STATE OF NEVADA

AGENCY FOR NUCLEAR PROJECTS/ NUCLEAR WASTE PROJECT OFFICE

STATE OF NEVADA COMMENTS

ON THE

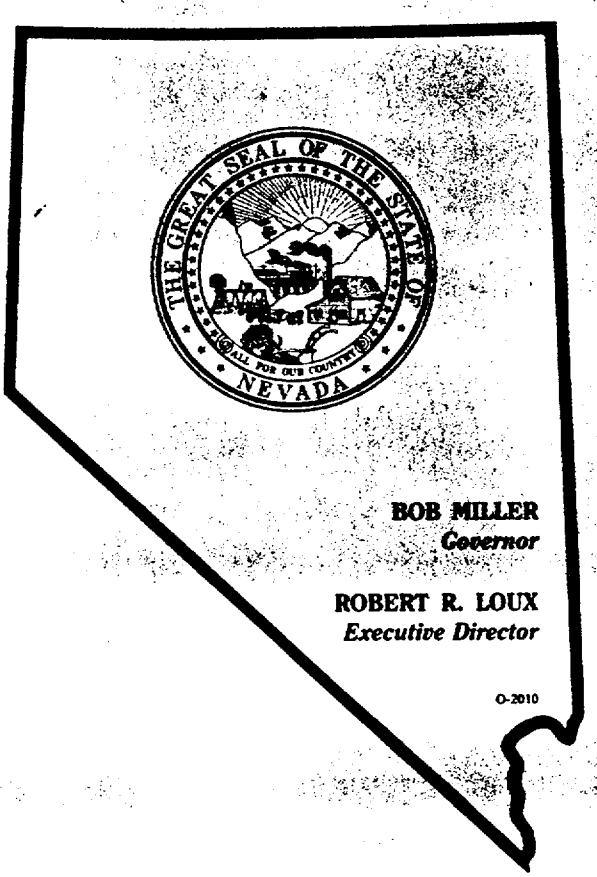
U.S. DEPARTMENT OF ENERGY

SITE CHARACTERIZATION PLAN

YUCCA MOUNTAIN SITE

NEVADA

VOLUME III



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VOLUME III

PREPARED BY

NEVADA AGENCY FOR NUCLEAR PROJECTS/
NUCLEAR WASTE PROJECT OFFICE

SEPTEMBER 1989

COMMENTS OF

L. LEHMAN & ASSOCIATES

TECHNICAL REVIEW OF THE

SITE CHARACTERIZATION PLAN

YUCCA MOUNTAIN SITE
NEVADA RESEARCH AND DEVELOPMENT AREA, NEVADA
DEPARTMENT OF ENERGY, DECEMBER 1988

Prepared for

Nevada Nuclear Waste Project Office
Capitol Complex
Carson City, Nevada 89710

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June 29, 1989

EXECUTIVE SUMMARY

Yucca Mountain, Nevada has been selected as a potential high-level radioactive waste repository, the Nation's first. The waste would be emplaced about 200 meters above the water table in a volcanic rock called tuff. Because of the highly radiologic character of the waste, it must be isolated from the accessible environment for 10,000 years as defined in 40 CFR Part 191.

To determine if the Yucca Mountain site is a suitable location for permanent geologic disposal of this waste, the Department of Energy (DOE) has proposed a complex plan of testing as outlined in the Site Characterization Plan (SCP). The SCP reviews the available information on the physical, chemical, biological and human systems of the Yucca Mountain area. It then outlines a course of study of these systems, a design of the repository and related engineering structures, and plans for assessing the performance of the repository.

One of the most important systems to understand, yet one of the least understood, is the hydrologic system at Yucca Mountain. The importance of this system is that it probably contains the most likely pathways for radionuclide escape from the repository to the accessible environment. The hydrology of the unsaturated highly-fractured tuffs, in which the proposed repository would be constructed, is poorly understood. This is because very little scientific study of this type of hydrogeologic system had been made prior to the selection of Yucca Mountain as a potential repository.

