generally reading between the lines and judging the activity from several perspectives.

Technical Review Criteria: The four criteria adopted in the MAI activity reviews are: 1) conceptual completeness and focus; 2) appropriateness of methodology to accomplish stated objectives; 3) availability of supportive technology; and 4) probability of success and/or feasibility. There are, however, no detailed DOE **work plans** or **technical procedures**, included in the SCP, for each activity upon which we can base an indepth review. Our ability to review conceptual aspects of a given DOE activity is, therefore, better than our ability to review the DOE methodology, since the details of methodology are often not complete.

Technical Review Comments: In reviewing the SCP, we recognize the following as major deficiencies:

- The DOE maintains a site-advocate position, which includes nonconservative conceptual models and, therefore, a favorable hypothesis of the postclosure behavior of the proposed high-level nuclear waste repository. Alternative, more conservative, hypotheses are not given serious and comprehensive investigative attention. Unsubstantiated site characteristics have been and will be used to model site behavior. These characteristics meet the "tentative goals" of the DOE, but have not been documented on a site-specific basis. Consequently, the SCP follows a conceptual approach over a deterministic one.

- There is no DOE planned program to address the concept of the "most likely path of travel." This concept remains totally undefined with respect to site-specific perturbations, geochemical and hydrogeologic considerations, and repository-induced site modifications.

- There appears to be no meaningful DOE field data-collection effort described, to characterize the Calico Hills Formation, a key hydrostratigraphic unit for travel-time calculations and sorption credit. This is an unacceptable omission in the DOE site characterization program.

- The DOE states that predominant sorption credit will be taken at the Calico Hills Formation; yet:

  a. The DOE utilizes the Bandelier Tuff of Los Alamos National Laboratory, New Mexico for intermediate-scale sorption tests. Intermediate-scale field sorption tests for the Calico Hills Formation of Yucca Mountain, Nevada can not be accomplished with crushed Bandelier Tuff of New Mexico.

  b. There is no identifiable program for DOE to acquire a sufficient number of samples from the Calico Hills Formation to be used for sorption experiments. There is a total of four (4) sampling locations of which two (2) are within site boundaries.

  c. The DOE sorption program utilizes tuffs from the Topopah Springs Member of the Paintbrush Tuff, which is apparently dissimilar in mineral content, porosity, and texture to the Calico Hills Tuff. We note that sorption credit will be taken for the Calico Hills Formation, but not necessarily for the Topopah Springs Tuff. The DOE sorption studies shall be done predominantly on the Topopah Springs Tuff, not on the Calico Hills Tuff. This approach will not result in a well-characterized site.

  d. The DOE sorption laboratory and field programs fall short of describing the potential retardation behavior of the tuffs and their corresponding minerals at Yucca Mountain. Although some data collected in the DOE program will provide a baseline for understanding radionuclide behavior, the program itself is not comprehensive enough to acquire sufficient data on actinide behavior, technetium, carbon-14, tritium, iodine-129, sorbing mineral exposure to radionuclide fluids in the natural transport environment, multiple-speciation problems, mass-action competition for sorption sites, mineral stability, and desorption characteristics. Sufficient data must be collected in all of these areas of concern prior to DOE taking sorption credit.

- The DOE has no studies planned for dissolution, in the Rock Dissolution Program. It is doubtful whether this determination is based upon a sound data-collection program, to the extent that all dissolution data necessary for site characterization has been already collected. The DOE dissolution studies planned for geochemistry and waste-package programs will not realistically characterize the expected nature of dissolution for the proposed repository site. The DOE claims that minerals in the host rock at Yucca Mountain are considered "insoluble", yet no definition, criteria or citation is offered in support of this contention. It is well known that even minerals with very low solubilities can exhibit significant mass transport in a thermal gradient.

- The DOE vadose-zone data collection efforts, with respect to characterization of the vadose-zone water chemistry and fluid transport, are not given the comprehensive attention required for confident site characterization. There is an overreliance on site modeling, using codes that have not been validated in the fractured-rock environments of Yucca Mountain, with minimum attention paid to real-world data collection.

- The DOE exploratory shaft mining activities will use J-13 or a similar saturated-zone water. This will make acquisition of uncontaminated water samples from fractures in the vicinity of the exploratory shaft most difficult, if not impossible. The DOE vadose-zone water characterization

needs to be performed with dual-tube reverse-circulation drilling activities. These activities are required in all quadrants of the proposed facility, in order to acquire meaningful variations in vadose-water chemistry and transport characteristics.

- In general, the DOE plans to locate and sample perched water encountered during all characterization activities have not been developed.

- The development of a DOE program for assessing **in-situ** moisture conditions **below** the **repository horizon** in the **vadose zone is not addressed**. Without this program, confident determination of the Yucca Mountain site ground-water travel time and waste isolation will be impossible.

- Insufficient data are being collected by the DOE, with respect to the carbonate aquifer to characterize its relationship to the tuff aquifers and regional flow. The DOE saturated-zone hydrologic program is poorly focused, and admits to incomplete data collection efforts. Often, the methodologies utilized by DOE will not yield appropriate data to respond to stated objectives. There is an overreliance on the use of models, with minimum attention paid by DOE to data collection.

- In all of the DOE programs reviewed, technical procedures are not completed; analytical methodology is not always specified; and in some cases, important techniques are omitted.

- The DOE hydrogeologic conceptual models of flow through the vadose zone are not well supported by the available data already collected at the site. No alternative models are being investigated by the DOE, as the individual SCP studies do not describe activities for their assessment.

- Models and associated codes are frequently and inappropriately utilized by the DOE to answer questions concerning the Yucca Mountain site. Models are useful tools, if developed and used to help resolve problems or gain insight, within the limitations of the databases available and the inherent weakness of the codes. The DOE has used models, poorly supported by process knowledge and data, to select Yucca Mountain as a proposed high-level nuclear waste repository site (DEA, EA). Now, at the time of repository characterization (when real data/site characteristics are to be determined), the DOE follows the established pattern of earlier work - characterization by and of models. The following are only a few of the many misuses of models planned:

  a. The DOE porous-media approach for the characterization of the saturated-zone ground-water flow system will be difficult to use due to the heterogeneities present (as evidenced from the C-hole complex). The DOE use of equivalent porous-media approach in studying ground-water travel time will not give the same results as assessing the significance of fracture flow.

  b. The DOE ground-water flow models are for the most part two dimensional rather than three dimensional (only one activity utilizes a three-dimensional model). These models will be used by DOE to obtain boundary conditions. There are significant problems with respect to the determination of boundary conditions (recharge and discharge areas are not defined) for the saturated-zone modeling. Recharge is not defined for vadose-zone modeling.

  c. An accurate field and laboratory determination of fracture flow and matrix flow characteristics attributed to the Calico Hills Formation is required prior to the DOE using conceptual flow characteristics in models.

d. The DOE characterization of the vadose-zone moisture conditions are based on porous-media approaches which are not appropriate to use, in the fractured tuff terrane of Yucca Mountain.

e. The DOE does not address the complexity of water vapor and simultaneous liquid movement under thermal gradient within the vadose porous and fractured tuff at Yucca Mountain, in sufficient detail. The DOE generally relies on numerical models to characterize the water vapor, liquid, and heat movement through Yucca Mountain. The DOE assumptions for most of these codes are not assessed by using reliable field and laboratory data (an empirical approach) and therefore the validity and accuracy of the models are in question .

f. Reliance on theoretical models to establish contamination of extracted vadose-zone waters is tenuous because this assumes that the models simulate all physico-chemical processes of rock-water interaction in the vadose zone perfectly. A more appropriate technique for determining the extent of contamination is to perform repeated extractions of the water using a variety of different extraction procedures.

g. Numerical models of rock-water interaction can not simulate the physico-chemical processes occurring in thermal gradients of the near-field environment.

h. Undue reliance on computer modeling is placed on the stress field surrounding the canister boreholes. Modeling results should be validated by in-situ observations of actual boreholes.

i. The DOE plans to verify one model with the use of another model. In addition, models will be used to verify field data. This is inappropriate.

j. Modeling efforts will be used to extrapolate vadose-zone data from saturated-zone data. This is also inappropriate.

k. Experiments should be validated by field tests before being used to validate models. Otherwise, the DOE models are generic and non-site specific. Further, the DOE field data collection and laboratory experiments are not always linked to the models.

l. Gas-transport test studies will only be done, if modeling studies indicate that there is a problem. There is already enough site-specific evidence to indicate the existence of a serious question requiring a comprehensive site-specific data collection program. Gas transport through unsaturated faults and fractures may provide the shortest and fastest path to the accessible environment.

GEOHYDROLOGY PROGRAM 8.3.1.2

GEOHYDROLOGY PROGRAM - REGIONAL

The DOE regional hydrology program consists of one investigation (8.3.1.2.1) containing four studies:

1. Characterization of the meteorology for regional hydrology.

2. Characterization of runoff and streamflow.

3. Characterization of the regional ground-water flow system.

4. Regional hydrologic system synthesis and modeling.

Comments relating to specific activities in the meteorology program (8.3.1.12.1) are applicable to the first study (8.3.1.2.1.1) in the regional hydrology program. It is not evident from the SCP description of the DOE meteorological plans of action, whether reasonable coverage will be given to the collection of precipitation data. As described in 8.3.1.12.1, the integrated precipitation network will not be of sufficient density to characterize site-specific precipitation events. It is not clear how the DOE data collection efforts will meet Quality Assurance (QA) program requirements considering the serious limitations of the stream and rain gauges. The efforts applied to this program are not in keeping with the level of technology presently available. This particular study can not address the long-term range in climatic variability, using the parameters in the meteorology section (8.3.1.12.1), nor will this study succeed with the approach taken here. We find that characterization will not be accomplished to the level required for a confident assessment.

The DOE characterization program for runoff and streamflow lacks the required support of meteorological data collection. Although the DOE attempts to collect meaningful data relative to target sites of opportunities through the use of "miscellaneous-measurement sites," a plan of action for this activity would of course determine whether various QA issues will be met. An alternative mode of attacking this problem might be for the DOE to expand the coverage of the permanent stations rather than to look for "windows of opportunity" during or after a storm that might occur on a Sunday afternoon. The contribution of mass transport during or immediately after a storm event is not addressed in a practical manner. In order to accomplish a reasonable documentation of the characteristics of debris transport as a function of severe runoff, a more concerted effort must be applied to collect meaningful geomorphic field data.

It is difficult to determine how the modeling efforts could produce meaningful results given the numerous uncertainties of the input variables such as the location of recharge and discharge boundaries and the spatial distribution of the hydraulic properties of the lithologic units. In the SCP, the DOE acknowledges that for some existing ground-water models major assumptions pertaining to the location and magnitude of recharge and discharge boundary conditions and regional transmissivities are made, and that recharge estimates across model boundaries are often made for lack of sufficient data. This lack of sufficient data also bedevils the DOE modeling efforts. Site-specific data on the spatial distribution of all the hydrologic parameters (hydraulic gradients, hydraulic conductivities, potentiometric-surface configuration, discharge and recharge quantities and points), as well as fracture geometry, will be more relevant than a regional model. In general, the level of effort, the focus of that effort, and the almost certain lack of success that can be attributed to this DOE program is extremely disappointing.

APPENDIX A

GEOHYROLOGY PROGRAM - REGIONAL DOCUMENT REVIEW FORMS

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 1	CHAPTER/SECTION: 8.3.1.2.1.1.1 Activity: Precipitation and meteorological monitoring.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-97	This activity is the only activity for the characterization of the meteorology for regional hydrology study. We would like to recommend that the DOE consider using rain gauges on top of Yucca Mountain and in closer proximity to the repository surface boundary. The only attempt at adding to precipitation measurement points of the CD-SCP is made under another related study's activity (8.3.1.2.1.2.1). For this activity to be complete, conceptually, there is the need for one or two rain gauges on top of Yucca Mountain--one at the extreme north of the Perimeter Drift, and the other at the extreme south.

REVIEWER: O. A. Adenle	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 29 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 2	CHAPTER/SECTION: 8.3.1.2.1.2.1 Activity: Surface-water runoff monitoring.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-103	The 8.3.1.2.1.2.1 (surface-water runoff monitoring) activity description mentions expanding the regional stream-flow measurement network in the Fortymile Wash basin to support the recharge study activity. In other words, approximately six additional stream-flow measurement stations, three snow courses, six precipitation-measurement sites, and two air-temperature measurement sites will be installed and operated in the Fortymile Wash upper drainage basin. The above additions do not negate nor replace the need for at least one rain gauge on top of Yucca Mountain to record the probable difference in magnitude of precipitation between places located at markedly different elevations. This activity is one of two activities for the characterization of runoff and streamflow.

REVIEWER: O. A. Adenle Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 23 June 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 3	CHAPTER/SECTION: 8.3.1.2.1.2.2 Activity: Transport of debris by severe runoff.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-112	This is a new activity and is part of the characterization of the meteorology for regional hydrology study. This activity is supposedly closely tied to Activity 8.3.1.2.1.2.1 (surface-water runoff monitoring). The methods proposed to study this activity are: scour chains, land-surface photography, aerial photography, and remote sensing, which will be used in the post-fact analyses of debris movement. These methods should be supplemented by periodic in-situ measurements to reference points and periodic surveys of both channel cross-sections and long-profiles. The contribution of mass movement, as a supplier of material to drainage courses during or immediately after storm events, needs to be considered under this activity. Conceptually, this activity is focused but incomplete. Mass movement needs to be considered as an important process in debris generation. The methodology proposed needs to be supplemented as mentioned above. This activity is likely to succeed using existing technology, and is feasible in terms of time, funding, and human resources. However, it is doubtful if justice can be done to this activity before the construction of the physical surface facilities at the repository site.

REVIEWER: O. A. Adenle	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 23 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 4	CHAPTER/SECTION: 8.3.1.2.1.3.1 Activity: Assessment of the regional hydrogeologic data needs in the saturated zone.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-114	This activity is a part of the characterization of the meteorology for regional hydrology study. The use of 2-D ground-water flow model is not the way to assess data needs. Model results from this study will not be reliable. Hence, we recommend that the DOE adopt a drilling program based on clear hydrogeologic objectives instead of 2-D modeling. The reasons offered by the DOE for attempting to use a 2-D model, claiming that it is one of various methods that will be used, and that it will be updated to evaluate the adequacy of regional hydrogeolgic data to guide future data collection, are not convincing. In the SCP, DOE also notes (hopefully to remove part of the uncertainty in boundary conditions) that the effects of the positions and conditions of lateral-flow boundaries will be tested by specifying alternative configurations of model grids or meshes. This is one of a series of promises made by DOE. It is hoped that these promises are going to be kept. We are pleased to learn that (1) the DOE has collected hydrologic data from boreholes drilled in the Amargosa Desert by a mining company, and (2) that the DOE is considering (a) construction of a piezometer net (150 m deep) along the eastern edge of the Funeral Mountains, (b) drilling a deep borehole into the Paloeozic rocks beneath ahe Amargosa Desert, and (c) deepening of proposed drillholes USW WT-21 and USW WT-2 into Paleozoic rocks. Although the SCP approach appears to be an improvement over the CD-SCP, there is still need for DOE to be fully committed to a drilling program (instead of using some mining company's drillholes), and not just paying lipservice to it. This will help clarify the ground-water divide suspected to be under the Greenwater Range between Death Valley and the Amargosa Desert. Such a drilling program would provide useful information on the variations in the hydraulic properties within lithologic units and between them. This would facilitate achieving a meaningul subdivision of the various lithologic units into hydrogeologic units.

REVIEWER: O. A. Adenle Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 5	CHAPTER/SECTION: 8.3.1.2.1.3.2 Activity: Regional potentiometric-level distribution and hydrogeologic framework studies.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-118	This activity is part of the characterization of the regional ground-water flow system study. The CD-SCP "Regional potentiometric level studies" activity is divided into two activities in the SCP, and includes the following parameters: storativity, lineaments, fractures, and hydrostratigraphic units. This activity is generally focused, but incomplete with respect to carbonate aquifer; the methodology proposed will probably establish stated objectives, but the scope is too limited with respect to number of boreholes; and this activity will probably succeed using existing technology, but Jackass Flats area is neglected. Furthermore, this activity has failed to acknowledge that there is more than one flow system in the Yucca Mountain area, and needs not only to address this issue but also to attempt to show how the different flow systems in the area could be separated. The proposed drilling and existing drillholes are all located within a radius of about 7 miles from the Perimeter Drift, as shown in Figure 8.3.1.2-8 of the SCP. A regional study of this nature and of this area should include Jackass Flats and Amargosa Valley. As yet, there has been no serious study as to where the ground-water flow in the Yucca Mountain area is derived. Is it from the Pahute Mesa-Cactus Flat-Gold Flat systems, and/or by upward leakage from the carbonate rock system near Yucca Mountain? How is it possible to make the related model studies without knowing the boundary conditions?

REVIEWER: O. A. Adenle Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 26 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 6	CHAPTER/SECTION: 8.3.1.2.1.3.3 Activity: Fortymile Wash recharge study.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-125	This activity is part of the characterization of regional ground-water flow system study. This activity is conceptually complete and focused; methodologies proposed to establish stated objective are considered appropriate; success using existing technology is considered probable; and this activity is considered feasible in terms of time, funding, and human resources. However, there is the need for more drillholes along the Fortymile Wash. Although the DOE is considering a series of piezometer nests which will be installed across Fortymile Wash, to obtain aqueous and gas samples in order to estalish the timing of recharge to the regional ground-water system (an improvement on the CD-SCP), the success of this activity is difficult to judge without access to answers to following questions: How many piezometer nests will be set up and operational? How long will these piezometer nests be in operation? What is the spacing between these nests? Where are these nests to be located? How deep are these piezometers going to be? etc..

REVIEWER: O. A. Adenle Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 23 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 7	CHAPTER/SECTION: 8.3.1.2.1.3.4 Activity: Evapotranspiration studies.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-134	This activity is part of the characterization of regional ground-water flow system study. In the SCP, DOE mentions using both tensiometers and piezometers to determine the existence or nonexistence of upward hydraulic gradient. Ten to thirty nests of piezometers and tensiometers are planned in the area defined by phreatophyte mapping for the purpose of monitoring the unsaturated zone. This is an improvement; however, attempts should be aimed at complete regional coverage.

REVIEWER: O. A. Adenle Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 23 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 8	CHAPTER/SECTION: 8.3.1.2.1.4.1 Activity: Conceptualization of regional hydrologic flow models.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-137	This activity is part of the regional hydrologic-system synthesis and modeling study. The CD-SCP list of the parameters "Water flux" is SCP "ground-water flux"; "Potentiometric-surface configuration" is added to the SCP. CD-SCP's table of methods shows that "Analyses and interpretation of regional flow system" is replaced by "Assimilation of data and interpretations into a conceptual description of regional flow systems" and "use of conceptual description of flow system to update regional ground-water flow model" in the SCP. Despite the above modifications, this activity is conceptually unfocused and should be incorporated in the "integrated drilling program" because 1) uncertainties exist regarding the location of recharge and discharge boundaries, and 2) more drillholes are required for adequate spatial coverage of the region before a regional hydrology flow model can be reasonably conceptualized.

REVIEWER: O. A. Adenle Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 23 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 9	CHAPTER/SECTION: 8.3.1.2.1.4.2 Activity: Subregional two-dimensional areal hydrologic modeling.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-142	This activity is part of the regional hydrologic system synthesis and modeling study. In a subregional hydrologic modeling of the Yucca Mountain area, a two-dimensional (2-D) approach is inappropriate, because no consideration is given to anisotropy or fractures; and desired parameters will be nonrepresentative since equivalent porous medium is assumed. DOE treatment of this activity in the SCP is geared towards justifying the use of the 2-D model. DOE claims that the refined 2-D model will be a highly simplified representation of a complex three-dimensional system and that it is expected to be useful for various applications, such as preliminary evaluations of the effects of potential future pumping on the hydrologic system, and using the model to help guide development of more vigorous three-dimensional models which will be used to test the impacts of future ground-water development, tectonic events, and climatic changes on the saturated-zone hydrologic system. Additional justification is made rather cautiously by stating that "on a regional-scale vertical flux probably is small relative to horizontal flux." DOE claims that this concept of "negligible regional vertical flux" will be tested as new data are obtained and by means of a 2-D cross-sectional model. The validity of this concept ("negligible regional vertical flux") is highly questionable. A detailed study of all the hydrogeologic units will be necessary before "negligible regional vertical flux" may or may not be confidently assumed.

REVIEWER: O. A. Adenle Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 23 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE TECHNICAL REVIEW COMMENT	
DOCUMENT TITLE: Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).	
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 10	CHAPTER/SECTION: 8.3.1.2.1.4.3 Activity: Subregional two-dimensional cross-sectional hydrologic modeling.
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-142	This activity is part of the regional hydrologic system synthesis and modeling study. A review of this activity gives rise to the following comments: 1. No hope of realism in these simulations. (This activity is conceptually incomplete and not focused). 2. Setting up this model will be just guesswork. (Methodology proposed will not establish objective). 3. Could succeed if accompanied by comprehensive deep drilling program. (Success unlikely using existing technology). 4. Much additional drilling would be required to adequately characterize fracture-system geometry, heterogeneity, anisotropy. (Probably not feasible in terms of time, funding, and human resources). DOE CD-SCP activity objectives have been significantly modified in the SCP. The second part of CD-SCP's objective "to help establish hydrologic boundary conditions at the boundary of the accessible environment" is SCP's "to help test the assumption of horizontal flow." In spite of this modification, assumption of horizontal flow on a regional basis seems improper because of the complex nature of the area in terms of geologic structures. Furthermore, hydraulic conductivity is one of the hydrogeologic properties of the saturated-zone rock units and the spatial distribution of all these properties should be considered along with spatial distribution of recharge and discharge as input in developing a 2-D cross-sectional hydrologic model for the subregion.
REVIEWER: O. A. Adenle Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 23 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 11	CHAPTER/SECTION: 8.3.1.2.1.4.4 Activity: Regional three-dimensional hydrologic modeling.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-145	This activity is part of the regional hydrologic system synthesis and modeling study. The proposed methodology probably will not establish the stated objective and it is very unlikely that the understanding of regional ground-water flow will be improved by this model. DOE's claim that remote-sensing studies will provide information on ground-water flow paths is questionable. The objectives of this activity are feasible given competent geologic input and substantial investment in drilling and testing. The development of a reasonable and conservative three-dimensional hydrologic model will require as input spatial distribution of transmissivity and all other hydrogeologic properties of the saturated-zone rock units, as well as hydraulic gradient, water flux, recharge, discharge, and potentiometric levels.

REVIEWER: O. A. Adenle	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 23 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 12	CHAPTER/SECTION: 8.3.1.2.2.2.1 Activity: Chloride and Chloride-36 measurements...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-180	Other than the addition of the table of technical procedures, this activity is virtually unchanged from the CD-SCP. Conceptually, this activity is generally complete (except as noted below) and the methodology will probably establish the objectives, but the selection of sample locations is critical. However, the unfounded assumption that the tuff matrix will retard water and solutes needs to be established. Furthermore, the focused flow of downward percolation into fracture zones in gullies and washes definitely should be investigated. Fracture flow is most likely the dominant transport mechanism in the vadose zone and must be thoroughly studied. Otherwise, any conclusions or interpretatons reached are incomplete and biased.

REVIEWER: D. L. Shettel, Jr. Don L. Shettel Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 05 May 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 13	CHAPTER/SECTION: 8.3.1.2.2.4.8 Activity: Hydrochemistry tests in the ESF.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-304	This activity is essentially unchanged from CD-SCP. Conceptually, this activity is generally complete except for the omission of provisions for sampling perched water or saturated fractures, if encountered. It may be difficult to determine flux and flow directions with isotopic techniques unless there is an adequate three-dimensional spatial distribution of samples. The ESF is essentially one-dimensional. Extraction for moisture by vacuum distillation from those samples with less than 11% water will be adequate for stable isotope (oxygen and hydrogen) analyses, but chemical analyses are needed of this water as well, because this is the "true" matrix water.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 08 May 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 14	CHAPTER/SECTION: 8.3.1.2.2.7.1 Gaseous-phase chemical investigations.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-334	This activity is essentially unchanged from CD-SCP except for methods and technical procedures in the table. Flux/flow should be measured directly (then these procedures would not belong in this activity) by monitoring specific intervals between long intervals of packers. These properties could be determined by pressure changes. Flux, flow, and travel time may be difficult to determine by isotopic analyses of the gas-phase cinstituents because the vadose zone is essentially an open system representing a mixture of atmospheric gases and those from the water table. Details of how the measured data will be interpreted (or references to similar studies) are not provided, thus it is difficult to determine the probability of success of this activity.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
D. L. Shettel Jr. Signature	DATE: 08 May 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 15	CHAPTER/SECTION: 8.3.1.2.2.7.2 Activity: Aqueous-phase chemical investigations.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-337	This activity has been expanded by the addition of the third paragraph (page 8.3.1.2-339) and the four numbered items under it. There is no provision (in methods and technical procedures table) for handling perched water and/or saturated fractures if they are encountered. Furthermore, no emphasis is placed on identifying and sampling perched water if it occurs other than at the ESF, such as in other drillholes. This would help determine the extent of perched water, supposedly one of DOE goals. The implication that water in the rock surrounding a fracture is somehow related to fracture flow by being "sucked" into the matrix is totally unfounded due to the probable predominance of fracture over matrix flow and the possible rapidity of fracture flow.

REVIEWER: D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 09 May 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 16	CHAPTER/SECTION: 8.3.1.2.2.7.2 Activity: Aqueous-phase chemical investigations.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-338	This activity is an outstanding example of DOE's wish list--proposing to do all sorts of test and analyses. However, there are a few problems with their present approach. 1. Squeezing of cores, to date, has not produced suffient water to analyze for aluminum, a key element whose concentration **must** be known in the vadose water for accurate and realistic modeling of rock-water interactions. 2. An extraction technique has not been devised for analysis ot the "true" matrix water, that less than 11% left in the rock originally, or after other techniques have been attempted. 3. Lastly, and most importantly, the methodology proposed is grossly slanted towards analyses of matrix water in the vadose zone. Thus, flow direction, flux, and travel time of water will be biased towards matrix flow and will result in an extremely misleading and nonconservative representation of the vadose zone. Because fracture flow is most likely the dominant mechanism of transport in the vadose zone, it is the mechanism DOE investigators should be studying, as fracture flow has major consequences for waste isolation, retardation, and ground-water travel time.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
D. L. Shettel Jr. Signature	DATE: 03 July 1989

MY890703a

GEOHYDROLOGY PROGRAM - VADOSE-ZONE

"Those who cannot remember the past [or learn from it] are condemned to repeat it."
- George Santayana, 1905 -

INTRODUCTION

The DOE vadose-zone hydrogeologic program consists of the following nine studies which are designed to give technical rationale for the DOE investigation of the Yucca Mountain site:

1. Characterization of unsaturated-zone infiltration;
2. Water movement tracer tests using chloride and chlorine-36 measurements of percolation at Yucca Mountain;
3. Characterization of percolation in the unsaturated-zone surface-based study;
4. Characterization of Yucca Mountain percolation in the unsaturated-zone exploratory shaft facility studies;
5. Diffusion tests in the exploratory shaft facility;
6. Characterization of gaseous-phase movement in the unsaturated zone;
7. Hydrochemical characterization of the unsaturated-zone;
8. Fluid flow in unsaturated, fractured rock; and
9. Site unsaturated-zone modeling and synthesis.

Under these studies, the DOE is planning 29 activities that address prototype tests as well as laboratory and field activities to gather data and information needed for site characterization of the vadose hydrogeologic-stratigraphic units of Yucca Mountain tuffs.

OVERVIEW CONCERNS

The DOE should, regardless of failings in any other aspect of site characterization, effectively mount investigations for resolving the most basic questions of the waste isolation at Yucca Mountain:

I. Is there adequate travel time along the fastest most likely pathway to the accessible environment via downward migration of ground water (at least 1,000 years)?

II. Is there adequate travel time along the fastest most likely pathway to the accessible environment via the upward migration route of soil gas to the land surface (at least 1,000 years)?

Both questions are no longer scoping modeling exercises, as there exists data (some of which are still unpublished years after sample collection and analyses) and general understanding of Yucca Mountain to indicate possible negative answers to the above questions. However, we find no well thought-out, site-specific, field data collection programs that will answer these two fundamental questions about waste containment at the proposed site.

The DOE study philosophy of highly localized sampling strategy might be adequate for a saturated zone of classical porous media, where validated transport and flow models can be reasonably applied if localized site-specific data are established. However, Yucca Mountain is not such a site. Aridity (absence of flux) is the natural site aspect called upon to establish waste isolation in highly fractured,

generally very low permeability rock in the vadose zone. The availability of moisture for flux is not **uniformly distributed in either time or space, pneumatically and hydraulically connected fracture networks are generally unpredictable in space**, and there are no well-demonstrated field or validated modeling techniques that are known to yield reliable information on site-specific gas, heat, or liquid flow in the proposed environment. Some of the proposed study activities are out of the realm of practical feasibility (as measured in terms of time and technical resources and therefore confident realization of objectives) and others are feasible but merely wishful thinking in terms of developing data sets that are comprehensive and reliable for modeling purposes over the three-dimensional extent of the repository block. The DOE approach of planning to use highly demanding codes (most of which can not be validated) without developing ample data which the codes demand to characterize the transport and flow systems of the site, raises the question of whether the SCP is a serious scientific effort or a staged political document. We believe that the DOE has, or could readily develop, adequate scientific resources to develop a site characterization plan that would answer at least the basic questions of waste isolation.

However, the SCP is a document of rhetorical technical jargon that frequently calls upon impossible models (in terms of meaningful results) to answer key licensing issues, and systematically fails to establish field-data collection programs that are:

1. comprehensive within the context of the potentially varied conditions throughout the repository block;

2. feasible to execute within realistic time frames; and

3. supported by demonstrated technology or programs to develop the needed technology.

Examples of two types of serious deficiencies in the SCP are the several activities for the vadose zone that call upon drilling and coring with air and associated modeling. The inexperienced would assume that such drilling and coring methodology is well-established and feasible--nearly all vadose-zone data collection activities depend on this drilling and coring. However, there are no technical procedures nor work plans for these activities. Since 1984, the State of Nevada has recognized the need for such development and demonstration of the drilling techniques with air and has proposed dual-tube reverse-circulation air drilling in its overview program (this proposed drilling by the State of Nevada has been successfully blocked to the present date). Thus, there **is no site-specific experience** for the DOE to call upon, and all the activities that require such drilling are predicated on the assumption that it will prove feasible. In our judgment, several years of trial and error field experiments will be needed at the minimum to establish confident procedures for the range of dry drilling called for in the SCP **before** reliable procedures and samples can be established. The coring, in our experience, will not prove very successful in terms of maintaining low-core temperatures to avoid moisture losses. There are other potential problems as well. For example, it is unknown how much fracture plugging occurs during air drilling, and therefore, it is unknown how representative pneumatic experiments in such constructed boreholes might be.

The second example, just as problematical, is the inappropriate use of models. The DOE generally ignores such problems as validated modeling codes, the need for data distribution in three dimensions to establishing boundary conditions and other parameters, and the inappropriate use of porous media assumptions for fractured rock media. Models will be used to check models, to model processes we have no idea about on the basis of in-situ site-specific data, to test compliance with release rates, etc. This model everything approach taken by the DOE is not defendable when challenged from the perspective of repository-block databases, validated codes, or sufficient databases for establishing valid conceptual models for the design of model processes and boundary conditions.

The DOE does not recognize the high probability of, nor design investigative activities for the apparent transient nature of vadose-zone hydrology in the fractured tuffs. The best (and only?) analog data base in the NTS region is from Rainier Mesa tunnels where, in a fractured and zeolitic tuff sequence similar to that of Yucca Mountain, seasonal pulses of fracture flow are known to occur, and perched water

is present (Russell, 1987; Henne, 1982; Thordarson, 1965).

The DOE hydrogeologic conceptual model of flow through the vadose zone is not well-supported by the available technical data. The model is generally based on a series of assumptions that need to be tested and evaluated during site characterization. The planned activities **may not accomplish the goal of evaluating the applicability of the proposed conceptual model to the Yucca Mountain site.** In addition, the DOE does not consider conservative conceptual models that fit the limited site-specific data and the hydrogeologic information available in the open literature.

The DOE methods and concepts proposed to evaluate the in-situ moisture conditions are based on **porous-media approaches, which may not be appropriate for the fractured tuff at Yucca Mountain.** The DOE should develop, if necessary, new methods that can be used to evaluate the role of moisture within fractured-porous media.

The proposed DOE **conceptual model of recharge** through the Yucca Mountain tuff formation may be **incorrect and inadequate in desert terrane.** The proposed methodologies would provide results which do not lead to an understanding of the recharge processes nor to accurately evaluating the recharge **fluxes** through the tuff formation.

The DOE claims and concludes that **very low flux and, in turn, long ground-water travel time** (GWTT), is evident at Yucca Mountain. However, the sparse in-situ data does not clearly support this conclusion.

The DOE does not establish a comprehensive three-dimensional water and soil-gas sampling investigation of the repository block (or immediate perimeter area) to establish samples for chemical, biological (colloids which are known to complex with actinides) stable and environmental isotopes, and trace gases. Such an investigation is the best method to resolve fracture flow/matrix flow travel time questions and should have been conducted during site-selection studies.

The DOE does not address, in sufficient detail, the **complexity of water vapor and simultaneous liquid movement under thermal gradient** within unsaturated porous and fractured tuff at Yucca Mountain, especially the implications of these processes on waste isolation for thousands of years.

The planned unsaturated-zone **borehole drilling program and exploratory shaft do not develop a database for in-situ moisture conditions** below the repository horizon. In addition, no provision is made to address the possibility of perched water throughout the unsaturated zone at Yucca Mountain. Perched water has already been encountered in more than one borehole during earlier drilling.

The DOE **relies heavily on computer and numerical models to characterize the water vapor, liquid, and heat movement through Yucca Mountain tuff.** The assumptions of most of these codes are not assessed by using reliable laboratory or field data and may not be valid or adequate in predicting the behavior of the unsaturated-zone hydrologic processes.

CONCEPTUAL MODEL COMMENTS

On page 3-144 of the SCP, the DOE describes the three major hydrostratigraphic groups of Yucca Mountain site as follows:

1. **The upper group is** "...densely to moderately welded tuffs that are highly fractured. This group includes units TCw and TSw of Table 3-22 and is characterized by low saturated hydraulic conductivity of the rock matrix (about 1 x 10^{-11} m/s) and relatively high fracture densities (about 10 to 40 fractures/m^3). Under fully saturated conditions, the fracture hydraulic conductivity probably exceeds that of the rock matrix by several order of magnitude. The rocks of this group

are characterized by relatively low matrix porosities of about 10 percent."

2. **The middle group is** "...nonwelded vitric tuffs containing few fractures. This group includes the PTn and CHnv units of Table 3-22 and is characterized by relatively high saturated hydraulic conductivity of the rock matrix (about 10^{-8} to 10^{-6} m/s) and low fracture densities (1 to 3 or fewer fractures/m^3). These rocks have relatively high matrix porosities (about 30 to 45 percent). "

3. **The lower group is** "...nonwelded zeolitized tuffs containing few fractures. The prototype example is the CHnz unit of Table 3-22, which has a saturated hydraulic conductivity of about 10^{-11} m/s or less, a fracture density of 1 fracture/m^3 or less, and a matrix porosity of about 30 percent. A tuff sample need not be completely zeolitized to belong in this classification. The tuffs in CHnz range from partially to completely zeolitized but are grouped into this one rock type when their hydrologic properties are similar."

On page 3-146 of the SCP, the DOE also states:

"The formulation of a conceptual model of a natural process or phenomenon is the essence of scientific method that according to Russell (1948), 'consists in inventing hypotheses which fit the (available) data, which are as simple as is compatible with this requirement, and which make it possible to draw inferences subsequently confirmed by observation.' In general, the conceptual model of a natural hydrologic system considers the environmental setting and the internal geometry of the system together with the hydrologic and other related physical processes operating within the system. The development of a conceptual model is an ongoing, frequently iterative process of hypothesis testing; data analyses and interpretation; and numerical experimentation coupled with impartial, critical peer review."

The DOE **preferred generalized conceptual model** for the hydrologic system within the vadose zone at Yucca Mountain is described in detail by Montazer and Wilson (1984) and Sinnock, et al. (1986). In the SCP, the DOE presents the principal aspects of moisture flow within the unsaturated zone as follows:

1. **The water entering the TCw unit may be drawn into the matrix before the full thickness of the TCw unit is traversed;**

2. **Hydraulic gradients directed parallel to the dip may induce lateral flow either under saturated or unsaturated conditions at the contact between the TCw unit and the underlying Paintbrush nonwelded unit (PTn);**

3. **Both vertical and lateral flow may occur in the relatively high-conductivity PTn unit;**

4. **Flow in the TSw unit is expected to be essentially vertical and, under steady-state conditions, to occur as flow within the matrix;**

5. **At low fluxes within the TSw unit, lateral flow may be produced by capillary-barrier effects within the matrix of the TSw unit where it overlies the CHnv unit;**

6. **Flow in both the CHnv and CHnz units is predominantly vertical through the matrix;**

7. **Faults may impede lateral flow and may thus produce perched-water bodies where the faults transect zones or horizons of significant lateral flow;**

8. **Under steady-state conditions, the upward movement of water vapor in the air-filled**

fracture openings would be compensated by downward return flow of liquid water within the rock matrix; and

9. **Moisture flow within the deep unsaturated zone at Yucca Mountain may be occurring under essentially steady-state conditions.**

The SCP investigation 8.3.1.2.2 presents the DOE purpose and objective, as: "to develop a model of the unsaturated-zone hydrologic system at Yucca Mountain that will assist in assessing the suitability of the site to contain and isolate waste." It also states that, in developing the model, the needed information will be provided through studies to characterize the flow and transport through the Yucca Mountain unsaturated zone. Major studies the DOE plans to conduct during site characterization address unsaturated-zone infiltration, percolation, gaseous-phase circulation, and hydrochemistry. The attached comments on the individual activities indicate our technical opinion of these investigations to adequately establish site characterization objectives.

The DOE conceptual model of water flow through the vadose zone, as summarized above, is generally based on the assumption of steady-state and uniformly-distributed downward flow. A second assumption is that the water flux through the vadose zone is so small that most water flow is through the matrix of the rock and not through fractures. A third assumption is that matrix flow will predominate through the repository horizon (Topopah Spring). This assumption largely depends upon the hypothesis that excess recharge is both diverted away from the repository horizon and retarded by capillary and permeability barriers at the contacts between the Tiva Canyon welded unit and the underlying Paintbrush Tuff nonwelded unit, and between the Topopah Spring welded unit and the overlying Paintbrush Tuff nonwelded unit.

In reviewing the SCP, we have become aware of two important facts. First, **the DOE does not seriously consider conservative and alternative conceptual models** that fit the limited site-specific data and the open-literature data. Second, the DOE conceptual model satisfies all of the following conditions:

"(i) Low moisture flux in the host rock and in the overlying and underlying hydrogeologic units;

(ii) A water table sufficiently below the underground facility such that fully saturated voids contiguous to the water table do not encounter the underground facility;

(iii) A laterally-extensive, low-permeability, hydrogeologic unit above the host rock that would inhibit the downward movement of water or divert downward-moving water to a location beyond the limits of the underground facility;

(iv) A host rock that provides for free drainage; or

(v) A climatic regime in which the average annual historic precipitation is a small percentage of the average annual potential evapotranspiration." (10 CFR 60.122(b)(8)).

The above are the NRC favorable conditions for a repository in an vadose-zone environment.

We think the DOE conceptual model of flow of water through the vadose zone is not based on nor supported by the available technical data. The estimated downward ground-water flux may be low in light of published data. Estimates of the downward vertical matrix flux (no fracture flow) through the repository-horizon host rock range from a low value of 0.003 mm/year (based on laboratory determinations on core, Weeks and Wilson, 1984) to a high of 10 mm/yr (Sass and Lachenbruch, 1982) based on the geothermal-gradient analyses. Montazer and Wilson (1984) data from borehole UZ-1 show negative (upward) flux of approximately 1 to 2 mm/yr in the Topopah Spring unit. They also estimate that a downward flux through the same unit to be 1 mm/yr based on geometric mean of the saturated

hydraulic-conductivity measurements on core samples assuming a hydraulic gradient of one. However, Montazer and Wilson (1985) report that the measured hydraulic conductivity of two saturated samples was two-orders-of-magnitude greater than the geometric mean. For the Paintbrush Tuff nonwelded unit, they estimate that a vertical flux of 0.1 to about 100 mm/yr may be occurring. Additional uncertainty on the estimated flux under present conditions is introduced by recharge estimates of 4.5 mm/yr (Rush, 1970) to 5 mm/yr (Waddell, et al., 1984). These estimates of recharge are inconsistent with the postulated 1 mm/yr in the SCP. If the saturated-matrix conductivity of the Topopah Spring unit is limited to a maximum of 1 mm/yr as DOE indicates, then all flux above 1 mm/yr must pass through the repository-horizon host rock (Topopah Spring) as fracture flow.

The DOE conceptual model also assumes, by implication, that the recharge throughout the proposed repository boundary area is uniformly distributed. In desert terrane such as the Yucca Mountain site, recharge may be low and variable. However, much of the recharge is likely concentrated and focused beneath washes, in and through open and exposed fractures, and through faults in the rock matrix of the repository block. It is very likely that any flow through the fractures at any horizon in the vadose zone dramatically shortens the ground-water travel times to the accessible environment.

The DOE assumption that a capillary barrier exists at the contacts between the Tiva Canyon welded unit and the underlying Paintbrush Tuff nonwelded unit, and between the Topopah Spring welded unit and the overlying Paintbrush Tuff nonwelded unit is not based on the available information provided by the DOE. There is no data or evidence that recharge moves laterally downdip at the contact between the fracture networks of the Tiva Canyon welded unit and the matrix of the Paintbrush Tuff nonwelded unit. To date, no field or laboratory data have been published by DOE which indicate that saturated conditions have been observed at or near the contact. It is unlikely that water will move laterally over significant distances unless the tuff is almost saturated. Even the bedded tuffs are highly fractured.

In addition to the above, the DOE postulates the existence of a capillary barrier between the Paintbrush Tuff nonwelded and the Topopah Spring units. There is no evidence that water is present across this contact or as a general condition across the site. Therefore, there is no basis to assume that "excess recharge" has been stored or that significant lateral flow is occurring within this unit.

The DOE discusses (SCP, pages 8.3.1.2-304 to 308) the use of the geochemical approach to evaluate and determine the flow direction, water flux, and ground-water travel time in the vadose zone by isotopic techniques. And states:

> "Pore fluids from the matrix and near fractures will be extracted from exploratory shaft rubble core for chemical and isotope analyses.", "Fracture fluids are expected to permeate the surrounding matrix.", and "Fluids from samples with moisture contents less than 11 percent (including samples that have been squeezed and centrifuged) will be extracted using the vacuum distillation method."

This technique may be useful in estimating and evaluating the ground-water travel times of **water in the matrix**. However, it is not clear from the SCP how water in the fractures, especially the Topopah Spring unit, will be sampled for the geochemical isotopic technique. There is no comprehensive activity included to explain how fracture waters will be sampled and analyzed when encountered. There are no activities that address field determination of saturated fractures, or ephemeral fracture flow. Other unaddressed problems are the distributed nature of recharge over the repository block, the scale at which data is developed, the three-dimensional distribution in space of data collection, and the manner in which interpretations of these data will be made. Based on surface mapping and the core data, there are several **million fractures** within each hydrogeologic unit of the repository block and every one of these is a possible conduit for both liquid and vapor flow. In addition, there are very significant lithologic units and associated facies that can markedly impact matrix-hydraulic conductivities. We find no activities that recognize and deal effectively with these problems.

GROUND-WATER TRAVEL TIME

In reviewing the DOE general approach to resolving the GWTT issue, we believe it unlikely that the DOE will develop and establish plan and technical program that will provide a viable new database to resolve the pre-waste-emplacement GWTT with reasonable assurance, as required by the NRC 10 CFR 60.113(a)(2). This conclusion is supported by the following comments:

1. The DOE performance allocation for issue 1.6 is described in Table 8.3.5.12-1, page 8.3.5.12-9, for **all** hydrogeologic components available (unsaturated and saturated zones) at Yucca Mountain. It is clearly noted that DOE confidently places a **primary reliance** on the Calico Hills units (CHnv and CHnz) for the GWTT performance measure. The DOE claims that Darcian flow within these primary hydrogeologic units will be relied upon for the matrix-dominated flow **and fracture flow, if substantial flow is identified during characterization.** In order for DOE to deliver on the above claims, it is **required** that the hydrogeologic characteristics of the Calico Hills units **be well established and defined throughout the repository block and beyond** so that the "fastest path" is defined by field data. The performance parameters for GWTT listed in Tables 8.3.5.12-1 and 8.3.5.12-2 cannot be directly related to the hydrogeologic test program listed in section 8.3.1.2 of the SCP. It is our opinion that DOE should directly connect the hydrogeologic investigation program with the Issue Resolution Strategy for GWTT. (See comment for Activity 8.3.1.2.2.4.6).

2. The DOE states that the uncertainty in calculating GWTT caused by alternative conceptual models will be included in the cumulative distribution curves by subjective weighing based on peer review. Peer review is no substitute for confident site-specific data to constrain the conceptual model. It is of concern that these procedures may be insufficient for determining the GWTT along the fastest path to the accessible environment. It is clear that the cumulative distribution function (cdf) for calculating GWTT for each hydrogeologic unit will be affected by many interrelated factors relative to the amount of spreading or flattening of the cdf's. It is possible that these factors, such as variable flow-path lengths, parameter uncertainties of Monte Carlo analyses, uncertainties of alternative models, effects of matrix dispersion and diffusion, and considering GWTT as a random process, may not be separable, thus making their evaluation and understanding uncertain. Therefore, it is our belief that the use of cdf's as described in the SCP **will not** resolve the NRC regulatory requirement.

3. The DOE hydrogeologic conceptual model of matrix-dominated flow through the vadose zone is not supported by the available technical data. The model is based on assumptions that need to be tested and evaluated during site characterization. The planned activities, as described in the SCP, will not test the assumptions in a confident manner. The SCP does not consider conservative conceptual models that fit the limited site-specific data and the hydrogeologic information available in the open literature.

4. The methods and concepts proposed in the SCP to evaluate the in-situ moisture conditions are based on porous-media approaches, which may not be appropriate to use for the fractured tuff at Yucca Mountain. The DOE should develop, if necessary, new methods that can be used to evaluate the role of moisture within fractured-porous media.

5. The proposed conceptual model of recharge through the Yucca Mountain tuff formation may be incorrect and inadequate in desert terrane. The proposed methodologies would provide results which do not lead to an understanding of the recharge processes, nor to accurately evaluating the recharge **fluxes** through the tuff formation (see comment for Activity 8.3.1.2.2.1.2).

6. The DOE concludes that very low flux and, in turn, long ground-water travel time (GWTT), is evident at Yucca Mountain. However, most available in-situ data do not support this conclusion. This conclusion is based on totally unsupported assumptions and not on a conservative evaluation of existing data.

7. The DOE does not address, in sufficient detail, the complexity of water vapor and simultaneous liquid movement under thermal gradient within unsaturated porous and fractured tuff at Yucca Mountain, especially the implication of that process on the waste isolation for thousands of years.

8. The planned unsaturated-zone borehole drilling program does not address the issue of developing a new database for in-situ moisture conditions below the repository horizon. In addition, no provision is made to address the presence and distribution of perched water in the vadose zone at Yucca Mountain. (See comment for Activity 8.3.1.2.2.3.2).

9. The DOE relies heavily on computer and numerical models to **characterize** the water vapor, liquid, and heat movement through Yucca Mountain tuff. The assumptions of most of these codes are not assessed by using reliable laboratory or field data and, therefore, they can not confidently predict the behavior of the vadose-zone hydrologic processes.

10. The DOE does not provide studies for the known transient nature of vadose-zone hydrology.

VADOSE ZONE BOREHOLE STUDY

Activity 8.3.1.2.2.3.2 (on page 8.3.1.2-200) entitled "Site vertical borehole studies" describes the DOE investigation which involves dry drilling and coring of nine planned boreholes that will range in depth from 122 to 460 meters below the land surface. **We are concerned about the apparent strategy of the unsaturated-zone drilling program.** Based on the existing data on moisture in the vadose zone, it could be interpreted that the drilling plan has been designed to **avoid** developing additional data on perched water, or resolving already-developed ambiguous data. Specifically UZ-14, near UZ-1, has a design depth of 120 m. Thus, it will avoid encountering known saturation at 387 m, which stopped UZ-1 drilling. Also, it may not be deep enough to provide much data to resolve the potential ambiguity of records for UZ-1 in the Topopah Spring.

In addition, all the deep boreholes (UZ-9, UZ-9a, UZ-9b, UZ-2, UZ-3, UZ-10) are useless with respect to evaluating the occurrence and extent of perched water at or below the repository horizon in the repository block. UZ-2 and UZ-3 are shallower than UZ-6 and located very close to UZ-6, hence no new data on the distribution of perched water is likely to be established. UZ-9, UZ-9a, UZ-9b, and UZ-10 are too far from the repository block to be directly representative of the block conditions. The remaining boreholes are too shallow to develop data at or below the repository horizon. Such a plan is unlikely to establish new information on perched water nor can it resolve existing questions about already encountered perched water. One can justifiably conclude that the DOE does not want to test the assumptions of the DOE-favored conceptual model of the vadose zone.

We find that the same two drilling techniques previously used in site-selection studies are planned for future surface based vadose zone studies. Both of these drilling methods have serious weaknesses that are well known to DOE from experience, and these weaknesses limit the ability of the DOE to characterize the vadose zone. The ODEX method is slow and has produced a depth maximum of around 400 feet. The reverse-air vacuum produces a large-diameter borehole, cannot drill through perched water, produces unstable boreholes in fractured tuff, and is **unnecessarily costly.** The moisture data from UZ-1 and UZ-6 are compromised by the large diameter of the borehole and the prolonged drilling time. There is an activity to test a new method for coring and drilling with air, but no details are given.

VADOSE ZONE SITING CRITERIA

The NRC siting criteria set forth in 10 CFR 60.122 consist of two sets of conditions. The first set (10 CFR 60.122(b)) encompasses favorable conditions, and the second set (10 CFR 60.122(c)) encompasses the potentially-adverse conditions. The NRC siting criteria include the requirement that the DOE must demonstrate and show by analysis, that the potentially-adverse conditions, if present at the site, do not significantly affect the ability of the geologic repository to meet the performance objective related to isolation of the waste. The DOE sets out a plan to prove a conceptual model of favorable conditions. In doing so, it fails to provide a **plan of activities that test for unfavorable conditions in the vadose zone.**

SUMMARY

We find that the DOE provides a very limited and uncertain field-data collection program that is unlikely to develop a new database which will confidently demonstrate waste-isolation attributes of the proposed site. The program is also unlikely to develop enough new data to resolve the meaning of already-existing data which argues against significant waste-isolation attributes at the site. The bottom-line strategy of the DOE is to characterize the site on the basis of a series of assumptions about an unknown complex environment, with no serious testing of these assumptions by development of a site-specific database of sufficient quality and distribution for confident resolution of the assumptions.

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APPENDIX B

GEOHYDROLOGY PROGRAM- UNSATURATED ZONE DOCUMENT REVIEW FORMS

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 17	CHAPTER/SECTION: 8.3.1.2.2.1.1 Activity: Characterization of hydrologic properties of surficial materials.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-157	This activity is part of the characterization of the unsaturated-zone infiltration. 1. I think that this activity is generally incomplete and poorly focused. The SCP states that "The main purpose of these tests is to help characterize the infiltration-related hydrologic properties of the surficial materials of Yucca Mountain." Tests and methods described and listed under this activity, such as remote sensing, geostatistical, borehole nuclear geophysical logging , surface seismic methods, and geotomographic studies will not establish or result in information that directly establishes the hydrologic properties of the surficial materials. These methods are not sensitive to the changes of hydrologic properties of surficial materials, such as infiltration rates, water content, water potential, and runoff rates, that could be encountered at the Yucca Mountain site. The location of each experiment is critical in evaluating the usefulness of the results and this information is not supplied. 2. Most of the methods and technical procedures that are provided are listed by titles only and given the designation "TBD" which makes it impossible to technically review this activity.

REVIEWER: Atef Elzeftawy Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 18	CHAPTER/SECTION: 8.3.1.2.2.1.2 Activity: Evaluation of natural infiltration.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-164	This activity is part of the characterization of unsaturated-zone infiltration. 1. This activity does not address the evaluation of the upper flux boundary for Yucca Mountain which is the main purpose of this study. Because of the expected low flux, the water budget studies and some methodologies listed on pages 8.3.1.2-170 to 8.3.1.2-171 may not be appropriate for evaluation of the upper flux boundary. A serious weakness of the water budget methods is that the local setting variations and site specific information may not be delineated accurately to evaluate the recharge flux with reasonable certainty which could be reflected on the ground-water travel time calculations. It is also undemonstrated that mean annual precipitation is the best parameter of climate from which to estimate the recharge flux. 2. It is my technical opinion that this study could be feasible to accomplish if the correct existing technology is used. For example, it is suggested that control-plot studies be expanded and tritium-profiling methods be utilized.

REVIEWER: Atef Elzeftawy	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 29 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 19	CHAPTER/SECTION: 8.3.1.2.2.1.3 Activity: Evaluation of artifical infiltration.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-172	This activity is part of the characterization of unsaturated-zone infiltration. 1. The focus of this activity is to characterize the water movement through the surficial materials that cover Yucca Mountain; however, in our opinion, the focus should be to characterize the flow pathways, flow fluxes, and the water pressure potentials throughout the hydrogeologic units of the Mountain. In addition, shifting the focus of this activity would ensure that the parameters of this activity which are listed on page 8.3.1.2-173 would be properly evaluated using the same technical procedures listed on pages 8.3.1.2-176-179. 2. The listed methodologies and procedures are suitable for porous media. It is suggested that DOE develop a new method or modify the existing technical approach to address the nature of the fractured and nonwelded tuff of Yucca Mountain.

REVIEWER: Atef Elzeftawy Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 20 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 20	CHAPTER/SECTION: 8.3.1.2.2.1 Activity: Chloride and chlorine-36 measurements of percolation at Yucca Mountain.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-180	This activity is the only activity under water movement tracer tests using chloride and chlorine-36 measurements of percolation at Yucca Mountain. 1. The movement or transport of dissolved radionuclides and isotopes through unsaturated porous media is a dynamic and complex process. To address the percolation process of chloride and chlorine-36 through the tuff formations of Yucca Mountain, many questions need to be resolved; such as, where should samples be collected? By what technical procedure? How much water sample is needed? How often should samples be collected? What kind of precaution is taken to insure the pristine conditions of the water samples? These questions are essential with regard to the database upon which the numerical models are built and utilized for estimating the effective infiltration rate at the site. 2. The newly added table on page 8.3.1.2-181 does not include substantial information for technical review.

REVIEWER: Atef Elzeftawy Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 21	CHAPTER/SECTION: 8.3.1.2.2.3.1 Activity: Matrix hydrologic properties testing.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-183	This activity is under the characterization of percolation in the unsaturated-zone surface-based study. 1. This activity, if properly executed, will result in developing the in-situ matrix hydrologic data. Data that are obtained from cores may not be applicable to the field scale of Yucca Mountain. In addition, it is not clear how the properties evaluated would be useful in terms of determining the water flux of the matrix. 2. It is not clearly explained how the statistical and the geostatistical models would be used to calculate, with known certainty, the water flux values related to the matrix hydrogeologic properties.

REVIEWER: Atef Elzeftawy	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 29 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 22	CHAPTER/SECTION: 8.3.1.2.2.3.2 Activity: Site vertical borehole studies.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-200	This activity is under the characterization of percolation in the unsaturated-zone surface-based study. 1. It is our technical opinion that all planned deep boreholes (UZ-2, UZ-3, UZ-9 series and UZ-10) are essentially useless with respect to evaluating the occurrence and the extent of perched groundwater above, at, or below the repository horizon. No new data are likely to be obtained or established because of the limited depths listed on Table 8.3.1.2-7. Boreholes UZ-2, UZ-3, UZ-9 series, and UZ-10 are each planned to be drilled to a total depth no deeper than 460 meters below the land surface. Borehole UZ-6 was drilled to a depth of 575.2 meters in 1984 and did not produce meaningful data with respect to the uansaturated zone hydrogeologic properties and parameters. Some of the boreholes are too far from the repository block to produce meaningful site-specific data. For example, UZ-9 series, UZ-10, and UZ-13 are located about 1 to 2 kilometers beyond the repository block boundary. 2. The two drilling techniques previously used during site studies are planned for future studies under this activity. Both of these drilling methods (the ODEX and reverse-air vacuum methods) have major weaknesses. For the ODEX, these weaknesses include the limited depth of penetration from the land surface to about 400 feet, the large size of the borehole, slow drilling, and inability to drill past the saturation zone. These seriously limit DOE's ability to characterize the vadose zone at Yucca Mountain.

REVIEWER: Atef Elzeftawy Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 23	CHAPTER/SECTION: 8.3.1.2.2.3.3 Activity: Solitario Canyon horizontal borehole study.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-221	This activity is part of the characterization of percolation in the unsaturated-zone surface-based study. The objectives of this activity are (1) to examine the extent of fracturing and gouge development associated with the Solitario Canyon fault, and (2) to evaluate the local significance of fault-related features on water movement within the fault zone. 1. It is impossible to reach the objectives of this activity with the level of effort proposed by DOE. The one proposed horizontal borehole for this activity is not sufficient to evaluate the role of the hydrogeologic significance of the Solitario Canyon fault zone with respect to features related to water movement. Instead, DOE should consider more than one location for this activity because of the statistical importance of the collected data. 2. I also question the probability of a successful horizontal drilling operation for 300 meters or more. It has been our observation that DOE used a great deal of foam and water to drill about 50 meters of a horizontal borehole in a tuff formation. We are unclear as to how much foam and water would be used to drill about 300 meters of a horizontal hole. My concern is that too much foam would prevent recognition of any unsaturated zone water encountered during the drilling operation and, thus, impact the quality of water samples.

REVIEWER: Atef Elzeftawy Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 24	CHAPTER/SECTION: 8.3.1.2.2.4.1 Activity: Intact-fracture test in the exploratory shaft facility.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-238	This activity is a part of the characterization of Yucca Mountain percolation in the unsaturated-zone exploratory-shaft facility study. The objective of this activity is to study the flow of water and chemicals through a single, undisturbed fracture. 1. This intact fracture test is being planned to be conducted in the laboratory. The proposed work probably will succeed and produce some results and data applicable to that particular block of tuff; however, laboratory information does not necessarily apply to field situation. At this point, it should be stated that any evaluations or estimations of scale dependency of the needed hydrologic parameters during this test will be applicable only to the immediate test area due to the heterogeneity of the fractured tuff and the spatial variation of its hydrologic properties. 2. This test is of questionable value and useless for developing information needed to evaluate the suitability of fractured tuff to isolate high-level radioactive waste for these two important reasons: a. The laboratory tests uses only very small segments of fractures that can be tested, and thus the laboratory data and results have little meaning with respect to to the total behavior of fractures in their natural setting. b. Only relatively "tight" fracture planes will be successfully sampled and tested. Therefore, fracture planes which are basically open, and highly-fractured zones will not be sampled successfully. 3. DOE should address field evaluation of the role of fractures with regard to the unsaturated zone hydrogeology. New technology may have to be developed to fully understand unsaturated fractured flow through Yucca Mountain. 4. Many methods and technical procedures are listed as "TBD" which makes them difficult to review.

REVIEWER: Atef Elzeftawy Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 25	CHAPTER/SECTION: 8.3.1.2.2.4.2 Activity: Percolation tests in the exploratory shaft facility.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-252	This activity has been somewhat modified and expanded. For example, a pillar of welded tuff on the lower breakout horizon of the exploratory shaft will be isolated and a test block will be cut. It is stated that the test block is not representative of the REV (representative elementary volume) of the tuff. However, it is chosen to be 2 m x 2 m because of the increasing difficulty in attaining steady-state flow in large volume of low permeability rock. Upon reviewing this activity, it is my concern that great caution should be taken in conducting these experiments with respect to the fracture flow of water and tracers. For example, if fracture flow was induced at the early stages of the experiment, what actions should be taken to evaluate that process? In addition, this experiment is loaded with uncertainties in terms of its feasibility of execution and appropriate methodologies. It represents a heavy investment in terms of time and effort for obtaining results that might be representative of 2 x 2 x 2 m of host rock, and the results are biased by the initial selection of the rock and by the degree of successes and failures of each procedure needed to execute the experiment. There is no obvious recognition of the impact of very low hydraulic conductivities of the matrix on the experiment. Many years (much longer than the assumed characterization period) would be required for reaching equilibrium in the matrix for each state of flow. The idea of using such an experiment to determine the four parameter areas of both fractures and matrix is highly idealistic and totally impractical from the perspective of site characterization.

REVIEWER: Atef Elzeftawy Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE TECHNICAL REVIEW COMMENT	
DOCUMENT TITLE: Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).	
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 26 (1 of 2)	CHAPTER/SECTION: 8.3.1.2.2.4.3 Activity: Bulk-permeability test in the exploratory shaft facility.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-271	This activity is part of the characterization of Yucca Mountain percolation in the unsaturated-zone exploratory-shaft facility study. The objectives of this activity are (1) to determine the scale to which the host rock behaves as an equivalent porous medium (EPM); (2) to compare hydraulic test results against simulated results; and (3) to use numerical fracture-flow model to establish the minimum dimensions for fracture/porous rock behavior as EPM. 1. It may not be possible to confidently reach any of the stated objectives with the effort described and proposed under this activity. There are two procedures upon which this activity depends: a. Method for dry drilling (without any drilling fluids, except clean air) and coring vertical and horizontal boreholes, and b. Method for cleaning drilled boreholes to avoid sealing effect. If these methods are not available or if they do not work, the entire activity is open to question with regard to its feasibility of determining meaningful data for gas/air characterization of the site.

REVIEWER: Atef Elzeftawy Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 21 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 26 (2 of 2)	CHAPTER/SECTION: 8.3.1.2.2.4.3 Activity: Bulk-permeability test in the exploratory shaft facility.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-271	2. The air permeability before and after excavation is no longer being considered for evaluation in the SCP. It is observed that no explanation is given as to why this parameter is neglected. 3. Figures 8.3.1.2-17 and 8.3.1.2-18 of the CD-SCP have been <u>deleted</u> from the SCP. These dealt with the layout of the bulk permeability tests and the locations of the test holes. On pages 8.3.1.2-273 and 274 of the SCP, the DOE stated that the cross-hole testing method of injecting gas into the isolated test interval within a drill hole would be observed in nearby observation holes. The success of this method will depend, in great measure, on the locations of all boreholes and the way they are constructed, drilled and packed off. Thus, it is suggested that detailed plans with figures be included in the SCP so that the technical reviewer would have sufficient information that could lead to a meaningful review.

REVIEWER: Atef Elzeftawy Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 21 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 27 (1 of 2)	CHAPTER/SECTION: 8.3.1.2.2.4.4 Activity: Radial borehole tests in the exploratory shaft facility.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-281	This activity is part of the characterization of Yucca Mountain percolation in the unsaturated-zone exploratory-shaft facility study. The objectives of this activity are (1) to detect vertical movement of water in both the vapor and liquid form, and (2) to evaluate the radial extent of ES effects on hydrologic properties of unsaturated hydrogeologic units. Little modification was made in Figure 8.3.1.2-16 entitled "Schematic of the radial boreholes tests (CD-SCP Figure 8.3.1.2-19)." The Calico Hills breakout test room in the CD-SCP Figure has been eliminated in the new Figure of the SCP. The DOE considers the tuffs of the Calico Hills hydrostratigraphic unit a primary barrier for the flow of water and the transport of radionuclides from the repository horizon to the ground-water table of the saturated zone below the repository, assuming only downward flow of water through the unsaturated zone.

REVIEWER: Atef Elzeftawy	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 29 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 27 (2 of 2)	CHAPTER/SECTION: 8.3.1.2.2.4.4 Activity: Radial borehole tests in the exploratory shaft facility.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-281	The DOE postulates that the tuffs of the Calico Hills constitute the primary barrier unit under the repository for long travel times and radionuclide sorption or retardation. Yet, the site-characterization program essentially has no program to test this hypothesis. If DOE believes that this unit must not be penetrated to maintain its integrity, then the entire waste isolation capacity for downward movement of gas and liquids under the repository block will be based on conceptualized ideas and nothing more. If this approach is perpetrated, the site remains, for all practical purposes, uncharacterized in its most fundamental aspects, that is, unknown with respect to downward moving fluids. Therefore, an alternative program of characterization is needed for this zone. Perhaps several shafts and break-out zones or horizontal drilling with air (assuming the technical feasibility of such drilling, as does the SCP) around the repository block are necessary to at least establish a real database in a close analog environment. It is my opinion that samples from the postulated primary barrier unit should be collected for hydrogeologic studies. Rock samples from boreholes should be collected and studied to evaluate hydrogeologic behavior. This is the only reasonable way to study the movement of radionuclides through the rock.

REVIEWER: Atef Elzeftawy	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 29 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
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DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 28	CHAPTER/SECTION: 8.3.1.2.2.4.5 Activity: Excavation effects test in the exploratory shaft.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-293	This activity is part of the characterization of Yucca Mountain percolation in the unsaturated-zone exploratory-shaft facility study. In reviewing this activity, I find that it has not been significantly changed or modified in response to our previous comments on the DOE Consultation Draft of Yucca Mountain Site Characterization Plan (DOE/RW-0160), January 1988. However, a modified Figure 8.3.1.2-17 is included with a plan view and cross section. In reviewing this activity, I find that DOE has not addressed or explained the relationship between the stresses in the rock and the unsaturated zone hydrogeology. The stated objective of this activity is to validate and calibrate a coupled hydraulic-mechanical, finite-element model by using the gathered data of this activity. It is not clear to the reader how these parameters, such as in-situ degree of saturation, air-permeability profiles, and other hydrologic parameters, would be affected by the stress in the rock matrix. Why not drill the holes before excavation and establish monitoring from land surface down to some depth (feasible) then, if effects are important, establish the subsurface study at a lower depth. Also, why is the hydrologic effect of excavation water not mentioned? This has the potential to totally modify, and perhaps compromise, the majority of hydrologic testing planned. There seems to be no common sense, or no seriousness, displayed in terms of what is actually feasible and what the shaft construction procedures will create in highly permeable, fractured rock.

REVIEWER: Atef Elzeftawy	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 29 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 29	CHAPTER/SECTION: 8.3.1.2.2.4.6 Activity: Calico Hills test in the exploratory shaft facility.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-300	This activity is a part of the characterization of Yucca Mountain percolation in the unsaturated-zone exploratory-shaft facility study. This activity has almost been deleted from the program because of the consideration that the Calico Hills nonwelded unit is expected to be a principal barrier to the flow of ground water and transport of the radioactive nuclides. As justification for the scoping down of work under this activity, the DOE stated on page 8.3.1.2-300 that, "...it is possible, in some circumstances, that penetration of the unit within the repository block for testing purposes could affect the performance of the site." It also states that a risk/benefit analysis and a selection of appropriate test options will be prepared. It is not very clear how the DOE would approach the evaluation of ground-water travel time criteria through this zone without sampling through it.

REVIEWER: Atef Elzeftawy Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 22 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 30	CHAPTER/SECTION: 8.3.1.2.2.4.7 Activity: Perched water test in the exploratory shaft.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-300	This activity is part of the characterization of Yucca Mountain percolation in the unsaturated-zone exploratory-shaft facility study. The objectives of this activity are (1) to detect the occurrence of perched water, (2) to estimate the hydraulic properties, and (3) to determine the implication on water flux, flow paths, and travels times through the unsaturated, fractured tuff. 1. Nowhere in the text do I find what the DOE strategy would be in addressing the adverse impact on the hydrologic characteristic of the unsaturated zone surrounding the exploratory shaft facility in the case of finding larger volumes of water as perched water. 2. The text of this activity does not explain or state how DOE is planning to accomplish the objectives listed on page 8.3.1.2-300. 3. The SCP, on page 8.3.1.2-301, states," If a seep or wet zone of <u>low discharge is encountered</u>, a small-diameter lateral hole will be drilled into the shaft wall. <u>This will increase the flow rate by concentrating and confining the flow</u> of a perforated well casing to make accurate flow measurements and collect representative water samples" (emphasis added). This statement is very disturbing on the basis of my understanding of the physical law of the unsaturated-zone hydrology. It is suggested that DOE support this approach with a technical discussion of why the flow would be concentrated.

REVIEWER: Atef Elzeftawy Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 31 (1 of 2)	CHAPTER/SECTION: 8.3.1.2.2.4.8 Activity: Hydrochemistry tests in the exploratory-shaft facility.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-304	This activity is part of the characterization of Yucca Mountain percolation in the unsaturated-zone exploratory-shaft facility study. The objectives of this activity, as noted on page 8.3.1.2-304 of the SCP, are: 1. Understand the gas transport processes within the unsaturated zone and to provide independent evidence of flow direction, flux, and travel time of gas. 2. Design and implement methods for extracting uncontaminated pore fluid from rock excavated during shaft construction. 3. Determine the flow direction, flux, and travel time of water in the unsaturated zone by isotope geochemistry techniques. 4. Determine the extent of the water-rock interaction so that geochemical modeling can be performed to deduce the flow path and to understand the geochemical evolution of the unsaturated zone water. 1. The objectives of this activity as listed on page 8.3.1.2-304 may be practically impossible to accomplish given the description, methods, and technical procedures listed for this work. It should be stated that DOE is over-simplifying the complexity of unsaturated-zone geochemistry. Tracers and isotopic information for pore water from fractures and matrix of the tuff may be easily misinterpreted and lead to erroneous results and conclusions. The hydrogeologic heterogeneities of the Yucca Mountain fractured tuffs are well recognized and undoubtedly will have an impact on the quality of water within the unsaturated zone and especially the isotopic data.

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Signature	DATE: 22 June 1989

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 31 (2 of 2)	CHAPTER/SECTION: 8.3.1.2.2.4.8 Activity: Hydrochemistry tests in the exploratory-shaft facility.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-304	2. This activity does not provide for a plan of action in the event of encountering a large amount of water from a perched groundwater or from large or small saturated fractures in the tuff. 3. It is my technical opinion that the isotopic data may not be feasible to use to determine fluxes and flow directions within the unsaturated fractured tuff. The following points are suggested for the DOE to consider during the revision of the statuary SCP: a. Sampling the carbon dioxide and water vapor from rock formations at the Yucca Mountain site may be feasible and possible. However, the quality of the samples as taken is the most important factor of this evaluation with respect to the stable isotope ratios (for carbon or oxygen). b. The extraction of pore fluids from the matrix and near fractures may be obtainable with ease in the laboratory from core samples; however, our greatest concern is how DOE would be able to assume that field operations do not interfere with the quality of fluids extracted from field sites within the exploratory shaft facility. c. DOE should consider that Yucca Mountain is an open unsaturated system, unless proven otherwise.

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 32	CHAPTER/SECTION: 8.3.1.2.2.4.9 Activity: Multipurpose-borehole testing near the exploratory shaft.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-308	This activity is an addition to Study 8.3.1.2.2.4 of the statuary SCP (Characterization of Yucca Mountain percolation in the unsaturated zone--exploratory shaft facility study). This activity could be one of the most important activities under Investigation 8.3.1.2.2: Studies to provide a description of the unsaturated zone hydrologic system at the site. The DOE is planning to use **a dry drilling method** "to evaluate the hydrologic and engineering interference effects from exploratory shaft construction..., to identify possible occurrence of perched water..., and to confirm engineering and hydrogeologic properties on which the ESF (exploratory shaft facility) design is based..." I agree that **a dry drilling method** should be utilized during this investigation for evaluating the unsaturated zone hydrologiic parameters of the Yucca Mountain site. However, in the course of reviewing this activity, I suggest the following: 1. The objectives of this activity should be modified to address the issue of installing devices to monitor the changes in the hydrologic parameters for 3 to 4 years, at the least, and this installation should be done in such a manner as to avoid the problems encountered at boreholes USW UZ-1 and UZ-6. 2. The dry drilling of USW MP-1 and MP-2 boreholes should continue until the **regional groundwater** table is reached. 3. A complete study, with field verification, addressing the effect of generated heat on the initial moisture content of the cored rocks during the coring process should be made before beginning dry drilling. 4. It is strongly suggested that DOE consider drilling more than two "multipurpose boreholes" to penetrate the rock formation at the Yucca Mountain site and to reach the regional ground-water table. The locations of additional boreholes should address the need for a stronger and wider database and new information to resolve the issue of ground-water travel time (GWTT) evaluation, especially within the unsaturated zone.

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 33	CHAPTER/SECTION: 8.3.1.2.2.4.10 Activity: Hydrologic properties of major faults encountered in main test level of the exploratory-shaft facility (ESF).

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-316	This activity is the last activity for this study (8.3.1.2.2.4). It is an addition to the statuary SCP. Under this activity, DOE is planning to drill horizontal boreholes in the long drifts at the main test level of the ESF. The activity calls for using air as the drilling fluid for all boreholes. The objective is to investigate the permeability and flow conditions of the major faults, such as the Ghost Dance Fault, Drill Hole Wash Fault, and the imbricate fault zone. DOE is planning to evaluate many hydrologic (including air permeability) and chemical parameters of these faults. However, until DOE provides more information on how these parameters would be evaluated under the field conditions to determine the impact of the existing faults on the unsaturated zone properties, technical review of this activity is impossible. In addition, the technical feasibility of dry-drilled, long, horizontal boreholes within the ESF is not demonstrated.

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 34	CHAPTER/SECTION: 8.3.1.2.2.5.1 Activity: Diffusion tests in the exploratory shaft facility.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-320	This is the only activity under the diffusion tests in the exploratory shaft facility. The objective of this activity is to determine the in-situ extent to which nonsorbing tracers diffuse into the water-filled pores of the tuff of the Topopah Spring welded unit. 1. This objective may be impossible to accomplish under field conditions of unsaturated flow regimens of the tuff. The DOE diffusion tests are to be conducted in small-diameter boreholes to model the transport of "nonreactive radionuclides" from the repository horizon to the ground-water table. This activity will <u>only</u> provide information about the diffusion process applicable <u>only</u> to the immediate locale of the boreholes. Using this information to model the transport of iodine-129 and technetium-99 below the repository will be difficult due to the fact that the diffusion coefficients are scale, velocity, and moisture-content dependent. 2. The application of the tracer solution in the boreholes will create a saturated boundary flux in the boreholes which does not reflect the <u>in-situ</u> characteristic of the unsaturated-zone moisture and potential conditions in the fractured tuff.

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 35 (1 of 2)	CHAPTER/SECTION: 8.3.1.2.2.6 Study: Characterization of gaseous-phase movement in the unsaturated zone.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-323	The objectives of this study are: 1) to describe the pre-waste emplacement gas-flow field; 2) to identify structured controls on fluid flow; 3) to determine conductive and dispersive properties of the unsaturated zone for a gas flow; and 4) to model the transport of water and tracers in the gas phase. 1. It is impossible to confidently reach any of the objectives (1, 2, 3, 4) with the level of effort proposed in the two activities. The boreholes proposed are very near the existing UZ-6 and UZ-6s, and, therefore, only a localized evaluation of an area of the repository block (extreme SW corner) that is already compromised by the short-circuiting effects of UZ-6 can be made, and in another area (UE25 UZ-9) about one kilometer from the SE border of the repository block. The former area has been altered by the several years of UZ-6 acting as artifical connection between the atmosphere and various zones in the subsurface, and the latter area may behave entirely differently as it lies to the east beyond the Ghost Dance Fault. 2. It is absolutely critical to repository characterization (demonstrate if there is waste isolation with respect to gas releases) to establish the degree of connection of the soil-gas circulation in the repository horizon with the atmosphere at land surface **over the entire repository block area**. There is an estimate in the literature which indicates that the release of only 1/4 of the C^{14} inventory from **one** canister puts the radionuclide release rate at the EPA limit if it circulates to land surface. 3. It is necessary to establish where the soil-gas circulation occurs in terms of the stratigraphy of the repository block. The existing UZ holes are not designed to establish this, nor does Activity 8.3.1.2.2.6.1 recognize the importance of the design of the data collection wells in terms of both depth and lateral distribution (location).

REVIEWER: M. D. Mifflin Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June 1989

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 35 (2 of 2)	CHAPTER/SECTION: 8.3.1.2.2.6 Study: Characterization of gaseous-phase movement in the unsaturated zone.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-323	4. This study fails to consider documenting where the soil gas is being inhaled and discharged in the Yucca Mountain area. How is it possible to model, even in the most simplistic terms, such a circulation system if there is no idea of where and how the exchange with atmospheric reservoir is occurring? In a similar sense, how is it possible to model the system over the three-dimensional extent of the repository if the lateral and the vertical extents (depth of the active reservoir) have not been established? There is good evidence that the similar processes, if not the same reservoir, are operating on both sides of Solitario Canyon Fault. 5. The statement is made that only modeling permits the evaluation of the magnitude of vapor fluxes and gas transport. This is false and misleading if the in-situ field data is insufficient to establish all boundary conditions as well as properties of the reservoir for the entire repository area. This statement also fails to recognize the objectives of the site characterization, that is, whether the site meets licensing criteria. It is travel time to the accessible environment by the most rapid pathway (NRC has defined all vadose zone moisture as ground water) and mass release rates for radionuclides. A conservative interpretation of the presently limited information of soil gas circulation at Yucca Mountain suggests that neither licensing criteria will be met due to the active soil-gas circulation apparently as deep as the repository horizon. A much more comprehensive site-specific data-collection program is necessary to confidently resolve these licensing issues.

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 36	CHAPTER/SECTION: 8.3.1.2.2.6.1 Activity: Gaseous-phase circulation study.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-323	This is the only activity under the study entitled "Characterization of gaseous-phase movement in the unsaturated zone." The objectives of this study are: 1) to describe the pre-waste emplacement gas-flow field; 2) to identify structured controls on fluid flow; 3) to determine conductive and dispersive properties of the unsaturated zone for a gas flow; and 4) to model the transport of water and tracers in the gas phase. 1. It may be impossible to establish any of the above objectives of this activity. The proposed locations of boreholes UZ-9 series, UZ-11, and UZ-12 for gas sampling may be compromised by (1) the short-circuiting of UZ-6 and UZ-6s, and (2) the location of UZ-9 series being more than 1/2 mile from the repository block which may behave differently because of the existence of the north/south trending faults. 2. It is my concern that sampling the gaseous phase, as described in this activity, may not produce results or information that would lead to a model of the gas flow from the repository to the accessible environment. The gas phase of an unsaturated rock system, such as this site, is in constant dynamic change in response to the changes in atmospheric air pressure. 3. Some of the parameters, such as fault conductivity, effective porosity, convective dispersivity, etc., may have to be defined by DOE, since there is no explanation in the text as to their meaning relative to the gaseous flow through the unsaturated rock.

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 37	CHAPTER/SECTION: 8.3.1.2.2.6.1 Activity: Gaseous-phase circulation study.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-323	This activity describes the DOE field data-collection modeling activities. 1. Referring to the modeling, the following quote is very presumptive considering the existing gas circulation evidence and key licensing criteria: "These results will be useful in evaluating water vapor and gaseous radionuclide transport from Yucca Moutain **once the repository is in place**" (emphasis added). It makes one wonder about how serious the DOE intent is to create a model based on site-specific boundary conditions and soil-gas reservoir parameters, particularly when the field data-collection program described is so limited with respect to resolving the licensing issues for the repository block. Without data, one can readily bias modeling results by varying assumptions and playing statistical games with sparse datasets with respect to boundary conditions and reservoir parameters. 2. Data from UE-25UZ9, 9a, and 9b are too far from the repository block to be clearly representative of the repository block, or for that matter, that area around UZ6 where the other database will be developed (~2 km to the west). 3. The field data-collection program (and perhaps the entire study) should be focused on determining the degree of pneumatic continuity between the repository horizon in the welded tuff and the land surface **for the entire repository block**. This cannot be established without carefully designed and constructed boreholes open at varying depths, including the Topopah Spring repository zone welded tuff, for each quadrant of the repository block.

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 38 (1 of 2)	CHAPTER/SECTION: 8.3.1.2.2.7.1 Activity: Gaseous-phase chemical investigations.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-334	This activity is part of the hydrochemical characterization of the unsaturated-zone study. The objective of this activity is to understand the gas transport mechanism and to provide evidence of gas flow direction, flux, and travel time within the unsaturated zone. 1. The gas samples are planned to be collected from the following unsaturated zone holes: UZ-1, UZ-2, UZ-3, UZ-4, UZ-5, UZ-6, UZ-7, UZ-8, UZ-9 series, UZ-10, UZ-11, UZ-12, UZ-13, and UZ-17 (listed on Figure 8.3.1.2-20, page 8.3.1.2-336 in the SCP), after packing and instrumentation. There is a fundamental problem with the location of all these boreholes. These UZ holes are not designed to establish the gas-flow direction or travel times within the stratigraphy of the repository block. First of all, holes UZ-4, UZ-5, UZ-9 series, UZ-10, and UZ-13 are too far from the repository block boundary (1 to 2 miles), thus the gathered data may not display the same characteristic behavior as the repository block. Secondly, data from boreholes UZ-2, UZ-3, UZ-11, and UZ-12 could be compromised by the short circuiting of boreholes UZ-6 and UZ-6s. Thirdly, both UZ-11 and UZ-12 could behave entirely different than the repository block because of the existence of the Solitario Canyon Fault. Therefore, it is doubtful that meaningful data or information could be developed for licensing the site.

REVIEWER: Atef Elzeftawy Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 22 June 1989

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 38 (2 of 2)	CHAPTER/SECTION: 8.3.1.2.2.7.1 Activity: Gaseous-phase chemical investigations.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-334	2. The unsaturated fractured tuff formations at Yucca Mountain should be considered an open system and, consequently, the determination of the age of the unsaturated zone gases using carbon-14, carbon-13, and carbon-12 isotopic ratios may not result in meaningful and useful data. In addition, flux and flow conditions will be difficult to determine, even if DOE obtains three-dimensional data, due to the complexity of identifying the source boundaries. 3. Multiple packed-off horizons in boreholes with flow meters' methodology may produce some information related to the composition of gaseous phase, but the interpretation and the meaning of the results will be difficult to assess with regard to the issue of gas flow to the accessible environment.

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 39	CHAPTER/SECTION: 8.3.1.2.2.7.2 Activity: Aqueous-phase chemical investigations.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-337	This activity is part of the hydrochemical characterization of the unsaturated zone. The objectives of this activity are (1) to design and implement methods for extracting pore fluids from unsaturated tuff units, (2) to provide evidence of flow direction, flux, and travel time in the unsaturated zone, and (3) to determine the extent of water-rock interaction to model the geochemistry of the unsaturated zone. 1. The objectives of this activity may not be possible to confidently reach based on the SCP description of the field sampling program. Without a reliable and pristine sampling program of the unsaturated-zone waters from all stratigraphic units at Yucca Mountain, one may wonder how serious the DOE's intent is to study key licensing criteria. The modeling of unsaturated-zone geochemistry by varying assumptions and manipulating sparse data for the statistical goal may not lead to resolving the technical issues needed for licensing of the site. 2. The activity calls for extracting pore fluids using core samples obtained from the rock matrix and near fractures by applying pressure or centrifuge methods. It is very likely that these methods would produce information relative to the composition of the pore fluids from tuffs; however, our greatest concern is that the interpretation of these data will be difficult or even impossible due to the mixing that may occur within the pore systems of the rock and between the matrix and fracture water. 3. It is strongly suggested that DOE consider some provision for the possibility of perched groundwater and saturated fractures within the unsaturated rock formations of Yucca Mountain.

REVIEWER: Atef Elzeftawy	ORGANIZATION: Mifflin & Associates, Inc.
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 40	CHAPTER/SECTION: 8.3.1.2.2.8 Study: Fluid flow in unsaturated, fractured rock.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-341	This study may appear to the casual reader as if it is a new study added to the investigation of the unsaturated zone hydrologic system at the Yucca Mountain site. In actuality, however, it combines three prior activities; namely, 8.3.1.2.1.9.1, 8.3.1.2.2.9.2, and 8.3.1.2.2.9.3 of the CD-SCP study entitled "unsaturated-zone flow and transport modeling" (8.3.1.2.2.9). Upon careful review and comparison with the previous activities, DOE has not changed its direction with this new activity. The study still does not acknowledge the limited understanding of the physics of unsaturated flow through fractured media under thermal gradients and large field scale. The reliance upon modeling to establish the degree of waste isolation of the site is a very weak approach in light of the 1000 years' ground-water travel time requirement.

REVIEWER: Atef Elzeftawy	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 23 June 1989

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AUTHOR(S):	U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE:	DOE/RW-0199 (December 1988).
COMMENT #: 41	CHAPTER/SECTION: 8.3.1.2.2.8.1 Activity: Development of conceptual and numerical models of fluid flow in unsaturated, fractured rock.		
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:		
Page 8.3.1.2-342	This activity is part of the study entitled "Fluid flow in unsaturated, fractured rock." As we stated in our comments on this study (see comment #40), it appears that this activity is a new addition to the study of modeling flow in fractured media. Although some modifications have been made, the intent of this new activity is exactly the same as the previous one in the CD-SCP. The basic premise of developing hydrologic concepts through modeling without field-scale hydrologic parameters has not changed in the SCP document. It is my opinion that, in order to model the hydrologic phenomena under field conditions, the physical understanding and the limitations of the use of hydrologic physical laws should be established before any future prediction is made by modeling results.		
REVIEWER:	Atef Elzeftawy Signature	ORGANIZATION:	Mifflin & Associates, Inc. DATE: 29 June 1989

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 42	CHAPTER/SECTION: 8.3.1.2.2.8.2 Activity: Validation of conceptual and numerical models of fluid flow through unsaturated, fractured rock.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-345	This activity is part of the study entitled "Fluid flow in unsaturated, fractured rock." As we stated in our comments on this study (see comment #40), it appears that this activity is a new addition to the study of modeling flow in fractured media. Although some modifications have been made, the intent of this new activity is exactly the same as the previous one in the CD-SCP. It is very distrubing to note that DOE strategy for validation of numerical and conceptual models is summed up in paragraph 2, page 8.3.1.2-346 of the SCP. "Hypotheses that describe fluid flow and transport processes in fractured rock are preliminary in nature and will require validation through field and laboratory testing, as described in Study 8.3.1.2.2.4. The process of model validation is intended to ensure that the model can adequately describe the system to which it is being applied. As discussed in the previous activity (8.3.1.2.2.8.1), the reasonableness of a modeling approach can often be evaluated by comparing simulated results from the model with those of a more detailed, and presumably more accurate and realistic model. The limitations of a simpler model can often be exposed in this manner. However, those models determined to be compatible and internally consistent must still be tested by devising experiments that isolate and test individual components in each model. This ensures that these components adequately describe the physical processes at the temporal and spatial scales at which the model application is to be made. By comparing measured and simulated results, a determination is then made as to whether or not the model appears to be adequate for its intended application. In the context of waste repository licensing, "adequacy" may mean simply that the model is accurate enough that a clear-cut decision may be made concerning whether the proposed facility would satisfy the regulatory requirements" (emphasis added). It is strongly recommended that DOE revise its strategy in accordance with accepted scientific research standards, that is, comparisons between simulated data and experimental data should be made, first, by testing the hypotheses of the model against the physics of the system which the model describes and, secondly, by generating laboratories and field data that explain the physics of the flow of liquids and the dissolved chemicals in it.

REVIEWER: Atef Elzeftawy	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 29 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 43	CHAPTER/SECTION: 8.3.1.2.2.9 Study: Site unsaturated-zone modeling and synthesis.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-350	This study has been renamed, rewritten, modified and expanded to five activities; namely, 8.3.1.2.2.9.1 through 8.3.1.2.2.9.5 beyond the CD-SCP study entitled "unsaturated-zone system analysis and integration" (8.3.1.2.2.10). Upon careful review and comparison of this new study with the activities of the CD-SCP study, it is clear, as previously commented on 8.3.1.2.2.8 (see comment #40), that DOE has not changed its approach or direction relative to its reliance upon modeling the physics of flow of fluids through the fractured rocks of Yucca Mountain. It is very important that DOE test the assumptions utilizing laboratory and field data. One of the major assumptions DOE must evaluate by field and laboratory testing and not modeling is whether or not fracture flow of water is the predominant mechanism through the unsaturated rock at Yucca Mountain. The current assumption of matrix flow is the major issue for the repository performance as it impacts the waste-isolation criteria.

REVIEWER: Atef Elzeftawy	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 29 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 44	CHAPTER/SECTION: 8.3.1.2.2.9.1 Activity: Conceptualization of the unsaturated-zone hydrogeologic system.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-351	This activity is part of the site unsaturated-zone modeling and synthesis study. 1. Conceptual hydrogeologic models should be based on the hydrologic understanding of the system relative to the overall moisture flow and transport within the unsaturated zone at Yucca Mountain. It is very unlikely that computer modeling would provide the needed knowledge and understanding of the\physics of unsaturated flow through fractured rocks. However, computer modeling activities, as tools, could help us gain a new insight as to the role of different flow mechanisms within the unsaturated hydro-system. (See comment #43). 2. Most of the methods and technical procedures that are provided are listed by titles only and given the designation "TBD" which makes it impossible to technically review this activity.

REVIEWER: Atef Elzeftawy Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 45	CHAPTER/SECTION: 8.3.1.2.2.9.2 Activity: Selection, development, and testing of hydrologic-modeling computer codes.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-353	This activity is part of the site unsaturated-zone modeling and synthesis study. The objectives of this study are (1) to select, evaluate, and adopt existing numerical hydrologic modeling codes for application to the site unsaturated-zone hydrogeologic system, and (2) to modify existing codes to develop new codes to simulate particular problems within the Yucca Mountain system. 1. My primary concern with this activity is that it does not state if the model being selected will be based on porous or fracture media approach. It is not clear how DOE would be able to use a porous media model to predict the fast and significant fracture flow that is anticipated within the unsaturated Yucca Mountain stratigraphic units. If a fracture media model is chosen, DOE should provide the technical development and the rationale with respect to its applicability to the site. 2. My second concern is the quality assurance of computer codes and their verification and validation with respect to solving the hydrogeologic issues of the site. The second paragraph on page 8.3.1.2-355 states, " Complete documentation of the new or modified codes will include a description of the physical and mathematical basis of the code, instructions and requirements for implementing the code, and the results of at least some selected set of verification and empirical-testing exercises performed on the code (Silling, 1982). Both the documentation and the code will be subject to thorough independent peer review before any application of the code to develop a model or models for the Yucca Mountain system or any relevant subsystem." The major problem with the usage of computer codes is that only their authros are very successful in running and producing results with these codes. This has been my observation and experience with computer codes that simulate hydrogeologic results. 3. Most of the methods and technical procedures that are provided are listed by titles only and given the designation "TBD" which makes it impossible to technically review this activity.

REVIEWER: Atef Elzeftawy Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 46 (1 of 2)	CHAPTER/SECTION: 8.3.1.2.2.9.3 Activity: Simulation of the natural hydrogeologic system.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-356	This activity is part of the site unsaturated-zone modeling and synthesis study. On page 8.3.1.2-357, paragraph 3, the SCP states, "The final flow models will be used to perform a set of baseline simulations of the natural hydrogeologic system. A simulation of the presently existing natural system will be used as the initial conditions to perform a sequence of simulations to extrapolate the system both forward and backward in time. The forward extrapolation will be based on the most probable changes expected in the site climatic regime derived from Study 8.3.1.5.1.6 (characterization of the future regional climate and environment) and in the water-table configuration derived from Study 8.3.1.8.3.2 (analysis of the effect of tectonic processes and events on changes in water-table elevation). The backward extrapolations will be based on past climatic conditions and variations inferred from Study 8.3.1.5.1.4 (synthesis of the paleoenvironmental history of the Yucca Mountain region). The sequence of baseline simulations constitutes a standard set against which the effects of extreme or episodic changes in environmental conditions at the site may be assessed. The most probable limits of uncertainty attaching to the baseline simulations will be estimated as part of Activity 8.3.1.2.2.9.4 (stochastic modeling and uncertainty analysis). These flow models will be used to define flow paths and calculate fluxes and velocities within the unsaturated zone, as described under Activity 8.3.1.2.2.9.5 (system synthesis and integration)" (emphasis added). 1. The DOE is assuming that 1) validated and verified computer codes can be developed for the matrix/fracture vapor and liquid flow in heterogenous systems at Yucca Mountain; 2) that sufficient field data for each hydrologic parameter in a highly varying and complex three-dimensional system can be established (no such program of data-gathering has been described yet!); 3) that there will be site-specific data proven in terms of the unsaturated zone flow past climate effects; and 4) all of this work and effort can be accomplished in a few years of site characterization.