Our review of the hydrologic and hydrogeologic aspects of the SCP raises many serious concerns regarding both the current uncertainties regarding these systems, and more importantly, the DOE's plans for investigations of the hydrologic and hydrogeologic systems. The major concerns are of: 1) the time limitations for conducting the necessary investigations; 2) the great uncertainty regarding the hydrologic processes, especially fracture flow, in the unsaturated zone; 3) the inadequate consideration of various hydrogeologic and hydrologic factors, including coupled flow processes, recharge and discharge, and perched water zones; 4) the inadequate conceptual and numerical models of the saturated and unsaturated zones, and development of scenarios; 5) the flaws in the design and monitoring of observation wells; 6) the uncertainties in estimating infiltration, ground water travel time, the extent of the disturbed zone, and waste package integrity; and 7) the overall biased approach of the SCP. This report consists of a summary of these concerns, followed by specific comments on portions of Chapters 3 and 8 of the SCP.

APPROACH

Our review concentrated on all of Chapter 3, and major sections of Chapter 8 of the SCP. Familiarization with the relevant publications and research related to the Yucca Mountain area provided a background for the technical review of the SCP.

Many of the comments made on the Consultation Draft-SCP still apply to the SCP. To integrate these comments with the new comments, all of our original comments were reviewed against the applicable sections of the SCP. The comments were either retained as stated, modified if needed, or removed if the section had been changed to adequately address the concern of the original comment. Section 8.3 of the table of contents of the Consultation Draft SCP was then compared with Section 8.3 of the final SCP and changes were noted. Added or modified sections were then reviewed and commented upon where appropriate.

Selected sections of the SCP were reviewed by several individuals and additional comments were prepared. These were then edited, integrated with the original comments, arranged consecutively by page, numbered, and finally reviewed by our QA manager. The individual comments follow the discussion of major comments below, with the Chapter 3 comments preceding those of Chapter 8.

DISCUSSION

The Site Characterization Plan is an immense document that correlates in shear size with both the complexity of the physical systems in the Yucca Mountain region, and the lack of knowledge regarding the geologic, hydrologic, and engineering aspects and processes acting in this setting. To investigate Yucca Mountain and determine if high-level radioactive waste could be safely isolated from the environment there, will require a number of years of investigation and will be extremely costly. Our review points to the conclusion that characterization of the Yucca Mountain site will be very difficult and it appears unreasonable that it will be accomplished by the time slated for the license application.

The geologic setting itself is complicated with heterogeneous volcaniclastic sediments, which are moderately or heavily fractured. Numerous faults exist in the area, with some bisecting the proposed repository site. Although the faults were hypothesized to be old, it appears that some may have been active in the late-Quaternary. Volcanoes in the area originally assumed to be old, also may have been active in the late-Quaternary. Because Yucca Mountain is located in a tectonically active setting,

both tectonic stresses and thermal processes need to be considered in analyzing the behavior of the geologic media and its fluids.

Although the landscape is arid, both winter rains and infrequent summer thunderstorms occur and are the source of infiltrating waters that recharge the ground water system. In fact the unsaturated zone at Yucca Mountain is not dry, it is partially-saturated with saturations that range from about 50-90%. In the past (and probably again in the future) pluvial periods of greater precipitation caused ground water levels to rise and lakes to form in basins of Nevada and California. The flux of water through the unsaturated zone at Yucca Mountain is unknown today and unknown for past pluvial periods. The conditions that would allow fractures in the tuffs of Yucca Mountain to transmit water rapidly downward are unknown. It is not known whether fractures transmit water rapidly downward after storms. It is not even known whether the numerous faults are barriers to water flow or act as conduits. The distribution of perched water zones in southern Nevada or in Yucca Mountain are unknown. The controls on the development of perched water zones in the unsaturated tuffs are unknown; as is the nature of water movement in and around them.

Using theoretical models, which have not been confirmed by field-testing, some researchers believe that infiltrating water is drawn into the matrix pores of the tuffs leaving the fractures dry. From these models and limited field observations values of average flux, estimated to be very low, have then been used to show that the travel time of water downward through the unsaturated zone may be very long, tens of thousands of years or more. However, not far away at Rainier Mesa water occurs in fractures far above the water table, and springs emerging from perched water zones have seasonally-varying discharges. If water can move rapidly through fractures in the tuff at Rainier Mesa, which is geologically similar to Yucca Mountain, but receives somewhat higher precipitation, then this could occur also at Yucca Mountain, if not today, then perhaps in a future wetter period.