REVIEWER: Atef Elzeftawy	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 22 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE TECHNICAL REVIEW COMMENT	
DOCUMENT TITLE: Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).	
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 46 (2 of 2)	CHAPTER/SECTION: 8.3.1.2.2.9.3 Activity: Simulation of the natural hydrogeologic system.
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-356	Computer codes can be created and used, but not validated, and the necessary code parameters and boundary conditions can be assumed (but not demonstrated in terms of site-specific data) and, therefore, there can be no confident site-specific analysis or dependable predictive solutions of hydrologic conditions for the site. 2. In reviewing the above paragraph, it is our technical concern that DOE firmly believes that the hydrogeologic behavior at the Yucca Mountain site can be simulated by computer codes. The information necessary to understand the problem of fluid flow through the complex hydrogeologic setting of this mountain may prohibit DOE from using computer codes to model the present behavior of the site; in addition to the impossibility of predicting the future behavior of the rock after emplacing waste. 3. Most of the methods and technical procedures that are provided are listed by titles only and given the designation "TBD" which makes it impossible to technically review this activity.
REVIEWER: Atef Elzeftawy Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 22 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 47	CHAPTER/SECTION: 8.3.1.2.2.9.4 Activity: Stochastic modeling and uncertainty analysis.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-359	This activity is part of the site unsaturated-zone modeling and synthesis study. On page 8.3.1.2-359, paragraph 1, under "Description" heading, the SCP states, "An important aspect of modeling physical systems is to assess the accuracy with which the model predictions represent the real system and, thereby, to establish the validity of the model with respect to its intended application. As discussed in Section 8.3.5.20.4 (model validation), the classical approach to model validation is to compare directly the model predictions with the observed system performance. The models that will be applied to address repository postclosure issues, however, are required to predict the effects of probable or possible changing conditions over the next 10,000 to 100,000 yr. Consequently, direct model validation is infeasible. Indirect methods must be employed to establish model credibility and to provide reasonable assurance that the long-term model predictions coupled with asymptotic bounding calculations are sufficient to assess the long-term performance of the repository and its subsystems. For hydrogeologic models, uncertainty analyses can be performed to assess model accuracy, stability, and asymptotic behavior" (emphasis added). 1. In reviewing this paragraph, it is quite clear that DOE is not addressing a systematic and conservative approach of model validation that would lead to modeling the behavior of the hydrologic processes of the site, as required by the NRC regulation. It is my technical opinion that DOE should find a way to validate the computer codes that are needed to model the physical/hydrologic system that is acceptable to the scientific community. The "burden of proof" that the Yucca Mountain site is suitable as a geologic repository for high-level radioactive waste falls upon the DOE. 2. Most of the methods and technical procedures that are provided are listed by titles only and given the designation "TBD" which makes it impossible to technically review this activity.

REVIEWER: Atef Elzeftawy Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 03 July 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE TECHNICAL REVIEW COMMENT	
DOCUMENT TITLE: Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).	
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 48	CHAPTER/SECTION: 8.3.1.2.2.9.5 Activity: Site unsaturated-zone integration and synthesis.
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-361	This activity is part of the site unsaturated-zone modeling and synthesis study. 1. This activity could and should be the most important activity of the hydrogeologic investigation of the SCP. The integration of all data and information about the hydrogeologic processes of the site is a major and complex task, and it should be approached in a clear and systematic manner. However, in reviewing this activity, I find almost <u>no</u> information that would lead to an understanding of how DOE is planning to accomplish this major task or when most of the required hydrogeologic data would be provided that could lead to a complete license application to the NRC. (All the pieces of the puzzle need to be in place to solve that puzzle!). 2. Most of the methods and technical procedures that are provided are listed by titles only and given the designation "TBD" which makes it impossible to technically review this activity.
REVIEWER: Atef Elzeftawy Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June 1989

GEOHYDROLOGY PROGRAM - SATURATED ZONE

The DOE geohydrology program for the saturated zone consists of three studies:

1. Characterization of the site saturated zone ground-water flow system,
2. Characterization of the site saturated zone hydrochemistry, and
3. Saturated zone hydrologic system synthesis and modeling.

The activities for the first study are:

1. Solitario Canyon Fault study,
2. Site potentiometric level evaluation,
3. Analysis of single and multiple-well hydraulic stress tests,
4. Multiple-well interference testing,
5. Testing at the C-hole sites with conservative tracers,
6. Well testing with conservative tracers throughout the site,
7. Testing at the C-hole site with reactive tracers, and
8. Well testing with reactive tracers throughout the site.

The activities for the second study are:

1. Assessment of site and regional hydrochemical data availability and needs and
2. Hydrochemical characterization of water in the upper part of the saturated zone.

The activities for the third study are:

1. Conceptualization of the saturated flow models within the boundaries of the accessible environment;
2. The development of a fracture network model; and
3. The calculation of flow paths, fluxes, and velocities within the saturated zone.

The Solitario Canyon Fault study is one of the activities aimed at characterizing the site saturated-zone ground-water flow system. The main objective of this study is to understand the hydraulic properties of the faults in the repository area. For this study to have complete and meaningful coverage, both conceptually and regionally, other faults in the repository area should be equally and carefully studied. The DOE should consider the need for more boreholes north and south of USW-H6, USW-H7 and WT8 as well as geophysical survey spreads across the canyon near these boreholes and other points remote from them. It is unacceptable for the DOE to rule out a thorough investigation of the normal faults east of the repository block mainly "...because these faults are **expected** to be **hydraulically indistinguishable** from the surrounding fractured tuff..." (emphasis added). There is a high degree of uncertainty regarding the hydrogeologic characteristics of the faults bordering the Perimeter Drift. Though the DOE claims that evidence indicates that some faults, such as the Solitario Canyon Fault may act as barriers, whereas others such as a fault east of Yucca Mountain may act as conduits, the activities devoted to fault studies are quite inadequate to address these uncertainties.

The DOE should consider the vertical components of fluid potential gradients in evaluating the site-potentiometric level at Yucca Mountain. The point must be made that there is the need to consider/acknowledge the presence of perched water in the vadose zone, and the DOE should opt for a 3-D approach in their evaluation.

The DOE claims that the site of the C-hole complex was chosen because of its position (down the hydraulic gradient from Yucca Mountain) and because the saturated zone at the site was believed to represent stratigraphic and structural conditions along a flow path to the accessible environment. Could it be reasonably assumed that subsurface conditions at the C-hole complex site should be expected at other down gradient locations? The manner in which the DOE frames its explanation for the choice of the site of C-hole complex is quite revealing, "...**believed to represent** stratigraphic and structural conditions along flow path to the accessible environment..." (emphasis added). The appropriateness of these assumptions with respect to the validity of the regional representativeness of the C-hole complex is questionable. Should not activities be developed to address stratigraphic and structural conditions along other flow paths?

Heterogeneities evident at the C-hole complex pose some problems with regard to employing the porous media approach to the analysis of the single- and multiple-well stress test. Furthermore, the DOE should note that the use of the equivalent porous media approach in studying ground-water travel time will not give the same results as assessing the significance of fracture flow.

The success of tracer tests, reactive or conservative, depends on the extent to which porous media approximation applies and fracture geometry is known. There is therefore the need to focus tracer tests on exploring fracture geometry in a geologic context. Furthermore, tracer tests are more applicable when applied to a small area, and the applicability of the results of tracer tests done in a small locality on a regional basis is unacceptable.

The DOE ought to have analyzed existing hydrochemical data by now and determined where additional water samples should be collected. Doubts surround the commitment of the DOE to collecting necessary and reliable perched water samples in its drilling program. One welcomes the DOE proposal to drill eight additional WT wells in the course of other saturated-zone geohydrologic system investigations. But are these eight additional holes adequate and are they going to be judiciously distributed? Furthermore, one wonders whether or not the DOE attempt to synthesize the saturated-zone hydrogeochemistry is rather ambitious judging from the stated objectives and the absence of a program to establish carefully controlled water samples..

In the SCP, the DOE fails to describe the methodology it will use in the "conceptualization of saturated zone flow models within the boundaries of the accessible environment."

The applicability of the results of a fracture network model developed for a given multiple-well site to other areas of Yucca Mountain is doubtful and the validity of the assumption of the existence of an REV (Representative Elemental Volume) is questionable.

The success of the activity on the calculation of flow paths, fluxes, and velocities within the saturated zone to the accessible environment based on porous-media approximation by the DOE, requires adequate explanation of geologic controls, recognition of technological limitations, thorough field work (discrete fracture mapping), and an extensive drilling program. It is doubtful whether these requirements can be met by the DOE within a reasonable time period.

As indicated in the SCP:

> "The saturated zone beneath the site serves as the final portion of the flow path for ground-water flow and transport to the accessible environment. Evaluation of the regional saturated-zone flow system provides knowledge of the boundary conditions at the site; this knowledge is needed to assess accurately the impacts of changes (such as climate) on the flow system beneath the site."

Furthermore, the DOE claims that flow of interest at Yucca Mountain occurs primarily through fractured Tertiary volcanic rocks and that its system of Tertiary volcanics is separated from and lies above a deeper regional carbonate aquifer system with high hydraulic head. In addition, the DOE reports that in drillhole UE-25P#1 the hydraulic head in a carbonate unit underlying the Tertiary volcanic units is about 20 m higher than in the overlying units, but claims that data are few and structure complex. It acknowledges an alternative hypothesis that recognizes the significance of the Paleozoic carbonate unit in the flow system of Yucca Mountain if it is hydraulically connected to the Tertiary volcanic units. Apart from the deficiencies discussed above, a major flaw of the saturated-zone hydrogeology program is that none of the activities of this part of the SCP are developed to provide needed information and data on this important hydrogeologic characteristic of Yucca Mountain. The significance of the Paleozoic carbonate aquifer becomes obvious if it is realized that the postclosure performance of the repository would depend on the behavior of this aquifer, and how it is linked to the Tertiary volcanics and how these affect the GWTT between the disturbed zone and the accessible environment.

Saturated Zone Geohydrology - Ground-Water Travel Time (GWTT)

The DOE has directed its efforts towards predicting pre-waste-emplacement ground-water travel time by attempting development of calculational models. The following activity and subactivities are considered for this purpose: model development (activity), development of a theoretical framework for calculational models, verification and validation, verification of codes, validation of models, and saturated zone flow analysis (subactivities). Furthermore, the DOE discusses the activity on calculation of pre-waste-emplacement ground-water travel time and the following subactivities related to it - performance allocation for issue 1.6, sensitivity and uncertainty analyses of ground-water travel time and determination of the pre-waste-emplacement ground-water travel time.

In setting the stage for a discussion of GWTT, the DOE defines the disturbed zone as having its lower boundary at 50 m below the midplane of the repository. This definition is questionable, as well any model based upon it. The DOE contends that one of the pathways of radionuclide travel is downward, and recognizes other likely paths as the potential fracture zones associated with the Ghost Dance Faults or other faults and other local zones.

All of the activities and subactivities here are geared toward supporting a demonstration of the distribution of pre-waste-emplacement ground-water travel time (GWTT) along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment.

The DOE claims that, for purposes of conservatively evaluating GWTT, the saturated zone will probably be treated solely as an equivalent porous medium where fracture properties characterized the medium. The weakness of this approach can be seen in light of the fact that, before equivalent porous medium can be assumed, adequate knowledge of the fracture system geometry is necessary.

In developing a model for an area as complex as Yucca Mountain (for which fracture geometry information is unavailable) DOE should state the methodologies it will employ in acquiring basic necessary information such as the degree of interconnection between the assemblage of the discontinuous fracture planes, fracture density, and fracture orientations. The geophysical methods developed by the Lawrence Berkeley Laboratory to investigate fracture flow have not yet been perfected and it is doubtful whether the results of such surveys are applicable regionally.

The calibration of the models proposed by the DOE is difficult in that field data on flow are sparse and boundary conditions are uncertain. Furthermore, all lithologic units are complexly fractured and faulted, and information on the major discrete features, such as Solitario Canyon Faults and the Ghost Dance Fault, is insufficient.

The DOE should also realize that the feasibility of a meaningful simulation of the flow paths in the saturated and/or vadose zone is limited by the complexity of the structure at Yucca Mountain. This

limitation becomes more evident when one considers that the DOE seeks to use a two-dimensional (2-D) model in determining or evaluating flow paths at Yucca Mountain. We feel that the use of a 2-D model approach by the DOE lacks merit in that the approach tends to underestimate permeability, and the fracture network will appear to behave less like a continuum than it actually is in a three-dimensional system.

Finally, the DOE should recognize that, in the calculation and/or determination of pre-waste emplacement ground-water travel time, the problems of ill-defined Disturbed Zone boundary and flow paths need to be resolved.

APPENDIX C

GEOHYDROLOGY PROGRAM - SATURATED ZONE DOCUMENT REVIEW FORMS

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 49	CHAPTER/SECTION: 8.3.1.2.3.1.1 Activity: Solitario Canyon fault study in the saturated zone.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-372	This activity is par of the characterization of the site saturated-zone ground-water flow-system study. Methodology employed in studying the Solitario Canyon will not establish the stated objective. It is unlikely that the Solitario Canyon fault is uniform in its hydraulic properties. The investigation boreholes' locations may only be useful in characterizing a very limited part of the Solitario Canyon. Furthermore, it is doubtful if this activity will succeed because drilling and testing effort is too limited, and well spacings are too great. All these point to rather poor areal coverage. Thus, it is necessary to increase the number of boreholes for use in this study and to spatially distribute these boreholes such that a realistic picture of the degree of heterogeneity of this fault can be obtained. Boreholes with similar configuration to USW H-6, USW H-7, and USW WT-8 are needed at two points (both north and south, respectively of the location of the USW H-6, H-7, and WT-8 boreholes) on a minimum basis. Additionally, surface geophysical spreads across the canyon at the three borehole sites (listed above) and at other closely spaced locations are needed. The study also needs to include other known structures such as the Ghost Dance Fault. In the SCP, the Table of Methods and technical procedures has been modified, thus, "Borehole video fracture logging" has been changed to "Borehole fracture logging;" "Method for neutron scatter and gamma ray attenuation logging using the USGS logging van (I-139055)" and "Methods of monitoring water levels (dodge) are now replaced by "Method for monitoring water-level using pressure transducers," etc.

REVIEWER: O. A. Adenle Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE TECHNICAL REVIEW COMMENT			
DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).		
AUTHOR(S):	U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE:	DOE/RW-0199 (December 1988).
COMMENT #:	50 (1 of 2)	CHAPTER/SECTION:	8.3.1.2.3.1.1 Activity: Solitario Canyon fault study in the saturated zone.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-372	This activity is part of the characterization of the site saturated-zone ground-water flow-system study. On page 8.3.1.2-373, paragraph 1, the SCP states, "After the initial development and testing of drillhole USW H-7, including a borehole-flow survey, a long-term test (perhaps as much as 30 days) will be conducted. <u>This test will consist of pumping drillhole USW H-7</u> at an expected rate of 25 L/s or more while <u>observing hydraulic responses in water-level</u> monitoring drillholes located <u>throughout Yucca Mountain</u>, especially those located across (west of) the fault, such as drillholes USW H-6 and the proposed USW WT-8 (Figure 8.3.1.2-22)" (emphasis added). The question that should be posed here is how will the hydrogeologic role of the Solitario Canyon Fault be evaluated by interpreting the ground-water table-level data from drillholes located throughout the site and, especially, across from the fault? My concern is that monitoring water-level changes in drillholes throughout the Yucca Mountain site may be neither observable nor meaningful by pumping USW H-7 at a high rate for a long period of time. Additionally, monitoring drillholes located across the fault, such as USW H-6 and the proposed USW WT-8, while pumping USW-H-7 <u>will not</u> evaluate the hydrogeologic role of the fault. The SCP does not acknowledge that the fault could behave in two completely different ways which could result in misinterpretation of the pumping test data. The Solitario Canyon Fault could exhibit high hydraulic conductivity and storativity, or very low conductivity. In both cases, the fault may affect drawdowns in the pumped water-table aquifer such that water-level changes may not be noticable or observable across the fault from the pumping well. It is recommended that these possibilities be considered during the development of the overall testing plans.

REVIEWER:	Atef Elzeftawy	ORGANIZATION:	Mifflin & Associates, Inc.
Signature		DATE:	29 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 50 (2 of 2)	CHAPTER/SECTION: 8.3.1.2.3.1.1 Activity: Solitario Canyon fault study in the saturated zone.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-372	In summary, it is imperative that DOE evaluate the hydrogeologic characteristics of the Solitario Canyon fault by drilling boreholes similar to USW H-6 across the faulted zone of the rock formations. These boreholes should be in groups of three, located east and west of the faulted zone. Three stations located west of the repository boundary, along the fault (north-south), should be planned during the site-characterization period. Each borehole of these three stations should be pumped continuously for a long period of time (4 to 5 weeks, at the least), while those east and west of the fault are monitored at the same time. Following this suggestion, DOE may provide an explanation for the drop in the ground-water table across the Solitario Fault west of the repository. It is also strongly recommended that DOE plan and investigate the role of the existing faults north of the repository block area to provide an explanation for the 300 meters of drastic drop in the ground-water table elevation between boreholes USW G-2, UE-25 WT #6 and USW WT #10, UE-25 WT #16, USW G-1, USW H-1, and UE-25 WT #4.

REVIEWER: Atef Elzeftawy Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 51	CHAPTER/SECTION: 8.3.1.2.3.1.2 Activity: Site potentiometric-level evaluation.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-375	This is part of the study on the characterization of the site saturated-zone ground-water flow system. The activity objectives have been modified and rearranged; notably, the CD-SCP "List of parameters" is expanded in the SCP to include hydraulic diffusivity, huydraulic conductivity, and aquifer compressibility. In spite of these modifications, conceptually, this activity is incomplete and not focused. Assessment of vertical components of fluid potential gradients are neglected, as are perched-water zones in UZ-1. This activity may achieve limited success using existing technology because saturation in the vadose zone may not be recognizable, and vertical gradients are generally ignored. This activity is feasible in time, funding, and human resources. Precise fluid-potential measurement is feasible.

REVIEWER: O. A. Adenle Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 23 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 52	CHAPTER/SECTION: 8.3.1.2.3.1.3 Activity: Analysis of single- and multiple-well hydraulic stress tests.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-383	This activity is under the characterization of the site saturated-zone ground-water flow-system study. The CD-SCP title "Analysis of previously completed hydraulic stress tests" is SCP title "Analysis of single- and multiple-well hydraulic stress tests." Despite the title change, CD-SCP objectives in the SCP remain the same with one addition: "Determine the causes of the apparent deviant pressure transients observed in slug tests in UE-25C#1." In the SCP, DOE notes that in preliminary analysis of falling-head injection tests (slug tests), the observed pressure transients from many of the tests could not be represented adequately using available solution techniques. Two possible causes of these deviations are given in the CD-SCP; a third one ("the changing state of in-situ stresses may result from high initial injection heads [750 ft above static])" is added in the SCP. DOE claims that additional slug tests will be conducted in selected intervals in UE-25c#1 and possibly UE-25c#2, and UE-25c#3 for assessing the effect of the magnitude of initial injection heads on the resulting pressure transients. Three CD-SCP paragraphs on gas-phase modeling and investigations are deleted from the SCP "methods and procedures" section. The success and feasibility of this activity are doubtful, although the approach is acceptable and the methodology is correct. The flow-analysis procedures considered for this activity lean cautiously towards porous-media approach. The extent to which porous-media approach is applicable is questionable. Although the DOE recognized that these may not be established for aquifers with heterogeneities evident at the C-hole complex, the SCP only mentions that new techniques (which are not explained) that consider aquifer heterogeneity may be needed to develop an adequate conceptual model of flow at the C-hole complex.

REVIEWER: O. A. Adenle	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 23 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 53	CHAPTER/SECTION: 8.3.1.2.3.1.4 Activity: Multiple-well interference testing.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-393	This activity is part of the characterization of the site saturated-zone ground-water flow system study. The CD-SCP table on "Methods and technical procedures" is expanded in the SCP to include detailed descriptions, listings, and dates of those activities that have been done and those that will be done (undetermined date). The following comments should be considered by the DOE: - Scope of work is much too limited with respect to number of test wells and very uncertain with respect to interpretation, although the approach taken is conventional and acceptable. - Porous media equivalency is not evident and discrete-fracture geometry is not known and very complex. Success depends on network model from SCP activity 8.3.1.2..3.3.1. - Any sample volume may be nonrepresentative, although the tests are feasible to the extent meaningful intervals in wells can be recognized and isolated. The second SCP objective ("Determine if the fractured media of Yucca Mountain can be represented as an anisotropic porous media at a scale of multiple-well tests or if a fracture-network model is more appropriate") illustrates a DOE attempt to over-extend and apply data from three boreholes (located in a small area) to all of Yucca Mountain.

REVIEWER: O. A. Adenle Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 23 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 54	CHAPTER/SECTION: 8.3.1.2.3.1.5 Activity: Testing of the C-hole sites with conservative tracers.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-400	This activity is part of the characterization of the site saturated-zone ground-water flow system study. Except for two modifications in the SCP, the CD-SCP text remains the same. The first, with respect to DOE's explanation of what will be done to determine the effect of matrix diffusion on tracer migration, states, "Colloids of various sizes will be considered for use in conjunction with conservative tracers, such as 3-trifluoromethylbenzoate. Colloidal and other tracers will be selected such that some tracers will be expected to diffuse into the rock matrix whereas others will not." The second states that "additional tests will be done using various combinations of pumping and injection intervals to evaluate directional characteristics of hydraulic and transport properties." We would like to recommend that tracer tests should be focused on exploring fracture geometry in a geologic context. It is necessary to note that results of this type of activity may be impossible to interpret in a fractured terrane, except on a small scale such as the C-well site. Thus, the applicability of the results of tracer tests on this type of scale in obtaining regional aquifer properties, as indicated in the objectives is questionable.

REVIEWER: O. A. Adenle Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 23 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 55	CHAPTER/SECTION: 8.3.1.2.3.1.6 Activity: Well testing with conservative tracers throughout the site.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-408	This activity is included in the study on the characterization of the saturated-zone ground-water flow system. The CD-SCP text remains the same, except for the expansion of the SCP table on "Methods and technical procedures," which is now divided into two parts--"Single-well tests" and "Multiple-well tests." This slight modification notwithstanding, we would like to comment as follows: Scope of the study should emphasize fracture geometry rather than numerical model-related parameters. It is only when sufficient information is derivable that definite decisions can be made regarding the applicability of porous media approach. Representative discrete fractures are not evaluated and most wells are not constructed to allow definitive tracer tests. The tests will be more applicable to individual areas investigated than to the entire project area. The success of the test depends on the extent to which porous media approximation applies and fracture geometry is known.

REVIEWER: O. A. Adenle Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 03 July 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 56	CHAPTER/SECTION: 8.3.1.2.3.1.7 Activity: Testing of the C-hole sites with reactive tracers.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-417	This activity is part of the study on the characterization of the saturated-zone ground-water flow-system study. According to DOE (in the SCP), screening of potential tracers will not be limited to intensive literature review (as advocated in the CD-SCP). Screening will also include expert consultations. DOE claims that geochemical modeling will be used in defining prevailing sorption mechanisms in laboratory studies. However, sorption mechanisms must be known before they can be modeled. Compared to the CD-SCP, DOE is more cautious in handling this SCP activity. Still, we believe that tracer tests should be focused on exploring fracture geometry in a geologic context rather than on obtaining estimates for model-related parameters. The fatal flaw of this activity is unknown fracture geometry; success depends on fracture network model from activity 8.3.1.2.3.3.2.

REVIEWER: O. A. Adenle Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 23 June 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 57	CHAPTER/SECTION: 8.3.1.2.3.1.8 Activity: Well testing with reactive tracers throughout the site.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-423	This activity is part of the characterization of the saturated-zone ground-water flow-system study. See comment for Activity 8.3.1.2.3.1.7.

REVIEWER: O. A. Adenle	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 12 April 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 58	CHAPTER/SECTION: 8.3.1.2.3.2.1 Activity: Assessment of saturated-zone hydrochemical data availability and needs.
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-425	The CD-SCP word "Site" is replaced by the SCP "Saturated-zone." The CD-SCP objectives are expanded in the SCP to include: "Augment extant information by collecting and analyzing new hydrochemical samples and data."
REVIEWER: O. A. Adenle Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 12 April 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 59	CHAPTER/SECTION: 8.3.1.2.3.2.1 Activity: Assessment of saturated-zone hydrochemical data...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-425	This activity has been revised and extended from that in the CD-SCP. Existing data could and should have been analyzed by now to determine where additional water samples might be taken. Although DOE says other water samples will be collected as the opportunities arise, we are skeptical because in the past DOE has missed and/or intentionally avoided taking samples of perched water in the vadose zone. During their drilling programs, DOE must establish the priority that if any water is encountered (assuming dry drilling techniques are utilized) anywhere in the section, drilling must stop and the water sampled and pumped to determine its extent. Perhaps the hole should even be abandoned if perched water is suspected and another hole started close by on the same pad so that the water level and chemistry can be monitored through time.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Don L. Shettel, Jr. Signature	DATE: 23 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 60	CHAPTER/SECTION: 8.3.1.2.3.2.1 Activity: Assessment of saturated-zone hydrochemical data...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-426	There are no methods and/or technical procedures specified for laboratory analyses of inorganic chemical concentrations, activities of selected radioisotopes , and ratios of selected stable isotopes.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 23 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE TECHNICAL REVIEW COMMENT			
DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).		
AUTHOR(S):	U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE:	DOE/RW-0199 (December 1988).
COMMENT #: 61	CHAPTER/SECTION: 8.3.1.2.3.2.1 Activity: Hydrochemical characterization of water in the upper part of the saturated zone.		
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:		
Page 8.3.1.2-426	In the SCP, DOE provides for drilling eight additional WT wells in the course of other saturated zone geohydrologic system investigations. We hope this will be done and that these holes will be judiciously spaced. In the SCP, DOE notes that data collection for this activity will be carried out under Activity 8.3.1.4.2.1.3 (borehole geophysical surveys).		
REVIEWER:	O. A. Adenle Signature	ORGANIZATION:	Mifflin & Associates, Inc. DATE: 23 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 62	CHAPTER/SECTION: 8.3.1.2.3.2.2 Activity: Hydrochemical characterization of water...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-426	This activity has been revised and expanded from that in the original CD-SCP. The planned WT holes should be drilled with dry drilling technology (not specified) so that any occurrence of water in the vadose zone can be investigated and sampled. Furthermore, as this activity deals with the upper part of the saturated zone, the very uppermost part of the saturated zone should be sampled as soon as it is penetrated. In other words, DOE should not drill to the intended depth into the saturated zone before sampling the water; sampling should occur after drilling1 m, then 2 m, then 5 m then 10 m, then 20 m, then 50 m, and then 100 m, for example. After total depth is reached, into the satuated zone, packers may be set and the upper and lower parts of the saturated zone sampled and monitored, if desired.

REVIEWER: D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 23 June 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE TECHNICAL REVIEW COMMENT	
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 63	CHAPTER/SECTION: 8.3.1.2.3.2.2 Activity: Hydrochemical characterization of water...
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-429	The paragraph on geophysical logs is totally out of place in an activity that is hydrochemical characterization. These measurements should be in the drilling investigations or a separate activity under the drilling section (as is specified). Paragraph should be removed as it is out of place and context.
REVIEWER: D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 23 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 64	CHAPTER/SECTION: 8.3.1.2.3.2.3 Activity: Regional hydrochemical characterization...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-431	This is a new activity, not in the CD-SCP. With the exception of the addition of springs, this activity is very similar to Activity 8.3.1.2.3.2.1 "Asessment of saturated-zone hydrochemical data..." This activity is redundant and should be incorporated into the previously-mentioned activity by adding the word(s) spring(s) to it.

REVIEWER: D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 10 May 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 65	CHAPTER/SECTION: 8.3.1.2.3.2.4 Activity: Synthesis of saturated-zone hydrochemistry.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-433	This is a new activity, not present in the CD-SCP. This is a very ambitious activity judging from the objectives. However, it is not clear that the objectives can be accomplished with existing methodologies/technologies. Specifically, how can sources and areas of recharge be inferred unless these have been sampled and are part of the database? The probability of success and the feasibility of accomplishing objectives cannot be judged due to the lack of information.

REVIEWER: D. L. Shettel, Jr. D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 10 May 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 66	CHAPTER/SECTION: 8.3.1.2.3.3.1 Activity: Conceptualization of saturated zone flow models within the boundaries...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-435	This activity is part of the saturated-zone hyrologic system synthesis and modeling study. "Potentiometric surface configuration" is added to the SCP list of parameters. In the SCP, DOE added qualifying words to some sections, for example, the activity objectives are rewritten, with the addition of the underlined words: "The data objectives of this activity are to synthesize the available hydrogeologic data to develop a conceptual model and make a qualitative analysis of how the site saturated-zone hydrogeologic system is functioning." The SCP fails to state or describe any methodology for this activity, just as the CD-SCP lacked a section that describes the methodology to be used.

REVIEWER: O. A. Adenle Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 23 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 67	CHAPTER/SECTION: 8.3.1.2.3.3.2 Activity: Development of fracture network model.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-436	This activity is one of three planned for the saturated-zone hydrologic system synthesis and modeling study. The results of this activity at a given multiple-well site cannot be extrapolated to the Yucca Mountain site in general. Furthermore, the assumption of the existence of an R.E.V. is questionable, although development of this type of model is feasible; successful application may not be. Verification and validation may never be attained. A quick comparison of the CD-SCP and SCP yields the following: 1. The activity description is expanded and includes seismic tomography (Activity 8.3.1.4.2.2.5) in characterizing fracture networks. 2. DOE states that geophysical models will be utilized to estimate fracture geometry. However, although the seismic-hydraulic approach to modeling flow in fractured rocks is being developed, it is still in the developmental stage. 3. Model refinement will be based on well testing at UE-25c and model validation at a second multiple-well location. However, despite DOE utilization of geophysics and an additional multiple-well location, applicability of the activity results to the whole Yucca Mountain repository site area is still questionable, because data derived from a particular location will be more relevant to that particular site than to the entire region. What can be considered as an acceptable coverage certainly depends on the degree of heterogeneity of the site. The number of multiple-well locations needed should reflect this heterogeneity, thus each major lithologic unit of the unsaturated zone needs multiple-well testing.

REVIEWER: O. A. Adenle Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 23 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 68	CHAPTER/SECTION: 8.3.1.2.3.3.3 Activity: Calculation of flow paths, fluxes, and velocities within the saturated zone...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.2-441	This activity is the third of three activities planned for the saturated-zone hydrologic system synthesis and modeling study. Although there is hardly any viable alternative to porous-medium approximation given, geologic controls are inadequately explored and technological limitations are not recognized. Direct field observation must be more thorough before modeling is justified. What about discrete fracture mapping? Success is unlikely at the proposed level of drilling and testing. Would require much more drilling and much less statistical manipulation to succeed (not feasible).

REVIEWER: O. A. Adenle	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 03 July 1989

MY890703a

GEOCHEMISTRY PROGRAM

The DOE geochemistry program has been designed presumably to "...provide the information needed to develop a model of the geochemical conditions at the site and to supply the geochemical information needed for the resolution of performance and design issues." According to the SCP, there are eight DOE investigations conceived with the idea of providing information required on:

1. Water chemistry within the repository horizon and along potential flow paths;

2. Mineralogy, petrology, and rock chemistry within the repository horizon and along potential flow paths;

3. Stability of minerals and glasses;

4. Radionuclide retardation by sorption along flow paths to the accessible environment;

5. Radionuclide retardation by precipitation processes along flow paths to the accessible environment;

6. Radionuclide retardation by dispersive, diffusive, and advective transport processes along flow paths to the accessible environment;

7. Radionuclide retardation by all processes along flow paths to the accessible environment; and

8. Retardation of gaseous radionuclides along flow paths to the accessible environment.

Notice that all investigations mention "potential flow paths" or "flow paths to the accessible environment," but there is no mention or reference in the text to any other part of the SCP, as to how or when or where these will be determined. Instead of actually determining the flow paths (deterministic approach required by law), the DOE has made the rather naive assumption that the "flow path to the accessible environment" simply means the geologic rock or hydrogeologic units through which groundwater might travel. Consequently, primarily whole-rock samples or samples representative of matrix mineralogy are utilized in experiments. This assumption has been conveniently (but unjustifiably) made because the DOE has always contended that matrix flow predominates over fracture flow in the vadose zone.

The DOE utilizes a generic flowpath concept, unspecified with respect to fracture-fault conduits, uniform homogeneous matrix, and channeled matrix pathways within specific tuff horizons. If the Calico Hills unit is to provide principal sorption credit, it becomes absolutely necessary to characterize the "most likely" paths of flow within this unit with respect to the geometry of the pathways (fracture-fault, matrix channel, and/or uniform homogenous matrix). Characterization must consist of obtaining finite, in-situ data with respect to authigenic mineralogy (characterization of the mineral phases that have potential to provide retardation within the path of flow) and vadose-water chemistry within that pathway. Characterization of the mineralogy includes a determination of mineral chemistry, crystallographic orientation, percentage of mineral accessibility to transporting fluids, percentage of glass-surface area, percentage of nonsorbing minerals, fracture apertures and roughness, among other parameters of physical and geochemical significance. These data can then be utilized along with sorption behavior data obtained from buffered single mineral phases and well-characterized whole-rock experiments to predict the levels of sorption credit that can be used depending upon variations in the hydrologic regime.

Alternative hypotheses are poorly presented in the introduction to the geochemistry program, however most activities are essentially unchanged. The DOE failure to adequately address and evaluate alternative hypotheses is a serious shortcoming of the SCP. The DOE is apparently only paying lipservice to alternative conceptual models.

Other major comments, regarding activities under the sixteen studies of the DOE geochemistry program, include:

- In the DOE sorption programs, models are sometimes used to support other models; this is a dangerous precedent established by DOE that results from and is circular reasoning.

- Undue emphasis is placed on modeling before, and occasionally in place of, collecting laboratory data, and even field data. In an objective scientific process, models are properly used and validated, **only after** all the supporting data have been collected.

- Samples to be utilized in the DOE activities' studies are not clearly specified, nor are sample collection and preservation techniques.

- Technical procedures are not complete; analytical methodology is not always specified and, in some cases, important techniques are omitted.

- The use of crushed tuff in place of solid-rock cores for sorption experiments must be justified beyond the shadow of a doubt, because crushed rock has different characteristics than uncrushed, i.e., significantly increased surface area and activated surfaces.

- Experiments should be validated by field tests before being used to validate models. Otherwise, models are generic and non-site specific.

- Authors/editors of the SCP should review their usage of the terms "verify" and "validate" as these terms are not always used correctly. Data collected in the field and laboratory are utilized to validate models, not vice versa; computer models generate "output" or "printouts" not data.

- Use of J-13 water as the reference water for the saturated zone and even the vadose zone is totally unjustified. Activities that require vadose-zone water compositions should be delayed until these have been determined.

Furthermore, the allotted timeframe for completion of studies (approximately five years) seems too short for the DOE to adequately address the geochemical activities proposed. Because all the DOE studies are running concurrently, the interchange of information and interfacing between studies/activities will be insufficient to render the geochemistry program site-specific. For example, vadose-zone water chemistry and the "flow paths to the accessible environment" should be determined and well known before many studies begin, but according to the DOE schedule, this information will not be available (if even determined at all) until at least midway through studies or later on and, thus, under- or nonutilization of this information will result. This "shotgun" approach to the DOE geochemistry program will result in little or no feedback to other studies and will produce a generic, non-site specific characterization. Expanding the site characterization program to a minimum of ten years is perhaps more realistic in order for studies to be appropriately phased to provide needed information before starting the next studies requiring these data. Such an approach would provide the much needed feedback, interchange of information, and interaction among scientific researchers necessary for a site characterization program to successfully characterize a specific site.

Finally, we find that the present data set is not sufficient for developing appropriate and adequate plans for investigations, studies, and activities. Several assumptions utilized in this program are unjustifiable: 1) dominancy of matrix over fracture flow as transport mechanism in vadose zone, 2) vadose-zone water chemistry similarities to that in saturated zone, 3) flow path to accessible environment, 4) use of crushed tuff in sorption experiments to simulate in-situ conditions, and 5) use of J-13 as a reference water. In most cases, insufficient information is provided to determine whether the DOE activities are designed to obtain the data needed.

APPENDIX D

GEOCHEMISTRY PROGRAM
DOCUMENT REVIEW FORMS

APPENDIX D

GEOCHEMISTRY PROGRAM
DOCUMENT REVIEW FORMS

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 69	CHAPTER/SECTION: 8.3.1.3 Overview of geochemistry program

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-10 Second paragraph	DOE states that calculations of total-site performance are based on equivalent porous-media transport through the matrix. This is an unjustified assumption that DOE has clung to for many years and has no basis. Furthermore, DOE claims that "the geochemistry test program must provide the ... supporting geochemical information required for total system modeling..." This approach suggests an unconservative and subjective data collection that tends to support DOE's view that Yucca Mountain is a favorable site. Also in the same paragraph is: "A combination of laboratory experiments and modeling will be used by the geochemistry program to support the use of Rfs and the one-dimensional system model..." Why are field data being collected if they will not be used in the system model? Once again DOE has made unjustified assumptions in that the use of Rfs and one-dimensional models are valid before the site is characterized. Thus, we have the implication that data might be selectively used to support a favorable point of view. Laboratory experiments must be shown to be applicable to the field before they can be used to support anything, and models must be verified and validated. We question the use of one model to support another model.

REVIEWER: D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 30 June 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
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DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 70	CHAPTER/SECTION: 8.3.1.3 Overview of geochemistry program

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-13 Table 8.3.1.3-2	I fail to understand how an alternative hypothesis such as fracture flow (under Retardation model) can have, in all columns under "significance of alternative hypothesis," a significance that is "not applicable." Fracture flow is the most likely process occurring in the unsaturated-tuff environment, and as such is the major alternative to matrix flow.

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 71	CHAPTER/SECTION: 8.3.1.3 Overview of geochemistry program

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-13 Table 8.3.1.3-2	In the model element row "Gaseous pathway," all columns under "Significance of alternative hypothesis" are not applicable. We fail to understand the logic of this designation. The same comment could be made in the row labeled "Liquid pathway" on page 8.3.1.3-14.

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 72	CHAPTER/SECTION: 8.3.1.3 Overview of geochemistry program

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-18 Table 8.3.1.3-2	In the model element row labeled "Saturated zone," there is no alternative hypothesis, yet under the four columns of "Significance of Alternative Hypothesis" great detail is expounded upon. What sort of logic is being exhibited here? In some rows with alternative hypotheses, no significance is indicated; in another row with no alternative hypotheses shown, there is great significance.

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 73	CHAPTER/SECTION: 8.3.1.3 Overview of geochemistry program

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-20 Table 8.3.1.3-2	In the model element row labeled "Mineral stability," the alternative hypothesis is that "alternative rates are controlled by local conditions...and are too complex to model reliably." Then, under the "Need to reduce uncertainty" column, the response is "Low-alternative hypothesis not supported by existing data." I would like to know what the existing DOE database is because, under nonequilibrium (nonisothermal, irreversible) conditions, all kinetic parameters are empicrical and cannot be predicted, therefore, alteration rates are too complex to model. There is a definite need to reduce the uncertainty of mineral alteration rates in that volume of host rock affected by the thermal pulse.

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NEVADA NUCLEAR WASTE PROJECT OFFICE TECHNICAL REVIEW COMMENT	
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 74	CHAPTER/SECTION: 8.3.1.3 Overview of geochemistry program

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-20 Table 8.3.1.3-2	The column headings on the 8th page of this table are different from the other seven pages.

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NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 75	CHAPTER/SECTION: 8.3.1.3.1 Investigation: Studies to provide information on water chemistry ...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-36	Under "Parameters," the SCP states: "The following parameters will be measured or calculated as a result of site studies... 1. Saturated and unsaturated-zone ground-water chemistry." Since saturated-zone ground-water chemistry has been measured, and no plans are presented for sampling and analyzing vadose-zone water, one might reasonably assume that the DOE will calculate the vadose-zone water compositions. Furthermore, no sampling locations are presented; no technical procedures for sampling and analysis are cited or listed; and finally, there are no references to any other section of the SCP wherein the sampling and analysis of vadose-zone water might be performed. This apparent lack of intent to actually sample and chemically measure vadose-zone water compositions hinders the characterization process.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
D. L. Shettel, Jr. Signature	DATE: 30 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE TECHNICAL REVIEW COMMENT	
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 76	CHAPTER/SECTION: 8.3.1.3.1.1 Study: Ground-water chemistry model
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-37	Although the objectives of this study are lofty and well intentioned, without the study plan,* we cannot address: 1. The appropriateness of methodology (or alternatives) to establish stated objectives; 2. The probability of success using existing technology; and/or 3. The feasibility of completing study in the allotted time frame as, this study is dependent on many other studies/investigations/activities. * The study plans were to be provided at the same time as the SCP.
REVIEWER: D. L. Shettel, Jr. D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 30 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 77	CHAPTER/SECTION: 8.3.1.3 Overview of geochemistry program

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-42	One of the purposes of this investigation is the definition of the disturbed zone. This is commendable except that in the section on ground-water travel time (8.3.5.12) the boundary is assumed to be 50 meters. There should be better coordination of ideas between the technical groups.

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Signature	DATE: 30 June 1989

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 78	CHAPTER/SECTION: 8.3.1.3.2.1 Activity: Petrologic stratigraphy of Topopah Spring Member.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-44	It is our understanding that x-ray diffraction procedures for percentage of mineralogic species include a unique method for obtaining the percentage of glass by utilizing the background trace baseline. Prior to submitting these data for licensing, it might be advantageous to publish on the technique so that other laboratories might have the opportunity to assess its reliability.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June 1989

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 79	CHAPTER/SECTION: 8.3.1.3.2.1 Activity: Petrologic stratigraphy of Topopah Spring Member.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-44	This activity is incomplete in that sampling locations and the densities of sampling are not specified. Sampling will probably be limited by borehole density and cores may be affected by drilling fluids. DOE or their subcontactors have not established how they will handle cores affected by drilling fluids.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 80	CHAPTER/SECTION: 8.3.1.3.2.1 Activity: Petrologic stratigraphy of Topopah Spring Member.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-45	No scanning-electron microscopy (SEM) work is mentioned. SEM should be used to identify mineral phases in low abundance because quantitative X-ray diffraction cannot detect mineral phases below a certain level, usually 5%.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 30 June 1989

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 81	CHAPTER/SECTION: 8.3.1.3.2.1.2 Activity: Mineral distribution between host rock and the accessible environment.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-45	The probable flow paths to the accessible environment will be very difficult to determine. Deep core/boreholes will be required within and outside the repository block, that penetrate through the repository horizon and below the water table. The number of these and the difficulty in sealing them will determine whether the repository block is compromised.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
D. L. Shettel, Jr. Signature	DATE: 06 April 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 82	CHAPTER/SECTION: 8.3.1.3.2.1.2 Activity: Mineral distribution between host rock and the accessible environment.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-45	Scanning-electron microscopy (SEM) is a serious omission from the table of methods/technical procedures. Because quantitative X-ray diffraction cannot identify all phases, especially those below some threshold, typically 5%, and because it relates no information on texture, i.e., which phases (and percentages) may be exposed to flowing fluids, SEM work is vitally important.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
D. L. Shettel Jr. Signature	DATE: 30 June 1989

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 83	CHAPTER/SECTION: 8.3.1.3.2.1.2 Activity: Mineral distribution between host rock and the accessible environment.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.3-45 to 47	This activity requires specific samples from the Calico Hills Formation. There is no indication in the SCP that these samples will be provided. Consequently, we see no potential for this activity to succeed.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 84	CHAPTER/SECTION: 8.3.1.3.2.1.2 Activity: Mineral distribution between host rock and the accessible environment.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-46	The probable flow path to the accessible environment will determine the spacing and density of sampling. Random or fixed-interval sampling in the stratigraphic unit most likely to be encountered along the flow path is sufficient for determining bulk mineralogy of rock units, but is inappropriate for determining mineralogy along flow paths. The importance of fracture versus matrix flow must be known beforehand to guide the DOE sampling program.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
D. L. Shettel, Jr. Signature	DATE: 30 June 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 85	CHAPTER/SECTION: 8.3.1.3.2.1.3 Activity: Fracture mineralogy.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
page 8.3.1.3-47	Data that are needed should be factual knowledge of hydrologic flow in the vadose and saturated zones. If the models are accurately based on this factual knowledge, then they may be adequate. The models will not be appropriate, if based on the nonconservative assumptions DOE has been utilizing for many years.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
D. L. Shettel, Jr. Signature	DATE: 06 April 1989

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 86	CHAPTER/SECTION: 8.3.1.3.2.1.3 Activity: Fracture mineralogy.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-48	The choice of drilling/coring fluids can have a serious effect on the delicate textures and even the abundance of minerals in fractures. DOE does not address this potentially serious problem in this section.

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D. L. Shettel Jr. Signature	DATE: 06 April 1989

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 87	CHAPTER/SECTION: 8.3.1.3.2.2.1 Activity: History of mineralogic and geochemical...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-50	Stable isotope analyses of fluid inclusions as well as of vadose-zone matrix and perched water would assist tremendously in establishing the history of alteration.