Many of the answers to the questions about the hydrogeologic system remain unknown, primarily because little study has been made of the hydrologic processes in the geologic setting chosen for the repository. Ground water geology only began as a science about 100 years ago. For many years, studies concentrated on saturated ground water systems in permeable rocks, such as sandstone. Studies of saturated zone fracture flow followed, building on the foundation of the investigations of flow in permeable rocks. Soil scientists were the first to concentrate on unsaturated flow processes, and not until recently have soil scientists and hydrogeologists integrated their research. Prior to the selection of Yucca Mountain as a repository site, very little research of unsaturated zone fracture flow had been performed. In other words, to select Yucca Mountain as the repository site was to choose one of the least-studied hydrogeologic settings possible. To adequately characterize the hydrogeologic aspects of Yucca Mountain, if that is possible, will not only demand investigations of many

processes, but will require development of new techniques and methodologies to investigate the processes in this unfamiliar setting.

Although it may eventually be possible to decide if a repository in Yucca Mountain could keep radionuclides from the accessible environment as required, the investigations in this setting will be difficult, and will not be able to rely on much past experience. Because of this, the time to perform the necessary studies will be long, more than for other simpler or better studied geologic settings. It appears very unlikely that field investigations, laboratory investigations, and computer modeling can be near completion by the 1995 license application deadline. Instead more time and more money will be required to determine if Yucca Mountain will be suitable as a repository site.

The size of the SCP supports the contention that the setting is complex and many studies must begin to investigate the hydrologic, geologic, engineering and other aspects and processes at Yucca Mountain. Perhaps even more disconcerting though, is the lack of detail provided in the description of the proposed geohydrologic investigations in the SCP. This lack of detail appears to be a function of both the complexities and uncertainties of the system, as well as the lack of previous study, which would serve to guide the necessary research.

MAJOR COMMENTS

TIME LIMITATIONS

Many studies, including those investigating: unsaturated zone properties and flow processes, fracture flow, perched water zones, water table configuration and fluctuations, saturated zone flow field, spatial and temporal precipitation patterns, runoff and streamflow, will require many years to design, initiate, collect data, modify, interpret, model and validate. It is unreasonable to suppose that all of these studies can be accomplished by the 1995 license application deadline. Listed below are selected topics that will require more time for investigation.

The investigation of unsaturated zone fracture flow and matrix/fracture interactions under steady-state and transient conditions will require innovative research and development of new field, laboratory and modeling techniques. Conventional unsaturated zone monitoring equipment, such as psychrometers and tensiometers, is geared toward porous media rather than fractured media. Thus the feasibility of collecting meaningful unsaturated zone data, such as water content and pressure head, appears unlikely in the near future.

The current conceptual model of unsaturated zone flow, as explained in Chapter 3, is highly incomplete. At this time, the fundamentals of the most likely pathways for radionuclide transport are poorly understood. To develop and perform the crucial studies of the unsaturated zone hydrology will require a number of years. Based on the results of these studies, detailed conceptual models must then be developed. After more realistic conceptual models are available, numerical models will need to be developed or modified. When these models are available, they will need to be validated. Finally modeling to determine the ground water travel time in the unsaturated zone can commence, if it can be shown that modeling is applicable and can be validated. It is difficult to envision how all of this could be accomplished in the few years remaining until license application.

The chemistry of the unsaturated zone pore water is also important for assessing how radionuclides will react with these waters. The sorptive properties of the unsaturated zone geologic media and the water/rock reactions also need to be known. Our knowledge of this is very preliminary. To improve our understanding will depend on being able to develop and refine sampling methods for extracting pore water from low permeability tuff. The time to develop new methods, collect samples, analyze the data, conduct laboratory experiments, and model the geochemical system is insufficient.

To investigate in detail the water table configuration and its fluctuations over time will require a number of changes to existing studies. Designing and drilling a number of "true" water table wells, with sets of closely-spaced wells near potential recharge areas is needed. In addition the existing water table wells need to be modified so that they penetrate only a few meters beneath the water table. This will require at least several years. Once these new wells are ready, many years (possibly 10 or more) of detailed and continuous monitoring will be required to adequately evaluate the causes of water table fluctuations. This is because the fluctuations may be quite small considering the highly transmissive nature of the saturated media, and the time lag between precipitation events and possible recharge pulses may be long. Analyzing the data under strict quality assurance, lengthens the time for this study past the year 2000.

The time prior to license application for investigating the three-dimensional saturated flow field in the vicinity of Yucca Mountain is inadequate. At this time very little data are available on the saturated flow field, because almost all existing wells sample composite hydraulic heads over 10's to 100's of meters. Several years will be required to analyze existing data, test, and redesign the wells so that they will sample both high-permeability and low-permeability strata. To drill and install at least 10-15 piezometers, each with at least four (4) packed-off intervals, will require more time. Once the system is installed, monitoring will need to occur over a number of years to assess the stability of the flow field and the possible role of coupled processes. Performing all of this under strict quality assurance will produce extremely valuable data, but also lengthens the time for the overall project.

UNCERTAINTIES REGARDING MATRIX AND FRACTURE FLOW IN THE UNSATURATED ZONE

The basic interactions between fracture flow and matrix flow (whether it be for vapor or liquid) are very poorly understood. Of particular importance are transient behavior and conditions when fracture flow might occur, and whether or not Darcian assumptions are valid. Fracture-matrix interactions are also crucial to understanding solute transport, because DOE apparently wishes to rely on matrix diffusion as a radionuclide retardation mechanism. Some of the tracer testing described in the SCP needs modification in order to properly evaluate matrix diffusion.

Stress-testing of the unsaturated, fractured tuffs to determine hydraulic properties using gas (pneumatic) or liquid (water) will require much prototype testing. Moreover, data analysis techniques have yet to be developed for such tests. Yet in the SCP, these tests are presented as if they are routine.

Transient fracture flow through preferred pathways (extreme channelling) is also inadequately discussed. This is probably because detailed investigations in the laboratory and field are only beginning. Because so little is currently known, the SCP should consider all possible scenarios of how moisture moves through the unsaturated zone. Other studies should be conducted to determine the role of fast flow paths, the development of fracture skins and their role in limiting water movement between fractures and matrix, the role of fractures in more permeable geologic media, and the role of tectonics in changing fracture apertures. A serious problem is that reliable technology for measuring transient pulses of water in fractures does not exist and will probably not be ready in time for site characterization studies.

HYDROGEOLOGIC AND HYDROLOGIC CONSIDERATIONS

The unsaturated and saturated zone ground water systems of Yucca Mountain and their interactions are very poorly known. Because of the tectonically active setting, the interactions between the hydraulic and thermal potential fields, and the stress fields need to be investigated. However, the SCP does not adequately address these aspects. The current data on the distribution of hydraulic potential in the saturated zone is very limited. The details regarding the transmissive properties of permeable and less permeable zones in the tuffs are not known and it is unclear whether these will be considered. The geologic media are highly fractured and contain numerous faults that trend roughly north-south, yet the SCP continues to consider these media isotropic.

Theoretical models on which to base aquifer test data interpretation are not well established. These models may need to account for fracture skins, anisotropy, highly-variable hydraulic conductivity zones, and effective porosity in a dual-porosity medium. This, too, points out the need for additional time for site characterization. For those saturated zone tests that are described in relative detail, some testing locations are questionable.

Recharge and discharge processes and their distribution are very poorly known. Recharge is hypothesized to occur beneath the higher mountain ranges and beneath the major washes or their tributaries. However, its temporal distribution and lag between precipitation events and when water reaches the water table is essentially unknown. It is not clear that the proposed studies will allow this to be determined, especially because the number and location of water table wells may be inadequate. Discharge occurs either by springs, or by evapotranspiration. The spring discharge flux can be estimated fairly reliably, however, the evapotranspiration flux, which is more difficult to determine, can only be roughly approximated. This is probably underestimated, which is important because then the recharge flux in the basin or sub-basin will also be underestimated, if a mass balance approach is utilized.