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Signature	DATE: 06 April 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE TECHNICAL REVIEW COMMENT	
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 88	CHAPTER/SECTION: 8.3.1.3.2.2.2 Activity: Smectite, zeolite, manganese...
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-52	This activity is essentially unchanged from the CD-SCP. The rates of mineral transformation and smectite and zeolite rehydration may be somewhat dependent on water chemistry. Thus, vadose-zone water compositions must be known; this activity is probably feasible providing vadose-water chemistry is determined early in the DOE site-characterization process.
REVIEWER: D. L. Shettel, Jr. Don L. Shettel Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 30 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 89	CHAPTER/SECTION: 8.3.1.3.3.3.1 Study: Natural analog of hydrothermal systems in tuff.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.3-56 to 58	This activity is essentially unchanged from the CD-SCP. Because the natural analog system or systems to be compared to Yucca Mountain are not known, it is difficult to judge the probability of success of this study. Furthermore, there are at least two known problems relative to EQ3/6 and this study: 1. Meeting quality-assurance levels, and 2. This geochemical modeling package does not handle boiling of fluids, which will be essential for comparison of any natural analog to the thermal-pulse induced drying-out phase of the near-field environment. Finally, this study is also dependent on knowledge of vadose-zone water chemistry, although this is not explicitly stated.

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 90	CHAPTER/SECTION: 8.3.1.3.3.2.1 Activity: Kinetic studies of zeolite and...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-60	This activity is essentially unchanged from the CD-SCP. The title of this activity still does not accurately reflect its content. The importance of this activity to issue resolution is not clear. In the time taken to produce two versions of the SCP, the literature survey could have been completed. Why has it not been finished? Although there is kinetic data available for the silica polymorphs, that for zeolites is questionable. No alternatives are presented, if kinetic data are lacking for zeolites. The mention of the term "reaction progress" suggests that EQ3/6 will be utilized in this activity, but is not mentioned. Insufficient detail given to judge the probability of success and feasibility of this activity.

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COMMENT #: 91	CHAPTER/SECTION: 8.3.1.3.3.2.2 Activity: Determination of end-member...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.3-61 to 63	This activity is essentially unchanged from the CD-SCP. The number of solubility measurerments could possibly be reduced by performing calorimetry to obtain $\Delta s°_f$ and $\Delta H°_f$, which would then permit temperature extrapolations and/or interpolations of the free-energy values.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
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DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 92	CHAPTER/SECTION: 8.3.1.3.3.2.3 Activity: Solid solution description of clinoptilolite-heulandite and analcime.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-63	This activity is unchanged from the CD-SCP. If crystallographic information does not exist, refinements need to be performed at the begining of this activity. I see no provision for this possibility. A literature survey, performed during the preparation and writing of this activity, could have determined the need for crystallographic refinements. I fail to see how pure mineral samples are data. Furthermore, solubility measurements will be performed on minerals of "intermediate compositions," not on the pure minerals needed. Apparently, experiments will not be performed on the samples needed? This poorly-written activity does not lend confidence to the feasibility or probability of success of this endeavor.

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 93	CHAPTER/SECTION: 8.3.1.3.3.3 Study: Conceptual model of mineral evolution.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-64	This study is unchanged from the CD-SCP. It is difficult to determine how a model of "ideas" can make a "significant contribution to Issue 1.1... in its transport calculation." I fail to understand the DOE conversion of "ideas" into quantitative calculations. Furthermore, the study relates that codes will be developed as needed; codes are usually quantitative. It also appears that the Common Los Alamos Mathematical Software routines are inadequate for this task, as they consist of the thermodynamics of analcime and albite, statistical routines, and graphic display routines. In summary, there is inadequate information to judge feasibility and probability of success of this study. In fact, the study seems ill-conceived and poorly planned.

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 94	CHAPTER/SECTION: 8.3.1.3.4.1.1 Activity: Batch sorption measurements as a...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.3-69 to 73	This activity has been changed somewhat from the CD-SCP. The applicability of sorption experiment, on crushed rocks and minerals to the field situation must be proven before significant time and money are wasted on this activity. Experiments on pure minerals would be useful, if carried out on well-characterized single crystals, such that the influence of crystal faces is considered. Dilution of solutions of known speciation is dangerous, as speciation may change. Technique is only valid if it can be proven that speciation of radionuclide elements does not change.

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 95	CHAPTER/SECTION: 8.3.1.3.4.1.2 Activity: Sorption as a function of sorbing element...
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.3-74 to 76	This activity has been changed somewhat from the CD-SCP. The applicability of sorption experiments on crushed material to the field situation must be demonstrated, before significant effort and money are expended on this activity. There is no provision for determining sorption as a function of the presence and concentration of other radionuclides present. Competition for sorption sites could have a significant effect on sorption isotherms and needs to be considered in the planned modeling of the Yucca Mountain site.
REVIEWER: D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 30 June 1989

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 96	CHAPTER/SECTION: 8.3.1.3.4.1.3 Activity: Sorption as a function of ground-water composition...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.3-76 to 77	This activity has been changed somewhat from the CD-SCP. Again, we cannot emphasize enough that DOE must demonstrate that sorption experiments on crushed material are a suitable proxy for the field situation. Failure to do so will render any models generated from this data of questionable and nonconservative value. Due to lack of development of methods and technical procedures, we cannot judge the feasibility and probability of success of this activity.

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 97	CHAPTER/SECTION: 8.3.1.3.4.1.3 Activity: Sorption on particulates and colloids.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.3-77 to 79	The only perceptible change in this activity from the CD-SCP is the removal of the table. There is nothing in this activity on how particulates and colloids will be collected at Yucca Mountain, or on the density or frequency of sampling. Batch methods utilizing crushed material are unproven in terms of their applicability to the true field situation. We find that we cannot judge the feasibility and probabitity of success of this activity due to lack of information.

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 98	CHAPTER/SECTION: 8.3.1.3.4.1.5 Activity: Statistical analysis of sorption data.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-79	This activity is essentially unchanged from the CD-SCP. If the applicability of the sorption measurements to reality at Yucca Mountain is unknown, then the meaning of statistical analyses is also unknown. Although the statistical analyses can undoubtedly be performed, if data are available, the result most likely will be GIGO (garbage in, garbage out) unless the utility of the sorption measurements is demonstrated.

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 99	CHAPTER/SECTION: 8.3.1.3.4.2 Study: Biological sorption and transport.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.3-80 to 82	This activity is unchanged from the CD-SCP. Under the Parameters list, the second item in the list of data needed is "Flow rates and directions of water flows in the unsaturated and saturated zone." This is very important information, yet there is no reference to any other study or investigation. Thus, one might assume that these data will be collected in the biological sorption study, but there is no other mention of these data or plans to collect it. Without this information, there can be no realistic model of any type of sorption and/or transport.

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 100	CHAPTER/SECTION: 8.3.1.3.4.2 Study: Biological sorption and transport.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-81	The study is overly concerned with (limited exclusively to) the influence of drilling fluids on growth of microorganisms. While millions of gallons of foam drilling fluid have already been lost at Yucca Mountain, this study should also look at the effects of microorganisms away from areas contaminated by foam. It also mentions that only soil samples will be used for culturing bacteria. This assumes bacteria at depth are the same as those in the soil zone; this assumption must be proven before it is taken for granted. Aseptic drilling techniques exist for obtaining biological samples at depth. What about the effect of radiation on the natural bacterial population? Will hardier strains develop around the canisters and what will their effect be on sorption and transport of radionuclides?

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 101	CHAPTER/SECTION: 8.3.1.3.4.2 Study: Development of sorption models.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-83	This study is changed from the CD-SCP. All the data going into these sorption models are based on batch sorption experiments, e.g., crushed rocks and minerals. There has been no mention of any attempt to demonstrate that the results of these experiments are appropriate and apply to "uncrushed" rocks and minerals such as exist in situ at Yucca Mountain. Without factual evidence that these data apply to reality in the field, the models should not be used in a site-specific case such as Yucca Mountain.

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 102	CHAPTER/SECTION: 8.3.1.3.5.1 Study: Dissolved species concentration limts.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-88	Please refer to existing data or references that describe "conditions that are characteristic of the repository and along flow paths toward the accessible environment." If previous data are nonexistent, refer to other investigations, studies or activities that will be gathering this information.

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 103	CHAPTER/SECTION: 8.3.1.3.5.1.1 Activity: Solubility measurements

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.3-88 to 91	This activity is unchanged from the CD-SCP. The first water to come in contact with the nuclear waste canisters and thus transport radionuclides is vadose-zone water. The chemistry of vadose-zone water is not known, yet three water compositions have already been chosen for experiments. Clearly, these solubility measurements apply to the saturated zone and **not** the vadose zone. In view of the fact that most of the credit for ground-water travel time is in the vadose zone, lack of consideration of vadose-zone water chemistry is a serious omission.

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 104	CHAPTER/SECTION: 8.3.1.3.5.1.2 Activity: Speciation measurements.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-91	This activity is virtually unchanged from the CD-SCP. Vadose-zone water chemistry is needed. Although this activity will probablly succeed, there is insufficient information to judge the feasibility in terms of time, funding, and human resources.

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 105	CHAPTER/SECTION: 8.3.1.3.5.1.3 Activity: Solubility modeling.
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-92	This activity is unchanged from the CD-SCP. Although this activity will most likely succeed, if an adequate database exists or can be developed, more specific methods and procedures need to be developed. Insufficient information exists to determine feasibility in terms of time, funding, and human and material resources.
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AUTHOR(S):	U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE:	DOE/RW-0199 (December 1988).
COMMENT #: 106	CHAPTER/SECTION: 8.3.1.3.5.2.1 Activity: Colloid formation characterizaton.		
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:		
Page 8.3.1.3-93	This activity is conceptually incomplete because no attempt is made to determine what, if any, natural colloids exist at or near Yucca Mountain. Probability of success and feasibility of this activity cannot be determined due to lack of technical procedures and other information.		
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 107	CHAPTER/SECTION: 8.3.1.3.5.2.2 Activity: Colloid modeling.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-94	The activity is unchanged from the CD-SCP. Without knowledge of natural colloid concentrations, it is difficult to understand how colloids can be modeled, except in a generic, non-site specific manner. Modeling will be nonconservative, and results have the potential to be biased and not objective, if not tied to reality, e.g., actual field measurements or measurements of field samples. Lack of specific methods and procedures tends to suggest that this activity will fail. Insufficient information exists to judge feasibitiy in terms of time, funding, and human resources.

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 108	CHAPTER/SECTION: 8.3.1.3.6 Investigation: Studies to provide the information required on radionuclide...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-95	Listed under "the following parameters will be measured, calculated, or derived..." are ten items, all of which consist of data. Strictly speaking, only data can be measured. Another term must be used for parameters that are calculated or derived. Please indicate which of the ten items are to be measured (true data) and which fall into the other category of nondata.

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 109 (1 of 3)	CHAPTER/SECTION: 8.3.1.3.6 Investigation: Studies to provide the information required on radionuclide retardation by dispersive, diffusive, and advective transport...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.3-95 through 8.3.1.3-115	This investigation is part of the geochemistry program (Section 8.3.1.3). There are eight activities grouped in two studies; namely, (1) dynamic transport column experiments, and (2) diffusion. In reviewing this investigation and all its activities, we have focused on the hydrologic issue and its parameters relevant to conducting the geochemical studies under unsaturated flow conditions. DOE claims that part of this investigation will provide data related to the following unsaturated hydro-parameters; namely, (1) matrix and longitudinal diffusion, (2) diffusion without advection, (3) adsorption, (4) hydrodynamic and channeling disperson, (5) anion exclusion, (6) soption kinetcs, (7) colloidal movement, and (8) flow in fractured tuff. Additionally, these data would be used in the transport model for fracture flow named TOSPAC (Total System Performance Assessment Code) for the resolution of the following issues that are related to the performance of the repository. These are issues 1.1 and 1.6, as defined by DOE: (1) Issue 1.1: Will the mined geologic disposal system meet the system performance objective for limiting radionuclide releases to the accessible environment as required by 10 CFR 60.112 and 40 CFR 191.13? (2) Issue 1.6: Will the site meet the performance objectives for pre-waste-emplacement ground-water travel time as required by 10 CFR 60.113?

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 109 (2 of 3)	CHAPTER/SECTION: 8.3.1.3.6 Investigation: Studies to provide the information required on radionuclide retardation by dispersive, diffusive, and advective transport...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.3-95 through 8.3.1.3-115	It is appropriate to offer the following comments: 1. This investigation relies heavily on the hydrologic conceptual model presented in the TOSPAC report. Page 3 of the report states, "Briefly, it is believed that, within each unsaturated-zone rock unit, liquid water will flow mainly downward and mainly in the matrices of the rock units, with spatially averaged percolation flux not exceeding 0.5 mm/yr. Some lateral diversion of flux may occur at the interfaces between distinct hydrogeologic units" (emphasis added). It is recognized that alternative conceptual models are supported by the existing site data. These alternative models should be fully considered in planning the tests of this investigation to provide new site-specific data needed to resolve issue 1.1. 2. It is observed that the geochemical retardation testing is only being planned under water flow in the matrix-anticipated conditions. It is recommended that this testing should be carried out under groundwater fracture flow conditions that are relevant to the fractured nature of Yucca Mountain tuff. (NRC rule requires that site characterization of the repository be done under anticipated and unanticipated conditions). 3. It is my technical opinion that column tests may not produce results that are relevant or characteristic of field-scale conditions. It is unlikely that column samples will remain unaffected by the mechanical disturbance that is encountered in the coring, excavation, transportation, and overburden pressure factors. Encountering such disturbances, these planned tests may not produce information that support issues 1.1 and 1.6.

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 109 (3 of 3)	CHAPTER/SECTION: 8.3.1.3.6 Investigation: Studies to provide the information required on radionuclide retardation by dispersive, diffusive, and advective transport...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages8.3.1.3-95 through 8.3.1.3-115	4. The moisture content during columns' testing is determined by the unsaturated flow boundary conditions. Consequently, the flow conditions would have a great affect on the geochemical parameters that is planned under this investigation. It is recommended that great attention be given to flow conditions that would be similar to field site conditions, such as fractures and matrix flow. 5. Crushed tuff flow experiments are not relevant to realistic in-situ vadose-zone conditions.

REVIEWER: Atef Elzeftawy	ORGANIZATION: Mifflin & Associates, Inc.
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 110	CHAPTER/SECTION: 8.3.1.3.6.1.1 Activity: Crushed tuff column experiments.
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-101	This activity is essentially identical to that in the CD-SCP. The continued reliance on experiments, such as this one that utilize crushed rock or minerals to determine sorption coefficients/retardation coefficients, is totally unjustified and may be a complete waste of time and resources, until the applicability of these experiments to the field (uncrushed tuff) is proven. Furthermore, although crushed tuff column experiments may validate batch experiments (or vice versa?), neither by itself, nor in combination, proves that the use of crushed rock or mineral accurately resembles the whole rock in the field. In fact, one might assume that crushed materials behave differently from uncrushed because the act of crushing alters the surfaces of minerals and changes the surface area and behavior.
REVIEWER: D. L. Shettel, Jr. Don L Shettel Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 30 June 1989

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 111	CHAPTER/SECTION: 8.3.1.3.6.1.1 Activity: Crushed tuff column experiments.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-104	First paragraph under "Description" states that, "samples were chosen to have mineralogic and sorptive properties that are representative of minerals located along flow paths to the accessible environment." The fallacies in this line of thought include: 1. Sorptive properties of minerals are not completely known, so how can representative samples be chosen? 2. Crushing the minerals changes their sorptive properties, which is also related to the representativeness of samples; and 3. Flow paths are not known with any degree of certainty, especially the degree to which fracture flow predominates over matrix flow in the vadose zone, as well as the saturated zone.

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AUTHOR(S):	U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE:	DOE/RW-0199 (December 1988).
COMMENT #: 112		CHAPTER/SECTION:	8.3.1.3.6.1.1 Activity: Crushed tuff column experiments.
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:		
Page 8.3.1.3-104	Sampling locations are not specified, nor whether samples will represent fracture or matrix mineralogy. Chemical composition of water to be used in experiments is not specified. In sum, there is insufficient information provided to determine: (1) probability of success using existing technology, and (2) feasibility in terms of time, funding, and human resources.		
REVIEWER:	D. L. Shettel, Jr. Signature	ORGANIZATION:	Mifflin & Associates, Inc. DATE: 30 June 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 113	CHAPTER/SECTION: 8.3.1.3.6.1.2 Activity: Mass transfer kinetics.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-105	This activity is unchanged from the CD-SCP. Mass transfer kinetics should only be determined for sorption on crystal faces of a single crystal of known chemical composition and mineralogy. Crushed tuff columns, a supposedly homogeneous system, seem especially inappropriate for the reasons elucidated in comments on the previous activity, and because the data will be difficult if not impossible to interpret, unless it is used only for bulk rock. Whereas, data for crystallographic faces of a mineral can be used to evaluate in-situ retardation, if the mineralogy and exposed surface area of mineral faces on fracture surfaces and in matrix pores have been determined.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 30 June 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
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DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 114	CHAPTER/SECTION: 8.3.1.3.6.1.2 Activity: Mass transfer kinetics.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-106	This activity appears to contain less detail than most in that: 1. The probability of success using existing technology; 2. The appropriateness of methodology; and 3. The feasibility in terms of time, funding, and human resources, cannot be ascertained or is incorrect, as for the case of 2 above.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 14 April 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 115	CHAPTER/SECTION: 8.3.1.3.6.1.3 Activity: Unsaturated tuff column.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-107	In the case of this activity, it is questionable whether DOE can "validate models used to calculate unsaturated flow and transport" for unsaturated tuff experiments. If the tuff column is composed of crushed rock, then validation is seriously in doubt due to the different physical characteristics of crushed versus whole rock. Validation of models and experiments are usually performed by field tests; DOE must justify beyond a reasonable doubt their validation methods.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 18 April 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 116	CHAPTER/SECTION: 8.3.1.3.6.1.3 Activity: Unsaturated tuff column.
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-107	Only the first paragraph of this activity has apparently been changed from the CD-SCP.
REVIEWER: D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 18 April 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 117	CHAPTER/SECTION: 8.3.1.3.6.1.3 Activity: Unsaturated tuff column.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-108	It is not clear whether the column is crushed rock (most likely) or solid cores. What effect, if any, will the increased pressure of the column have on the results? For an activity that is developmental in nature, how can DOE "ensure the applicability of sorption values of saturated flow in tuff to an unsaturated system."

REVIEWER: D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 30 June 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
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DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 118	CHAPTER/SECTION: 8.3.1.3.6.1.3 Activity: Unsaturated tuff column.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-108	Without the study plan, we find that we cannot judge the: (1) appropriateness of methodology to establish stated objectives; (2) probability of success using existing technology (it is to be developed); and (3) feasibility in terms of time, funding, and human resources due to insufficient information. The question could be asked if this technology can be developed during the site characterization. DOE obviously assumes that it can because no alternatives are given.

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NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 119	CHAPTER/SECTION: 8.3.1.3.6.1.3 Activity: Fractured tuff column studies.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-109	This activity is very similar to the corresponding one in the CD-SCP. Only the first paragraph has been modified by the addition of a sentence. This activity addresses saturated fractured tuff core studies, but does not cover unsaturated fractured tuff cores. DOE is assuming that fractures in the vadose and saturated zones behave identically with respect to transport and diffusion of radionuclides. This assumption must be proven by reference to published literature or by experiments. DOE does not address this problem.

REVIEWER: D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 30 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE TECHNICAL REVIEW COMMENT	
DOCUMENT TITLE: Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).	
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 120	CHAPTER/SECTION: 8.3.1.3.6.1.3 Activity: Fractured tuff column studies.
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-109	Experiments should be validated by field tests before the experiments are used to validate models describing transport in fractures.
REVIEWER: D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 18 April 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 121	CHAPTER/SECTION: 8.3.1.3.6.1.5 Activity: Filtration.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.3-110 to 111	This activity is unchanged from the CD-SCP. The use of samples from other experiements must be justified, otherwise, it is a questionable practice. The use of high pressures must also be justified. We recognize that this will shorten experimental run times, but can the results be applied to the atmospheric pressure existing in the natural vadose environment. Should not a natural filtration test be performed in the field to validate these experiments?

REVIEWER: D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 30 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 122	CHAPTER/SECTION: 8.3.1.3.6.1.5 Activity: Filtration.
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-111	There is insufficient information to judge: (1) the probability of success of this activity because procedure and techniques have not been developed, and (2) the feasibility in terms of resources, including human, funding, and time.
REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Dan L. Shettel, Jr. Signature	DATE: 21 April 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 123	CHAPTER/SECTION: 8.3.1.3.6.2.1 Activity: Uptake of radionuclides on rock beakers in a saturated system.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-112	This activity is unchanged from CD-SCP. Insufficient information is provided on sample localities for the rock beakers.

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Signature	DATE: 30 June 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE TECHNICAL REVIEW COMMENT			
DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).		
AUTHOR(S):	U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE:	DOE/RW-0199 (December 1988).
COMMENT #: 124	CHAPTER/SECTION: 8.3.1.3.6.2.1 Activity: Uptake of radionuclides on rock beakers in a saturated system.		
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:		
Page 8.3.1.3-112	Insufficient information is provided to judge: (1) the probablility of success using existing technology, and (2) the feasibility of accomplishing this activity in terms of the time available, level of funding, and the allocation of human resources.		
REVIEWER: D. L. Shettel, Jr. Signature		ORGANIZATION: Mifflin & Associates, Inc. DATE: 30 June 1989	

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NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 125	CHAPTER/SECTION: 8.3.1.3.6.2.2 Activity: Diffusion through a saturated tuff slab.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-113	This activity is unchanged from the CD-SCP. The appropriateness of the methodology to establish the stated objectives cannot be evaluated because no information has been provided on the methods for measuring pore tortuosity and pore constrictivity. Insufficient information is provided on the location of samples.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 30 June 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE TECHNICAL REVIEW COMMENT	
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 126	CHAPTER/SECTION: 8.3.1.3.6.2.2 Activity: Diffusion through a saturated tuff slab.
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-113	There is insufficient information to judge: 1. Probability of success using existing technology (technical procedures not yet developed or available), and 2. Feasibility of completing activity in terms of time, funding, and human resources.
REVIEWER: D. L. Shettel, Jr. D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 30 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
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DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 127	CHAPTER/SECTION: 8.3.1.3.6.2.2 Activity: Diffusion through a saturated tuff slab.
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-114	There is insufficient information to judge: 1. Appropriateness of methodology (no technical procedures or study plans available), and 2. Feasibility of completing the activity in allotted time with respect to level of funding and human resources.
REVIEWER: D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 21 April 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE TECHNICAL REVIEW COMMENT	
DOCUMENT TITLE: Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).	
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 128	CHAPTER/SECTION: 8.3.1.3.6.2.2 Activity: Diffusion through a saturated tuff slab.
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-114	This activity is unchanged from CD-SCP. Information on sample locations is too vague. There is no information on preparation of the tuff block for the experiments: Will it be used as is, or dried out completely? How will the initial degree of saturation be determined? How long will experiment be run? Will time be an experimental variable? What tracers/radionuclides will be utilized? Will the tracers be used in combination with one another or singly?
REVIEWER: D. L. Shettel, Jr. D. L. Shettel Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 30 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 129	CHAPTER/SECTION: 8.3.1.3.7.1.1 Activity: Analysis of physical/chemical processes affecting transport.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-119 Paragraph 1, under Objectives	The use of the term "validation" is incorrect. Transport calculations should be validated by results from the laboratory, exploratory shaft, and experimental field tests.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 30 June 1989

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 130	CHAPTER/SECTION: 8.3.1.3.7.1.1 Activity: Analysis of physical/chemical processes affecting transport.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-119 Paragraph 2	Under item (4), we deplore the use of the term "verify" in that its usage is not as defined on the previous page. The applicability of using parameter values determined in the laboratory under saturated conditions **cannot** be used to "verify" calculations of transport in the vadose zone. The authors/editors of this activity should recheck their terminology and perhaps their logical thought processes.

REVIEWER: D. L. Shettel, Jr. D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 30 June 1989

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 131	CHAPTER/SECTION: 8.3.1.3.7.1.1 Activity: Analysis of physical/chemical processes affecting transport.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-121	This activity is unchanged from the CD-SCP. The objectives of this activity are quite lofty, but the continued misuse of the term "verifying" ("validate" should be used instead) casts serious doubts on whether the activity will be properly executed or the results properly interpreted. There is very little information on how the objectives are to be obtained, other than through the use of computer codes which themselves need to be verified and validated.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 30 June 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE TECHNICAL REVIEW COMMENT	
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 132	CHAPTER/SECTION: 8.3.1.3.7.1.1 Activity: Analysis of physical/chemical processes affecting transport.
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-121	The LBL computer code for the transport of gas and heat in the unsaturated zone, TOUGH, has been omitted or overlooked. DOE needs to justify the choice of selected computer codes and the rejection of others.
REVIEWER: D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 30 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 133	CHAPTER/SECTION: 8.3.1.3.7.1.2 Activity: Geochemical/geophysical model of Yucca Mountain and integrated geochemical transport calculations.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-123	This activity is unchanged from CD-SCP. The objectives of this activity are highly idealistic, but it is not clear how one performs quantitative calculations from "an integrated, **conceptual** geochemical-geophysical model." I am not aware of any individual or group that has successfully accomplished such an integrated, "everything-under-the-sun," all-encompassing type of computation such as DOE is proposing here, but if they can succeed in the allotted time, it will be quite a feat.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
D. L. Shettel, Jr. Signature	DATE: 30 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 134	CHAPTER/SECTION: 8.3.1.3.7.1.2 Activity: Geochemical/geophysical model of Yucca Mountain and integrated geochemical transport calculations.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-124	The DOE is prematurely jumping to conclusions that the calculations of this activity "will support and give confidence to the assumptions made by performance assessment...in its use of a one-dimensional system model..." Furthermore, the basis for a one-dimensional model has not been established, as the computations for this activity have not yet been performed. Validation of one-dimensional performance assessment models by the results of calculations from other models is **not** proper scientific procedure.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 30 June 1989

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 135	CHAPTER/SECTION: 8.3.1.3.7.1.3 Activity: Transport models and related support.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-125 Paragraph 2	We totally disagree with the use of the term "investigate" in the statement, "Computer models are used to investigate the physical and geochemical processes affecting transport..." If the fundamental principles underlying the physical and geochemical processes affecting transport of radionuclides are not understood by field and laboratory tests, then no amount of "tweaking" by computer models will produce realistic and accurate results that can be used in the licensing process.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 30 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 136	CHAPTER/SECTION: 8.3.1.3.7.2 Study: Demonstration of applicability of laboratory data to repository transport...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-127	In the one and only paragraph under "Objectives," the transport model that will be used is the code TRACR3D. No reasons are given as to why this particular code was selected or what are the alternatives. The choice of this code should be defended. The author(s)/editor(s) of this paragraph apparently do not understand the validation process. Data are **not** to be validated by computer codes, but rather data are used to validate the computer codes.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
D. L. Shettel, Jr. Signature	DATE: 30 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 137	CHAPTER/SECTION: 8.3.1.3.7.2 Study: Demonstration of applicability of laboratory data to repository transport...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.3-129 to 130	A. Intermediate-scale tests (caisson tests) The use of crushed tuff in the caisson tests is totally unjustified and absolutely bears no resemblance to field conditions at Yucca Mountain. Tuff from Yucca Mountain will not even be used in these experiments. Unless uncrushed blocks of tuff from Yucca Mountain are used, results from these tests have no relevance and should not be used in the site-characterization process.

REVIEWER: D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 30 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE TECHNICAL REVIEW COMMENT	
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 138	CHAPTER/SECTION: 8.3.1.3.8.1 Study: Gaseous radionuclide transport calculations and measurements.
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-136 Paragraph 1	DOE's attitude toward validation is unacceptable. They contend that, if calculations "to assess the release of gaseous radionuclides for performance assessment..." are adequate, then experimental measurements are not necessary. DOE should be erring on the side of conservatism in that any calculations should be validated by experimental and field tests of the transport of gaseous radionuclides. The release of gaseous radionuclides to the accessible environment (land surface) is most likely to be the first breach of the repository.
REVIEWER: D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 30 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
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DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 139	CHAPTER/SECTION: 8.3.1.3.8.1.1 Activity: Physical transport mechanisms and rates--retardation...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-136	This activity is essentially unchanged from the CD-SCP. If models do not exist in literature, no alternative approaches are presented for how DOE will determine the manner in which gaseous species are transported in the vadose zone. Furthermore, it seems that a literature survey could have been completed by the time of this version of the SCP. What are the scientists in this field of research doing?

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 30 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE TECHNICAL REVIEW COMMENT			
DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).		
AUTHOR(S):	U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE:	DOE/RW-0199 (December 1988).
COMMENT #: 140		CHAPTER/SECTION:	8.3.1.3.8.1.2 Activity: Gas transport measurements.
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:		
Page 8.3.1.3-137	This activity is essentially unchanged from the CD-SCP. The author(s)/editor(s) of this activity really should learn the difference between "verify" and "validate." Experimental measurements may validate (not verify) calculational models of gas transport of radionuclides.		
REVIEWER:	D. L. Shettel, Jr. Signature	ORGANIZATION:	Mifflin & Associates, Inc.
		DATE:	30 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 141	CHAPTER/SECTION: 8.3.1.3.8.1.2 Activity: Gas transport measurements.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.3-137	As sufficient details of experiments to be performed during this activity are not provided, the following facts gleaned from the open literature should be taken into consideration in the study plans of this and the preceeding activity: 1. Partitioning of iodine between water/air decreases with increasing temperature (Lin, 1981). 2. Formation of organic-iodine complexes favors partitioning of the I into the vapor phase (Rai & Serne, 1978). 3. In dissolution tests of spent fuel, ^{129}I and ^{14}C are released preferentially relative to actinides and the release rates of I increase with temperature (Wilson, 1987). 4. Steam stripping of I reduces the liquid phase concentration by up to 35% by transfer to the vapor phase (Birdwell and Weber, 1986). 5. Release of tritium from spent fuel and zircaloy cladding proceeds at much higher rates in boiling acidic solutions (Bleier, et al., 1984). Water in the immediate vicinity of waste canisters contains radiolytically-produced hydrogen peroxide and nitric acid (Glass, 1985). 6. Incongruent matrix release of ^{129}I by dissolution from spent fuel is calculated to exceed NRC limits (Apted, et al., 1987).

REVIEWER: D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 30 June 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE TECHNICAL REVIEW COMMENT			
DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).		
AUTHOR(S):	U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE:	DOE/RW-0199 (December 1988).
COMMENT #: 142	CHAPTER/SECTION: 8.3.1.3.9 Schedule for the geochemistry program.		
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:		
Pages 8.3.1.3-138 to 158	In general, it appears that, even if the individual studies could be completed in the allotted approximate 5 years, because all studies are running concurrently, the interchange of information and interfacing between studies will be insufficient to render the geochemistry program site-specific. For example, vadose-zone water chemistry and the "flow paths to the accessible environment" should be known/determined before many studies begin, but this information will not be available (if even determined) until midway through studies (or later) and, thus, insufficient utilization of such information may result. The schedule suggests DOE is "shotgunning" the geochemistry program, in the sense that everything is starting at about the same time, with little or no feedback. Such a program is generic in that it is not site-specific. The site-characterization program should probably be expanded to a minimm of ten years (under qualified QA/QC plan), with the studies phased to provide needed information before starting the next study requiring such data.		
REVIEWER:	D. L. Shettel, Jr.	ORGANIZATION:	Mifflin & Associates, Inc.
Signature		DATE:	02 June 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 143	CHAPTER/SECTION: 8.3.1.3.9 Schedule for the geochemistry program.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Table 8.3.1.3-8 (p. 13 of 16) Page 8.3.1.3-154	Under study number 8.3.1.3.7.1 (retardation sensitivity analysis [ongoing]), it seems totally questionable to be updating "the geochemical/geophysical model available to DOE" (major event A) on 12/88 before even a study plan is approved, much less the site-characterization plan has been allowed to run its course. It is doubtful that a qualified QA/QC plan is in place. This represents but another example of DOE attempting to refine models before data are collected. Such actions provide further evidence that the SCP is probabilistic, rather than deterministic (as required by law), non-site specific, non-conservative, and mission-oriented.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 02 June 1989

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ROCK-CHARACTERISTICS PROGRAM

The DOE rock characteristics program is composed of three investigations, in the SCP:

1. The development of an integrated drilling program and integration of geophysical activities;

2. The geologic framework of the Yucca Mountain site; and

3. The development of three-dimensional models of rock characteristics at the repository site.

These investigations are designed to provide site-specific information, which will be used in the design of underground repository facilities and to support assessments of site performance for ground-water travel time, waste-package lifetime, and radionuclide releases from the engineered-barrier to the accessible environment.

It is presently uncertain whether the alternative hypotheses as listed in Table 8.3.1.4-2 starting on page 8.3.1.4-19 will help to insure that the approach to this program is comprehensive, as it is nearly impossible to assess how the alternative hypotheses are actually being tested in the three investigations and their respective activities.

The DOE rock-characteristics program seems to be the main avenue for geophysical activities in the overall DOE site-characterization program. Early in our discussion, it is important to point out the DOE overreliance on geophysical techniques to obtain in-situ data. It is true that geophysical techniques, for the most part, do not compromise site integrity and, therefore, If they can produce the desired results, they are possibly the best choice. The DOE paranoia over maintaining site integrity over accomplishing a conservative, well-planned site-characterization effort may prove to be the key choice, promulgating failure during licensing proceedings. Many, if not all, of the geophysical methods chosen are untested in similar environments and may not produce usable results. For example, it is difficult to see how seismic data can be used to investigate the continuity, thickness, and properties of the non-welded Calico Hills unit. We would presume the non-welded units would have significantly lower velocities than the highly-welded units which overlie them. Although one might expect to see a conductivity anomaly in the bedded units using EM survey methods, if greater than 60% of the pore spaces contain vapor in the other units, this task might be most difficult for other than shallow surveys. Without going through all of the potential stumbling blocks, it seems most prudent to establish alternative methodologies for collecting physical-properties data beyond those which have been presented.

One of the most productive techniques to provide in-situ data-gathering would be to significantly expand the coring program. This would provide direct information with respect to tuff formation properties and, at the same time, provide samples for laboratory analyses. This type of action would reduce the need to apply guesswork in place of true determinative scientific investigation. Further, if this type of data-gathering effort were mounted under an integrated program appropriately managed and focused on performance-assessment issues, there would be a reasonable chance of success, especially if the time to accomplish these tasks was extended. The DOE systematic drilling program should probably be moved to the DOE vadose zone hydrogeology program. An entirely new activity should be constructed for the rock properties program, because the systematic drilling program is the only activity in the SCP, that has the potential to obtain needed hydrogeological information, in a three-dimensional network throughout the repository block, in the vadose and uppermost saturated zones.

The systematic drilling program (activity 8.3.1.4.3.1.1) provides a reasonable spatial distribution of boreholes for SD1 through SD7 and a potential clustering problem for SD8 through SD12. Data from these boreholes should be utilized to develop a flow and transport data for evaluating the hydrogeology of the vadose zone. These boreholes in addition to others could then be utilized to obtain physical properties data to evaluate rock characteristics. It is important to recognize the need to obtain rock characteristics and hydrogeologic properties from the repository horizon to the water table to be able to

provide an appropriate assessment of repository performance. One particular problem that will be encountered in the present planned investigation is that dry drilling with air has the potential to dry out the cores. An alternative methodology might consider using nitrogen during the coring process. Well-dried out cores and borehole wall rock will not yield either reliable hydrogeological or rock characteristics properties that can be assigned to represent in-situ vadose characteristics necessary for confident site assessment.

At present, the DOE rock-characteristics program is not designed to provide an integrated framework of activities that can accomplish its stated goals. Consequently, the DOE site-characterization accomplishments in this program will prove to be minimal.

APPENDIX E

ROCK CHARACTERISTICS PROGRAM DOCUMENT REVIEW FORMS

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 144	CHAPTER/SECTION: 8.3.1.4.1.1 Activity: Development of an integrated drilling program.
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.4-24 to 26	This activity has no individual parameters, as no data will be collected. The purpose of this activity is to integrate the drilling program. Little, if any, useful information is offered in the description of the activity. It is obvious that, if this activity is responsible for planning the surface-based drilling program so as to acquire all information that is needed for the characterization effort, it has missed its goal, because there is a paucity of data collection in the Calico Hills Formation, which is the most critical horizon with respect to travel time and sorption issues.
REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 05 May 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 145	CHAPTER/SECTION: 8.3.1.4.1.2 Activity: Integration of geophysical activities.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.4-26 to 27	This activity has no individual parameters, as no data will be collected. The purpose of this activity is to: a. provide a mechanism for information exchange, b. provide an analysis of data and other technical information, c. provide an overview of planned geophysical site-characterization activities. This activity "will review and evaluate planned geophysical surveys for (1) consistency with the results from past surveys,"... It is important for the SCP to describe the methodology used, if new survey data is inconsistent with old survey data.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 05 May 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 146	CHAPTER/SECTION: 8.3.1.4.2.1.1 Activity: Surface and subsurface stratigraphic studies of the host rocks and surrounding units.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.4-32 to 41	This activity is in support of 8.3.1.4.2.1 Study: Characterization of the vertical and lateral distribution of stratigraphic units within the site area. On page 8.3.1.4.35, second to last paragraph, it is not well understood how SEM analyses will be used to interpret modes and environments of deposition. When studying the zeolite mineralogy of the Calico Hills Formation, it will be important to relate the distribution of the mineralogy to open pores and fractures. Studies on the morphology of zeolites are important and we suggest that these studies concentrate on crystal orientation, and multiple crystal growths and overgrowths, to determine a baseline of information relating to mineral accessibility for sorption. There is no mention of determining the age of zeolitization for the zone II zeolite horizon. For surface mapping near USW G-5 and USW G-6, we would be interested in obtaining documentation of basaltic injection deposits and their relation to subsurface fracture and fault networks. The effects of these injections on tuff mineralogy would be most interesting and would apply directly to site characterization. Paleomagnetic sampling should be tightly spaced--spacing is unknown here. The sampling interval for mineralogy is not clear. There should be a statement concerning fracture versus matrix mineralogy data collection.

REVIEWER: M. E. Morgenstein M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 05 May 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 147	CHAPTER/SECTION: 8.3.1.4.2.1.2 Activity: Surface-based geophysical surveys.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.4-41 to 57	Seismic, gravity, magnetics, and EM surveys will be attempted in this activity to assist and improve the confidence in stratigraphic models of Yucca Mountain. It is presumed that horizons, such as the bedded units, are of lower seismic velocity than the units above and below it. This will cause a significant seismic interpretation problem. EM, magnetic, and gravity surveys may provide meaningful information. Prior to full-scale survey efforts, these surveys should be planned (as described) for seismic surveys ("proof-of-technique trials"). More data should be presented in electromagnetic survey descriptions, as there are a large variety of instruments which will offer varied results. In general, we are somewhat cautious concerning the use of standard geophysical techniques in the Yucca Mountain region because of the difficulty in obtaining real-world data of usable value. This problem is apparently true for much of the Great Basin.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 05 May 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE TECHNICAL REVIEW COMMENT	
DOCUMENT TITLE: Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).	
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 148	CHAPTER/SECTION: 8.3.1.4.2.1.3 Activity: Borehole geophysical surveys.
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.4-57 to 59	We assume that induction, resistivity, and spectral-gamma logs are expected to serve as indicators of smectite and zeolite-rich intervals, as a consequence of a higher moisture content expected in these intervals. A host of other possible interpretations are possible, and certain care must be exercised in making mineral content interpretations from geophysical logging data. We suggest that this section be rewritten using a more conservative approach. This can be accomplished with back-up petrology and mineral data.
REVIEWER: M. E. Morgenstein M E Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 05 May 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE TECHNICAL REVIEW COMMENT	
DOCUMENT TITLE: Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).	
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 149	CHAPTER/SECTION: 8.3.1.4.2.1.4 Activity: Petrophysical properties testing.
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.4-59 to 60	More detail needs to be provided on the methodology to be used to obtain: 1. preferential patterns for water flow; 2. the potential for contaminant transport by means of diffusion processes; 3. concentrations of clays and zeolites within the measured stratigraphic section; 4. degree of rock or mineral alteration. The activity stipulates petrophysical properties testing, and the above four items fall into classifications that are not necessarily petrophysical properties. The potential for contaminant transport by diffusion is not a property by itself. It would be nice to know what is being measured in either case. Clay and zeolite concentrations should be determined by standard mineralogical procedures; however, there does not seem to be any provision for this in the methodology section.
REVIEWER: M. E. Morgenstein M E Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 150	CHAPTER/SECTION: 8.3.1.4.2.1.5 Activity: Magnetic properties and stratigraphic correlations.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.4-60 to 64	This activity is in support of 8.3.1.4.2.1 Study: Characterization of the vertical and lateral distribution of stratigraphic units within the site area. In order for this program to function on a conservative level, there needs to be an appropriate calibration of physical-property variations to mineralogy and petrology, prior to obtaining magnetic-property measurements. The overall concept (objectives) is well stated. The parameters required for this activity to proceed should include more detailed mineralogical data collection. It might be advisable to review Schlinger, C. M., 1989, "Magnetic stratigraphy of ash-flow sheets at Yucca Mountain, Nevada;" Eng. Geol. & Geotech. Eng., Watters (ed.), Balkem, Ruttendam ISBM 90-619-8782 (pages 19 to 24).

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
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DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 151	CHAPTER/SECTION: 8.3.1.4.2.1.6 Activity: Integration of geophysical activities.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.4-64	This activity has no individual parameters, as no data will be collected. The purpose of this activity is to integrate the geophysical activities. We suggest that this activity be expanded to include the integration of geophysical techniques with the mineralogy and geochemistry programs. If the purpose of the geophysical program is to develop data for geochemical modeling, the program will certainly fail without appropriate interaction with geochemists.

REVIEWER: M. E. Morgenstein M E Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 05 May 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 152	CHAPTER/SECTION: 8.3.1.4.2.2.1 Activity: Geologic mapping of zonal features in the Paintbrush Tuff.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.4-66 to 68	This activity is in support of 8.3.1.4.2.2 Study: Characterization of the structural features within the site area. A statement on the value of this activity with respect to licensing issues should be provided, and it should be related to work already completed. A discussion is required describing the determination of the boundary of the "Preliminary boundary of accessible environment" (shown on Figure 8.3.1.4-9). What criteria are used to determine the boundary configuration? It is difficult to determine the value of this activity with respect to site characterization issues.

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NEVADA NUCLEAR WASTE PROJECT OFFICE TECHNICAL REVIEW COMMENT	
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 153	CHAPTER/SECTION: 8.3.1.4.2.2.2 Activity: Surface-fracture network studies.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.4-68 to 70	This activity is in support of 8.3.1.4.2.2 Study: Characterization of the structural features within the site area. A correlation between fractures at the surface and subsurface is needed to be able to utilize the surface fracture data in the planned modeling effort of hydrologic potential flow paths in the vadose zone. Surface fractures and faults may not be similar to subsurface features because: 1. Surface fractures may be soil-carbonate filled; whereas, at depth, similar or identical fractures may be completely open. 2. Fracture distribution for tensile displacements may be partially dependent upon the cooling history of that particular stratigraphic level of the tuff and, therefore, may differ with depth. 3. Weathering of surface fractures may drastically change fracture morphologies, such as roughness and aperture. 4. Authigenic mineral fracture filling will probably change with depth. There is no discussion of the potential use of subsurface fracture data to support the modeling effort. Consequently, it is difficult to see how this activity could possibly be utilized to address site-specific performance issues. Activities 8.3.1.4.2.2.3 and 8.3.1.4.2.2.4 could begin to satisfy the subsurface requirements; however, this is not in the discussion of their support of the modeling effort. Consequently, it is doubtful that this activity will be able to provide meaningful information towards characterization.

REVIEWER: M. E. Morgenstein M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 154	CHAPTER/SECTION: 8.3.1.4.2.2.3 Activity: Borehole evaluation of faults and fractures.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.4-70 to 74	This activity is in support of 8.3.1.4.2.2 Study: Characterization of the structural features within the site area. This activity needs to be utilized to support activity 8.3.1.4.2.2.2. Additionally, other subsurface data need to be collected. Although a statement is made concerning the use of surface data to assist this activity, no statement is made in the reverse; therefore, modeling activities will be based upon less than site-specific data (see comments under 8.3.1.4.2.2.2).