The importance of perched water zones to the unsaturated zone hydrology is just beginning to be realized. These zones must be studied in detail; not only to identify their current extent beneath Yucca Mountain, but also to assess the likelihood of coalescence into large perched water zones. Because of the difficulty of studying perched water zones without compromising the integrity of the tuff at Yucca Mountain, these should be studied in several analog settings, such as Rainier Mesa. Methodology and instrumentation to detect perched water zones should be tested at such analog sites before being applied at Yucca Mountain. The possibility that springs discharging from perched water zones could develop on the flank of Yucca Mountain during wetter periods must also receive greater attention. The SCP states that it may not be possible to characterize lateral flow in the unsaturated zone during site characterization. Lateral flow in and around perched zones must be investigated, if not a potential rapid pathway of radionuclide migration will be ignored.

CONCEPTUAL/NUMERICAL MODELS AND SCENARIO DEVELOPMENT

The conceptual model of the unsaturated zone may need substantial modification, if detailed and well-designed studies are forthcoming. Currently the SCP relies heavily on the concept that most or all of the flux in the unsaturated zone is via matrix flow, which is steady, small, and evenly distributed over the repository block. Although this mode may be important, a wide range of alternative models needs to be considered. Field evidence of rapid water transmission in the unsaturated zone or the existence of perched waters are difficult to explain with the preferred model of steady-state small

unsaturated zone flux. To improve the conceptual model of the unsaturated zone, more emphasis should be placed on field-based testing, especially of analog sites. At these sites, unsaturated zone processes can be studied under different hydrologic and geologic conditions. This will provide a much improved foundation for assessing unsaturated zone flow now and under conditions of increased precipitation. In-situ and laboratory investigations of flow through fractured tuffs, especially of transient processes, must receive much more attention.

Many faults are located within the controlled area and some extend into or through the repository area. Investigations should proceed at several sites to assess the hydrologic behavior of these features. Fault and fault zones could serve as preferred pathways for water movement in the unsaturated zone, and may make this site unsuitable as a repository. Unfortunately, little is currently known about the hydraulic properties of these features. Studies to ascertain this will be difficult to design and quality assure. Inclusion of faults in the unsaturated zone modeling will be challenging.

Fundamental processes governing vapor flow and radionuclide transport in the unsaturated zone at Yucca Mountain are virtually unknown. However, it is very possible that vapor phase flow may represent a fast path of radionuclide migration in relation to Ground Water Travel Time. Furthermore, vapor phase transport of radionuclides conceivably could dominate releases to the accessible environment.

Besides including the above aspects in a modified conceptual model of the unsaturated zone, this model should not be restricted to the site. It is not apparent why so much more effort should be made to construct regional, sub-regional, and site three-dimensional saturated ground water models, when only one unsaturated zone model of the site will be designed. This underscores the fact that our general knowledge of unsaturated flow is so poor, especially in this fractured tuff setting. It is crucial that the unsaturated zone in tuff at other sites, having different hydrologic inputs and outputs than at Yucca Mountain, are studied. This will greatly increase the assurance in our ability to predict the behavior of water today and in the future.

The SCP attempts to portray the geologic media of the unsaturated zone as being readily definable and possessing relatively uniform properties within each unit. However, in the discussion of the saturated zone system the SCP states that such hydrogeologic units cannot be defined for the saturated zone on the basis of hydraulic tests. In reality the geology is highly complex and detailed hydrogeologic facies models for the Yucca Mountain site are not considered in the SCP. A detailed hydrogeologic facies model should be developed that incorporates the natural variability in the volcaniclastic sediments. This variability is the result of the original depositional processes as well as the post-depositional changes. Geostatistical characterization of the hydraulic properties of the geologic formations should then be overlain onto the hydrogeologic facies model. Other models, such as those

incorporating fractal mathematics should be studied to determine if they better approximate the real variability in hydraulic properties. It appears that not enough study of the heterogeneity of hydraulic conductivity or the hydrogeologic facies in the tuffs is planned.

The saturated ground water system will be modeled at a variety of scales and will be monitored via water table wells and piezometers. However, the SCP is vague in its planned modeling. It is not clear how fractures or faults will be incorporated in the models. Anisotropy is definitely important at Yucca Mountain, but receives little consideration in the proposed modeling. The SCP suggests that the saturated system at Yucca Mountain can be reasonably modeled by two-dimensional ground water flow models. However, the apparent very steep water-table gradient and the much higher hydraulic head in the lower carbonate aquifer indicate that the flow field is three-dimensional. Little is currently known regarding the interaction of the tuff aquifer and the lower carbonate aquifer at Yucca Mountain. The values of hydraulic potential at various depths in a number of geologic units, needed to confirm the accuracy of the flow model, are not available and may not be available given the plans for piezometers described by the SCP.

Studies to further refine the conceptual model of the saturated zone should better address coupled flow aspects. It is not apparent from the proposed studies how or if the hydraulic, thermal, and stress fields will be integrated in the conceptual and numerical models.

The site hydrogeologic system should not be restricted to the controlled area. Natural boundaries beyond the controlled area may allow boundary conditions to be specified more accurately for the site hydrogeologic system. For example, a fault may serve as an acceptable boundary, if enough data can be gathered to define the hydrologic parameters at the selected feature.

The understanding of "validation" of models presented in the SCP appears vague. First, calibration is not the same as validation. Second, the validation efforts will be very time consuming.

Of particular concern to the State is the process by which events and scenarios will be formulated. It is not clear in the SCP on what specific bases these scenarios will be developed. Also, it is not clear what role the affected parties will play in developing scenarios.

DESIGN OF WATER-TABLE WELLS AND PIEZOMETERS

Nearly all of the water-table wells and piezometers are not well designed for determining meaningful hydraulic potentials or for collecting representative water samples. The existing piezometers commonly measure composite heads over thick intervals (tens or hundreds of meters) and probably withdraw water unequally from many levels, which cannot be defined. The water table wells commonly penetrate 65-75 meters beneath the water table and thus also measure composite heads. For these reasons the three-dimensional distribution of heads within the saturated zone is essentially unknown. The detailed configuration of the water table and its fluctuations over time are equally uncertain. Chemistry or isotopic data on water samples are also very difficult to interpret, because of the composite nature of the samples.

A better characterization of the saturated ground water flow field will allow better assessment of recharge, ground water travel time, and coupled processes. Defining the flow field is also needed prior to sampling for ground water age determination and for designing natural gradient tracer testing. It also allows improved understanding of results from chemistry and isotopic studies.

Other problems exist besides the design and construction of the wells. There is an insufficient total number of wells and selected areas should have a greater density of wells. In the past, measurement methods have changed often, and values apparently change when the methods change, making time series analyses of water level changes difficult. Calibration problems and drifting of pressure transducer measurements make the available data suspect.

To investigate the water table configuration and changes over time, "true" water table wells should be drilled, or modified by packing off the wells within a meter or two of the water table. The water level monitoring program needs to improve its quality assurance by building in redundancy to pressure transducer measurements and making more frequent calibration measurements. We also suggest investigating the development of alternative technologies for water level measurements in deep wells. These data are extremely important, but if their accuracy is questionable then the data are of limited use. Without properly designed water table wells, it may be impossible to identify water table fluctuations associated with recharge events. Long-term records of water levels must be obtained in order to correlate fluctuations with yearly variations in possible recharge.

Water samples that have been analyzed thus far are composite samples collected from significant thicknesses of geologic formations. This means that the water samples draw from many different flow paths of various lengths and could be mixing water of very different ages. In addition, some ages have been measured for samples withdrawn from wells that have had significant pumpage. Flow lines around these wells could

be highly altered from the original natural flow field and thus the ground water ages may not be readily comparable with samples from wells that have not been pumped.

Attempting to perform geochemical flowpath modeling is more difficult, because the flow field is poorly known at this time. General interpretation of chemistries is made more difficult by the composite nature of the samples. Low-permeability zones may have different water chemistry than the higher-permeability zones, but the higher-permeability zones are probably preferentially sampled when a well is pumped. If there is a vertical component to the natural flow field near a well, the water withdrawn during pumping may also be preferentially extracted from certain intervals.

ESTIMATES OF INFILTRATION

Estimates of infiltration will be very difficult to determine given the geologic media, which is highly fractured. The SCP continues to consider their annual recharge flux estimate of 0.5 mm/yr as conservative, yet no persuasive technical support has been forthcoming. Specific references regarding the techniques by which the various field data (e.g. neutron logging) will be analyzed to determine infiltration need to be established prior to field activities. At this point, it is not clear if the infiltration processes are adequately understood so that testing in the surficial materials at Yucca Mountain will be successful.