REVIEWER: M. E. Morgenstein M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 05 May 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE TECHNICAL REVIEW COMMENT			
DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).		
AUTHOR(S):	U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE:	DOE/RW-0199 (December 1988).
COMMENT #: 155	CHAPTER/SECTION: 8.3.1.4.2.2.4 Activity: Geologic mapping of the exploratory shaft and drifts.		
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:		
Pages 8.3.1.4-74 to 80	This activity is in support of 8.3.1.4.2.2 Study: Characterization of the structural features within the site area. The discussion on fracture-filling minerals needs to detail methodology to locate such zones and methodology of sampling. What constitutes "An unusual zone of alteration?" Does this statement imply only very selective zones of alteration will be studied and reported? It is interesting to note that the basic compositional chemistry of fracture minerals is not included in the planned activities. ESR dating of quartz and K-Ar dating of clays may not offer any valuable information on age of zeolites. How shall this problem be solved on a direct data collection basis? If the shaft and drifts do not extend to the Calico Hills, what value will the mineral data have with respect to site licensing? If vadose liquids are encountered, will they be reported? Collected? Analyzed? And if so, will they be related to authigenic-mineral chemistry? If not, why not? Carlos (LA-11504-MS, 1989), describes fracture mineralogy of drill hole J-13. She notes a marked difference in the heulandite distribution above and below the water table. This information has direct bearing on the present and past hydrologic conditions. To what extent will there be an attempt to distinguish between heulandite and clinoptilolite in fractures analyzed? Might not Si/Al ratios be of some assistance? This activity needs to broaden its data gathering, in order to meet licensing and performance characterization criteria. In its present state, it falls short.		
REVIEWER: M. E. Morgenstein M E Morgenstein Signature		ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June 1989	

NEVADA NUCLEAR WASTE PROJECT OFFICE
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DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 156	CHAPTER/SECTION: 8.3.1.4.2.2.5 Activity: Seismic tomography/vertical seismic profiling.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.4-79 to 80	This may be a difficult activity to successfully perform due to the potentially large variation of fracture assemblages, as exemplified by numerous tensile displacements which are apparently cut by well-controlled mohr-columb assemblages of shears. In areas of high fracture density, seismic tomography may be overwhelmed with refractions and reflections, and interpretation of the results may be impossible. The activity has value and the methods should be tested prior to starting. Testing should take place in the field in a region which has fairly good control data. This testing concept may also assist in the development of a technical procedure for this project.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 05 May 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE TECHNICAL REVIEW COMMENT			
DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).		
AUTHOR(S):	U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE:	DOE/RW-0199 (December 1988).
COMMENT #: 157	CHAPTER/SECTION:	8.3.1.4.2.3.1 Activity: Development of a three-dimensional geologic model of the site area.	
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:		
Pages 8.3.1.4-81 to 82	This activity is short-sighted because it is not utilizing basic data (geological and geochemical) developed by the mineralogy and geochemistry programs. An integration of activities, studies, and investigations in various programs is required to build a model that will contribute to the understanding of site characteristics. The degree to which faults and fractures can be delineated, traced, and described will be limited by the comprehensiveness of the program and the complexity of the site. The age relationship of fractures may be obtainable for a selected few fracture assemblages that will be sampled. Modeling these activities may prove to be most difficult without utilizing basic assumptions that will have little and possibly no bearing on real-world conditions.		
REVIEWER:	M. E. Morgenstein Signature	ORGANIZATION:	Mifflin & Associates, Inc. DATE: 29 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 158 (1 of 2)	CHAPTER/SECTION: 8.3.1.4.3.1.1 Activity: Systematic drilling program.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.4-87	This is the only activity under the study entitled "Systematic aquisition of site-specific subsurface information " (8.3.1.4.3.1). This study is part of investigation 8.3.1.4.3, "Development of three-dimensional models of rock characteristics at the repository site." The systematic drilling program appears to be a step in the right direction. However, this activity is in the wrong program because the primary objective with regard to licensing is the hydrogeologic characteristics of the various rock units in the repository area. The focus should be primarily to develop a three-dimensional flow and transport field data for evaluating the hydrogeology of the unsaturated zone of the site, in addition to evaluating rock characteristics. In reviewing this activity, it is noted that DOE is planning seven <u>new</u> boreholes, USW SD-1 through USW SD-7, during the site-characterization period. These new boreholes are located within or just oustide of the repository boundary, as shown in Figure 8.3.1.4-11 on page 8.3.1.4-90 of the SCP. The spatial distribution of boreholes SD1-SD7 appears acceptable, but the clustering of SD8-SD12 in the vicinity of UZ-9, UZ-9a and UZ-9b is of some concern, because the proposed drilling technique to be used for the UZ-9 group of boreholes is quite different from that proposed for SD8-SD-12. Therefore, the unsaturated hydrologic parameters derivable from each group of boreholes would reflect the effect of the drilling methodology. The dry drilling method that uses air and is proposed for coring in this program poses a problem because the heat generated during coring with air will affect the physical characteristics of the unsaturated zone. We would recommend that DOE come up with a drilling method that guards against this problem under this proposed program.

REVIEWER: Atef Elzeftawy and O. Adenle Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 30 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 158 (2 of 2)	CHAPTER/SECTION: 8.3.1.4.3.1.1 Activity: Systematic drilling program.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.4-87	We feel that the depth of penetration should be just below the water table and not 100 m below it, as indicated in this program. The hole diameter should be small, in order to ensure minimal disturbance of the unsaturated zone. These holes could be used for monitoring the unsaturated zone. Furthermore, we question the pooling of data from the SD holes with other existing holes (which were drilled with various drilling techniques) because probable data variations may be due to drilling techniques, rather than to rock characteristics. It is strongly recommended that DOE develop detailed plans and procedures that will ensure the pristine quality of rock and water samples from the unsaturated zone at Yucca Mountain. We doubt if any meaningful site-specific data could be obtained on some of the parameters considered in this program (especially location and characteristics of faults and fracture frequency and orientation) on the basis of one investigation point for every 3000 feet.

REVIEWER: Atef Elzeftawy and O. Adenle	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 30 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 159	CHAPTER/SECTION: 8.3.1.4.3.1.1 Activity: Systematic drilling program.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.4-87 to 100	This activity is the only activity in support of 8.3.1.4.3.1 Study: Systematic acquisition of site-specific subsurface information. It is not at all clear how, for example, geochemical variables will be characterized by this program. It is unclear what samples will be collected, methodology of collection, quantity of disturbance during the collection process, and required quality control. No provisions have been made for the collection of vadose water, as specifically demonstrated in the discussions. Without this information, it is unclear how the characterization process will meet its licensing characterization objectives. Holes will be drilled to only 200 feet below the static-water table. This may not be deep enough. Even though there are about 12 (?) new holes proposed (an improvement in CD-SCP), adequate hole spacing is still questionable. The determination of adequate characterization of spatial variability will depend heavily upon geostatical techniques and will be identified in close cooperation with the modeling efforts of study 8.3.1.4.3.2. We find that the correlation distances are expected to be much less than nominal borehole spacing. Adequate characterization of borehole data may not be technologically feasible. In addition, we do not have the same positive expectations from geophysical methods, as is expressed in this program.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
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DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 160	CHAPTER/SECTION: 8.3.1.4.3.2.1 Activity: Development of three-dimensional models of rock characteristics at the repository site.
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.4-100 to 103	The optimum number of geostatistical manipulations required to develop a reasonably accurate 3-D model of rock characteristics at the repository site is zero. The more uncertain the database, and the greater the interpretation required, the less valid and usable the product. Apparently, this activity would benefit from a comprehensive field program collecting meaningful data at numerous locations. We see little value in the presently planned exercise. The field program required, however, will probably compromise the site integrity. The drilling program planned is much too limited, and too much emphasis is placed on untested geophysical methods.
REVIEWER: M. E. Morgenstein M E Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 05 May 1989

MY890703a

CLIMATE CHANGE PROGRAM

"Goals are for those who need them."

The DOE climate-change program, as described in the SCP, contains investigations that are designed to provide data on past, present, and future climate conditions. These data will describe changes in climate and the effects of these changes on surface, vadose, and saturated-zone hydrogeology. These potential climate-change effects are important to the site-characterization effort because they may contribute to radionuclide releases that might exceed performance requirements over the long term of a 100,000-year isolation period.

The DOE recognizes four substantial goals in their climate site-characterization program. These goals are currently perceived as extreme values that would be acceptable because radionuclide release rates would not be affected. The DOE program and program scientists are apparently charged with reaching these "tentative goals" as described in Table 8.3.1.5-1 (on pages 8.3.1.5.4 to 5) and summarized below:

1. Show that the expected flux change with a climate-caused increase in infiltration over a controlled area will be less than 5 mm/year over the next 10,000 years; and 100,00 years.

2. Show that the expected magnitude of change in water-table altitude, given a climate-caused increase in altitude to the water table, will be less than +100 meters over the next 10,000 years; and 100,000 years.

3. Show that a climate change causing an increase in the gradient of the water table within a controlled area will be less than 2×10^{-3} over the next 10,00 years; and 100,000 years.

4. Show that no significant surficial discharge points could appear within a controlled area, given a water-table rise of less than +160 meters over the next 10,000 years; and 100,000 years.

The DOE approaches this site-characterization effort from a context of satisfying performance and design requirements (an engineering approach). Unfortunately, the natural geologic barrier system must perform on its own merit and can not be engineered to function in accordance with the DOE goals. Consequently, in terms of confident site characterization, the DOE approach should be focused on a program of exploration and research based upon well-formulated hypotheses that provide a breadth of coverage that could conservatively assess the Yucca Mountain site characteristics.

The DOE alternative hypotheses are presented in Tables 8.3.1.5-3 to 5. In these tables, there is a minimum coverage of "current representations" (for example, there is no mention of current local precipitation) and, as such, alternative concepts that might prove significant to address are not addressed. Paleoclimate alternative hypotheses will not necessarily be appropriately addressed by the DOE studies or activities presented, as there are few recognizable tasks that will actually cover (in a data-collection sense) the characterization of the alternative hypotheses. Alternative hypotheses are not listed or tabled in the CD-SCP. The activities described in the SCP are principally similar and/or unchanged, for the most part, from those presented in the CD-SCP. It appears that these tables are added in response to CD-SCP review comments, but there is no functional change between the CD-SCP and the SCP with respect to addressing the alternative hypotheses in a comprehensive and serious manner.

Climate change is a key issue with respect to repository performance, since the most significant element, that potentially favors a high-level radionuclide repository at Yucca Mountain, is the location of the site, in a generally arid region. Nonetheless, the present-day meteorological conditions regarding precipitation, snowpack accumulation, wind, temperature, cloud cover, among other parameters, are poorly known for the site itself. The DOE data represented as in-situ meteorological records have been acquired in areas other than Yucca Mountain, such as at Yucca Flat (at a lower elevation, in a basin setting, presumably with greater aridity). These data have been modeled and manipulated into the present-day DOE hypothesis of a conceptually-favorable site.

As recently as 10,000 years ago, many currently arid basins of the Great Basin contained pluvial lakes and local discharge deposits that suggest greater availability of effective moisture than the present day. This greater availability of effective moisture as a function of runoff, infiltration, and net ground-water recharge is related to climatic parameters, such as the temperature regime; the areas receiving precipitation; the timing and magnitude of that precipitation; the hydrogeologic characteristics of the terrane, including regional transmissivity; and the position of local saturation with respect to interacting surface-water drainages. The response of vadose- and saturated-zone systems to climate change, during future plenipluvial periods within the immediate Yucca Mountain region, represents information which is required to be collected by the past-climate program. If there are to be any programmatic goals, they must be focused on the collection of data, which will result in a more comprehensive understanding of the local Yucca Mountain response to climatic fluctuations, and to the identification of what these fluctuations might be. The DOE attempts to quantify and correlate paleoclimatic parameters, such as temperature, rainfall, and snowmelt, among others, on global, regional, and local scales, is overly optimistic because, in order to accomplish this, it is necessary to obtain finite boundary conditions in geographic and temporal spans, at levels of accuracy which are most probably beyond our present technological capability.

Quantitative data may be most difficult to obtain from paleoecological records due to the presently poor understanding of the range of a single specie's response to variations in climate and the paucity of present-day data on endemic communities' tolerance for short periods of significant climate change, possibly meaningful in terms of a greater net moisture infiltration. The DOE approaches taken to determine vegetation/climate relationships generally provide analytical information of quantitative uncertainty when measured in hydrologic site-specific parameters. The DOE modeling activities, especially those on a global scale (such as the general circulation model) or those concerned with orbital forcing, appear as unconstructive tasks, poorly contrived, and not responsive to a focused effort concerned with site performance. If one is to invoke astronomical forcing models of the Malinkovitchian type as causative factors regarding past climate performance and future climatic behavior, one must also consider the sensitivity of these models to determine maximum rainfall, evapotranspiration, temperature, infiltration, runoff, etc., on a local scale. A variety of global-scale circulation models produce different results for regional areas of interest. The choice of which model to use becomes a critical issue itself and certainly predetermines the results obtained.

Global-oceanic and atmospheric circulations are responsible for the generation of cloud cover and these circulations respond to the distribution of the clouds. Therefore, a change in climate could modify the net-cloud forcing and a net-cloud forcing could cause a change in climate. The El Niño event is a short-term example of cloud forcing which produces a climate change as a consequence of warm sea surface temperatures in the Pacific which create a cloud cover. The effects of man's industrial activities, such as, alteration of the surface by deforestation and reduction of the ozone layer by the increase in trace gas emissions, may be responsible for changes in the cloud cover and, hence, the global climate. The coupling between atmospheric density, land and ocean biota productivity and biochemistry, natural earth aerosol emissions, cloud cover, and finally climate itself is extremely complex. To our knowledge, there is no model available that can account for these interactions, and the interactions are obviously important with respect to understanding climate theory. Global-scale models, which attempt to balance the energy functions, examine radiative and convective equilibrium, and look at the dynamic interactions of radiation and convection, are, in themselves, inadequate to provide a meaningful understanding of climate theory and hence, behavior. The DOE arguments supporting local and regional climate modeling efforts rely on scenario development, with a minimum conceptual framework of climate theory. Again, the concept is that the coupling of global-scale events assists in the determination of local patterns of circulation, yet it is practically impossible to utilize a global-scale model to predict local events because the boundary conditions are undeterminable. Therefore, local and regional modeling efforts may not be usable within the context of Yucca Mountain site characterization.

The DOE activities regarding the aeolian history of Yucca Mountain, evaluation of past discharge areas, analog recharge studies, analyses of packrat middens, and chronologic analyses of lake, playa,

and marsh deposits are, for the most part, well-focused objective activities that have very good chances of producing meaningful results that can be applied to site performance issues. Most of the other DOE activities, however, will be of little value in resolving the site-specific performance questions. The DOE climate-change program should be a well-focused effort capable of linking regional and local climatic and paleoclimatic parameters to ground-water behavior on a site-specific basis.

Some of the activities proposed incorrectly presume that the modeling approaches are valid and that meteorological data collection will provide an adequate picture of present-day weather extremes. These underlying assumptions are incorrect. It is impossible to collect the desired meteorologic data within the short time frame available because, for example, extremes in weather patterns can not show up with a five-year collection program and long-term historic records do not include the Yucca Mountain region. Consequently, some of the DOE activities are not correctly designed to obtain the desired information. It is questionable whether the DOE climate-change program activities described in the SCP are powerful enough to allow the DOE to "establish the geologic condition and the ranges of the parameters of" the Yucca Mountain site.

APPENDIX F

CLIMATE CHANGE PROGRAM DOCUMENT REVIEW FORMS

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 161	CHAPTER/SECTION: 8.3.1.5.1.1.1 Activity: Synoptic characterization of regional climate.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.5-40 to 42	This is the only activity under the study to characterize the modern regional climate. It is not clear how the carbon isotope analyses will support the objective of the activity to characterize the regional climate. The number of stations and configuration of the weather station network must be predicated on the regional detail necessary to respond to three objectives listed. Yucca Mountain, itself, requires inclusion in the network, as it is the subject area of the study and local meteorological pertubations need to be analyzed. The use of tree ring data has major significance in high orographic regions, but may be quite limiting in the lower desert. Special attention must be paid to this problem, in order to satisfy a reasonable statistical coverage.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 04 April 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 162	CHAPTER/SECTION: 8.3.1.5.1.2.1 Activity: Paleontologic analysis.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.5-42 to 47	This activity supports the study of paleoclimate, which includes lake, playa, and marsh deposits. There are two very significant problems suggesting that the objectives of this activity will not be met. 1. Biocarbonate tests such as ostracods can possibly be dated by C-14 (or other techniques), if enough material is collected. We find an extremely limited discussion of the mechanisms that will be employed to make age determinations, which are absolutely necessary to determine climatic (environmental) timing. The methods and technical procedures section makes no provision for age determinations. Consequently in terms of paleoclimate, it is uncertain how the record will be obtained. 2. There is a paucity of published papers on the environmental autecology (environmental interaction of species) of ostracods and diatoms, with respect to the Great Basin. Consequently, the interpretation of species environmental adaptations emphasizes a database that is not readily available to the public. Provision, therefore, must be made to provide a comprehensive core of published references that will or could be used to independently interpret the autecology of each species used in the environmental interpretation. It is imperative that this information be made public prior to the commencement ot the planned activity.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 26 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 163	CHAPTER/SECTION: 8.3.1.5.1.2.2 Activity: Analysis of the stratigraphy-sedimentology of marsh, lacustrine, and playa deposits.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.5-47 to 49	1. We note that there are no established procedures for seismic data collection described in the methods and technical procedures section, even though the description of the activity includes seismic techniques (unless GP-02, RO includes seismic data collection; if so, this should be clarified). 2. It is uncertain how seismic techniques will be used to refine or define the lithostratigraphy of marsh, lake,and playa deposits. In order for seismics to be useful, there would have to be a correlation between core and seismic reflection data. Clarification is required. 3. Procedures need to be developed for the chemical analyses of core material, as they are not listed nor described in this section. 4. It is uncertain how successful this activity will be with respect to accomplishing its stated goals, as there appears to be a lack of coordinated effort in the SCP description and methodology sections.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 04 April 1989

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 164	CHAPTER/SECTION: 8.3.1.5.1.2.3 Activity: Geochemical analyses of lake, marsh, and playa deposits.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.5-49 to 51	1. The overall objective of this study is good, but the study activity proposed will not yield the required results due to poor focus. The activity should be retitled to provide correct focus. As structured, it will provide basic information for chemical sedimentology and should, therefore, fit into activity 8.3.1.5.1.2.2. 2. In order to respond effectively to the stated objectives, the activity should concentrate on fluid inclusion and authigenic mineral geochemistry, with supporting data derived from micropaleontology. 3. X-ray diffraction analyses of carbonate minerals is not sensitive enough to see carbonates that are in concentrations of less than about 5%. Other techniques may be more applicable, especially to assist in the derivation of water chemistry and sediment provenance. 4. This activity needs to be closely tied to field mapping, so that the information retrieved may be usable in a focused context. 5. Some methodology is needed to assist in the interpretation of sedimentary changes that might occur during post-depositional diagenesis (conditions that do not represent chemostratigraphic environment of sedimentation or precipitation).

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 04 April 1989

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 165	CHAPTER/SECTION: 8.3.1.5.1.2.4 Activity: Chronologic analyses of lake, playa, and marsh deposits.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.5-51 to 54	This activity is well focused and its descriptions and methods appear to support its main objectives. Multiple dating on similar samples is desirable to increase the confidence of the ages obtained.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 26 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 166	CHAPTER/SECTION: 8.3.1.5.1.3.1 Activity: Analyses of packrat middens.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.5-54 to 56	This activity supports the climatic implications of terrestrial paleoecology study. The methodology section requires more information than is offered. This requires revision prior to starting the studies.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 04 April 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 167	CHAPTER/SECTION: 8.3.1.5.1.3.2 Activity: Analyses of pollen samples.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.5-56 to 57	This activity supports the climatic implications of terrestrial paleoecology study. The activity for analyzing pollen (and spore?) is suitable for support of Activity 8.3.1.5.1.3.1 (analysis of packrat middens) and 8.3.1.5.1.2.1 (Paleontologic analyses), but requires a cross referencing beyond that which is supplied in the description of each activity. Pollen and spores are poorly preserved in oxidizing sediments and, as such, have limited value with respect to obtaining a reliable record of vegetation change in arid and oxidizing sediments of the Great Basin. Since pollen and spores are deposited both as localized and foreign clastics subject to redistribution, as a consequence of dust storms among other modes of transport, it is difficult to establish meaningful plant taxa plots using anything other than the highly-concentrated grains (tails of the gaussian curve are difficult to use since they may not represent local pollen and spore production). In addition, climatically-diagnostic grains, such as those belonging to Pinus, have strongly-developed flanges, which help promote long transport paths by aeolian action. The appearance, therefore, of Pine family pollen in lower desert soils and marshes may not indicate local vegetation indicative of cooler, wetter climatic regions, but rather may indicate transport from higher elevations. Consequently, in order to establish a well-focused program directed towards the past-climate issues concerning Yucca Mountain project, it becomes necessary to identify the localities and activities that will be used at those localities to derive the required data which will support the objectives. This activity, among most of the others in the past-climate section, have not been described with this detail. There is no cohesive picture of the program presented and its appropriateness, focus, and probability of success remains unestablished.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 04 April 1989

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 168 (1 of 2)	CHAPTER/SECTION: 8.3.1.5.1.3.3 Activity: Determination of vegetation - climate relationships.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.5-57 to 59	The transfer function and response function approaches have potentially serious flaws with respect to their treatment of pollen and spore populations derived from either packrat midden or sediments analyzed under Activity 8.3.1.5.1.2.4. For the transfer function approach, pollen types representing the full spectrum of the gaussian population curve will be used. It is and will remain unknown whether or not the tails of the population represent local population diversity or are merely a function of erratic deposition. For the response function, the presence or absence of taxa may be used without regard to their endemic quality. Judgement variables will have to be applied to these approaches utilizing a QA/QC program. It is doubtful that success can be achieved, since the judgement factors applied have to be different for each pollen family and, in some cases, possibly different at the species level. Packrat middens are skewed with respect to their pollen package and cannot be used to represent endemic plant communities; consequently, it is easy to see the reasoning behind using lake, playa, and marsh deposits in an attempt to survey an entire (semicomplete) plant community. Nevertheless, the activity will fall short given the approaches attempted. It may be more fruitful to ascertain the amplitude of tolerance of vegetation species using a present-day survey (Shefford's law of tolerance) of the Great Basin. The optimum frequency of individuals within a given species can be compared with the gaussian tail range, under a sequence of environmental variables. Individual plants can be compared to their soil pollen package, in an attempt to relate the parts (pollen) back to the actual individual. These data can then be compared on a species by species basis with fossil assemblages and used to acquire vegetation-climate relationships.

REVIEWER: M. E. Morgenstein M E Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 04 April 1989

MY890703a

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 168 (2 of 2)	CHAPTER/SECTION: 8.3.1.5.1.3.3 Activity: Determination of vegetation-climate relationships.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.5-57 to 59	It is important to remember that intra-species genetic differences will cause a range of response to climatic variables. No two individuals of the same species will have the same response to climatic factors and identical amplitudes of tolerance. Pollen are not individual species, but are produced in different numbers by different families, genera, and species. Pollen are also not well suited to statistical manipulation, as a true species individual fossil would be. The activity is therefore plagued with difficult problems that may not be easy or possible to resolve.

REVIEWER: M. E. Morgenstein	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 26 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 169	CHAPTER/SECTION: 8.3.1.5.1.4.1 Activity: Modeling of soil properties in the Yucca Mountain region.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.5-61 to 65	It is uncertain that cation ratios of rock varnish provide realistically usable dates. As there appears to be sufficient disagreement in the literature, it would be more conservative not to utilize this method until such a time that it is better understood. Chlorine-36 appears to be a better choice at the present time. Alternative concepts of carbonate (K-horizon development) deposition in desert regimes may be necessary to fully explain and utilize these deposits as climatic indicators or for chronological control. Rates of soil development may not be adequately ascertained and require more comprehensive data collection (including recognized and accepted dating techniques) before they are utilized as tools for response to the objectives of the activity.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 04 April 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 170	CHAPTER/SECTION: 8.3.1.5.1.4.2 Activity: Surficial deposits mapping of Yucca Mountain area.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.5-66 to 72	In the CD-SCP, this activity number was devoted to soil moisture analog study. In the SCP, this study has been removed. In the CD-SCP, the surficial deposits mapping activity was listed as 8.3.1.5.1.4.3 and is now listed as 8.3.1.5.1.4.2. A new addition to the objectives of this activity (from the CD-SCP) is to determine the distribution of major concentrations of calcite-silica vein deposits, at or near the ground surface at Yucca Mountain. Insufficient information is presented concerning these data and the means of data collection for the calcite-silica vein deposits. It is understood that the primary purpose is to map these deposits and possibly to date them using uranium series techniques. The means used for locating these deposits needs clarification, as does the chemical, mineralogical, and possibly paleontological techniques that will also be used to assess their genesis. A statement of clarification is needed to support how these deposits relate to the climate-change problem relating to Yucca Mountain.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 04 April 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 171	CHAPTER/SECTION: 8.3.1.5.1.4.3 Activity: Aeolian history of the Yucca Mountain region.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.5-72 to 76	We find that this activity is very well focused and complete.

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 172	CHAPTER/SECTION: 8.3.1.5.1.5.1 Activity: Paleoclimate - paleoenvironmental synthesis.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.5-77 to 78	1. Quantitative data may not be obtainable from the paleoecology and paleoenvironmental activities and studies and, therefore, numerical models may be difficult to construct. Most of what might be developed may be no more than gross estimates at various "snapshots" in time. 2. Paleotemperatures and paleoprecipitation data will be needed within a geographic and temporal span, in order to focus the synthesis on licensing issues. These data together form a picture of paleoclimate. It is doubtful whether these independent variables can be acquired at the level of sensitivity necessary to provide a meaningful analyses of paleoclimate.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 04 April 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
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DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 173	CHAPTER/SECTION: 8.3.1.5.1.6.1 Activity: Global climate modeling.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.5-79 to 83	There should be more useful data presented in a regional model (Activity 8.3.1.5.1.6.2) than in a global model. The reasoning behind attempting a global climate model escapes us. It is doubtful whether a global model of general circulation (GCM), in a complex region such as the Great Basin, will provide sufficient sensitivity to obtain boundary conditions for precipitation, temperature, among other parameters listed in this activity. Further, it is obvious from the methods and technical procedures section that an extensive effort is required in software development. It may not be wise to place such a resource expenditure within an area of research where the results may be tenuous at best.

REVIEWER: M. E. Morgenstein	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 04 April 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 174	CHAPTER/SECTION: 8.3.1.5.1.6.2 Activity: Regional climate modeling.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.5-83 to 84	Validation of the regional climate model using paleoclimate data will be less precise than desirable, since the Quaternary paleoclimate data used for validation will represent climatic factors of indirect measurement. Although we feel that a regional climate modeling effort is certainly better than a global effort, we are not sure whether the specific effort described in this activity will produce successful results. The effort might be assisted with the calibration of the regional model with closed basin lake hydrology of the Great Basin.

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NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 175	CHAPTER/SECTION: 8.3.1.5.1.6.3 Activity: Linked global-regional climate modeling.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.5-84 to 86	Comments on activities 8.3.1.5.1.6.1 and 8.3.1.5.1.6.2 are applicable here.

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Signature	DATE: 04 April 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 176	CHAPTER/SECTION: 8.3.1.5.1.6.4 Activity: Empirical climate modeling.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.5-86 to 88	The empirical modeling approach used in this activity is plagued with numerical (statistical) manipulations which detract from its potential usability. It is difficult to understand how statistical confirmation will be used with respect to orbital forcing. It is also not clear how recent human-induced atmospheric perturbations will be overlapped onto the astronomical forcing model.

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 177	CHAPTER/SECTION: 8.3.1.5.2.1.1 Activity: Regional paleoflood evaluation.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#,	COMMENT:
Pages 8.3.1.5-94 to 96	This activity requires accurate dating techniques to be applied to the paleoflood deposits, scars, stone strips, etc., otherwise, it will not be known whether these deposits and features are of the Quaternary. Dating techniques capable of providing accurate chronological determination of when these features were formed or deposits initially laid down might prove more challenging than realized. For example, the dating of carbonate soil K horizons may not offer a good means to determine the age of the actual clastics in the sedimentary regime studied.

REVIEWER: M. E. Morgenstein	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 04 April 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 178	CHAPTER/SECTION: 8.3.1.5.2.1.2 Activity: Quaternary unsaturated zone hydrochemical analysis.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.5-96 to 98	On page 8.3.1.5-96, DOE states, "The chemical and isotopic data will be collected in Activities 8.3.1.2.2.8.1, 8.3.1.2.2.8.2, and 8.3.1.2.2.4.8." The first two activities relate to the development and validation of conceptual and numerical models of fluid flow in unsaturated, fractured rock. No samples are taken or analyzed in these two activities. The last activity will collect samples from the exploratory shaft. The samples will be gases, centrifuged water, and distilled water. This study will produce limited data relating only to the exploratory shaft; and as such, it will have limited value. The utility of the data could be greatly improved with reverse circulation drilling to obtain fracture water from various locations on Yucca Mountain. Accurate characterization of the past and present percolation history of Yucca Mountain will not be accomplished by the present limited scope of this activity.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 04 April 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 179	CHAPTER/SECTION: 8.3.1.5.2.1.3 Activity: Evaluation of past discharge areas
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.5-89 to 106	This activity is well focused and is conceptually complete. Remote-sensing studies require a ground truth backup. This activity is similar to investigations now underway by the State of Nevada.
REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 05 May 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 180	CHAPTER/SECTION: 8.3.1.5.2.1.4 Activity: Analog recharge studies.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.5-106 to 110	This activity is almost identical in conceptual design to the analog recharge studies proposed by the State of Nevada in 1984.

REVIEWER: M. E. Morgenstein	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 05 May 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
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DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 181	CHAPTER/SECTION: 8.3.1.5.2.1.5 Activity: Studies of calcite and opaline silica vein deposits.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.5-110 to 118	In order to fully utilize ostracod data, a published account of the ecological database for recent species would be desirable. These data may prove to be highly significant in obtaining an understanding of the genesis of the opaline-carbonate deposits and, as such, should be made public. A full study plan is required prior to commenting further on this activity, as insufficient information is offered in the SCP.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 05 May 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 182	CHAPTER/SECTION: 8.3.1.5.2.2.1 Activity: Analysis of future surface hydrologic due to climate changes.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.5-118 to 119	It is doubtful whether there is sufficient data available, or that could be made available, in the relatively short term of this activity, to model runoff. The model validation as described in this activity is poorly chosen and will not effectuate a valid approach. The discussion concerning past proxy records requires considerable clarification. There is a paucity of technology available to construct arid/semi-arid stream-flow regimes in the Southern Nevada Yucca Mountain region.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 05 May 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 183	CHAPTER/SECTION: 8.3.1.5.2.2.2 Activity: Analyses of future unsaturated zone hydrology due to climage changes

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.5-119 to 120	A properly-validated vadose-zone hydrologic model, that is calibrated with present-day flow conditions, needs to be emplaced prior to the initiation of this activity. It is doubtful whether the sensitivity analyses can be performed, as it is improbable that an appropriate valid model will be developed using real-world data in activity 8.3.1.2.2.9.3. Artifical infiltration studies (8.3.1.2.2.1.3) are poorly conceptualized and will require a competent focus prior to being usable in this activity.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 05 May 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 184	CHAPTER/SECTION: 8.3.1.5.2.2.3 Activity: Synthesis of effects of possible future recharge due to climate changes on hydrologic characteristics of the Yucca Mountain saturated zone

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.5-121 to 122	The approach taken may have some benefits, but it is compromised by the probable lack of model sensitivity in the area of discharge, where the changes of water level are established. The terrain responsible for the significantly active recharge must be adequately identified. This may not be feasible given the approaches defined in the SCP. A thorough understanding of matrix and fracture flow for the recharge areas is also required to competently obtain recharge parameters.

REVIEWER: M. E. Morgenstein	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 05 May 1989

MY890703a

ROCK DISSOLUTION PROGRAM

"Men argue, Nature acts."
- Voltaire, 1764 -

Section 8.3.1.7, "Overview of rock dissolution program," consists of only two pages and is unchanged from the CD-SCP. There is only one investigation in the program:

8.3.1.7.1 Investigation: rates of dissolution of crystalline and noncrystalline components in tuff.

All of our previous comments on the DEA, the EA, and the CD-SCP regarding dissolution have not been adequately addressed and are therefore repeated.

The use of the terms "program" and "investigation" by DOE with regard to the rock dissolution section is a misnomer. There is no program; no investigation is planned; and none will be carried out (according to this section). The DOE claims that there is no evidence for dissolution of the host rock because of the lack of dissolution features. Only the EA is cited, and it contains no other references; the lack of cited references to support this claim is disturbing. The presence of clay and zeolite alteration products is evidence of glass dissolution; thus, the DOE claim is incorrect. Furthermore, it is well known that even substances with very low solubilities, such as aluminosilicate minerals, may undergo significant mass transport in a thermal gradient, such as a "heat pipe."

There are other investigations, studies, or activities in the SCP, such as in geochemistry:

8.3.1.3.2.2. Study: History of mineralogic and geochemical alteration of Yucca Mountain (and two associated activities),

8.3.1.3.3 Investigation: Studies to provide information required on stability of minerals and glasses (and three studies and three activities under this investigation),

and in the waste-package environment program:

8.3.4.2.4.1 Study 1.10.4.1: Characterize chemical and mineralogical changes in the postemplacement environment (and the seven associated activities),

that are concerned with dissolution, yet are not mentioned in the rock-dissolution program. This lack of coordination and connection between different parts of the SCP related to dissolution is appalling. Better interaction and integration of related aspects of the SCP between DOE editors and scientists is required.

Finally, the present data set of mineral solubility is sufficient to conclude that an erroneous statement has been made in the DOE rock-dissolution program. On the basis of the statement that minerals in the host rock are insoluble, the program's underlying assumption is indefensible. No investigations, studies, or activities have been designed to obtain any information and, thus, there is no schedule.

APPENDIX G

ROCK DISSOLUTION PROGRAM
DOCUMENT REVIEW FORMS

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 185	CHAPTER/SECTION: Overview of Rock Dissolution Program: 8.3.1.7

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.7-1	Our previous comments on dissolution in our reviews of DOE's Draft Environmental Assessment, Environmental Assessment, and Consultation Draft of the Site Chracterization Plan have been essentially ignored, as there are no changes whatsoever in this section.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 28 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE TECHNICAL REVIEW COMMENT	
DOCUMENT TITLE: Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).	
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 186	CHAPTER/SECTION: 8.3.1.7.1 Investigation: Rates of dissolution of crystalline and non-crystalline components in tuff...
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.7-1	Use of the term "Investigation" is misleading at best, deceptive at worst, because no investigation is planned and none has been carried out. If this section were truly an investigation, it would have objectives and a purpose.
REVIEWER: D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 28 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 187	CHAPTER/SECTION: 8.3.1.7.1 Investigation: Rates of dissolution of crystalline and non-crystalline components in tuff...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.7-1	If this investigation were satisfied, as claimed, it should not be part of site-characterization plans. The three conclusions listed in the Environmental Assessment (EA) are flawed because: 1. There are no references, other than the EA (which contains no references), to any work specifically dealing with the lack of evidence of dissolution features. However, the formation of clay and zeolite alteration products is evidence of glass dissolution. 2. No definition or criteria for the claim that minerals in the host rock are insoluble is given. Nor are there any references to the conditions under which these criteria or definitions might apply, such as expected repository conditions. It is well known that even substances with very low solubilities may undergo significant mass transport in a thermal gradient, such as a "heat pipe." 3. Expected repository conditions will be different from past geologic conditions, therefore use of the past to predict potential significant future dissolution is without basis. 4. Again, regarding the insolubility of the minerals that compose the host rock, there is no definition for the criteria of "insolubility." Several minerals may be metastable with respect to expected repository conditions or even present-day conditions such as cristobalite, tridymite, clays, and zeolites. One potential for significant future dissolution that may lead to increased hydraulic connectivity, and therefore loss of integrity of the repository, is the conversion of the silica polymorphs cristobalite and tridymite to quartz, resulting in an increase in porosity of 12 and 14.5%, respectively (of the silica polymorph volumes). Such an increase in porosity could result in loss of rock strength, collapse of mined openings, and puncturing of canisters.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
D. L. Shettel, Jr. Signature	DATE: 28 June 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 188	CHAPTER/SECTION: 8.3.1.7.1 Investigation: Rates of dissolution of crystalline and non-crystalline components in tuff...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.7-1	It is not clear from discussion how the various sections of Chapter 4 (Review of Geochemistry) relate to dissolution, as no specific page numbers, statements, or references are cited. In fact, the lack of cited references within the dissolution section is appalling; only the EA is cited and it shares many of the same problems as mentioned in this review.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 28 June 1989

MY890703a

METEOROLOGY PROGRAM

The DOE meteorology program is composed of four (4) investigations:

1. Studies to provide data on regional meteorological conditions.

2. Studies to provide data on atmospheric and meteorological phenomena and potential locations of surface facilities.

3. Studies to provide data on the location of population centers relative to wind patterns in the general region of the site. (There are no studies or activities under this investigation).

4. Studies to provide data on potential extreme weather phenomena and their recurrence intervals.

This DOE program is designed to collect meteorological data during a five-year period of time, which is insufficient with respect to the development of:

1. Site-specific, modern-day climatological assessment.

2. Long-term extreme weather assessment for modern climate.

3. Sufficient modern-day data (site-specific base) for comparison to past-climate data collection

This DOE program appears to be designed to provide general information for unscheduled radiological releases, as might be experienced in the weapons program, for repository design considerations, and for preclosure conditions. Little effort has been offered with respect to geohydrological and past-climate considerations. The SCP program 8.3.1.2 (geohydrology) requires a comprehensive understanding of present-day precipitation, temperature, evapotranspiration, among other meteorological parameters, including isotope geochemistry of precipitation events. The SCP program 8.3.1.5 (Climate) requires a comprehensive understanding of the present-day local and regional climate to be able to assess paleoclimatic variations and predict future climatic impacts. Both programs require meteorological data collection beyond that which is planned in the SCP. There appears to be little interaction between the DOE managers of these three programs, consequently, the focus of the DOE meteorological program is short-sighted. This DOE meteorology program will not produce sufficient usable information for site-performance assessment. Consequently, characterization of the site will have to be on a probabilistic basis, rather than on a deterministic basis. This is fundamentally inappropriate and does not meet licensing requirements.

APPENDIX H

METEOROLOGY PROGRAM
DOCUMENT REVIEW FORMS

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 189	CHAPTER/SECTION: 8.3.1.12.1.1 Study: Characterization of the regional meteorological conditions.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.12-10 to 11	There are no activities associated with this study. This study will contact potential sources of meteorological data and determine what available data is of interest to the program. These data will be assembled into a regional summary report. A list of eight (8) parameters of interest is offered; however, chemical data are apparently not of interest, as they are not included in the list. There is no discussion concerning the methodology to be used to choose between data desired and data that is undersired. There is no QA/QC program stipulating the controls of previous data collection; therefore, it is difficult to see how these data will be applied to a QA/QC controlled program of site characterization. We feel this exercise is of benefit to the program and are very surprised that this activity has not taken place much earlier. If this information is readily available, it should have been used in Chapter 5. The fact that these data have not been previously collected indicates that Chapter 5 is presently incomplete. This is certainly unacceptable if one considers that, presumably, the main attribute of the site is its meteorological characteristics.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 28 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 190	CHAPTER/SECTION: 8.3.1.12.1.2 Study: Plan for synthesis of Yucca Mountain Project meteorological mionitoring.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.12-11 to 12	There are no activities associated with this study. This study will develop a plan that provides necessary elements of coordination of meteorological monitoring efforts. Hopefully, this plan of action will not take too long to develop, as the time limit for meteorological data collection is certainly short. Any delay may be of great significance. This study <u>does</u> include chemical data. Therefore, chemical data will be taken into account with respect to coordination (8.3.1.12.1.2) but not collection (8.3.1.12.1.1).

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 26 May 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 191	CHAPTER/SECTION: 8.3.1.12.2.1.1 Activity: Site meteorological monitoring program.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.12-12 to 22	This activity will concentrate on the collection of meteorological data capable of determining wind-flow patterns in the vicinity of Yucca Mountain. Precipitation data will also be collected (as it is listed in the parameters of interest) and will be collected in accordance with EPA and NRC regulations and guidelines. There are a total of five (5) data-collection sites in the vicinity of Yucca Mountain. Yucca Mountain, itself, is the highest data-collection site; therefore, data averaging may be misleading because there may be a tendency towards lower precipitation values. We find that this activity is fairly well-focused and, if it were to be emplaced and active for about 50 years or so, there might be significant data collected to characterize the local meteorological parameters of the site. Data collection should start in 1989, and licensing application is due in 1995. It is difficult to see how any significant statistical data would be collected. We note that no chemical information will be collected from precipitate events. Without this baseline information, we fail to see how paleoclimate-isotopic precipitation data collection activities will have any meaning. On this basis, we find this program deficient.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 28 June 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
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DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 192	CHAPTER/SECTION: 8.3.1.12.2.1.2 Activity: Data summary for input to dose assessments.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.12-22	This activity will process the meteorological data into a format that can be used to assess radiological impacts. It is not certain that the data-collection points represent the most ideal locations from which to model variations in terrain. Additional meteorological stations might assist in this effort.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 28 June 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
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DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 193	CHAPTER/SECTION: 8.3.1.12.4.1 Study: Characterize the potential extreme weather phenomena and their recurrence intervals.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.12-27 to 28	This study will utilize existing data to quantify the extreme weather phenomena that might be expected at Yucca Mountain, and determine their recurrence intervals. There is no indication that: 1. Sufficient data are available to reasonably accomplish the tasks of this study. 2. Sufficient data will be collected to reasonably accomplish the tasks of this study. There are no activities associated with this study.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 26 May 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
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DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 194	CHAPTER/SECTION: 8.3.1.12 Overview of the meteorology program: Description of meteorological conditions required by the performance and design issues.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.1.12-1 through 8.3.1.12-31	There are four investigations under this meteorology program. According to the DOE, the purpose of this program is to establish (1) regional conditions, (2) atmospheric phenomena at locations of the repository surface facilities, (3) locations of population relative to wind patterns, and (4) potential extreme weather phenomena. In reviewing this program, I focused on how the planning and execution of this program would impact the evaluation of the hydrological surface boundary water flux at the Yucca Mountain site. Meteorological parameters that are important to the upper boundary water flux are ambient temperature, atmospheric moisture, and type, amount, frequencey of occurence, and intensity of precipitation. The DOE is planning to monitor the above parameters, among others; however, I believe that the five stations located near the repository site may be insufficient in number (see Figure 8.3.1.12-2 on page 8.3.1.12-7 and Table 8.3.1.12-2 on page 8.3.1.12-18 of the SCP) to evaluate, with any certainty, the upper water flux parameter. I strongly suggest that at least two or three more meteorological towers be placed on the crest of the mountain. In addition, the DOE should evaluate the evaporation and evapotranspiration parameter at each tower facility location.

REVIEWER: Atef Elzeftawy Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June 1989

MY890703a

WASTE PACKAGE PROGRAM

Only those studies or activities related to geochemical, hydrological, or mechanical aspects of the DOE waste-package environment are reviewed. These are all under:

8.3.4.2.4 Information Need 1.10.4: Postemplacement near-field environment.

The four studies listed under this information need are:

8.3.4.2.4.1 Study 1.10.4.1 Characterize chemical and mineralogical changes in the post-emplacement environment (with seven activities);

8.3.4.2.4.2 Study 1.10.4.2: Hydrologic properties of the waste-package environment (with three related activities);

8.3.4.2.4.3 Study 1.10.4.3: Mechanical attributes of the waste-package environment (one associated activity); and

8.3.4.2.4.4 Study 1.10.4.4: Engineered-barrier system field test (with three activities).

The comments on this section include:

- The DOE plans to continue using J-13 water as the reference water for all vadose-zone experiments. Most, if not all, experiments should be delayed until vadose-zone water chemistry has been determined.

- Rock-water interactions are to be performed under unrealistic conditions, isothermally, with a close approach to equilibrium. These experiments will provide a base line, albeit generic, that is non-site specific and not representative of expected post-closure behavior in the near-field environment. Experiments should consider thermal gradients along with refluxing of boiling fluids.

- Fracture mineralogy is considerably more important than whole rock or matrix mineralogy for water-rock interactions because the fractures will provide the pathway and the first chance for retardation for fluids exiting the near-field environment as the canisters heat-up the repository, and as a pathway for condensed fluids to trickle back down to the repository level.

- The DOE use of theoretical models to determine the degree of contamination of extracted vadose-zone waters could potentially be misleading because this approach assumes that the models simulate all physico-chemical processes of rock-water interaction in the vadose zone perfectly (assuming, of course, there are few, if any, analytical foul-ups). A better procedure for determining the extent of the contamination of extracted pore waters would be to perform repeated analyses of the water using as many different extraction and analytical techniques as work.

- Present numerical models for rock-water interaction can not simulate the physico-chemical processes occurring in the thermal gradients of the near-field environment.

- The DOE places undue reliance on computer modeling of the stress field surrounding canister boreholes. The deterministic approach that should be followed requires validation of the models by in-situ observations of actual boreholes.

- The ambitious objectives of some activities tend to lack the full support of the methods and technical procedures. This suggests that activities have been hastily thought out and will probably not achieve their objectives.

Finally, although the present data set may be sufficient, appropriate and adequate plans of investigation have not, in most cases, been developed. A thread woven through the SCP, including the waste-package program, is the reliance upon the assumption that matrix flow is the dominant mechanism of transport in the vadose zone. This assumption is indefensible. The actual investigations, studies, and activities of the waste-package program that were reviewed will not, in general, obtain information relevant to a site-specific characterization. Although the proposed activities may, in general, be accomplishable in the proposed time frame, there will be little time to consider relevant information gathered in activities of other programs. This lack of program integration and site specificity is unacceptable and suggests that the SCP is not a serious endeavor.

APPENDIX I

WASTE PACKAGE PROGRAM
DOCUMENT REVIEW FORMS

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 195	CHAPTER/SECTION: 8.3.4.2 Issue Resolution Strategy for issue 1.10...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Table 8.3.4.2-2 Pages 8.3.4.2-9 to 10	(Performance measures and goals for Issue 1.10) We object to the column heading labeled "Tentative Goal" because natural processes occurring within the earth cannot be controlled from an engineering standpoint as DOE is apparently assuming. These geologic processes, as listed in this table, include: - quantity of liquid water that can contact container, - quality of liquid water that can contact container, - rock-induced load on waste package, - temperature vs. time in waste-package environment, and - tectonic processes. DOE cannot engineer the natural environment to meet their goals. DOE must establish maximum limits for the laws and regulations that can be tolerated and then determine from the site-characterization studies whether the site meets these limits. An equally distasteful alternative possibility is that DOE believes the tentative goals are those which their models must achieve in the near-field environment. As long as models are based on sufficient and accurate site characterization data, the models may predict future postclosure behavior of the repository with some semblance of confidence, but if the models will be deceptively used to show tha,t under some conditions (assumptions usually), the "tentative goals" may be met, then DOE is doing a disservice to the site-characterization process. The latter possibility seems more likely because DOE has a history in the high-level nuclear waste program of utilizing assumptions favorable to their mission without sufficient data for support.