CALCULATION OF GROUND WATER TRAVEL TIME

Because it is currently not known whether transient, fracture flow occurs in the unsaturated zone at Yucca Mountain, current estimates of ground water travel time are essentially meaningless. It appears that DOE plans to incorporate non-conservativisms such as matrix diffusion, which is unsubstantiated, and multiple path averaging, which is inconsistent with the regulations, into the estimates for the ground water travel time. The determination of fastest path needs to be based primarily on field testing, rather than modeling. Vapor phase flow may also need to be incorporated into ground water travel time calculations.

DETERMINATION OF THE DISTURBED ZONE

The plans to determine the Disturbed Zone appear to be limited to stress-redistribution analyses and the effects on the rock. However, thermal and physio-chemical processes that affect both the rock and the pore water need to be evaluated.

For example, changes in hydraulic conductivity (not just intrinsic permeability) need to be considered.

WASTE PACKAGE INTEGRITY, HYDROLOGIC CONSIDERATIONS

The discussion in the SCP regarding waste package failure/release processes is too narrow. For example, localized and/or late time corrosion is not adequately addressed. Other factors, such as varying flux conditions and mechanical processes related to stress, are also not adequately considered.

BIASED APPROACH OF THE SCP

A number of biased comments regarding the unsaturated and saturated systems are presented in the SCP. Even though the SCP stresses the need to consider alternative hypotheses, these in fact are de-emphasized. For example, in the early parts of Chapter 3 some alternative models are presented. The later sections, such as the conclusions and summary, essentially only discuss the preferred conceptual models, such as steady-state small matrix flux in the unsaturated zone. Occasional mixing of assumptions and facts also lead to a biased portrayal of the hydrology. For example, the statement that more recharge is occurring beneath Fortymile Canyon is not substantiated by any data, and in fact no water table mound is evident from existing data beneath Fortymile Canyon. The model that more recharge occurs beneath Fortymile Canyon is at this time only a hypothesis not a fact. The conceptual model presented at the end of Chapter 3, is a mixture of solid facts and very tenuous hypotheses.

The SCP heavily cites favorable aspects of reports, such as sections of Montazer and Wilson (1984) and cites unfavorable data or reports, such as sections of Szymanski (1987), much less. An unbalanced approach weakens the overall credibility of site characterization and may allow flawed concepts to be adopted. Misstatements are more commonly favorable for repository siting.

The DOE plans to establish "performance goals" and then work towards meeting these as their approach to issue resolution. However, DOE has not developed adequate contingency plans in regard to issue resolution. For example, what will happen if "performance goals" are not met? Will the goals be lowered, or will there be retesting? It appears the setting of performance goals will be very subjective and it is not clear who will have input to this process.

SPECIFIC COMMENTS

Chapter 3

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-1 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.2.2 (3-78)	The number of wells or piezometers used to characterize the regional hydrogeologic system is inadequate in a number of regions of southern Nevada, including an area just north and west of Yucca Mountain. In addition the data only provide a very approximate view of the regional gradient of the saturated ground water system, because the data are collected from springs and wells of various depths.

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DATE: June 29, 1989

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TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-2 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.3.1.1 (3-83)	Because of the significant range in ground water temperature and the spatial variability in the chemistry of the water, there is a greater possibility of coupled thermal or tectonic processes acting in the area. Concepts such as those presented by Szymanski, 1987, could apply to southern Nevada and should be investigated in the Yucca Mountain area. REFERENCE: Szymanski, J.S., 1987, Conceptual considerations of the Death Valley groundwater system with special emphasis on the adequacy of this system to accommodate the high-level nuclear waste repository: U.S. Department of Energy.

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-3 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.3.1.1 (3-85)	Significant chemical changes along the flow paths in the carbonate aquifer imply significant addition of water from the tuff aquitard. The chemistry, especially the sodium content, of wells on the eastern side of the NTS is apparently consistent with the concept of movement of water from the tuff aquitard down into the carbonate aquifer. Because this movement is important near Yucca Mountain and because the three-dimensional flow field at Yucca Mountain is very poorly known, flow from the tuff units to the carbonate aquifer should be considered at Yucca Mountain.