REVIEWER: D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 28 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE TECHNICAL REVIEW COMMENT	
DOCUMENT TITLE: Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).	
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 196	CHAPTER/SECTION: 8.3.4.2 Issue Resolution Strategy for issue 1.10...
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.4.2-23	Although it may seem appropriate to have characterization goals for [vadose] water chemistry to establish the best metal for the canisters, in reality, as the canisters heat up and then cool down, refluxing and boiling of vadose zone fluids will most likely occur. The water contacting the waste canisters could have a much different chemical composition than the original vadose zone water.
REVIEWER: D. L. Shettel, Jr. D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 28 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 197	CHAPTER/SECTION: 8.3.4.2.4.1.1 Activity 1.10.4.1.1: Rock-water interactions...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.4.2-42	This activity is very similar to that in the CD-SCP except for the addition of the table of methods and technical procedures. Thus, our comments are repeated: The use of J-13 water as a reference for saturated-zone water is questionable; therefore, its use as a reference for vadose-zone water is extremely dubious. The experiments will apparently be conducted isothermally, and equilibrium closely approached. In reality, the near-field environment will be dynamic--the temperature of the system will slowly rise, peak, and then slowly decrease. Furthermore, the rock will be in a thermal gradient, which promotes mass transfer. Even the small solubilities of the silica polymorphs can result in very significant mass transfer. The experiments will not allow boiling off of the fluid, with the resulting changes in fluid chemistry and precipitated solids that may change porosity and permeability of the rock.

REVIEWER: D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June 1989

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 198	CHAPTER/SECTION: 8.3.4.2.4.1.1 Activity 1.10.4.1.1: Rock-water interactions...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.4.2-43	The use of model abundance of solid reactants (Topopah Spring Tuff) is questionable because, as the rock heats up to the boiling temperature, fluid and vapor will be driven to escape the environment, most likely along fractures. Fracture mineralogy is, therefore, especially important because the vapors will travel a short distance, condense, and trickle back down towards the repository level under gravitational forces. This refluxing of fluids will affect the aqueous chemistry, as well as solid precipitates, and should be considered in rock-water interactions.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
D. L. Shettel, Jr. Signature	DATE: 16 May 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 199	CHAPTER/SECTION: 8.3.4.2.4.1.1 Activity 1.10.4.1.2: Effect of grout, concrete...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.4.2-45	This activity is unchanged from CD-SCP and is under the study to characterize chemical and mineralogical changes in the post emplacement environment. As the activity only concerns the addition of grouts, concretes, and other repository sealing materials to the rock-water experiments described in the previous activity, refer to my comments for the previous activity (8.3.4.2.4.1.1).

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 16 May 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 200	CHAPTER/SECTION: 8.3.4.2.4.1.3 Activity 1.10.4.1.3: Composition of vadose water...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.4.2-46	This activity is identical to that in the CD-SCP except for the addition of the second paragraph under the "Description" section. This activity is very similar to that described under section 8.3.1.2.2.8.2. Refer to those comments, in addition to those below. Comparison of collected waters with theoretical models of rock-water interactions (such as EQ 3/6?) and known characteristics of vadose fluids in equilibrium with minerals present in the rock (what is the citation for this, we would like to obtain a copy) to determine contamination is extremely dangerous because it assumes the models know "nature" perfectly. If this were the case, why is DOE bothering to sample at all; alternatively, the degree of contamination and the variability of the vadose-zone water should be established by repeated measurements using as many different extraction techniques as work.

REVIEWER: D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 17 May 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
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DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 201	CHAPTER/SECTION: 8.3.4.2.4.1.4 Activity 1.10.4.1.4: Dissolution of phases...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.4.2-46	This activity is identical to that in the CD-SCP. This activity is fine as far as it goes, but the conditions of the experiments, the minerals to be used, and the water composition to be employed are omitted. A far larger omission is the condition expected in the waste-package environment, which includes thermal gradients and boiling and refluxing of aqueous fluids. It will be very interesting to see how, or even if, DOE handles this area of investigation.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 17 May 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 202	CHAPTER/SECTION: 8.3.4.2.4.1.5 Activity 1.10.4.1.5: Effects of radiation on water chemistry.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.4.2-47	This activity is essentially unchanged from the CD-SCP. In the absence of a study plan for this activity, the only apparent drawback obvious at this time is the use of the J-13 reference water. Actual vadose water compositions should be used in this activity, and the activity delayed until these are available.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 17 May 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 203	CHAPTER/SECTION: 8.3.4.2.4.1.6 Activity 1.10.4.1.6 : Effects of container and borehole...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.4.2-49	This activity is identical to that in the CD-SCP. In view of the very limited information provided in this activity, the following comments are appropriate: 1. Actual vadose-zone water compositions should be used. 2. Thermal gradient experiments should be planned on in addition to the isothermal ones. 3. In conjunction with (2) above, experiments with a boiling vadose zone water in a thermal gradient would be representative of the expected near-field environment and should be considered.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 17 May 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 204	CHAPTER/SECTION: 8.3.4.2.4.1.7 Activity 1.10.4.1.7: Numerical analysis and...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.4.2-49	Except for the addition of the "Methods and Technical Procedures" section, this activity is identical to that in the CD-SCP. This activity will utterly fail to achieve its objectives for numerous reasons. The only laboratory experiments planned are under isothermal conditions, not thermal gradients. All the known thermodynamic and kinetic data apply to equilibrium and/or isothermal conditions. Although DOE's geochemical modeling package can handle a thermal gradient in the sense that each step of reaction progress can have a different temperature, it is totally unknown and unlikely that it bears any resemblance to reality in the waste-package environment. From a kinetic standpoint, there are many parameters that represent the interactions of such factors as temperature, gravity, diffusion, and electrical fields that are totally unknown, yet must be quantified to accurately predict rock-water interactions in a thermal gradient.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 17 May 1989

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 205	CHAPTER/SECTION: 8.3.4.2.4.2.1 Activity 1.10.4.2.1: Single-phase fluid system properties.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.4.2-52 to 54	Except for the addition of the "Methods and Technical Procedures" section, this activity is identical to that in the CD-SCP. The use of J-13 water is questionable, as actual vadose-zone water compositions should be used, at least initially. These experiments seem well-designed, conceptually, but it is not clear if the cores will be characterized afterwards to determine the extent mineralogical changes affected porosity and permeability changes. Extraction of fluid after the experiment (by the methods under development by DOE for pore water) for chemical and isotopic analyses would also be useful as well as interesting.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 17 May 1989

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 206	CHAPTER/SECTION: 8.3.4.2.4.2.2 Activity 1.10.4.2.2: Two-phase fluid system properties.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.4.2-54 to 55	This activity is identical to that in the CD-SCP. The objectives of this activity are well thought out conceptually, but the methodology is subject to the same comments as made on Activity 8.3.4.2.4.2.1. There is insufficient information to judge the probability of success using existing technology and the feasibility of completing this activity in terms of time, funding, and human resources.

REVIEWER: D. L. Shettel, Jr. D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 17 May 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 207	CHAPTER/SECTION: 8.3.4.2.4.2.3 Activity 1.10.4.2.3: Numerical analysis of flow and...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.4.2-55	This activity is identical to that in the CD-SCP. I agree that laboratory tests are useful for the initial development and validation of flow and transport code and that in-situ investigations are equally necessary, as well. The problem is that, other than mentioning that both laboratory and in-situ tests are needed, no information is provided on the in-situ tests. Lack of information prevents judging the probability of success using existing technology or the feasibility of completing this activity.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 28 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
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DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 208	CHAPTER/SECTION: 8.3.4.2.4.3.1 Activity 1.10.4.3.1: Waste package environment stress...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.4.2-56	This activity is identical to that in the CD-SCP, but the study over this activity has dropped the thermal attributes of the waste-package environment and the thermal activity has been deleted, as well. The reliance on computer modeling and the lack of in-situ field observations of canister boreholes is somewhat disturbing and should be corrected.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
D. L. Shettel Jr. Signature	DATE: 28 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 209	CHAPTER/SECTION: 8.3.4.2.4.4.1 Activity 1.10.4.4.1: Repository horizon near-field...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.4.2-57	This activity is unchanged from the CD-SCP. Although the objectives appear to be conceptually complete, focused, and extremely lofty, there is almost a complete lack of information to judge the appropriateness of the methodology, the probability of success, and the feasibility of accomplishment.

REVIEWER: D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 28 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 210	CHAPTER/SECTION: 8.3.4.2.4.4.2 Activity 1.10.4.4.2: Repository horizon rock-water interaction.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.4.2-58	Except for the addition of the "Methods and Technical Procedures" section, this activity is identical to that in the CD-SCP. Although the objective appears to be reasonable, the methods and technical procedures listed do not apparently support the parameters. Methods and procedures that would support collection of data needed are not cited. The methodology, as presented, will <u>not</u> establish the stated objectives, and thus the activity will fail to succeed. Furthermore, activity is apparently not feasible given the listed methods and technical procedures.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 28 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 211	CHAPTER/SECTION: 8.3.4.2.4.4.3 Activity 1.10.4.4.3: Numerical analysis of fluid flow...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.4.2-61	This activity has been expanded from that in the CD-SCP by the addition of two paragraphs under the "Description" section (one on thermal studies and the following one on modeling of thermal history) and the "Methods and Technical Procedures" section. The objective appears conceptually complete, if not extremely ambitious. The parameter list is incomplete in that flow and flux are not included, and it is not clear if degree and distribution of saturation refers to the matrix, fractures, or both. The list of methods and procedures appears fine, as far as it goes, but not all procedures necessary to support the determination of the parameters and, thus, the objective are included. Missing, for example, are those for extraction and analysis of fluid samples.

REVIEWER: D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 18 May 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 212	CHAPTER/SECTION: 8.3.4.2.4.4.3 Activity 1:10.4.4.3: Numerical analysis...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.4.2-63	It is extremely difficult to judge the probability of success of this activity utilizing existing technology because it has not all been specified or cited. Insufficient information exists to determine the feasibility of accomplishing the objective of this activity.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 28 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 213	CHAPTER/SECTION: 8.3.4.2.5 Schedule for postclosure waste package characteristics.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Fig. 8.3.4.2-3 Page 8.3.4.2-66	The length of time (2-3 months) between updating of models (items F, G, and H on timeline 1.10.4.1) and issuance of final reports before the draft environmental impact statement seems much too short.

REVIEWER: D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 28 June 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 214	CHAPTER/SECTION: 8.3.4.2.5 Schedule for postclosure waste package characteristics.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Fig. 8.3.4.2-3 Page 8.3.4.2-67	The thermal attributes aspect of study 1.10.4.3 were dropped from the text, but not from this figure.

REVIEWER: D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 28 June 1989

PERFORMANCE ASSESSMENT PROGRAM: ENGINEERED BARRIER SYSTEM RELEASE RATES

This performance issue addresses the ability of the waste package and repository-engineered barrier systems to comply with the radionuclide release rates as stipulated in 10CFR60.113(a)(1)(ii). Under the program currently proposed by the DOE, as reported in the SCP (8.3.5.10), the characterization process will specifically concentrate on assessing the DOE conceptual model (designated the reference case) of repository performance. No alternative hypotheses are offered; however, bounding cases are, in fact, recognized. The rationale behind choosing the particular bounding cases is not offered. For all practical purposes, the significant elements of this conceptual model are as follows:

1. The repository horizon is located in the vadose zone in an area in which the downward vertical water flux is believed to be less than 0.5 mm/yr. Negligible water is expected to make contact with the waste containers during the post-containment period.

2. The potential release of radionuclides has been analyzed for the case in which some water may contact the waste packages as the repository cools. During the containment period, a maximum of 5 L/yr was allowed to contact up to 10 percent of the packages.

3. In the post-containment period, the allowable quantity of water has been increased to reflect the possible increased capacity of existing water flow paths due to contraction cooling of the rock mass that causes increased fracture aperture, or the anticipated range of changes in climate during the post-containment period."

4. The bounding case allows 20 L/yr to contact the waste forms in up to 10 percent of the waste packages.

5. The approach taken to resolve issues 1.5 takes into account both a transition period, when the fraction of failed containers may increase and the fraction of wetted containers may increase, **and an upper-limit period considering the environment and container performance limits of Table 8.3.5.10-2 as a steady state** (emphasis added). Possible pulse release from spent fuel of fractions of carbon-14 and of gap and grain boundary elements must be considered during the transition period.

6. No assumption is made about the container performance during the containment period for the assessment of issue 1.5; all possibilities between 0 and 1 fraction of containers failed and between 0 and 0.10 of waste package in contact with liquid water at the start of the controlled-release period will be considered.

There are numerous tables of programmatic goals. Needless to say, the reference case (DOE conceptual model) and the bounding cases (we think these are really an extension of the DOE conceptual model and not offered as alternative hypotheses) are **included within the listed "Tentative Goals"** (see Table 8.3.5.10-2 and page 8.3.5.10-17). Therefore, there does not appear to be any constructive attempt in the SCP to address anything other than site-acceptable parameters. This program, as designed, is incomplete and will not provide reasonable assurances that true bounding conditions and alternative hypotheses have been considered. We have little, if any, confidence that the data collected in this program will be deterministic with respect to repository performance or diagnostic with respect to the associated modeling efforts (model validations will be accomplished in some cases by peer review. A review of the NRC Draft Generic Technical Position on Peer Review of June, 1986 sets out conditions where peer review may be indicated. It is doubtful that model validation can be included within the intent of this listing).

The following general comments are made with reference to Section 8.3.5.10:

- There are no alternative hypotheses being considered. The DOE conceptual model and its bounding cases is the only concept being considered.

- Tentative goals are provided in several tables. Those goals have no deterministic considerations.

- The chemistry of the host environment has not been characterized (for example, vadose water chemistry which might be considered, or ranging between matrix and fracture-flow compositions). The oxidation state of vadose water and its Eh are unknown.

- The mode of emplacement of the canisters has not yet been determined (vertical or horizontal), therefore, experiments must take both modes into account. To date, the experiments do not accomplish this.

- The behavior of actinides as colloids can not be addressed with modeling efforts without first understanding their basic behavior. Modeling efforts in this area are meaningless. How will EQ3/6 treat this issue? It is certainly not discussed in the SCP; yet, actinide transport may be the most critical aspect of repository performance.

- The behavior of the waste canister will vary depending upon the location of failure (e.g., welds versus canister bottom or sides). This issue is not addressed in the SCP.

- Dissolution reactions under repository conditions will most likely effect vadose-water chemistry. This issue is not addressed in the SCP.

- There is a serious overuse of modeling effort, an unacceptable lack of in-situ data gathering, an overreliance on the probabilistic approach using conceptual information, and a general disregard of a deterministic approach.

- Multiple scenarios need to be considered with the same modeling effort.

- The behavior of glass waste appears to be poorly understood for Yucca Mountain because, even though the major impact parameters are water distribution, temperature, reaction time, and rock and water interaction, **no site-specific data has yet been collected**, and little is planned during site characterization, according to the SCP.

- This program appears to be primarily an exercise in probabilistic simulations and is apparently unsupported by a realistic field program of data collection.

- It is doubtful that SCP section 8.3.5.10 under Performance Assessment will allow the DOE to "establish the geologic condition and the ranges of the parameters of" the Yucca Mountain site.

REFERENCES

U. S. Nuclear Regulatory Commission, 1986, Draft Generic Technical Position on Peer Review, Washington, D. C.

APPENDIX J

PERFORMANCE ASSESSMENT - ENGINEERED BARRIER SYSTEM RELEASE RATES DOCUMENT REVIEW FORMS

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 215	CHAPTER/SECTION: 8.3.5.10.1.1 Activity: Integrate waste form data and waste package.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.5.10-41 to 42	This subactivity contains no tests or analyses. This subactivity will determine whether specified parameter information needed can be provided. It would be interesting to determine why this information has not been previously collected. More descriptive information could be presented in the SCP than one sentence.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 19 May 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 216	CHAPTER/SECTION: 8.3.5.10.1.1.2 Subactivity: Integrate glass waste form information.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.5.10-42	No tests or analyses will be performed by this subactivity. The major goal is to insure that the glass waste data needed can be provided. The SCP provides little information to ascertain what this subactivity is all about.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 19 May 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S):	U.S. Department of Energy/ Office of Civilian Radioactive Waste Management
REFERENCE:	DOE/RW-0199 (December 1988).
COMMENT #: 217	CHAPTER/SECTION: 8.3.5.10.1.1.3 Subactivity: Integrate waste package and repository design information.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.5.10-42	There are no tests or analyses performed by this subactivity. This subactivity will apparently do what the previous subactivities have not done; however, the one-sentence description does not really give one a clue as to what that is.

REVIEWER: M. E. Morgenstein M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 19 May 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 218	CHAPTER/SECTION: 8.3.5.10.2.1 Activity 1.5.2.1: Characterization of spent fuel waste form. Subactivity 8.3.5.10.2.1.1: Dissolution and leaching of spent fuel.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.5.10-44 to 45	This subactivity is a classic example of misuse of J-13 "reference" well water. There is no indication whether the chemical composition of J-13 water is similar or equivalent to vadose-zone water. If DOE does not believe its vadose-zone water chemistry derived from squeezing experiments, then why is this methodology so heavily relied upon in the SCP? The information derived from this subactivity will be nearly meaningless with respect to site-characterization efforts.

REVIEWER: M. E. Morgenstein M E Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 219	CHAPTER/SECTION: 8.3.5.10.2.1.2 Subactivity: Oxidation of spent fuel.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.5.10-46	This subactivity appears to be well focused and has a high chance of success. It would be of interest to include a methodology section, along with a listing of technical procedures to be used. It is not obvious why these items are missing.

REVIEWER: M. E. Morgenstein M E Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 19 May 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 220	CHAPTER/SECTION: 8.3.5.10.2.1.3 Subactivity: Corrosion of zircaloy.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.5.10-46 to 48	The composition (or range of compositions) of the water to be used is not expressly stated. This requires clarification, especially in light of the statement on page 48 that "ground water" will be used. We would hope that this is actually vadose-zone water. A methods and technical procedures section certainly would be helpful.

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 221	CHAPTER/SECTION: 8.3.5.10.2.1.4 Subactivity: Corrosion of and radionuclide release from other materials in the spent fuel waste form.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.5.10-49	There seems to be a lack of actual commitment to this subactivity. The varieties of experiments that are planned should be described. Since this is in its planning stage now, the next version should prove to be highly decisive. Presumably, technical procedures will be added also.

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NEVADA NUCLEAR WASTE PROJECT OFFICE
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DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 222	CHAPTER/SECTION: 8.3.5.10.2.1.5 Subactivity: Evaluation of the inventory and release of carbon -14 from zircaloy cladding.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.5.10-49 to 50	This subactivity appears to be well focused. A more complete description of the methods and a listing of technical procedures would be advantageous. What instrumentation shall be used during these tests?

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 223	CHAPTER/SECTION: 8.3.5.10.2.1.6 Subactivity: Other experiments on the spent fuel waste form.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.5.10-50 to 51	This subactivity is designed to be located here in the event more tests are required, if these tests are different from ones previously described. We will be more than happy to review the future subactivity tests when they are presented to us.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 19 May 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 224	CHAPTER/SECTION: 8.3.5.10.2.2 Activity 1.5.2.2: Characterization of the glass waste form. 8.3.5.10.2.2.1 Subactivity: Leaching testing of glass.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.5.10-51 to 52	The chemical composition(s) of the waste that will be used during the tests is not offered. Temperature range for leaching is not offered. The method(s) for determining the extent of leaching or in situ hydration are not offered. There is no methods section. Technical procedures are not listed.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 19 May 1989

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DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 225	CHAPTER/SECTION: 8.3.5.10.2.2.2 Subactivity: Materials interactions affecting glass leaching.
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.5.10-52 to 53	It might be advantageous to have new vadose-zone water chemistry data, or to use the existing vadose data in these experiments. There is no methods section. Technical procedures are not offered.
REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 19 May 1989

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 226	CHAPTER/SECTION: 8.3.5.10.2.2.3 Subactivity: Cooperative testing with waste producers.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.5.10-53 to 54	Vadose-zone water chemistry should be used during these tests. A methods section is required. Technical procedures are not offered. Variations in water chemistry versus variable glass composition should be added to the parameters required.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 19 May 1989

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 227	CHAPTER/SECTION: 8.3.5.10.3.1 Activity 1.5.3.1: Integrate scenarios for release from waste package. 8.3.5.10.3.1.1, 8.3.5.10.3.1.2, 8.3.5.10.3.1.3 and 8.3.5.10.3.1.4.
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.5.10-58 to 62	There are a total of four subactivities, interrelated and equally obtuse in their descriptions. After several readings, it was still impossible to assess the logic behind the scenario development. We suggest that a range of scenarios be considered that encompass all reasonable possibilities.
REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 228	CHAPTER/SECTION: 8.3.5.10.3.2 Activity 1.5.3.2: Develop geochemical speciation and reaction model. 8.3.5.10.3.2.1 Subactivity: Develop database for geochemical...
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.5.10-62 to 64	There appears to be a significant absence of data on Al, Ba, Fe, and Mn. It is not clear why these elements have been omitted. It is doubtful that reasonably usable data will be derived from this subactivity, due to the paucity of real-world vadose-zone data and the difficulty of the tests themselves. It does not appear that colloids will be addressed in the modeling effort; consequently, one questions the validity and applicability of this approach.
REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June 1989

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DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 229	CHAPTER/SECTION: 8.3.5.10.3.2.2 Subactivity: Develop geochemical modeling code.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.5.10-64 to 66	One must presume that the upgrade will be an "equilibrium sorption model" that may not be applicable to transient reactions and products produced under repository conditions. It would be advantageous to have technical procedures listed. One needs to address how colloids will be handled by this subactivity.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 19 May 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 230	CHAPTER/SECTION: 8.3.5.10.3.3 Activity: Generate models for release from spent fuel. 8.3.5.10.3.3.1 Subactivity: Generate release for spent fuel models.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.5.10-66 to 68	This subactivity relies on scenario development (activity 1.5.3.1) which attests to a serious lack of organizational framework. The submodels need to account for variations in vadose-water chemistry, including present-day vadose-water compositions.

REVIEWER: M. E. Morgenstein	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 29 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 231	CHAPTER/SECTION: 8.3.5.10.3.4 Activity: Generate models for release from glass waste form. 8.3.5.10.3.4.1 Subactivity: Generate release models for glass waste forms.
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.5.10-68 to 70	This subactivity relies on scenarios developed in activity 1.5.3.1 which have not been proven capable of providing usable information. The models need to account for variations in vadose-water chemistry (particularly Na, K, and Fe concentrations), especially the present-day vadose water compositions. Variations in temperature are also key in the reaction process. A methodology section is required, and technical procedures should have been listed.
REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 232	CHAPTER/SECTION: 8.3.5.10.3.5 Activity: Waste package performance assessment model development. 8.3.5.10.3.5.1 Subactivity: Development of system model.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.5.10-70 to 73	This activity does not address the appropriateness of anticipated/unanticipated scenarios. Peer review does not provide an acceptable quality-assurance method for model validation. Unless this problem can be overcome, this activity will not succeed.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
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DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 233	CHAPTER/SECTION: 8.3.5.10.3.5.2 Subactivity: Development of uncertainty methodology.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.5.10-73 to 74	The system model cannot be validated through peer review. There seems to be a significant problem with this subactivity. Clearly, well-formulated field data collection and waste-package experimentation would alleviate many of the modeling problems that exist. Where this is not possible, technology may not be sufficiently developed to assess the site characteristics under scrutiny.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 19 May 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 234	CHAPTER/SECTION: 8.3.5.10.3.5.3 Subactivity: Water flow into and out of a breached container.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.5.10-74 to 75	It has not been established that a capillary barrier will prevent liquid water from contacting the waste container. This statement is an example of how far an unsupported generalized hypotheses permeates the entire DOE site-characterization program. The object of this subactivity is to determine what fraction of the water that "drips" (another hypothesis) onto a container would enter the container through a break in the container wall. I would presume that all of the tests using the metal cylinders will be on level surfaces. There is no guarantee that the container in the tunnel site will be on a level surface. Some of the tests should investigate this property. Other tests should investigate flowing water, rather than dripping water. Where are the alternative hypotheses? The vertical or horizontal emplacement of the canister may provide major differences in the results of the experiments. There does not seem to be any attempt to investigate this situation.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 235	CHAPTER/SECTION: 8.3.5.10.4.1 Activity: Deterministic calculation of releases from the waste package.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.5.10-77	It has not been determined whether reasonable scenarios will be developed in activity 1.5.3.1 (section 8.3.5.10.3.1); therefore, the prediction of the waste-package performance may not be possible. A methods section has not been offered. A technical procedures listing has not been offered. We do not see much likelihood of success for this activity.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 236	CHAPTER/SECTION: 8.3.5.10.4.2 Activity: Probabilistic calculation of releases from the waste package.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.5.10-78	See comments on the previous section.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 19 May 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S):	U.S. Department of Energy/ Office of Civilian Radioactive Waste Management
REFERENCE:	DOE/RW-0199 (December 1988).
COMMENT #: 237	CHAPTER/SECTION: 8.3.5.10.5.1 Activity: Determine radionuclide transport parameters. 8.3.5.10.5.1.1 Subactivity: Radionuclide distribution in tuff wafers.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.5.10-80 to 81	The waste-form dissolution tests do not simulate field conditions (for example, the liquid-rock ratios may not be of similar magnitude). This subactivity lends nothing to the characterization process of Yucca Mountain. No methodology section is offered. No technical procedures are offered.

REVIEWER: M. E. Morgenstein	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 29 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 238	CHAPTER/SECTION: 8.3.5.10.5.1.2 Subactivity: Radionuclide distribution in tuff cores.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.5.10-81	There is no methodology section. No technical procedures are offered. There is no indication that the planned experiments represent in situ conditions. There are indications that they do not. Solutions of radionuclides have been forced through core samples at fixed rates, and results are available (Los Alamos). Some of these results at least indicate unusual selective pathways of transport, presumably not fracture-related. Break-through curves are presumably rapid. This subactivity needs to be redesigned to account for in situ properties and conditions.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 19 May 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 239	CHAPTER/SECTION: 8.3.5.10.5.2 Activity: Radionuclide transport modeling...8.3.5.10.5.2.1 Subactivity: Validation of near-field transport modeling using laboratory and...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.5.10-81 to 82	Model validation needs to be based on field tests. A methodology section should be supplied. Technical procedures are not offered.

REVIEWER: M. E. Morgenstein	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 19 May 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 240	CHAPTER/SECTION: 8.3.5.10.5.2.2 Subactivity: Application of near-field transport model to waste package releases.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.5.10-82	It is doubtful that this subactivity will succeed. It relies heavily on previous activities, and they are poorly-focused and conceptually incomplete. It appears that alternative hypotheses have not been addressed in the previous activities, and the model, therefore, will be selective in its behavior.

REVIEWER: M. E. Morgenstein Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 19 May 1989

MY890703a

PERFORMANCE ASSESSMENT - GROUND-WATER TRAVEL TIME (GWTT)

"We judge ourselves by what we think we can do; others judge us by what we have done."

One of the most important measures of the geologic waste isolation capacity of the geologic barrier associated with a proposed repository appears to be ground-water travel time siting criterion (Domenico, Lerman, and Bartlett, 1989). The NRC travel-time performance objective for a high-level waste repository in 10CFR60.113(a)(2) is:

> "The geologic repository shall be located so that pre-waste-emplacement ground-water travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment shall be at least 1,000 years or such other time as may be approved or specified by the Commission."
>
> The disturbed zone is defined in 10CFR60.2 as:
>
> "That portion of the controlled area the physical or chemical properties of which have changed as a result of underground facility construction or as a result of heat generated by the emplaced radioactive wastes such that the resultant change of properties may have a significant effect on the performance of the geologic repository."

The disturbed zone boundary is controversial with respect to the proposed Yucca Mountain repository. The State of Nevada position has been, and continues to be, that, because the repository horizon is at atmospheric pressure, the part of the thermal envelope greater than 95°C will release a very large volume of water stored in the matrix of the welded tuff. The resulting extent of this heat-generated multiphase hydrothermal system is part of the disturbed zone. The physical and chemical effects of the migrating and condensing steam from the heat envelope will heavily impact the performance of the the geologic repository. **The entire SCP is remarkably mute on this anticipated aspect of the disturbed zone.** The SCP fails to either recognize or discuss this in the activities designed to investigate the disturbed zone and in the performance-assessment program.

"He that knows nothing, doubts nothing."

PERFORMANCE ISSUE 1.6 (GWTT)

The statutory requirement for the evaluation of ground-water travel time (GWTT) presupposes a need for understanding the geometry and geologic controls on ground-water flow. Key issue I in the Office of Geologic Repositories issues hierarchy relates to whether the mined geologic-disposal system at Yucca Mountain will isolate the radioactive waste from the accessible environment after closure in accordance with the requirements set forth in 40 CFR Part 191, 10 CFR Part 60, and 10 CFR Part 960 (SCP, p. 8.2-2.). Performance issue 1.6, "Will the site meet the performance objective for prewaste-emplacement ground-water travel time as required by 10 CFR 60.113" (SCP, p. 8.2-5), dictates **information needs 1.6.1 through 1.6.5** of section 8.3.5.12 of the SCP, "Ground-water Travel Time":

Information Need (SCP)

1.6.1	Site information and design concepts needed to identify the **fastest path of likely radionuclide travel** and to calculate the ground-water travel time along that path.
1.6.2	**Calculational models to predict ground-water travel times** between the disturbed zone and the accessible environment.
1.6.3	**Identification of the paths of likely radionuclide travel** from the disturbed zone to the accessible environment and identification of the fastest path.

1.6.4 Determination of the pre-waste-emplacement **ground-water travel time along the fastest path of likely radionuclide travel** from the disturbed zone to the accessible environment.

1.6.5 **Boundary of the disturbed zone.**

The success of several investigations in the geochemistry program will depend on recognition of ground-water flowpaths:

SCP Section

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

8.3.1.3.2 Investigation: Studies to provide information on mineralogy, petrology, and rock chemistry within the potential emplacement horizon and along potential **flow paths**;

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

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

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

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

8.3.1.3.8 Investigation: Studies to provide the required information on retardation of gaseous radionuclides along **flow paths** to the accessible environment.

The conceptual framework for calculating ground-water travel time requires identification of "likely" flow paths to the accessible environment along which travel times are calculated, and a disturbed-zone boundary from which calculations are begun. The original disturbed-zone concept is based on a near-field region of difficult-to-model flow processes (46 FR 35280, 35281, July 8, 1981). Later, the NRC (Gordon, et al., 1986) has proposed to restrict the disturbed-zone definition to include only a region of intrinsic-property changes. However, this later proposal has not been formally adopted by the NRC, probably because of the large region of hydrothermal (heat-pipe) effects that may develop around emplaced waste, including non-Darcian fracture flow as condensate accumulates. Intrinsic-property changes will probably accompany boiling and condensation of pore fluids, so even if the restricted definition of the disturbed-zone boundary, such as proposed by Gordon, et al. (1986) were adopted by the NRC, the boundary may extend a considerable distance above and below the repository.

Ground-Water Flow Path

It appears that the DOE is approaching the problem of ground-water flow paths from the following perspectives:

1. Calculate flow paths using two-dimensional porous-medium model.

2. Map the intersection of land surface with a composite regional potentiometric surface that rises and falls over geologic time.

3. Determine physical-property conditions that govern fracture versus matrix flow.

4. Investigate apparently steep and apparently flat regions in the composite potentiometric surface by drilling additional WT-holes and by conducting tracer tests.

5. Prepare a plan to investigate the hydrologic significance of the Ghost Dance Fault.

Perspective	SCP Section	Methodology
Calculation based on fluid potentials	8.3.5.12.3.1.2	Numerical model
Intersection of composite regional potentiometric surface with land surface	8.3.1.2	Reexamine and redate paludal deposits
Determine physical-property conditions that govern fracture vs. matrix flow	8.3.1.2.3	Develop empirical relationships from laboratory tests
Investigate steep and flat regions in composite potentiometric surface	8.3.1.2.3.1	Drill WT-holes, hydrology hole, and possibly southern tracer test complex
Investigate steep and flat regions in composite potentiometric surface	8.3.1.2.2.3.3	Solitario Canyon horizontal borehole
Investigate hydrologic significance of Ghost Dance Fault	8.3.1.2.2.6	Develop plan only

Disturbed Zone

The DOE proposes to develop a disturbed-zone definition (8.3.5.12.5.2, activity 1.6.5.2), and reevaluate that definition based on unsaturated and saturated-zone system investigations (8.3.1.2.2 and 8.3.1.2.3). We strongly suggest that it is fundamental for the DOE to include activities that delineate the extent and character of the disturbed zone, as presently defined, in the SCP.

The disturbed zone is an important focus of State of Nevada review activities. We find that the zone of difficult-to-understand (and characterize) processes (46 FR 35280, 35281, July 8, 1981) has been equated conceptually by the DOE to the zone of intrinsic-property changes. The central concept of a zone of intrinsic-property changes appears in most, if not all, DOE-sponsored literature that requires a disturbed-zone definition (Langkopf, 1987 and SCP, Section 8.3.5.12.5, for example). However, even if there were no intrinsic-property changes whatsoever, **heat-driven changes in the hydrologic system at Yucca Mountain can reasonably be expected to be profound** (and extraordinarily complex from a modeling perspective). These hydrothermal processes can be reasonably expected to occur within 100 years of repository loading based on simple calculations using the DOE's physical-property values.

In the SCP, the DOE assumes that the NRC draft generic technical position (Gordon, et al., 1986) will be adopted formally by the NRC. The State of Nevada has pointed out to the NRC that that draft position fails to consider the hydrothermal effects of the waste, causing multiphase fluid flow. It is obvious that the more restricted (in space) the disturbed-zone definition, the longer the flow paths in the vadose zone along which travel times are calculated, and the longer the travel times in any flow scenario.

The potential hydrothermal effects in the vadose zone of Yucca Mountain due to waste-generated

temperatures which exceed the boiling temperature of water is generally unrecognized[1] in the SCP. Our analysis indicates marked increases in both vapor and liquid-phase flow are expected due to the strong thermal envelope generated by the waste. In the fractured-rock environment, the complexity of heat and mass-transfer processes and associated solution-mineral reactions will be greatly increased by the multiphase liquid and vapor-flow environment. **We estimate that about 10,000 acre-feet of water are present within the volume of rock that is expected to reach boiling temperature within 100 years.**

The DOE definition of the disturbed zone ignores the importance of multiphase fluid transport. The DOE definition is not as defined and intended in 10 CFR 60.2 (46 FR 35280, 35281, July 8, 1981). Instead of a mechanically-disturbed zone of the current DOE definition (measured as extending several meters from the repository horizon), hydrothermal effects have the potential to extend downward and upward tens to hundreds of meters from the repository horizon in fracture networks.

Based on our findings of: (a) a high probability of field-scale hydrothermal multiphase (heat-pipe) effects occurring during repository loading, and (b) the resultant zone of vaporization and condensation that could extend upward and downward significant distances from the repository horizon, we believe that a zone of intrinsic property changes is not conservative as a basis for defining the disturbed zone. Physical and chemical changes within the zone of vaporization and condensation will be difficult to characterize by direct observation, and will be impossible to predict accurately based on initial conditions only. The DOE needs to address and establish a research program to resolve both the thermal and hydrothermal effects on repository performance.

SCP Ground-Water Travel Time Strategy

The DOE recognizes the "reasonable assurance" licensing requirement (10 CFR 60.101(a)(2)) for ground-water travel time at Yucca Mountain is at least 1,000 years, leaving this issue ambiguous as to what constitutes data of sufficient quantity and quality (SCP, p. 8.3.5.12-10).

The DOE states (SCP, p. 8.0-9):

> "The top-level strategy focuses strongly on the investigations of the characteristics of the flow in the unsaturated zone, relying heavily on the current view that the percolation is low and that the water in the unsaturated zone is tightly confined within the rock matrix. If these concepts can be confirmed, then the general objective for the system and for the post closure performance of the engineered and natural barriers are very likely to be met. As part of these investigations, the program will address alternative concepts including flow in fractures, lateral movement of water at rock interfaces in the unsaturated zone, and the effect on the flow of structural features such as faults. The ability of the unsaturated rock to hold water and limit contact of water with the waste packages will also be investigated."

We find that the DOE approach indicated by the above warrants both applause and criticism. The correct issues have been identified, including fracture flow, but the characterization approach **is to prove conditions and processes** favorable to waste isolation. This would make good sense if there were established technologies, in-depth understanding of the processes, simple natural systems, and well understood analog environments. This is not the case for the vadose zone at Yucca Mountain. The DOE therefore needs to structure the SCP to **test for the unacceptable conditions** and, for the most part, it fails in terms of vadose-zone issues.

---

1. Langkopf (1987) refers to unpublished modeling studies by J. Gauthier and R. R. Peters in a 1986 internal memorandum (SANDIA) where water redistribution was considered from the repository midline to below the repository . Their reported findings support our scenario of total water expulsion as vapor in a 100-year period. However, their model assumes the matrix would absorb the moisture.

REFERENCES

Domenico, P. A., Lerman, A., and Bartlett, J. W., 1989, The disposal of nuclear waste: a problem in mass management? : Ground Water, vol. 27, no. 3.

Gordon, M., et al., 1986, Draft generic technical position: interpretation and identification of the extent of the disturbed zone in the high-level waste rule (10CFR60): U.S. Nuclear Regulatory Commission.

Langkopf, B. S., 1987, Proposed preliminary definition of the disturbed-zone boundary appropriate for a repository at Yucca Mountain: SAND86-1955.

10 CFR 60, Code of Federal Regulations, 1987. Title 10, "Energy," Part 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories," U. S. Government Printing Office, Washington, D. C., p. 627 to 658.

10 CFR 960, Code of Federal Regulations, 1987. Title 10, "Energy," Part 960, "General Guidelines for the Recommendation of Sites for Nuclear Waste Repositories," U. S. Government Printing Office, Washington, D. C., p. 518 to 551.

40 CFR 191, Code of Federal Regulations, 1986. Title 10, "Protection of Environment," Part 191, "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes," U. S. Government Printing Office, Washington, D. C., p. 7 to 16.

46 FR 35280 and 35281, 1981, Disposal of High-level Waste in a Geologic Repository, 46 FR 35280 to 35281, Washington, D. C.

APPENDIX K

PERFORMANCE ASSESSMENT - GROUND-WATER TRAVEL TIME DOCUMENT REVIEW FORMS

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 242	CHAPTER/SECTION: 8.3.5.12 Issue resolution strategy for Issue 1.6:...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.5.12-3 to 5	It seems that DOE's conceptual models for ground-water movement through the vadose zone are seriously flawed. The two general modes by which flow is thought to occur in the vadose zone are matrix flow and continuous flow through fractures and/or faults. Apparently, episodic or transient flow through fractures is not considered a plausible alternative by DOE. The Geohydrology program needs to become scientifically objective and determine the amount of flux related to <u>each</u> of the three above flow mechanisms.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
D. L. Shettel Jr. Signature	DATE: 03 July 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
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DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 241	CHAPTER/SECTION: 8.3.5.12 Issue resolution strategy for issue 1.6:...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.5.12-3	The DOE approach to ground-water travel time is to "support a demonstration of compliance with 10 CFR 60.113 requirements by providing for the determination of the distribution of pre-waste-emplacement ground-water travel times along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment." This wording suggests that data may be used selectively to support their mission-oriented objective of meeting the GWTT requirement rather than following an objective scientific approach of determining the actual GWTT. Secondly, the word likely in the phrase "...fastest path of likely radionuclide travel..." suggests that the path used is open to interpretation and, thus, should be subject to a balanced and objective peer review.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 02 July 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 243	CHAPTER/SECTION: 8.3.5.12 Ground-water travel time

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.5.12-13	The continued reliance by the DOE on the flawed ground-water travel time (GWTT) analysis by Sinnock, et al. (1986) is quite disturbing. Aside from the uncertainties of justification for the 900-some vertical columns and the ten-foot thick cells (other than to generate a large number of travel times), the assumptions regarding matrix flow over fracture flow, and the non-conservative use of very small estimates of recharge-infiltration flux, perhaps the most serious flaw is the misfitting of normally distributed (Guassian) curves to rock properties that, due to the small number of analyses, are clearly not normally distributed. Thus, the calculated means were the worst estimates of the population (Rock, 1987, Computers & Geosciences; 13 (5): 463), and the calculated standard deviations are meaningless. The result is a statiscally-biased analyses of GWTT and not necessarily on the side of conservatism, as DOE purportedly contends. The more statistical-abundant, the lower the hydraulic conductivities become, the more fracture flow that will occur, and the more rapid the travel time in the above type of analysis.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 03 July 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 244	CHAPTER/SECTION: 8.3.5.12.2.1 Activity: Model development.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.5.12-44	1. There is not enough information to judge this activity with respect to: a. Conceptual completeness and focus; b. Appropriateness of methodology to establish stated objectives; c. Probability of success using existing technology; and d. Feasibility in terms of time, funding, and human resources. 2. Unsaturated-zone matrix flow/fracture flow problem has not been recognized by DOE. In developing a model for an area as complex as Yucca Mountain (for which fracture-geometry information is unavailable), DOE needs to state how the basic input necessary for model development will be obtained. Such input includes information about the degree of interconnection between the assemblage of discontinuous fracture planes, fracture density, and fracture orientation. See also comments on Activity 8.3.1.2.3.3.2.

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 245	CHAPTER/SECTION: 8.3.5.12.2.1.1 Activity: Development of a theoretical framework for calculational models.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Subactivity 1.6.2.1.1 Page 8.3.5.12-45	There is not enough information to judge this activity with respect to: 1. Conceptual completeness and focus; 2. Appropriateness of methodology to establish stated objectives; 3. Probability of success using existing technology; and 4. Feasibility in terms of time, funding, and human resources. In the SCP, DOE claims that the correctness of the predicted results of the model will be tested against field data flow-phenomenon. Currently, however, these are sparse, boundary conditions are uncertain and, at Yucca Mountain, some lithologic units, such as the Tiva Canyon Member and tuffaceous beds of the Calico Hills, are complexly fractured and faulted. There is also insufficient information on the major discrete features, such as the Solitario Canyon Fault and the Ghost Dance Fault. (See also comments on Activity 8.3.5.12.2.1).

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 246	CHAPTER/SECTION: 8.3.5.12.2.2 Activity: Development of calculational models.
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Subactivity 1.6.2.1.2 Page 8.3.5.12-45	See comment on Activity 8.3.5.12.2.1.
REVIEWER: O. A. Adenle	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 12 April 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 247	CHAPTER/SECTION: 8.3.5.12.2.2 Activity: Verification and Validation.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.5.12-45	See comment on Activity 8.3.5.12.2.1.

REVIEWER: O. A. Adenle	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 12 April 1989

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 248	CHAPTER/SECTION: 8.3.5.12.2.2 Activity: Verification of codes.
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Subactivity 1.6.2.2.1 Page 8.3.5.12-45	See comment on Activity 8.3.5.12.2.1.
REVIEWER: O. A. Adenle	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 12 April 1989

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 249	CHAPTER/SECTION: 8.3.5.12.2.2.2 Activity: Validation of models.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Subactivity 1.6.2.2.2 Page 8.3.5.12-46	1. This activity is incomplete and not focused because there is no emphasis on the role of field-scale discrete fractures or vaporization/condensation in strong thermal gradients. 2. Methodology proposed will not establish stated objective because additional determinations of matrix characteristics do not constitute meaningful model validation to support information need 1.6.2. 3. This activity will probably not succeed because, although these experiments have been shown to succeed, they do not constitute meaningful model validations. 4. This activity is probably not feasible because validation of models that include strong thermal gradients cannot be accomplished by these experiements. The DOE still needs to adopt a methodology that will lead to more meaningful validation of models. (See also comments on Activity 8.3.5.12.2.1 with regard to methodology that will lead to more meaningful experiments).

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 250	CHAPTER/SECTION: 8.3.5.12.3.1.1 Activity: Unsaturated zone flow analysis.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Subactivity 1.6.3.1.1 Page 8.3.5.12-51	There is not enough information to judge this activity with respect to: 1. Conceptual completeness and focus; 2. Appropriateness of methodology to establish stated objectives; 3. Probability of success using existing technology; and 4. Feasibility in terms of time, funding, and human resources. It is doubtful whether a meaningful simulation of the flow paths in the unsaturated zone is feasible, considering the complexity of the structure at Yucca Mountain.

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 251	CHAPTER/SECTION: 8.3.5.12.3.1.2 Activity: Saturated flow analysis.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Subactivity 1.6.3.1.2 Page 8.3.5.12-51	1. This activity is not focused with respect to determining flow paths because it uses a two-dimensional (2-D) model in a region of complex and uncertain geologic structure. 2. The methodology considered will not establish stated objective because modeling activities proposed to resolve information need 1.6.3 do not adequately represent structural controls on ground-water flow. 3. There is no hope of success using existing technology in this geologic environment. 4. Characterization of all likely flow paths in the saturated zone at Yucca Mountain is not feasible. In the SCP, DOE insists on using 2-D models, which DOE claims will be evaluated for applicability to the travel-time determination (i.e., "If necessary to reach the necessary confidence in travel-time predictions, a two-dimensional model of a single layer will be developed. A three-dimensional or quasi-three-dimensional modeling approach would be developed only if two-dimensional models are shown to be inadequate"). DOE use of a 2-D modeling approach tends to underestimate permeability, if single-well derived hydraulic parameters are used. The fracture network will appear to behave less like a continuum than it actually is in three dimensions. This leads to uncertainty for conclusions on travel-time predictions.

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 252	CHAPTER/SECTION: 8.3.5.12.4.1 Activity: Calculation of pre-waste-emplacement ground-water travel time.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.5.12-53	There is not enough information to judge this activity with respect to: 1. Conceptual completeness and focus; 2. Appropriateness of methodology to establish stated objectives; 3. Probability of success using existing technology; and 4. Feasibility in terms of time, funding, and human resources.

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 253	CHAPTER/SECTION: 8.3.5.12.4.1.3 Activity: Determination of the pre-waste-emplacement ground-water travel time.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Subactivity 1.6.4.1.3 Page 8.3.5.12-54	1. This activity is incomplete and not focused because there is little hope of overcoming problems with the ill-defined Disturbed Zone boundary and flow paths. 2. Methodology proposed will not establish stated objective because the probablilistic approach is not justificable in the absence of knowledge of spatial correlation of parameters; this activity does not resolve information need 1.6.4. 3. This activity will probably not succeed because the validity of this approach cannot be assessed with the existing or expected databases. 4. This activity is probably not feasible because spatial correlations will not be known from proposed drilling effort, nor will properties of major discrete fractures.

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 254	CHAPTER/SECTION: 8.3.5.12.5.1 Activity: Ground-water travel time after repository construction and waste emplacement.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.5.12-62	There is not enough information to judge this activity with respect to: 1. Conceptual completeness and focus; 2. Appropriateness of methodology to establish stated objectives; 3. Probability of success using existing technology; and 4. Feasibility in terms of time, funding, and human resources.

REVIEWER: O. A. Adenle Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June 1989

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 255	CHAPTER/SECTION: 8.3.5.12.5.1 Activity 1.6.5.1: Ground-water travel time after repository construction and waste emplacement.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.5.12-62	DOE is rushing to finalize a calculation (the post-emplacement ground-water travel time, GWTT) by casting their approach "in concrete" before the site characterization even begins (major event A, milestone 10/88). The existing database upon which to base this calculation is inadequate and may not be useable due to quality-assurance problems. The location of existing perched water bodies is not known and, most likely, will remain unknown as DOE will only investigate these around the exploratory shafts. Heat-pipe effects are being ignored, as are vapor-liquid refluxing effects around the dried-out zone. There are few references to other investigations, studies, and/or activities that may provide new data useful to this activity.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 03 July 1989

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 256	CHAPTER/SECTION: 8.3.5.12.5.2 Activity 1.6.5.2: Definition of the disturbed zone.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.5.12-63	This activity should logically be placed before the preceding activity, as it is the basis for the starting point of the calculation. Comments on the previous activity also apply to this activity. DOE assumes predominantly matrix and/or perhaps continuous fracture flow. They should also consider episodic or transient fracture flow as the most likely scenario for transport to the saturated ground-water. Another viable scenario is steam geysers along connected fractures to the land surface. These could aid transport of gaseous radionuclides and may be one of the fatal flaws of this site.

REVIEWER: D. L. Shettel, Jr. D. L. Shettel Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 22 June 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 257 (1 of 5)	CHAPTER/SECTION: 8.3.5.12 Issue resolution strategy for Issue 1.6: Will the site meet the performance objective for pre-waste-emplacement ground-water travel time as...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.5.12-1 through 8.3.5.12-69	On page 8.3.5.12-1, the SCP states, 'One of the NRC performance objectives for high-level waste repositories is stated in 10 CFR 60.113 (a) (2) as: 'The geologic repository shall be located so that pre-waste-emplacement ground-water travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment shall be at least 1,000 years or such other time as may be approved or specified by the Commission.' The disturbed zone has been defined qualitatively in 10 CFR 60.2 as: 'That portion of the controlled area the physical or chemical properties of which have changed as a result of underground facility construction or as result of heat generated by the emplaced radioactive wastes such that the resultant change of properties may have a significant effect on the performance of the geologic repository.' The accessible environment has been defined in 10 CFR 60.2 to mean the atmosphere, the land surface, surface water, oceans, and the portion of the lithosphere that is outside the controlled area. The controlled area, defined in 40 CFR 191.12 (g), means: ' (1) A surface location, to be identified by passive institutional controls, that encompasses no more than 100 squre kilometers and extends horizontally no more than five kilometers in any direction from the outer boundary of the original location of the radioactive wastes in a disposal system, and (2) the subsurface underlying such a surface location.'"

REVIEWER: Atef Elzeftawy Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 03 July 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 257 (2 of 5)	CHAPTER/SECTION: 8.3.5.12 Issue resolution strategy for Issue 1.6: Will the site meet the performance objective for pre-waste-emplacement ground-water travel time as...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.5.12-1 through 8.3.5.12-69	The first general step of DOE's general approach to resolve the ground-water travel time (GWTT) issue is specified on pages 8.3.5.12-6 and 8.3.5.12-8 of the SCP. DOE is proposing the following five-part process: 1. **Identifying** all hydrogeologic units along potential flow paths to the accessible environment and identifying all potentially operating processes within each of these units. 2. **Classifying** hydrogeologic units and flow processes as primary, secondary, and auxiliary "barriers" to establish a defense-in-depth basis for reasonable assurance that flow time to the accessible environment is at least 1,000 yr. 3. **Establishing** measures of performance (i.e., travel time) that allow comparisons of the flow behavior in each unit to the 1,000-yr flow time requirement. 4. **Assigning** goals and associated levels of confidence for each performance measure. 5. **Identifying** relevant parameters and associated levels of confidence that will be used to predict the travel time and associated uncertainty through each unit. The second general step is to **define**, **construct**, and **apply numerical models** to make the GWTT predictions needed to satisfy the NRC rule. In reviewing DOE's general approach to resolve the GWTT issue, we find the SCP, given all data development, less likely to develop and establish a technical program and plan that will provide viable new information and database that would result in resolving the pre-waste-emplacement GWTT with reasonable assurance as required by the NRC 10 CFR 60.113(a)(2). This conclusion is supported by the following comments:

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COMMENT #: 257 (3 of 5)	CHAPTER/SECTION: 8.3.5.12 Issue resolution strategy for issue 1.6: Will the site meet the performance objective for pre-waste-emplacement ground-water travel time as...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.5.12-1 through 8.3.5.12-69	1. The SCP performance allocation for issue 1.6 is described in Table 8.3.5.12-1, page 8.3.5.12-9, for **all** hydrogeologic components available (unsaturated and saturated zones) at Yucca Mountain. It is clearly noted that DOE confidently places a **primary reliance** on the Calico Hills units (CHnv and CHnz) for the GWTT performance measure. DOE claims that Darcian flow within these primary hydrogeologic units will be relied upon for the matrix-dominated flow and fracture flow if substantial flow is identified during characterization. In order for DOE to establish the above claims, it is **essentially required** that the hydrogeologic characteristics of the Calico Hills units **be well established** and defined throughout the repository block and beyond so that the "fastest path" is physically defined in the field. It is our concern that the performance parameters for GWTT listed in Tables 8.3.5.12-1 and 8.3.5.12-2 cannot be directly related to the hydrogeologic test program listed in section 8.3.1.2 of the SCP. It is our opinion that DOE should directly connect the hydrogeologic investigation program with the Issue Resolution Strategy for GWTT. (See comment for Activity 8.3.1.2.2.4.6). 2. The SCP states that the uncertainty in calculating GWTT caused by alternative conceptual models will be included in the cumulative distribution curves by subjective weighting based on peer review. It is of concern that these procedures may not be adequate or sufficient for determining the GWTT along the fastest path to the accessible environment. It is clear that the cumulative distribution function (cdf) for calculating GWTT for each hydrogeologic unit will be affected by many interrelated factors relative to the amount of spreading or flattening of the cdf's. It is possible that these factors, such as variable flow-path lengths, parameter uncertainties of Monte Carlo analyses, uncertainties of alternative models, effects of matrix dispersion and diffusion, and considering GWTT as a random process, may not be separable, thus making uncertain their evaluation and understanding on the CWTT cdf. Therefore, it is our belief that the use of cdf's as described in the SCP **will not** resolve the NRC regulatory requirement.

REVIEWER: Atef Elzeftawy	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 03 July 1989

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COMMENT #: 257 (4 of 5)	CHAPTER/SECTION: 8.3.5.12 Issue resolution strategy for issue 1.6: Will the site meet the performance objective for pre-waste-emplacement ground-water travel time as...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.5.12-1 through 8.3.5.12-69	3. The SCP hydrogeologic conceptual model of matrix-dominated flow through the unsaturated zone is not supported by the available technical data. The model is generally based on assumptions that need to be tested and evaluated during site characterization. The planned activities, as described in the SCP, may not accomplish the goal of evaluating the applicability of the proposed conceptual model to the Yucca Mountain site. In addition, the SCP does not consider conservative conceptual models that fit the limited site-specific data and the hydrogeologic information available in open literature. 4. The methods and concepts proposed in the SCP to evaluate the in-situ moisture conditions are based on porous-media approaches, which may not be appropriate to use for the fractured tuff at Yucca Mountain. DOE should develop, if necessary, new methods that can be used to evaluate the role of moisture within fractured-porous media. 5. The proposed conceptual model of recharge through the Yucca Mountain tuff formations may be incorrect and inadequate in desert terrain. The proposed methodologies would provide results which do not lead to an understanding of the recharge processes, nor to accurately evaluating the recharge fluxes through the tuff formations. (See comment for Activity 8.3.1.2.2.1.2) 6. DOE claims and concludes that very low flux and, in turn, long ground-water travel time (GWTT), is evident at Yucca Mountain. However, most available in-situ data may not support this conclusion. 7. The SCP does not address, in sufficient detail, the complexity of water vapor and simultaneous liquid movement under thermal gradient within unsaturated porous and fractured tuff at Yucca Mountain, especially the implication of that process on the waste isolation for thousands of years.

REVIEWER: Atef Elzeftawy Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 03 July 1989

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 257 (5 of 5)	CHAPTER/SECTION: 8.3.5.12 Issue resolution strategy for issue 1.6: Will the site meet the performance objective for pre-waste-emplacement ground-water travel time as...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.5.12-1 through 8.3.5.12-69	8. The planned unsaturated-zone borehole drilling program does not address the issue of developing a new database for in-situ moisture conditions below the repository horizon. In addition, no provision is made to address the possibility of perched water in the unsaturated zone at Yucca Mountain. (See comment for Activity 8.3.1.2.2.3.2). 9. The SCP relies heavily on computer and numerical models to characterize the water vapor, liquid, and heat movement through Yucca Mountain tuff. The assumptions of most of these codes are not assessed by using reliable laboratory or field data and may not be valid or adequate in predicting the behavior of the unsaturated-zone hydrologic processes. 10. The SCP does not provide for the transient nature of unsaturated hydrologic parameters that could greatly impact the chemistry of radionuclides and their transport within the porous, fractured tuff formations at Yucca Mountain.

REVIEWER: Aref Elzeftawy Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 03 July 1989

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PERFORMANCE ASSESSMENT - TOTAL SYSTEM PERFORMANCE

This chapter of the SCP describes the plans for the following activities:

1.1.2.1 Preliminary identification of potentially significant release scenario classes.

1.1.2.2 Final selection at significant release-scenario classes to be used in licensing assessments.

1.1.3.1 Development of mathematical models of the scenario classes.

1.1.4.1 Screening of the potentially significant scenarios against the criterion of relative consequences.

1.1.4.2 Provision of simplified, computationally efficient models of the final scenario classes representing significant processes and events.

1.1.5.1 Calculation of empirical complementary cumulative distribution function.

Frankly we find this chapter so presumptive, so ambitious, and so far out of context of what the SCP database development program will produce, that we have not reviewed this chapter in depth. In this chapter, the SCP develops and discusses release models and heavily uses findings of Ross (1986,1987) to screen release scenarios. These models and the general approach warrant indepth review, and as sufficient time and the references were not available for such, we offer only initial impressions at this time. We have some general comments, and a few specific comments as examples to clarify the general comments.

The methodology proposed by the SCP to establish assessment of the total system performance seems to us potentially misleading and unnecessary. The construction of a complementary cumulative distribution function (CCDF) might be useful for site selection (screening) before site characterization. However, after site characterization, we believe it is the intent of licensing criteria that performance assessments are to be based on site-specific databases, that is, specific databases for a site that is not too complex for confident characterization. If the DOE must resort to the described approach, either a confident database has not been developed, or the site is too complex to be confidently characterized (and therefore does not meet licensing criteria). If the DOE uses the described approach, including the judgment calls on significant processes and events, and associated statistical techniques necessary to establish probabilities, there will be little useful information created by the CCDF. There will be however, considerable dust and feathers put into the air to create what some might term "smoke."

We find the screening process established by the DOE panel of experts (DOE, 1986a) and Ross (1986,1987) eliminates scenarios we think quite credible and several seem likely to us and key to effective waste isolation. We have essentially the same information base to work with as Ross (or DOE) yet at the most **qualitative** level, differing conclusions are made about scenarios of release. If such is the case, how will it be possible to assign viable probabilities to many of the scenarios as well as the release rates associated with each process or event?

We think it much more sound in approach to treat any documented site-specific process or event separately, with sensitivity analyses where possible on release aspects, and probabilities of frequency of occurrences only if the evidence is available. We think that many uncertainties associated with characterizing Yucca Mountain performance aspects warrant separate treatment so that each aspect of performance can be clearly examined from the perspective of the established databases, and not lumped into a CCDF type of analyses. The discussions of the necessary modeling giving rise to establishing expected partial performance measure (EPPM) suggest that this level of analysis may be appropriate and possible for some performance aspects. However, we do not see how a number of EPPMs can be coupled to form a CCDF that has any real meaning.

We find it fundamental that the databases used to establish the EPPMs be unbiased and carefully reexamined in terms of underlying assumptions. Our comments reflect some of the concerns, such as the basic assumption that batch experiment data on crushed tuffs (Table 8.3.5.13-4) from Daniels, et al. (1983) are useful and representative of the most likely pathways to the accessible environment. We can not accept the assumptions that the most likely pathways are in the rock matrix if fractures are present and flux pulses may exceed saturated hydraulic conductivities of the hydrogeologic units, and we can not accept that the Kd and Rm values established in crushed tuff have direct application to transport phenomena in uncrushed rock matrix or along fractures in any of the units. We find it just hard to believe that Table 8.3.5.13-5, giving estimates of ground-water travel time for the various units, has an acceptable level of certainty in establishing EPPMs. The entire analysis is based on unsupported assumptions of flux, a very limited database on saturated hydraulic conductivites, and no clear understanding or documentation of processes of water movement in the matrix of the fractured tuff units in the vadose zone. We think that reducing the uncertainty created by these types of assumptions is what site characterization is meant to be.

We find in general, that the performance assessment models needed for water and gas pathways releases unlikey to be verified or validated by the schedule indicated in Figure 8.3.4.13-7. Thus such performance modeling will be as uncertain as the codes and model parameters used to establish the mass transport relationships. The strategy adopted by the SCP seems to be that of establishing modeling analyses before there is a sufficient database and associated time to establish verified and validated site-specific transport models. The total system performance assessment, which should be designed to evaluate the overall performance of the site, will have built into it, the additional uncertainties related to the multitude of assumptions needed to establish the models, with uncertainties stemming from sparse databases, complex site characteristics, uncertain site specific processes, and models that probably can not be verified and validated. It is difficult to envision confident analyses suitable for licensing application by 1995.

APPENDIX L

PERFORMANCE ASSESSMENT - TOTAL SYSTEM PERFORMANCE DOCUMENT REVIEW FORMS

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 258	CHAPTER/SECTION: 8.3.5.13 Total System Performance.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.5.13-26 to 27 Table 8.3.5.13-1	The elimination of potentially significant scenarios regarding dissolution (3 and 4) is unjustified, especially for 3 (repository-induced dissolution of the host rock). The estimated 10,000 acre-feet of water that will be displaced by the thermal envelope surrounding the waste canisters could induce significant mass transport in a thermal gradient. Refluxing of vadose water above the repository level will result in steam condensing at some height above the zone of boiling and this condensate (essentially distilled water, except for bicarbonate content) will most likely induce serious dissolution of the host rock above the repository, but within the disturbed zone.

REVIEWER: D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 02 July 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE TECHNICAL REVIEW COMMENT	
DOCUMENT TITLE: Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).	
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 259	CHAPTER/SECTION: 8.3.5.13 Total System Performance.
SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.5.13-26 to 27	One serious flaw in total system performance is the dismissal of potential scenarios before data from site characterization have been collected and evaluated. Dismissal of potential scenarios has been based on biased and preconceived conceptual models of the site which are based on assumptions and which may not be supported by the collected evidence. Some of these dismissed scenarios that may be credible when sufficient data are available include: - formation of artificial geysers by steam pressure, - repository-induced dissolution of host rock, - transport of radioactive aerosols to surface through drained fractures, - thermal release of moisture from hydrated zeolites, - loss of mechanical strength due to thermal dehydration/rehydration of repository host rock, - disruptive ones that involve release and transport of ^{14}C and I to accessible environment. Failure to consider credible scenarios will render total systems performance incomplete in terms of licensing requirements.
REVIEWER: D. L. Shettel, Jr. D. L. Shettel Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 03 July 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 260	CHAPTER/SECTION: 8.3.5.13 Total System Performance

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.5.13-45	The equation should read: $2^{8+5} = 2^{13} = 8192$.

REVIEWER: M. D. Mifflin Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 02 July 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 261 1 of 2	CHAPTER/SECTION: 8.3.5.13 Total System Performance.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Table 8.3.5.13-4 Page 8.3.5.13-61	This table is very misleading and another example of the nonconservative use of data by DOE because: 1. Retardation factors assume porous flow. DOE wants to assume porous (i.e. matrix) flow, but this assumption is totally unjustified. Fracture flow is more likely, especially in welded tuff. 2. All of the data in Table 6-25 (DOE, 1986b) does in fact come from Daniels, et al. (1982). Thus, the use of another reference, apparently to make the data appear to be more credible, is deceptive. 3. The data are based on K_d's derived from batch experiments on crushed tuff. These experiments most likely have nothing to do with the field situation, as discussed in our comments on the Geochemistry Program. 4. The data for Am, Cs, Np, Pu, Sr, Tc, and U for welded and non-welded tuff refer to the Topopah Springs and Calico Hills, respectively. The corresponding data for radium (assuming barium as analog) should be 900 and 94,000 instead of 25,000 and 25,000 for welded and non-welded tuff, respectively. The source of the radium data is not obvious.

REVIEWER: D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 21 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 261 2 of 2	CHAPTER/SECTION: 8.3.5.13 Total System Performance.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Table 8.3.5.13-4 Page 8.3.5.13-61	5. The calculated retardation factors* seem to be non-conservatively higher than the use of the data in the footnotes would indicate. For example, for Am: Rm = 25,164 instead of 28,000 for welded tuff and Rm = 17,500 instead of 24,000 for non-welded tuff. For Ra (using Ba analog), I calculate: Rm (welded) = 524,300 instead of 580,000 and Rm (non-welded) = 95,100 instead of 130,000. However, using 900 and 94,000 for welded and non-welded tuff, respectively, I obtain for Ra: Rm (K_d = 900) = 18,900 for welded and Rm (K_d = 94,000) = 357,700 for non-welded tuff, instead of 580,000 and 130,000, respectively. *The standard formula for retardation factors is $R_f = 1 + K_d \rho([1-\phi/\rho])$ and differs from equation 8.3.5.13-14A which explains the difference between the retardation factors calculated above and those in Table 8.3.5.13-4. The reason for the use of a different equation from the standard one for retardation factors is not explained by DOE, other than it apparently yields higher retardation factors.

REVIEWER: D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 02 July 1989

MY890703a

PERFORMANCE ASSESSMENT - GROUND-WATER PROTECTION

Important "special" sources of ground water that are in close proximity to a repository should be well-characterized. Key Issue I in the Office of Geologic Repositories Issues hierarchy relates to whether the mined geologic-disposal system at Yucca Mountain will isolate the radioactive waste from the accessible environment after closure in accordance with the requirements set forth in 40 CFR Part 191, 10 CFR Part 60, and 10 CFR Part 960. Performance Issue 1.3, "Will the mined geologic disposal system meet the requirements for the protection of special sources of ground water as required by 40 CFR 191.16?" dictates information needs 1.3.1 and 1.3.2 of section 8.3.5.15 of the SCP, "Ground-water Protection". The regulatory basis for protection of special sources of ground water as stated in 40CFR191.16 has been vacated and EPA has been asked by the First District Court of Appeals to reevaluate the rule in light of other rules (more stringent) protecting ground water. It seems reasonable that the new EPA rules will be compatible with existing rules, and the SCP wisely is maintaining this issue.

Information Need (SCP)

1.3.1 Determination whether any Class 1 or special sources of ground water exist at Yucca Mountain, within the controlled area, or within 5 km of the controlled area boundary

1.3.2 Determine for all special sources whether concentrations of waste products in the ground water during the first 1,000 years after disposal will not exceed the limits established in 40 CFR 191.16 .

Section 191.16 of 40 CFR Part 191 was added to the final EPA rule to provide protection for those individuals in the vicinity of a disposal system (FR 38072, September 19, 1985). The SCP (p. 8.3.5.15-2) provides the following explanation of EPA water-source designations:

> "An aquifer must meet several criteria to be designated as a special source. The first step in the evaluation is to establish whether the aquifer is a Class I source as defined by the EPA Ground Water Protection Strategy of 1984 (EPA, 1984). The conditions that must be met for designation as a Class I source are (1) that the source is highly vulnerable to contamination because of the hydrologic characteristics and (2) that the source is irreplaceable in that no reasonable alternative is available to substantial populations or that the source is ecologically vital in that it provides baseflow to a sensitive ecological system.
>
> If an aquifer meets the criteria for a Class I source, the next step is to determine whether it qualifies as a special source of ground water. 40 CFR 191.12 defines a special source of groundwater as "those Class I ground waters identified in accordance with the agency's Ground-Water Protection Strategy . . . that: (1) are within the controlled area encompassing a disposal system or less than 5 km beyond the controlled area [the controlled area is the actual area chosen according to the 40 CFR 191.12 definition of the controlled area]; (2) are supplying drinking water for thousands of persons as of the date that the [DOE] chooses a location within that area for detailed characterization as a potential site for a disposal system (e.g., in accordance with Section 112(b) (1)(B) of the Nuclear Waste Policy Act); and (3) are irreplaceable in that no reasonable alternative source of drinking water is available to that population."

A valley-fill aquifer, a tuff aquifer, and a carbonate aquifer are present at Yucca Mountain. DOE states that only the valley-fill aquifer was serving a population of thousands of persons at the time that the site was chosen for characterization (SCP, Section 3.8). DOE also offers a preliminary determination that no potential special sources of ground water are present at the site, below the site, within the boundaries of the controlled area, or within 5 km of the controlled area boundary (SCP, p. 8.3.5.15-6). The hydrologic feasibility of developing the lower carbonate aquifer must consider the possibility of interbasin diversion of

baseflow to the Ash Meadows Springs (Section 8.3.1.9.2.). DOE also considers that the Ash Meadows area is part of a different ground-water subbasin (Ash Meadows) from the Alkali Flat-Furnace Creek Ranch ground-water subbasin, which contains Yucca Mountain (Section 3.6).

The content of Section 8.3.1.9.2 (Investigation: Studies to provide the information required on present and future value of energy, mineral, land, and ground-water resources) suggests that the SCP does not intend to refine the very poor understanding of the western margin of the Ash Meadows flow system between Yucca Mountain and Ash Meadows. The projection of this boundary north of Lathrop Wells is entirely speculative. DOE plans an analysis 1.3.1.1. (p. 8.3.5.15-7) to determine whether any aquifers near the site meet the Class I or special-source criteria. This analysis consists of two activities (1.3.1.1.1 and 1.3.1.1.2). These pull hydrologic data from other activities and demographic information into an assessment.

Comments and Discussion

DOE continues to prefer to ignore the fact that the western extent of the Ash Meadows' ground-water flow system is highly uncertain, as well as the carbonate aquifer's uncertain relationship with the tuff aquifers of Yucca Mountain and the valley-fill aquifer in Amargosa Valley.

Yucca Mountain overlies the fragmented western extent of a regional-carbonate aquifer (Winograd and Thordarson, 1975), which discharges on the order of 17,000 acre-feet per year of good-quality ground water near Ash Meadows. Structural relationships probably control the extent of the carbonate aquifer in this area. Four major Mesozoic thrust faults that involve the subvolcanic rocks are projected through the Yucca Mountain-Jackass Flats area by Wernicke (1988). From southeast to northwest, these are the Clery-Spector Range Thrust, the Schwaub Peak-Mine Mountain (?) Thrust, an equivalent of the back-facing Panama Thrust, and the Last Chance Thrust. These thrust sheets involve a nearly complete Paleozoic section that is known to include major aquifers in the region. If, as Carr and Monsen (1988) suggest, the breakaway zone for the Fluorspar Canyon Fault is west of Yucca Mountain and faults at Yucca Mountain are genetically related to the Crater Flat graben system, then Paleozoic carbonates could underlie the entire Yucca Mountain-Jackass Flats area. In the absence of large-magnitude Cenozoic extension, the Tertiary section would be expected to be underlain by an allochthonous wedge corresponding to rocks between the Marble Canyon and White Top Thrusts, and equivalents. The Cottonwood Mountains, southern Funeral Mountains, southern Bare Mountain, and Mine Mountain (NTS) offer the best exposures of tectonic elements that could be structurally analogous to those beneath Yucca Mountain. In the Grapevine Mountains, the same structural level of the fold and thrust belt is exposed, but Cenozoic rotation and extensional overprinting have confused relationships among pre-Tertiary units there somewhat more than in the other listed areas.

The Mesozoic fold and thrust belt that may underlie Yucca Mountain consists of several discrete thrust sheets with stratigraphic throws of up to 5 km and the full spectrum of brittle through ductile behavior. A key question is whether extensional crustal thinning has removed Paleozoic carbonates from beneath Yucca Mountain, and if the Silurian dolomite in UE25-p#1 is part of the laterally continuous carbonate aquifer, which discharges at Ash Meadows. The northwest strike of prethrust normal faults in the Spring Mountains region indicates that hydraulic relationship sin and beneath the thrust sheets between Yucca Mountain and the northern Specter Range-Ash Meadows area should be explored. Because of the water-resource potential of the regional-carbonate aquifer, an understanding of flow paths within it is needed to resolve performance issue 1.3. The carbonate aquifer serves as a water supply for NTS activities and supports the unique and endangered ecology of the Ash Meadows area, including the Devil's Hole part of Death Valley National Monument. In addition, the major spring areas in Death Valley National Monument are the principal water supply for the Furnace Creek area and may be part of the carbonate-aquifer system.

The available evidence indicates that:

1. The alluvial aquifer is Class 1.

2. The tuff aquifer is Class 1 because it is a prime recharge source to the alluvial aquifer.

3. The carbonate aquifers that discharge at Ash Meadows and at Death Valley are Class 1.

We see that the "special source" designation can only be confidently resolved by determining the flow-system relationships and boundary conditions between the three aquifers known to exist in the vicinity of the controlled area. The SCP has no data-collection activities that will produce a definitive database and, therefore, offers no useful plan to resolve the ground-water protection "special source" issues. We might add that both the Ash Meadows and Death Valley ground-water discharge areas support sensitive ecological systems.

REFERENCES

40 CFR 191, Code of Federal Regulations, 1986, Title 40, "Protection of Environment," Part 191, "Environmental Radiation Protection Standards for Manaagement and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes," U. S. Government Printing Office, Washington, D. C., p. 7 to 16.

50 FR 38072, 1985, "Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Waste," 50 FR 38072, Washington, D. C.

U. S. Environmental Protection Agency, 1986. Ground-water Quality Protection: State and Local Strategy Final Report : 1 October 1984 - 30 April 1986, Natural Research Council, Washington, D. C.

Winograd, I. J. and W. Thordarson, 1975. Hydrogeologic and hydrochemical framework, south-central Great Basin, Nevada-California, with special reference to the Nevada Test Site, USGS Prof. Paper 712-C.

Wernicke, B. P., 1988. Correlation of early Mesozoic thrusts in the southern Great Basin and their possible indication of 250-300 Km of Neogene crustal extension in Wiede, D.L. and M. L. Fager, eds.,1988, This extended land, geological journeys in the southern Basin and Range, Geological Society of America Cordilleran Section Field Trip Guidebook, p. 255 to 268.

APPENDIX M

PERFORMANCE ASSESSMENT - GROUND-WATER PROTECTION DOCUMENT REVIEW FORMS

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 262	CHAPTER/SECTION: 8.3.5.15.1.1.1 Activity 1.3.1.1.1: Synthesis and evaluation of...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.5.15-7 to 8	This activity is unchanged from that in the CD-SCP. The text of this activity is poorly focused and badly written. The first objective is "to raise the confidence levels of the previously obtained hydrologic and environmental data...," but in the description of how this is to be accomplished, it states, "This activity will extract its parameters from Investigations 8.3.1.2.1, 8.3.1.2.3, and 8.3.1.9.2, which are needed to raise the confidence on the determination whether any special source of ground water exists..." As there are no data-collection activities within this activity, we cannot see how the confidence of anything will be raised except in the level of "hype" expressed.

REVIEWER: D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 22 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 263	CHAPTER/SECTION: 8.3.5.15.1.1.2 Activity 1.3.1.1.2: Synthesis and evaluation of demographic...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.5.15-8	This activity is unchanged from that in the CD-SCP. It certainly seems that this activity could have been accomplished in the time DOE took to write and revise two versions of the SCP. The carbonate aquifers are sources of water on the NTS, thus it seems that these could be developed for the local population, expecially in light of the projected growth and dwindling water supplies for the major metropolitan area of Las Vegas.

REVIEWER: D. L. Shettel, Jr. Don L. Shettel Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 22 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 264	CHAPTER/SECTION: 8.3.5.15.2.2 Activity 1.3.2.1.1: Synthesis and evaluation of releases...

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.5.15-10	This activity is unchanged from that in the CD-SCP. As total systems performance (Section 8.3.5.13) goes, so goes this activity. Because total systems performance is seriously flawed (see our previous comments), successful completion of this activity is highly questionable.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 22 June 1989

MY890703a

PERFORMANCE ASSESSMENT - ANALYTICAL TECHNIQUES REQUIRING DEVELOPMENT

"Man can not make principles; he can only discover them."
- Thomas Paine, 1794 -

Peer review is not a scientifically acceptable validation technique for computer models. Due to the lack of sufficiently detailed information on verification and validation plans, the DOE should expand each activity that utilizes codes and models to include verification and validation activities. Verification can only be accomplished by strict checking of numerical accuracy which may include benchmarking, but benchmarking must not be the primary verification method. In the strictest sense, validation of computer models can only be achieved through the collection of field and laboratory data that establish beyond a reasonable doubt the actual in-situ processes occurring at the Yucca Mountain site.

We believe that if a careful review of the modeling efforts called upon in the SCP activites were made in terms of what is required for verification and validation, many of the planned modeling efforts would be abandoned in favor of site specific data gathering efforts. This exercise is strongly recommended, as the SCP modeling strategy is doomed to failure without appropriate databases. Appropriate use of peer reviews with respect to the modeling efforts is to avoid the use of unverified and unvalidated models in resolving licensing issues.

APPENDIX N

ANALYTICAL TECHNIQUES REQUIRING DEVELOPMENT DOCUMENT REVEIW FORMS

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 265	CHAPTER/SECTION: 8.3.5.20 Analytical techniques requiring development.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.5.20-3	DOE does not explicitly state that the five steps listed as a comprehensive set of verification steps will be performed. They state only that these <u>would</u> be comprehensive, if included in their program.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 30 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 266	CHAPTER/SECTION: 8.3.5.20 Analytical techniques requiring development.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.5.20-3	There are no descriptions of other verification activities to the same extent as benchmarking. Benchmarking of different computer models does not appear to fulfill the intent of verifying numerical accuracy, in that generation of similar results may be fortuitous and coincidental.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 03 July 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 267	CHAPTER/SECTION: 8.3.5.20 Analytical techniques requiring development.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 8.3.5.20-8 to 10	The geological, hydrogeological, geochemical, and geophysical models are ubiquitous in the DOE site-characterization process and must be validated in the purest sense of the word--through appropriate and realistic field and laboratory tests. The activities must be designed to not only investigate the "favorableness" of the site, but also to evaluate any fatal flaws of the site. Failure to adequately validate these models through a site-specific characterization program that collects sufficient data to evaluate all alternative models will render performance-assessment models derived from these primary models relatively worthless for licensing purposes. Validation of the primary models (geological, hydrogeological, geochemical, and geophysical) by peer review is not acceptable. Peer review cannot validate models under any circumstances. If the DOE chooses to use invalidated models in performance assessments, peer reviews may be advisable in attempts to avoid inappropriate model use.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 03 July 1989

MY890703a

MISCELLANEOUS COMMENTS

APPENDIX O

MISCELLANEOUS COMMENTS
DOCUMENT REVIEW FORMS

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 268	CHAPTER/SECTION: Table of Contents

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages xlv-xlvi	These pages are duplicates of pages xliii and xliv.

REVIEWER: D. L. Shettel, Jr.	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 31 May 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 269 (1 of 2)	CHAPTER/SECTION: Volume III, Part A, Chapter 7, Waste Package.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 7-11 through 7-53	In paragraph 2 of page 7-11 in the chapter entitled "Waste Package," the SCP states, "The model for flow in the unsaturated zone provides estimates of water fluxes through the various units at Yucca Mountain. Because of the potential for lateral flow within some units and at unit boundaries and of the effects of capillary barriers present in the natural setting, the flux through any given unit may be less than the net downward infiltration rate for the mountain as a whole. Indeed, it is possible for some units to have a net upward flux caused by vapor transport of water even though the system as a whole has a net downward flux (Montazer and Wilson, 1984). Geothermal data from the air-drilled drillhole USW UZ-1 indicate an upward flux of 1 to 2 mm/yr in the Topopah Spring welded unit although calculations of flux through the welded unit using effective permeability and hydraulic gradient in Darcy's equation give an estimate of flux of 0.0003 to 0.2 mm/yr downward (Weeks and Wilson, 1984). Calculations based on the in situ potential gradient measured in drillhole USW UZ-1 and the effective permeabilities measured using drill core from the adjacent drillhole gave estimates of downward flux ranging from 1×10^{-7} mm/yr to 2×10^{-4} mm/yr (Montazer and Wilson, 1984)" (emphasis added). After reviewing the noted references, we offer the following comments: 1. The model for flow in the unsaturated zone of Yucca Mountain, as Montazer and Wilson stated, is hypothetical and provides a basis for conducting preliminary assessment of the hydrogeologic setting of the repository site. DOE relies heavily on this model, without providing suitable uncertainties regarding its results with respect to the waste package design and its relationship to the waste package environment. 2. As we stated before in the initial review of the CD-SCP, we believe DOE should reassess their unsaturated zone conceptual model of Yucca Mountain by providing other alternative models based on the gathered and conflicting database from borehole USW UZ-1 and other surface data.

REVIEWER: Atef Elzeftawy Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 23 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

DOCUMENT TITLE:	Site Characterization Plan : Yucca Mountain Site, Nevada Research and Development Area, Nevada : Nuclear Waste Policy Act (Section 113).
AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 269 (2 of 2)	CHAPTER/SECTION: Volume III, Part A, Chapter 7, Waste Package.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Pages 7-11 through 7-53	3. DOE should re-examine their hypothetical proposal for the capillary barriers concept in the unsaturated-zone section of Yucca Mountain in light of the scientifically-accepted hydrological concepts and physical laws of the unsaturated-zone hydrology. 4. It is interesting to note that the water vapor flux (upward) is much greater than the liquid water flux (downward). It seems that the unsaturated zone at Yucca Mountain is drying up with time.

REVIEWER: Atef Elzeftawy Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 23 June 1989

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 270	CHAPTER/SECTION: 8.3.1.8.3.1.2 Activity: Assessment of the effects of igneous intrusions and volcanic events on flux rates.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.8-83	This activity is part of the study entitled "Annual probability of volcanic or igneous events in the controlled area." The text of this activity does not address the issue of flux rates or how the appearance of igneous intrusions and volcanic events could substantially alter average flux rates. No methods or technical procedures are provided which makes it impossible to technically review this activity.

REVIEWER: Atef Elzeftawy Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 05 May 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 271	CHAPTER/SECTION: 8.3.1.8.3.1.4 Activity: Effects of faulting on average flux rates.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.8-85	This activity is part of the study entitled "Annual probability of volcanic or igneous events in the controlled area." It is not clear how the average flux rates, especially within the unsaturated zone of Yucca Mountain, could be affected by faulting within the rock formations. No methods or technical procedures are provided which makes it impossible to technically review this activity.

REVIEWER: Atef Elzeftawy Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 05 May 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 272	CHAPTER/SECTION: 8.3.1.8.3.1.5 Activity: Assessment of the effects of faulting on flux rates.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.8-85	This activity is part of the study entitled "Annual probability of volcanic or igneous events in the controlled area." In my technical opinion, DOE's judgment that cumulative 2 m offset hydrogeologic rock units would produce a significant affect on water flux rates is not clear or justified based on the scientific information from open literature on the unsaturated-zone hydrology. No methods or technical procedures are provided which makes it impossible to technically review this activity.

REVIEWER: Atef Elzeftawy Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 273	CHAPTER/SECTION: 8.3.1.8.3.2.1 Activity: Thermal and barrier-to-flow effects of igneous intrusions on water-table elevation.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.8-88	This activity is part of study 8.3.1.8.3.2 entitled "Analyses of the effect of tectonic processes and events on changes in water-table elevation." According to the DOE, this activity would produce models to assess the effects of igneous intrusions on the water-table levels. It is not clear which models the DOE would use to accomplish this task, or how the needed data for the models would be obtained from field activities. No methods or technical procedures are provided which makes it impossible to technically review this activity.

REVIEWER: Atef Elzeftawy Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 28 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 274	CHAPTER/SECTION: 8.3.1.8.3.2.2 Activity: Assessment of the effects of igneous intrusions on water-table elevation.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.8-89	This activity is part of study 8.3.1.8.3.2 entitled "Analyses of the effect of tectonic processes and events on changes in water-table elevation." The DOE states that this activity "will use the data in activity 8.3.1.8.3.1.1 to estimate the probability of an igneous event occurring..." It is not clear from the text of this activity how igneous intrusions would cause significant changes in the elevations of the water table, potentiometric surface, hydraulic gradient, and the creation of discharge points that could be evaluated and predicted in numerical terms of distance, volume, and time within the controlled area of Yucca Mountain. In addition, the assessment of this effect using a probability approach may not lead to useful and meaningful results because of the nonexistence of field data in the open hydrogeologic literature. No methods or technical procedures are provided which makes it impossible to technically review this activity.

REVIEWER: Atef Elzeftawy Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 28 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 275	CHAPTER/SECTION: 8.3.1.8.3.2.3 Activity: Assessment of the effect of strain changes on water-table elevation.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.8-91	This activity is part of study 8.3.1.8.3.2 entitled "Analyses of the effect of tectonic processes and events on changes in water-table elevation." The strain changes within rock formations could affect the water pressure in the closed, saturated hydrogeologic systems (such as confined aquifers). However, unconfined hydrogeologic aquifers, such as found below the Yucca Mountain controlled area, may not exhibit these strain changes in terms of changes in water-table elevation. The fact that the water-table surface is considered to be the equilibrium surface of all forces within the system may prohibit obtaining meaningful results. No methods or technical procedures are provided which makes it impossible to technically review this activity.

REVIEWER: Atef Elzeftawy	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 28 June 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 276	CHAPTER/SECTION: 8.3.1.8.3.2.4 Activity: Assessment of the effect of folding, uplift, or subsidence on water-table elevation.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.8-92	This activity is part of study 8.3.1.8.3.2 entitled "Analyses of the effect of tectonic processes and events on changes in water-table elevation." It is unclear how DOE would gather the meaningful field data required to evaluate the probability that the repository will be lowered by 100 m through the action of geologic processes of folding, uplifting, and subsidence within the next 10,000 years. No methods or technical procedures are provided which makes it impossible to technically review this activity.

REVIEWER: Atef Elzeftawy Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 05 May 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 277	CHAPTER/SECTION: 8.3.1.8.3.2.5 Activity: Effects of faulting on water-table elevation.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.8-93	This activity is part of study 8.3.1.8.3.2 entitled "Analyses of the effect of tectonic processes and events on changes in water-table elevation." In the text of this activity, DOE claims that models of present flow in the unsaturated and saturated zones would be used to develop a model to predict the effect of faulting on water-table elevation at the site. It is my technical concern that most of the present hydrologic models do not address the faulting effects on the physical and hydrologic processes within the rock formations at the site. Scientific data are not readily available for computer models to be used to predict these faulting effects. No methods or technical procedures are provided which makes it impossible to technically review this activity.

REVIEWER: Atef Elzeftawy Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 29 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 278	CHAPTER/SECTION: 8.3.1.8.3.2.6 Activity: Assessment of the effect of faulting on water-table elevation.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.8-93	This activity is part of study 8.3.1.8.3.2 entitled "Analyses of the effect of tectonic processes and events on changes in water-table elevation." The DOE claims that probability of faulting offset within the rock formations at the site will be evaluated within 10,000-years' time-frame. The question is, how will the DOE obtain field hydrogeologic data to implement the statistical approach of determining probabilities that would assure the reliability of the model predictions for 10,000 years? No methods or technical procedures are provided which makes it impossible to technically review this activity.

REVIEWER: Atef Elzeftawy Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 28 June 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 279	CHAPTER/SECTION: 8.3.1.8.3.3.1 Activity: Assessment of the effects of igneous intrusions on local fracture permeability and effective porosities.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.8-95	This activity is part of study 8.3.1.8.3.3 entitled "Analysis of the effects of tectonic processes and events on local fracture permeability and effective porosity." The DOE asserts that this activity would result in assessment of how probable changes in physical properties could affect the movement of gaseous decay products in the unsaturated zone. It is understood from the text of this activity that these physical changes are the result of igneous intrusions near the Yucca Mountain site. It is our technical concern that this activity may not provide valuable hydrologic information that could evaluate the impact on the gaseous phase of the unsaturated zone. No methods or technical procedures are provided which makes it impossible to technically review this activity.

REVIEWER: Atef Elzeftawy	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 29 June 1989

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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 280	CHAPTER/SECTION: 8.3.1.8.3.3.2 Activity: Assessment of the effects of faulting on local fracture permeability and effective porosities.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.8-95	This activity is part of study 8.3.1.8.3.3 entitled "Analysis of the effects of tectonic processes and events on local fracture permeability and effective porosity." My concern here is similar to my comment on Activity 8.3.1.8.3.2.6. Evaluating statistical probabilities requires a massive amount of data that could result in meaningful probability values. No methods or technical procedures are provided which makes it impossible to technically review this activity.

REVIEWER: Atef Elzeftawy	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 29 June 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 281	CHAPTER/SECTION: 8.3.1.8.3.3.3 Activity: Assessment of the effects of stress or strain on hydrologic properties of the rock mass.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.1.8-96	This activity is part of study 8.3.1.8.3.3 entitled "Analysis of the effects of tectonic processes and events on local fracture permeability and effective porosity." The DOE states that modeling studies will be performed to assess the effect of stress and strain on hydrologic properties. It is our concern that these models, if they exist, may not be valid or usable because of the unavailability of field data required to evaluate meaningful probabilities for 10,000 years. No methods or technical procedures are provided which makes it impossible to technically review this activity.

REVIEWER: Atef Elzeftawy	ORGANIZATION: Mifflin & Associates, Inc.
Signature	DATE: 29 June 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 282	CHAPTER/SECTION: 8.3.5.17 NRC Siting Criteria

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.5.17-35	PAC 6: Potential for changes in hydrologic conditions resulting from reasonably foreseeable climate changes. DOE states that the changes in hydrologic conditions are not likely to <u>significantly</u> affect the performance of the repository. On page 8.3.5.17-48, first paragraph, this discussion includes some doublespeak about "significance" with respect to isolation. The NRC intent is clear--it wants to know if the waste isolation will be significantly affected by a climate-induced change in hydrology. In Table 8.3.5.17-7, the increased infiltration rate of <0.5 mm/yr under "Tentative parameter goal" is a value that is already exceeded by one DOE study and existing open literature. The table fails to include the scenarios of perching water and increased travel times due to increased fracture flow, as well as scenarios of enhanced hydrothermal envelopes due to increasing availability of recharge.

REVIEWER: M. D. Mifflin Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 02 July 1989

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COMMENT #: 283	CHAPTER/SECTION: 8.3.5.17 NRC Siting Criteria.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.5.17-55	PAC 9: Ground-water condition in the host rock that are not reducing. DOE expects to neutralize this PAC by showing that performance is not adversely affected by oxidizing conditions because of (1) low water flux through repository, and (2) sorptive capacity of host rock and surrounding units. First of all, low water flux has <u>not</u> been proven, is not justified on the basis of (or lack of) existing information. A spatially-distributed water flux (even if not low) is not justified, as most likely recharge is through fractures and/or faults that define washes. Secondly, the Calico Hills is the major sorption barrier, not the repository host rock. It is extremely doubtful that sorptive capacity of the rocks can be established due to the nature of the sorption experiments (these bear no similarity to realities of the actual field conditions), and to the lack of fully quality-assured samples with which to characterize the Calico Hills.

REVIEWER: D. L. Shettel, Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 21 June 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
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AUTHOR(S): U.S. Department of Energy/ Office of Civilian Radioactive Waste Management	REFERENCE: DOE/RW-0199 (December 1988).
COMMENT #: 284	CHAPTER/SECTION: 8.3.5.17 NRC Siting Criteria

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.5.17-81	PAC 23: Potential for existing or future perched-water bodies that may saturated portions of the underground facility or provide a faster flow path from an underground facility located in the unsaturated zone to the accessible environment. It should be pointed out that there is no activity in the SCP designed to determine the 3-D distribution of perched-water zones and, contrary to the statement on p. 8.3.5.17-81, perched water has been encountered to date in the drilling program. The two very important scenarios (ie. they are highly probable based on existing information) have been totally missed in Table 8.3.5.17-15. They are: 1. Perched water due to drilling water losses. 2. Perched water due to condensation of steam driven from the thermal envelope.

REVIEWER: M. D. Mifflin Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 02 July 1989

MY890703a

NEVADA NUCLEAR WASTE PROJECT OFFICE
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COMMENT #: 285	CHAPTER/SECTION: 8.3.5.17 NRC Siting Criteria.

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.5.17-81 and Table 8.3.5.17-15	PAC 23: Potential for perched water bodies that may saturate positions of the underground facility or provide a faster flow path to the accessible environment. According to the text and table, DOE will totally fail to accurately and reasonably evaluate this PAC, as the most likely scenario for formation of perched water bodies is not considered nor even mentioned. That scenario is a roughly-estimated 10,000 acre-feet of condensing water vapor displaced from the repository host rock forming perched water bodies surrounding the repository, with local plugging of pores and fractures resulting from the boiling off of the vadose and precipitation of mineral salts during refluxing. Furthermore, existing perched water bodies at the site will <u>not be satisfactorily evaluated</u> because DOE plans to only look for these near the two exploratory shafts.

REVIEWER: D. L. Shettel, Jr. D. L. Shettel Jr. Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 02 July 1989

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COMMENT #: 286	CHAPTER/SECTION: 8.3.5.17 NRC Siting Criteria

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.5.17-89	PAC 24: Potential for the movement of radionuclides in a gaseous state through air-filled pore spaces on unsaturated geologic medium to the accessible environment of an unsaturated geologic medium to the accessible environment. This resolution strategy fails to deal with other radionuclides (not just C-14). Additional radionuclides of greater inventory may be released in gaseous phase. In addition, the site-specific data collection in part of the program (8.3.1.2.2.3) is inadequate to resolve the rate of release at the site.

REVIEWER: M. D. Mifflin Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 02 July 1989

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COMMENT #: 287	CHAPTER/SECTION: 8.3.5.17 NRC Siting Criteria

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8.3.5.17-95	FC 8: For disposal in the unsaturated zone, hydrogeologic conditions...etc. The site-specific data collection-programs may not establish, with confidence, the first four of the five criteria. The fifth is already known.

REVIEWER: M. D. Mifflin Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 03 July 1989

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NEVADA NUCLEAR WASTE PROJECT OFFICE
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COMMENT #: 288	CHAPTER/SECTION: References

SUBSECTION, PAGE #, PARAGRAPH(S) # LINE(S) #, PLATE #, FIGURE #, TABLE #, GRAPH #, MAP#.	COMMENT:
Page 8R-43	Ross, 1985, as used in Total System Performance, p. 8.3.5.13-19, is not given in the references.

REVIEWER: M. D. Mifflin Signature	ORGANIZATION: Mifflin & Associates, Inc. DATE: 02 July 1989

MY890703a

COMMENTS OF

DIVISION OF EARTH SCIENCES,

ENVIRONMENTAL RESEARCH CENTER,

UNIVERSITY OF NEVADA - LAS VEGAS

GEOTHERMAL EVALUATION AND ANALYSIS OF THE YUCCA MOUNTAIN REPOSITORY, NEVADA

PREPARED BY

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AGENCY FOR NUCLEAR PROJECTS
NUCLEAR WASTE PROJECT OFFICE
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UNDER INTERLOCAL AGREEMENT
DATED - JUNE 17, 1988

AUTHORS:

Dennis T. Trexler - Principal Investigator
Joe M. Ratliff - Research Associate

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JUL 21 1989
NUCLEAR WASTE PROJECT OFFICE

III. SCP SECTIONS ADDRESSED BY DIVISION OF EARTH SCIENCES

1.3.2.1.2	Late Miocene to Holocene Volcanism
1.3.2.2.2	Structures and Structural History of Yucca Mountain
1.3.2.5.1	In Situ Temperatures in the southern Great Basin
1.3.2.5.2	In Situ Temperatures at Yucca Mountain
1.3.2.5.4	Relationship to Tectonics and Energy Resource Extraction
1.4.1.3	Determination of Earthquake-generating Potential of Geologic Structures and Seismotectonic Zones within the southern Great Basin
1.6.1.1	Summary of Drilling Activity
1.6.2.2.4	Temperature Logs
1.7	Mineral and Hydrocarbon Resources
1.7.1.5.2	Geothermal Resources
1.8.1.1	Geomorphology
1.8.1.3	Structural Geology and Tectonics
1.8.1.3.2	Discussion of Significant Results
1.8.1.5.1	Significant Results <u>Volcanic Hazards</u>
1.8.1.7	Mineral and Hydrocarbon Resources
1.8.3.3.5	Geothermal Regime
3.8.1.5	Water Use for Energy Development
3.9.4.2	Groundwater Travel Time in the Unsaturated Zone
8.3.1.2.3	Characterization Of Regional Groundwater Flow Systems
8.3.1.2.1.3.3	Fortymile Wash Recharge Study

8.3.1.2.2	Investigation: Studies to Provide a Description of the Unsaturated Zone Hydrologic System at the Site
8.3.1.8.1.1.8	Activity: Presence of Magma Bodies in the Vicinity of the Site
8.3.1.8.3.2.1	Activity: Thermal and Barrier-to-Flow Effects of Igneous Intrusions on Watertable Elevation
8.3.1.8.5.2.1	Activity: Evaluation of Depth of Curie Temperature Isotherm
8.3.1.9.2.1	Study: Natural Resource Assessment of Yucca Mountain, Nye County, Nevada
8.3.1.9.2.1.3	Activity: Assessment of the Potential for Geothermal Energy at Yucca Mountain, Nevada
8.7.3	Plans for Mitigation of any Significant Adverse Impacts Caused by Site Characterization Activities

IV. SPECIFIC COMMENTS

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	VOLUME	CHAPTER	COMMENT NO.
Late Miocene to Holocene Volcanism	I Part A	1	1

SEC. NO. PAGE NO.	SCP STATEMENT
1.3.2.1.2 1-99	According to Wells et al. (1988) and Crowe et al. (1988), comparison of the geomorphic characteristic of the cone with dated cones in the Cima volcanic field indicate that the age of the cone could be approximately 14,000 yr. Planned studies (Section 8.3.1.8.1) will refine the dating of such young basalts, because the dating may be important in preparing postclosure release scenarios.

COMMENT

Even though probability estimates of potential volcanic activity are low, the relatively young age of the Lathrop Wells Cinder Cone indicates there is a potential for renewed basaltic volcanism during the proposed life-span of the repository. Furthermore, aside from the possible damage to the repository and subsequent release of radionuclides, such an occurrence could alter the hydrologic, geothermal and fault/fracture characteristics of the site.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Joe M Rattliff	3/2/89	Dennis J. Lucas	3/16/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	Structures and structural history of Yucca Mountain	VOLUME I Part A	CHAPTER 1	COMMENT NO. 2

SEC. NO. PAGE NO.	SCP STATEMENT
1.3.2.2.2 1-133	The history of movement on the faults in Yucca Mountain has been complex. Data from stratigraphic offsets are not yet available to define the sense of movement on most faults in the Yucca Mountain area.
	COMMENT
	Due to the numerous faults and lineaments within the site area, and the historical data, some investigators have stated the potential exists for renewed movement and that certain faults may be near failure (Healy et al., 1988, Carr, 1984). Predicting when this may occur, is very difficult, if not impossible. Given a scenario where the repository may incur little or no damage from renewed fault displacement, other significant conditions may result. These could include changes in fracture conditions, geothermal activity, and the hydrologic regime. Future fault movements, and subsequent fracturing, could have significant effects on flow paths of geothermally heated water and vapor, and the relative ease or difficulty of accessibility for development.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Joe M. Rattlff	3/2/89	Dennis L. Tuttle	3/16/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	VOLUME	CHAPTER	COMMENT NO.
Structures and structural history of Yucca Mountain	I Part A	1	3

SEC. NO. PAGE NO.	SCP STATEMENT
1.3.2.2.2 1-135	Fractures are of particular importance either as barriers or as conduits for the flow of ground water. (Section 3.7).

COMMENT
Fractures are also very important as pathways for geothermally heated water and vapor to the surface. Future fracturing may result from a number of causative factors (i.e. seismic activity, volcanism, nuclear testing), and in turn, have potential significant effects on potential geothermal resources development and accessibility.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Joe M. Ratliff	3/10/89	Dennis J. Stephen	3/16/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	VOLUME	CHAPTER	COMMENT NO.
In situ temperature in the southern Great Basin	I Part A	1	4

SEC. NO. PAGE NO.	SCP STATEMENT
1.3.2.5.1 1-148	However, the area north of and adjacent to Yucca Mountain has a lower than average heat flow and has been termed the Eureka Low by Lachenbrach and Sass (1977) and Sass et al. (1971).

COMMENT

In a more recent study Sass et al. (1988) have placed Yucca Mountain in an extension of the Eureka Low. The SCP interpretation is modified by the following statement from Sass et al. (1988), "It could as easily have been contoured as an isolated thermal sink with then-existing heat-flow data". For either interpretation, the tectonic implications of the heat-flow data are largely inconclusive, inasmuch as the true regional heat flow is obscured by hydrologic processes.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Dennis L. Siefkin	3/23/89	Joe M. Nattleff	3/24/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	VOLUME	CHAPTER	COMMENT NO.
In Situ Temperatures at Yucca Mountain	I Part A	1	5

SEC. NO. PAGE NO.	SCP STATEMENT
1.3.2.5.2 1-148	In situ temperatures before waste emplacement can be derived from the data reported by Sass and Lachenbruch (1982)...

COMMENT
Using new data of Sass et al. (1988), temperatures as low as 22°C are not observed at 300 m in any hole used in that study. The SCP should incorporate most recent data available for design rationale.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Dennis J. Fugle	3/22/89	Joe W. Bartlett	3/24/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	VOLUME	CHAPTER	COMMENT NO.
In Situ Temperatures at Yucca Mountain	I Part A	1	6

SEC. NO. PAGE NO.	SCP STATEMENT
1.3.2.5.2 1-148	As in the Eureka low, heat flow appears to be reduced by downward-water movement. Even in the unsaturated zone, low heat flow may result from the lower thermal gradients caused by two-phase (vapor and liquid) water flow (Sass and Lachenbruch, 1982).

COMMENT

In a more recent study (Temperature, thermal conductivity, and heat flow near Yucca Mountain, Nevada: Some tectonic and hydrologic implications. Sass et al., 1988) state the quality of the presently available data set does not allow an unambiguous interpretation of heat-flow data from either the UZ or the SZ. The authors feel that the ambiguities will be resolved only by completing some of the planned wells with access pipes grouted into place, and with water-filled pipes (with annulus grouted) to evaluate the thermal state of the UZ. We feel this is a valid recommendation, based on the inconclusive evidence and data on heat-flow and thermal-gradients at Yucca Mountain.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Joe M. Hatchiff	3/22/89	Dennis J. Stoffler	3/27/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	VOLUME	CHAPTER	COMMENT NO.
Relationship to tectonics and energy resource extraction	I Part A	1	7

SEC. NO. PAGE NO.	SCP STATEMENT
1.3.2.5.4 1-150	The high heat flow that is characteristic of the Basin and Range Province, but that may be masked by groundwater flow of the Eureka low and adjoining areas that include Yucca Mountain, is discussed in detail in Section 1.7.1.4.2.

COMMENT

Section No. 1.7.1.4.2, should be changed to 1.7.1.5.2

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Joe M. Dorfliff	3/22/89	Donna J. Lufkin	3/27/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	Relationship to tectonics and energy resource extraction	VOLUME I Part A	CHAPTER 1	COMMENT NO. 8

SEC. NO. PAGE NO.	SCP STATEMENT
1.3.2.5.4 1-150	Regions of high heat flow have potential for geothermal energy production. However, the inferred downward flow of water in the Yucca Mountain region (Sections 1.3.2.5.1 and 1.3.2.5.2) and low temperature down-hole measurements (Section 1.7.1.4.2) indicate little low-temperature geothermal potential.

COMMENT

Heat-flow measurements to date do not provide consistent data indicating downward vertical flow. On the contrary, current data indicate there is a strong potential for a net vertical upflow from the Paleozoic carbonate aquifer (Sass et al. 1988). Robinson (1984) also reports significant hydraulic potentials for upward flow at USW H1, USW H3 and UE25pl.Some of the drill holes have not been constructed properly,that is with the annulus between access casing and borehole wall completely sealed off by grout, filled with water, and drilled preferably in intrusive rocks to at least several hundred meters.It seems apparent that additional testing is required in properly constructed drill holes in order to establish more confidence in the data.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Joe M. Ratliff	3/23/89	Dennis J. Stephens	3/27/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	VOLUME	CHAPTER	COMMENT NO.
Determination of earthquake-generating potential of geologic structures and seismotectonic zones within the southern Great Basin	I Part A	1	9

SEC. NO. PAGE NO.	SCP STATEMENT
1.4.1.3 1-187	Currently, there is a large uncertainty in the assessment of the earthquake potential of geologic structures and seismotectonic zones in the southern Great Basin... Consequently, there is potential (although currently unquantified) for movement on north-striking faults near Yucca Mountain, despite the current quiescence of the area.

COMMENT

There are a number of faults and lineaments, some of them north-striking, near the proposed repository site. Historically, the area has been seismically active. Future earthquakes of moderate to large magnitude could have significant effects on such factors as water table elevations and hydrothermal activity, not to mention the structural integrity of the proposed repository.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Jon M. Rathjll	3/23/89	Dennis J. Trapp	3/27/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	VOLUME	CHAPTER	COMMENT NO.
Summary of Drilling Activity	I Part A	1	10

SEC. NO. PAGE NO.	SCP STATEMENT
1.6.1.1 1-216	A total of 182 vertical and angle holes have been drilled within 10 km of the perimeter drift and outside of the perimeter drift. Of the 182 holes, 37 have been drilled inside the perimeter drift.

COMMENT

Of the 37 holes within the perimeter drift only 4 are deeper than 2000 feet. These are USW H-5 (4,000 ft), USW G-1 (2,995 ft), USW H-4 (4,000 ft) and USW WT-2 (2,040 ft). All of these holes plus UE-25a#6 (500 ft) were used by Sass et al. (1988) in the report on thermal gradients.

Of the 145 holes outside the drift, but within 10 km, only 17 have depths greater than 2,000 ft. Sass et al. (1988) used 29 of these wells and only 15 had depths greater than 2,000 ft. Two-thousand feet has typically been the industry standard for temperature gradient holes used in exploration programs.

The deepest hole drilled as part of the Yucca Mountain Project (USW G-2) was drilled to a depth of 6006 feet and did not intercept the deep carbonate aquifer. Only one hole drilled for this project, UE-25pl, has penetrated the deep carbonate aquifer. We do not believe that one hole in the entire study area, (i.e. 10 km from the perimeter drift) provides sufficient data on thermal gradients, heat flows, and groundwater flow, both vertically and horizontally, beneath Yucca Mountain.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Dennis L. Hoplin	4/6/89	Joe M. Rattiff	4/7/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	VOLUME	CHAPTER	COMMENT NO.
Temperature Logs	I Part A	1	11

SEC. NO. PAGE NO.	SCP STATEMENT
1.6.2.2.4 1-246	Description of temperature logging apparatus.

COMMENT

Based on TABLE 1-14 (Drill Holes Within the Outline of the Perimeter Drift) only 3 wells of the 37 that were drilled had temperature measurements. Similarly, of the 145 drill- holes within 10km of the perimeter drift, only 10 had temperature logs run, based on TABLE 1-15.

Temperature logs are one of the least expensive logging techniques and should be routinely run as part of any detailed geophysical logging program.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Dennis J. Triplett	4/6/87	Jon M. Ratliff	4/7/87

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	Mineral and Hydrocarbon Resources	VOLUME I Part A	CHAPTER 1	COMMENT NO. 12

SEC. NO. PAGE NO.	SCP STATEMENT
1.7 1-257	Exploration and production techniques that could affect a repository include drilling and the extraction of subsurface materials to produce the commodity being sought. Thus, a desirable quality of a repository site is that it does not attract the type of resource exploration that would lead to drilling, or have the resource potential that would lead to extraction.

COMMENT

A definitive answer to the lack of an economic commodity (i.e. geothermal) cannot be ruled out until deep drilling has been performed which indicates the absence or presence of a resource of potential economic importance.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Joe M. Rathoff	4/13/89	Dennis J. Lupton	4/6/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	VOLUME	CHAPTER	COMMENT NO.
Geothermal Resources	I Part A	1	13

SEC. NO. PAGE NO.	SCP STATEMENT
1.7.1.5.2 1-305	The short exploitation history of hydrothermal resources (White et al., 1971) leads to the difficult problem of assessing the future potential of hydrothermal resources and reserves.

COMMENT

The reference to White et al. (1971) certainly dates this statement since there has been 18 years of hydrothermal resource development since the cited reference was published.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Joe M. Dorthoff	4/13/89	Dennis J. Stephen	4/6/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	Geothermal Resources	VOLUME I Part A	CHAPTER 1	COMMENT NO. 14

SEC. NO. PAGE NO.	SCP STATEMENT
1.7.1.5.2 1-305	Classification of thermal reservoirs into 1) high-temperature systems, greater than 150°C; 2) intermediate-temperature systems, 90 to 150°C; and 3) low-temperature systems, less than 90°C. These thermal regimes correspond to potential uses of 1) high-temperature systems provide steam used in the generation of electrical power, 2) intermediate-temperature systems provide the heat used in various industrial processes (Brook et al., 1979), and 3) low-temperature systems are potentially available for space heating and agriculture (Samuel, 1979).

COMMENT

The first geothermal electric generation facility in Nevada uses a 108°C (226°F) resource temperature. The plant started production at Wabuska (Tad's Enterprises) in 1984. This would indicate the rapid advancements in technology which are not referenced in Brook et al. (1979), where intermediate resource temperatures are only suitable for industrial process heat. Additionally, stating that low temperature resources (i.e. less than 90°C) are only useful for space heating and agriculture is erroneous. Currently, Round Mountain Gold Mine is using 86°C (186°F) geothermal fluids in flat-plate heat exchangers to raise the temperature of the cyanide process steam. These are 2 examples of the fallacy of using old and outmoded classification schemes and certainly indicate the rapid technological changes within the last 10 years. The major questions revolve around what technological advances will take place in the next 10,000 years? The reference Samuel (1979) is incorrect, it should be Sammel (1979).

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Jac M. Bartlett	4/14/89	Dennis J. Stoller	4/6/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	Geothermal Resources-Geothermal Systems in Nevada and in the Vicinity of Yucca Mountain	VOLUME I Part A	CHAPTER 1	COMMENT NO. 15

SEC. NO. PAGE NO.	SCP STATEMENT
1.7.1.5.2 1-306	More than 300 thermal springs, spring clusters, and thermal wells occur throughout the state of Nevada (Garside and Schilling, 1979).
	COMMENT
	More recent data of Trexler et al. (1983) show more than 900 thermal springs and hot wells in a newer version of the 1979 map referenced in the SCP, and Garside and Schilling (1979). Once again, the SCP does not incorporate the most recent data available.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Joe M. Bartlett	4/5/89	Dennis J. Tiefler	4/6/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	Geothermal Resources-Geothermal Systems in Nevada and in the Vicinity of Yucca Mountain	VOLUME I Part A	CHAPTER 1	COMMENT NO. 16

SEC. NO. PAGE NO.	SCP STATEMENT
1.7.1.5.2 1-306	The hottest surface temperatures encountered are at Beowawe(25 to 212°), Brady (70 to 214°), Desert Peak (199 to 208°), and Steamboat Hot Springs (21 to 187°) (Garside and Schilling, 1979). These sites have been or are being investigated for electric power generation.
	COMMENT
	Three of the four sites mentioned have been producing electricity from geothermal power since 1985.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Joe M. Hartleff	4/7/89	Dennis J. Trexler	4/10/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	Geothermal Resources-Geothermal Systems in Nevada and in the Vicinity of Yucca Mountain	VOLUME I Part A	CHAPTER 1	COMMENT NO. 17

SEC. NO. PAGE NO.	SCP STATEMENT
1.7.1.5.2 1-306	Drillhole (UE-20f, located at Pahute Mesa) and having a maximum temperature of 125°C at a depth of nearly 3,700m.

COMMENT

To disregard any potential for a geothermal resource at Yucca Mountain is not warranted when temperatures of 125°C can be found in a well 12,140 ft deep, 48 km north of the site. Furthermore, the deepest well drilled at the site is only 6,006 feet.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
[illegible]	4/17/89	Dennis J. [illegible]	4/19/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	VOLUME	CHAPTER	COMMENT NO.
Geothermal Resources	I Part A	1	18

SEC. NO. PAGE NO.	SCP STATEMENT
1.7.1.5.2 1-311	Further evaluation and work on existing heat flow, temperature gradient data, and the timing of the measurement taken in comparison to drilling are planned, and the need for new data will be considered (Sections 8.3.1.2, 8.3.1.8, and 8.3.1.9). These activities and data collected will be used to assess various models for geothermal areas proposed for the Basin and Range (e.g., Blackwell and Chapman, 1977) in comparison to Yucca Mountain.

COMMENT

Is the SCP referring to past drilling activities or future drillhole construction (i.e.... timing of measurement taken in comparison to drilling...)? Inconsistencies in existing heat flow and temperature gradient data will make the utilization of models very difficult and subject to question.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Joe M Batliff	4/7/89	Dennis L. Saylor	4/10/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	Geothermal Resources	VOLUME I Part A	CHAPTER 1	COMMENT NO. 19

SEC. NO. PAGE NO.	SCP STATEMENT
1.7.1.5.2 1-313	It is concluded using the classification scheme of Muffler and Guffanty (1979), that because of their thermal condition, waters at Yucca Mountain are potential resources for space heating and some agriculture uses. However, Yucca Mountain is not currently considered a geothermal resource area because.....

COMMENT

Numerous geothermal wells and springs now exist in the Yucca Mountain region. They range from approximately 20° to 65°C. This temperature realm is now being utilized in Nevada in balneology (hot baths), aquaculture (production of fish and other aquatic species), agriculture (production of vegetables and ornamentals, and plant dehydration), and enhancement of cyanide heap-leaching for the extraction of gold and silver. Nevada is currently second only to California in geothermal utilization. Furthermore, over the next 10,000 years it will be very difficult to accurately predict human requirements, technological advancements, man's activities in and around the project site, climatic changes, and tectonic, seismic and volcanic activity. All of these factors could affect geothermal resource utilization in the project region.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Joe M. Whitney	4/11/89	Dennis J. Taylor	4/13/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	VOLUME	CHAPTER	COMMENT NO.
Geomorphology	I Part A	1	20

SEC. NO. PAGE NO.	SCP STATEMENT
1.8.1.1 1-324	During the next 10,000 yrs, the present warm, dry climate is likely to change little; the climate of the region probably remained semiarid even during Pleistocene continental glaciation, and periglacial processes were probably not significant.

COMMENT

A warming trend, caused primarily by heavier concentrations of CO_2 in the atmosphere, could possibly create major climatic changes in the next 10,000 years (i.e. melting at polar regions, heavier precipitation, higher water tables, higher average temperature). Such climatic alterations could have major effects on the surface and subsurface hydrological conditions in the Yucca Mountain region, and consequently on the repository.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Joe M. Bartlett	4/12/89	Dennis J. Trexler	4/13/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	VOLUME	CHAPTER	COMMENT NO.
Structural geology and tectonics	I Part A	1	21

SEC. NO. PAGE NO.	SCP STATEMENT
1.8.1.3 1-328	Local volcanic activity probably last occurred less than 0.3 million years ago; however, the dating method may have uncertainty ranges of several hundred thousand years (Sinnock and Easterling, 1983).

COMMENT

Such large uncertainty ranges are unacceptable. These imply that basaltic volcanic activity could occur in the region during the next 10,000 years. This subject deserves serious further evaluation (See Wells et al., 1988, A Geomorphic Assessment of Quaternary Volcanism in the Yucca Mountain Area, Nevada Test Site, Southern Nevada and Crowe et al., 1988, Volcanic Hazard Assessment for Storage of High-Level Radioactive Waste at Yucca Mountain, Nevada.)

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Joe M. Hartley	4/13/89	Dennis J. Tiegler	4/13/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	Structural geology and tectonics (geothermal regime)	VOLUME I Part A	CHAPTER 1	COMMENT NO. 22

SEC. NO. PAGE NO.	SCP STATEMENT
1.8.1.3 1-333	Assuming its depth to be about 300 m, expected ambient preemplacement temperatures for the repository are estimated to range from 21 to 30°C.

COMMENT

In Section No. 1.3.2.5.2 the SCP states that "Ambient Temperatures at that depth [300m] range from about 24 to 22°C (in drillhole USW GU-3, USW G-3 and USW H-5) to about 30°C (drillholes UE-25pl and J-13)". More recent work by Sass et al. (1988) indicate a temperature of 27°C in USW G-3. Previous sections of the SCP have not used minimum temperatures at 300m as low as 21°C. Using an ambient preemplacememt temperature of 21°C, when actual temperatures are more like 27°C would be a major flaw.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Dennis J. Stefler	3/1/89	Joe M. Dorthy	5/4/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	VOLUME	CHAPTER	COMMENT NO.
Structural geology and tectonics (Geothermal Regime)	I Part A	1	23

SEC. NO. PAGE NO.	SCP STATEMENT
1.8.1.3 1-333	The low heat flow values in the Yucca Mountain area imply that there is little local geothermal potential there. Locations in the Amargosa Desert, Sarcobatus Flat - Beatty areas and west of Goldfield have been considered favorable for geothermal development of low-temperature water, but development of such resources would almost certainly not affect the performance of the repository.

COMMENT

One of the more important parameters for placement of the repository in the unsaturated zone (UZ), is the assumption that lateral flows in the saturated zone (SZ) help to conduct heat out of the (UZ). Lateral groundwater flows in the (SZ) are believed to move from east to west under Yucca Mountain, with discharge areas in the southern Amargosa Desert (SCP, Section 3.7.1.1). Under these assumed conditions, possible future development of low-temperature geothermal resources in the Amargosa Desert/Sarcobatus Flats Areas could possibly alter the hydrologic and thermal regimes of the region and affect the performance characteristics of the repository.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Joe M. Rathliff	4/12/89	Dennis J. Stoffler	5/1/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	Discussion of significant results	VOLUME I Part A	CHAPTER 1	COMMENT NO. 24

SEC. NO. PAGE NO.	SCP STATEMENT
1.8.1.3.2 1-334	For the geothermal regime, a range of pre-waste-emplacement ambient temperatures has been estimated from drillhole-temperature profiles at Yucca Mountain. An important data requirement will be the continued gathering of subsurface temperature and thermal conductivity data in future drillholes and core samples, including those in the exploratory shaft.

COMMENT

As pointed out in a previous comment (p. 1-333) there is a discrepancy in the range of ambient temperatures estimated from drillholes. It is stated (above) that an important data requirement is continued gathering of subsurface temperatures. Subsurface temperatures will be taken in what drillhole locations and will the holes be properly constructed to provide useful temperature data (i.e. grouted casing, etc.)?

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Joe M. Nattlip	4/27/89	Dennis J. Triglia	5/1/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	VOLUME	CHAPTER	COMMENT NO.
Significant results Volcanic hazard	I Part A	1	25

SEC. NO. PAGE NO.	SCP STATEMENT
1.8.1.5.1 1-337	A principal hazard from basaltic volcanism would be the intersection of ascending magma with the repository, the incorporation of radioactive waste into the magma, and the dispersal of waste during a subsequent eruption...Potential radiation doses to those living in the area or in houses built of materials from such eruptions would be a few millirems, for an eruption occurring within 100 yr. of emplacement and less for a later eruption.

COMMENT

How were these radiation doses arrived at? A few millirems is a general and subjective term. More precise estimates of potential radioactive contamination of geologic materials (i.e. magma, rock, soil, ash), geothermal waters, and groundwater should be made. Contamination of water in the (SZ) could possibly have significant effects on future water usage (i.e. domestic, agriculture, commercial). Also, radionuclides entering the geothermal systems could reach the surface via springs and wells.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Joe III Hoffman	5/8/89	Dennis J. Trexler	5/11/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	Mineral and Hydrocarbon Resources	VOLUME I Part A	CHAPTER 1	COMMENT NO. 26

SEC. NO. PAGE NO.	SCP STATEMENT
1.8.1.7 1-341	The geothermal resources (section 1.7.1.5.2) at the site are classified as low-temperature (<90°C) resources located at depths greater than 1 km.

COMMENT

Recent advances in technology have provided applications for low-temperature resources not anticipated by Muffler and Guffanty (1979) (see section 1.7.1.5.2). Mineral processing using cyanidation is presently being performed at Round Mountain Gold Corporation using 86°C geothermal fluids. With the potential for previous metal deposits in the Bare Mountain Area west of Yucca Mountain, the geothermal resources beneath Yucca Mountain may become important in the future.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Joe M. Hattoff	5/8/89	Dennis J. Sutler	5/11/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	VOLUME	CHAPTER	COMMENT NO.
Geothermal Regime	I Part A	1	27

SEC. NO. PAGE NO.	SCP STATEMENT
1.8.3.3.5 1-351	Ongoing work includes the construction of cross sections based on existing drillholes at Yucca Mountain, showing temperature distribution using isothermal lines; and heat-flow calculations for the drillholes, including the WT (water table) series.

COMMENT

The ongoing work described has been completed and reported by Sass et al. (1988). I see no reason why this data was not incorporated into the SCP since many other 1988 references were cited, such as:

Vanieman et al., 1988

Veal, H.K., H.D. Duey, L.C. Bortz, and N.H. Foster, 1988a. "Grant Canyon and Bacon Flat Oil Fields", Railroad Valley, Nye County, Nevada, "Oil and Gas Journal, Vol. 86, No. 13, pp. 67-70.

Veal, H.K., H.D. Duey, L.C. Bortz, and N.H. Foster, 1988b. "Basin and Range May Hold More Big Fields", Oil and Gas Journal, Vol. 86, No. 13, pp. 56-59.

These references were cited on page 1R-50(References Section).

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Dennis J. Snyder	5/11/89	Joe M. Hoffman	5/15/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	VOLUME	CHAPTER	COMMENT NO.
Water Use for Energy Development	II Part A	3	28

SEC. NO. PAGE NO.	SCP STATEMENT
3.8.1.5 3-133	Current technology requires reservoir temperatures of at least 180°C for commercial power generation (White, 1973).

COMMENT

The first geothermal facility to produce electricity in Nevada uses 108°C geothermal fluids. A plant was also constructed in the San Emidio Desert in 1987 that uses 138°C fluids to produce electrical power. Once again, the SCP used old, outdated references as current technology.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Dennis J. Lybbe	5/11/89	Joe M. Dudley	5/15/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	Groundwater Travel Time in the Unsaturated Zone	VOLUME II Part A	CHAPTER 3	COMMENT NO. 29

SEC. NO. PAGE NO.	SCP STATEMENT
3.9.4.2 3-219	Table 3-31 summary of unsaturated zone travel time for vertical flux of 0.5mm/yr. Travel Path Travel Time Minimum 9,345 Mean 43,265 Maximum 80,095

COMMENT

Downward infiltration rates calculated by Sass et al., (1988) are 2 - 5mm/yr for the UZ. Also, Sass and Lachenbruch, 1982 state "Measurements in wells deeper than 1 km suggest a downward water movement with seepage velocity on the order of 1 - 10mm/yr." These discrepancies in vertical velocities calculated from hydrologic considerations and by heat flow must be reconciled.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Dennis J. Trexler	5/11/89	Joe M Bartlett	5/16/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	VOLUME	CHAPTER	COMMENT NO.
Natural Analogs- Warm and Hot Springs	II Part A	4	30

SEC. NO. PAGE NO.	SCP STATEMENT
4.3.1.1 4-130	Warm and hot springs are present in tuffaceous rocks at many locations in the western United States. Several locations have been studied in detail, including (1) the geyser basins in Yellowstone National Park...(2) the Valles Caldera in northern New Mexico... and (3) the Newberry Volcano in central Oregon.

COMMENT

Much discussion ensues about work that has been performed at Yellowstone and its application to Yucca Mountain. However, none of the sites listed above are located in the Great Basin and all are high-temperature geothermal resources.

It would certainly be of more value to have an analog that more closely represents the temperature regime and fluid chemistries at Yucca Mountain, rather than data from Yellowstone to use in geochemistry models.

A site which more closely meets the criteria of 1) being located in the Great Basin, 2) having tuffaceous rocks, 3) having geothermal fluid chemistries that more closely resemble fluids at Yucca Mountain and 4) has temperatures in the low to moderate range is the Darrough Hot Springs - Round Mountain Gold mine area. These sites are marginal to the Mt. Jefferson caldera in the Toquima Range, Nye County, Nevada. Although the U.S. Geological Survey has not performed extensive studies on alteration at Darrough Hot Springs, the Round Mountain Gold Mine has been studied and was used as an example in Section (1.7.1.2.2) - Epithermal volcanic associated gold, silver, and base metal deposits and occurrences in the vicinity of Yucca Mountain.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Dennis S. Trask	5/18/89	Joe M. Rhetts	5/19/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	Characterization of Regional Groundwater Flow Systems	VOLUME IV Part B	CHAPTER 8	COMMENT NO. 31

SEC. NO. PAGE NO.	SCP STATEMENT
8.3.1.2.3 8.3.1.2-116	Although these boreholes would greatly augment existing hydrogeologic data for the regional flow system, no drillholes have been constructed to penetrate and test Paleozoic hydrogeologic units (probably carbonate rocks) underlying Tertiary basin fill at estimated depths as great as 6,000 ft. (1,800 m) in the Amargosa Desert.

COMMENT

We feel that strong consideration should be given to constructing one or more deep boreholes (into the deep Paleozoic units) in the Amargosa Desert area. Furthermore, we recommend that data should be acquired on heat-flows, temperature and thermal-conductivity from new holes. From a regional point of view, it should be stressed that new heat-flow data should be taken whenever possible, even if this would necessitate the reconfiguration or modification of existing drillholes.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Joe M. Rutlin	5/16/89	Dennis J. Saylor	5/19/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	VOLUME	CHAPTER	COMMENT NO.
Fortymile wash recharge study	IV Part B	8	32

SEC. NO. PAGE NO.	SCP STATEMENT
8.3.1.2.1.3.3 8.3.1.2-127	Three drill holes (UE-25 FM#1, UE-25 FM#2 and UE-25 FM#3) will be drilled into the saturated zone to obtain unsaturated-zone moisture samples and saturated-zone water samples to determine the recharge history.

COMMENT

Will these drillholes be constructed with grouting between the annulus and casing? A number of investigators (Sass, et al. 1982, Robinson, 1984, etc.) have expressed concerns over the validity of hydrologic and thermal-gradient data obtained from existing wells which were not constructed in this manner.Are three wells adequate? The unsaturated and saturated-zone hydrologic conditions at Yucca Mountain are very complicated. It seems justified that additional deep drillholes should be placed in a network which not only will measure recharge rates, but verification of northeast to southwest lateral flows in the (SZ). Furthermore, such a net may also allow more meaningful, accurate heat-flow measurements.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Joe M. Ratliff	5/16/89	Dennis J. Triplett	5/18/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIINCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	VOLUME	CHAPTER	COMMENT NO.
Investigation: Studies to provide a description of the unsaturated zone hydrologic system at the site	IV Part B	8	33

SEC. NO. PAGE NO.	SCP STATEMENT
8.3.1.2.2 1-151	Although the general conditions just described probably exist, details of the hydrologic processes, conditions and properties in the unsaturated zone are poorly known. For this purpose, the unsaturated zone system at Yucca Mountain was divided into the infiltration boundary and the percolation region. Each component of the system will be studied by multidisciplinary approaches... to describe the spatial and temporal distributions of the flux and travel times within this system.

COMMENT

To adequately assess the unsaturated zone hydrologic system, proposed studies should be conducted over a time frame of more than just a few years. Precipitation, infiltration and other meteorological parameters vary yearly, thus affecting rates of recharge and discharge. The slow movement of moisture in the unsaturated zone also should require longer observation periods.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Gene M. Ward-Neff	5/17/89	Dennis J. Stephen	5/18/89

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TECHNICAL REVIEW COMMENT FORM

SUBJECT	VOLUME	CHAPTER	COMMENT NO.
Activity: Presence of magma bodies in the vicinity of the site	V Part B	8	34

SEC. NO. PAGE NO.	SCP STATEMENT
8.3.1.8.1.1.3 8.3.1.8-55	As noted in Chapter 1 (Section 1.5.1.1), an absence of shallow silicic magma bodies beneath the Yucca Mountain area is suggested by the low heat flow and absence of high temperature springs.

COMMENT

The lower than average heat flow at Yucca Mountain is presumably due to the transport of heat laterally away from the site by groundwater flow in the Paleozoic carbonates. Until such time when a drillhole penetrates the carbonates the presence or absence of a silicic magma body cannot be determined. The deep geophysical surveys proposed to augment this activity will not definitely resolve the question of the presence of magma bodies beneath the site.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Joe M. Hattig	5/17/89	Dennis J. Stephen	5/18/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	Activity: Thermal and Barrier-To-Flow Effects of Igneous Intrusions on Water-Table Elevation	VOLUME V Part B	CHAPTER 8	COMMENT NO. 35

SEC. NO. PAGE NO.	SCP STATEMENT
8.3.1.8.3.2.1 8.3.1.8-88	The parameters for this activity are models for predicting the effects of igneous intrusions on water-table levels. The data requirements supporting the modeling efforts and the relationship of the requirements to the data gathering activities that will support this activity are shown on Figure 8.3.1.8-6.

COMMENT

The key data gathering activity for thermal and barrier to flow effect of magma bodies is Activity 8.3.1.8.1.1.3 (Presence of magma bodies in vicinity of site, Figure 8.3.1.8-6). This figure indicates that the data required to satisfy the key data gathering activity is heat flow. If heat flow is calculated from temperatures measured in drill holes that are not completed specifically for temperature measurements then the heat flow values will be of questionable value, thus making the results of the final assessment activity 8.3.1.3.2.2 (Assessment of the effects of igneous intrusions on water-table elevations) suspect.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Joe M. Ratliff	5/15/89	Dennis L. Hoover	5/15/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	Activity: Evaluation of depth of curie temperature isotherm	VOLUME V Part B	CHAPTER 8	COMMENT NO. 36

SEC. NO. PAGE NO.	SCP STATEMENT
8.3.1.8.5.2. 8.3.1.8-124	The objective of this activity is to determine the depth of the curie temperature isotherm by analyses of existing magnetic survey data.

COMMENT

Detailed determinations of the "Curie-point" for the Yucca Mountain region, while interesting, will do little at this time to solve the question of the thermal character, given the nature of the assumptions and the fact that the smaller the area, the more difficult the technique is to apply. Furthermore, the correlation of "Curie-point" with heat flow has not been established for a complicated geologic, tectonic, and thermal regime like the Basin Range province. These considerations suggest that a detailed study of the correlation of heat flow to "Curie-point," and new determinations of heat flow values in deep bore holes which might be below shallow disturbances, are required to establish the thermal significance of any depth to "Curie-point" map which might be produced.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
David D. Blackwell	5/9/89	Dennis J. Stuckless	5/18/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	VOLUME	CHAPTER	COMMENT NO.
Study: Natural Resource Assessment of Yucca Mountain, Nye County, Nevada	V Part B	8	37

SEC. NO. PAGE NO.	SCP STATEMENT
8.3.1.9.2.1 8.3.1.9-27	Several types of geothermal reservoirs will be evaluated, including thermal water reservoirs resulting from (1) deep basin circulation, (2) hot-dry rock, or (3) igneous activity.

COMMENT

Hot-dry rock is considered a separate geothermal resource type and as the name implies, no fluids are associated with this type of resource. In fact, the SCP (section 1.7.1.5.2, page 1-305) describes two models in which thermal waters are generated from (1) areas of deep-seated regional high heat flow that form hydrothermal conductive systems which may be aided by convection (Renner et al., 1975; Brook et al., 1979) and (2) igneous related hydrothermal systems where cooling high-level silicic or mafic magma bodies provide the energy for high heat flow (Smith and Shaw, 1975, 1979).

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Dennis J. Stoeglin	5/12/89	Joe M. Devine	5/12/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	Study: Natural Resource Assessment of Yucca Mountain, Nye County, Nevada	VOLUME V Part B	CHAPTER 8	COMMENT NO. 38

SEC. NO. PAGE NO.	SCP STATEMENT
8.3.1.9.2.1 8.3.1.9-28	As a first approximation, the surface boundary for the detailed evaluation of geothermal and oil and gas resources is defined as within 5 (?) km of the center of the surface projection of the perimeter drift of the repository.
	COMMENT
	Why is the boundary for geothermal, oil and gas resources arbitrarily set at 5 km when all other studies use a 10 km radius from the perimeter drift?

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Joe M. Pattiff	5/18/89	Dennis J. Stuckless	5/18/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	VOLUME	CHAPTER	COMMENT NO.
Study Natural Resource Assessment of Yucca Mountain, Nye County, Nevada	V Part B	8	39

SEC. NO. PAGE NO.	SCP STATEMENT
8.3.1.9.2.1 8.3.1.9-28	As resources are located farther away from the repository or at deeper levels in the earth, exploration or extraction activities should have a diminishing potential for interacting with nuclear waste and thus, less potential for and impact on waste isolation.

COMMENT

This assumption is not valid since regional withdrawal of fluids from the deep carbonate aquifer system for either water supplies or for low temperature geothermal activities could affect lateral flow beneath the repository site. Further planned studies should be made to more accurately define at what actual distances exploration and/or extraction could affect waste isolation integrity.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Fee M. Hatch	5/2/89	Dennis J. Stuckless	5/18/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	VOLUME	CHAPTER	COMMENT NO.
Study: Natural Resource Assessment of Yucca Mountain, Nye County, Nevada	V Part B	8	40

SEC. NO. PAGE NO.	SCP STATEMENT
8.3.1.9.2.1 8.3.1.9-29	The regional hydrocarbon and geothermal energy resource assessments must consider source and reservoir rocks at considerable depth below the proposed repository, because these resources are generally accessed by the drilling of deep holes. The potential for these energy resources will be evaluated by considering information obtained in the region, the immediate vicinity, the drillholes in Paleozoic rocks near the site (e.g., drillhole UE-25p#1 and planned drillhole USW G-7). Depth to Paleozoic rock under the site are generally greater than 3 km. Presently, deep drillholes (9,000 to 20,000 ft) that could intersect Paleozoic rocks are not a planned activity because any specific drilling location would be an arbitrary decision for which no reasonable geologic or geophysical information has yet been established.

COMMENT

Data from two drillholes (one-planned) does not appear sufficient to assess the geothermal or hydrocarbon potential on the site. No mention is made of the types of additional evidence that will be gathered during site characterization and how it will be used to assess the need for additional drilling.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Jere H. Hatfield	5/12/89	Dennis J. Trexler	5/15/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	VOLUME	CHAPTER	COMMENT NO.
Activity: Assessment of the Potential for Geothermal Energy at Yucca Mountain, Nevada	V Part B	8	41

SEC. NO. PAGE NO.	SCP STATEMENT
8.3.1.9.2.1.3 8.3.1.9-35	Objectives 1. Temperature and other data will be collected under site unsaturated zone hydrology (Section 8.3.1.2.2) and site saturated zone hydrology (Section 8.3.1.2.3)

COMMENT

None of the holes planned for either UZ or SZ hydrology studies are to be completed in a manner suitable for high quality temperature measurements. The quality of measurements taken in such holes, will for the most part, be useless in interpreting heat flow and thermal gradients.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
for M Dettinger	5/13/89	Dennis J. Livingston	5/18/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	VOLUME	CHAPTER	COMMENT NO.
Activity: Assessment of the Potential for Geothermal Energy at Yucca Mountain, Nevada	V Part B	8	42

SEC. NO. PAGE NO.	SCP STATEMENT
8.3.1.9.2.1.3 8.3.1.9-35	Objectives Compile appropriate chemical and isotopic (oxygen and deuterium) analyses of water samples from springs and wells useful for predicting subsurface temperatures. These data will be useful in comparing subsurface temperatures at the site with measured temperature profiles and heat flow data for the region.

COMMENT

Comparing calculated geothermometer temperatures with measured temperature profiles and heatflow data that are of questionable quality will serve no purpose, (see preceding comment). It is apparent that geothermal and heat flow data collection are of minor importance since no holes are specifically planned for such data collection. To compare chemical geothermometers with questionable data appears a waste of time.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Fred M. Pattiff	5/13/89	Dennis J. Lugo	5/18/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	VOLUME	CHAPTER	COMMENT NO.
Activity: Assessment of the Potential for Geothermal Energy at Yucca Mountain, Nevada	V Part B	8	43

SEC. NO. PAGE NO.	SCP STATEMENT
8.3.1.9.2.1.3 8.3.1.9-35	Evaluate the existing data on geothermometry and heat flow necessary to adequately characterize the region for its geothermal resource potential.
	COMMENT
	What methods are to be used in evaluating existing data?

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Jeff M. Hatliff	5/4/89	Dennis S. Trujillo	3/16/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	VOLUME	CHAPTER	COMMENT NO.
Activity: Assessment of the Potential for Geothermal Energy at Yucca Mountain, Nevada	V Part B	8	44

SEC. NO. PAGE NO.	SCP STATEMENT
8.3.1.9.2.1.3 8.3.1.9-35	Objectives: Recommend whether additional studies may be needed, including the collection and integration of additional geothermal data from existing or planned drillholes.

COMMENT

Recommendations have already been made by the US Geological Survey (Sass et al. 1988), "The quality of the presently available data set does not allow an unambiguous interpretation of heat-flow data from either the UZ or the SZ. Some of the apparent hydrologic activity in the upper part of the SZ could be limited to the annulus between casing and the borehole wall, where water will respond readily to small head differences owing to the high transmissivity of the annulus. The ambiguity can be resolved only by completing some of the presently planned wells with access pipes grouted into place. It will be necessary to have water-filled pipes (also preferably with annulus grouted) to characterize adequately the thermal state of the UZ."

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Joe M. Rotkiff	5/5/89	Dennis J. Stuckless	5/18/89

UNIVERSITY OF NEVADA/LAS VEGAS, DIVISION OF EARTH SCIENCES
TECHNICAL REVIEW COMMENT FORM

SUBJECT	VOLUME	CHAPTER	COMMENT NO.
Plans for Mitigation of Any Significant Adverse Impacts Caused by Site Characterization Activities	VIII Part B	8	45

SEC. NO. PAGE NO.	SCP STATEMENT
8.7.3 8.7-6	It was determined in Chapter 4 of the Yucca Mountain environmental assessment (DOE, 1986) that conducting site characterization activities at Yucca Mountain would not result in significant environmental impacts.

COMMENT

Destruction of terrestrial vegetation and subsequent alteration and/or destruction of wildlife habitats, apparently, is only <u>significant</u> from the point of view of the affected wildlife. The Environmental Monitoring and Mitigation Plan (DOE, 1988) calls for the monitoring of sensitive species (i.e. Desert Tortoise, etc.), but makes no effort to explain, in detail, what monitoring programs will be undertaken, what parameters and by whom.

REVIEWED BY:	DATE	CONCURRED BY:	DATE
Joe W Dorthy	4/17/89	Dennis J. Trujillo	4/20/89

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