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-4 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.3.1.2 (3-93)	The chemistry of water from the valley fill is lower in ionic concentration than the water discharging from the springs at Ash Meadows, which apparently discharges directly from the lower carbonate aquifer. If the more dilute water in the valley fill aquifer in the east central Amargosa Desert, which is lower in elevation and thus drier than Yucca Mountain, is derived from recharge waters, then Yucca Mountain should also be considered as a possible site for significant recharge.

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-5 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.3.1.2 (3-94)	Three principal sources of recharge to the valley fill aquifer are identified. However, very little is actually known about the spatial and temporal distribution of recharge in southern Nevada. It is prudent to consider and discuss all possible mechanisms in Chapter 3. Spatially-variable recharge that is widely distributed in space, but variable in time is another possible characterization of recharge in this arid region where heavy rains occur occasionally.

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DOCUMENT TITLE: Site Characterization Plan	
COMMENT NO.: 3-6 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.3.2.1 (3-98)	The correct determination of apparent ground water ages based on carbon-14 content and the apparent lack of "old" waters, is highly dependent upon representative samples of ground water being collected at different positions and depths. In fact, the water samples that have been studied thus far are composite samples. Interpretation of apparent ages, which is always difficult because of the nature of ground water flow where mixing of water of various ages occurs, is even more suspect when the wells sample significant thicknesses of aquifers. These problems are not adequately considered in this section. Lack of "old" water could be the result of water of various ages at different depths being pumped together from a well.
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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-7 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.3.2.2 (3-102)	There is evidence of megascale channeling, with more rapid water movement, in parts of the carbonate aquifer (Winograd and Pearson, 1976). Because this apparently occurs in the southern Nevada region, then channeling of water flow could occur in the carbonate aquifer beneath Yucca Mountain as well, and could significantly shorten the ground water travel time in the carbonate aquifer. REFERENCE: Winograd, I.J., and F.J. Pearson, Jr., 1976, Major carbon-14 anomaly in a regional carbonate aquifer: possible evidence for megascale channeling, South Central Great Basin: Water Resources Research, v. 12, n. 6, p. 1125-1143.

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DOCUMENT TITLE: Site Characterization Plan	
COMMENT NO.: 3-8 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.4 (3-103)	Besides paleohydrologic studies determining the magnitude of increases in recharge, there should be investigations of the changing spatial and temporal patterns of recharge.
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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-9 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.4.1 (3-103)	If the potentiometric surface in the Ash Meadows discharge area was 50 meters higher in the past, then the water table upgradient from the discharge area was probably much more than 50 meters higher. As shown by Almendinger (1988), water tables change little in response to increased recharge in the discharge portion of flow systems, whereas much greater rises occur in the upgradient parts of flow systems nearer the ground water divide. Because Yucca Mountain is currently far from discharge locations, increased recharge could cause significant rises in the water table at Yucca Mountain. REFERENCE: Almendinger, J., 1988, Lake and groundwater paleohydrology: A groundwater model to explain past lake levels in west-central Minnesota [Ph.D. thesis]: Minneapolis, Minnesota, University of Minnesota, 123 p.

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COMMENT NO.: 3-10 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.4.1 (3-106)	Although the role of climate change and its connection to long-term changes in regional water levels is adequately presented, little discussion of the connection between tectonic changes is provided. If little information about the relationships between tectonics and water levels is available then this should be explicitly stated.

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-11 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.4.2 (3-107)	Uranium-disequilibrium ages on calcitic material from southern Nevada and southeastern California commonly yield questionable results. Any ages provided by this method should be identified as being tentative or preliminary.

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-12 p. 1 of 2 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.4.4 (3-111)	A quote is provided from Hunt and Mabey (1966) to provide support for the concept that Lake Manly was of very brief duration and that little field evidence of its existence is present. I have observed good geomorphic and sedimentologic field evidence for the existence of this lake and Hooke (1972) confirms the presence of this lake. Death Valley is one of the most dynamic areas in the Great Basin and the alluvial fans are continually modifying the landscape. For these reasons shoreline features are modified or eroded and only remain in protected or non-eroding locations. The statement on page 3-111: "Resolving whether this lake is closer to 100,000 or 1 million years old..." is a very biased interpretation of the facts. In fact the lake is closer to 10,000 years old, rather than the old ages provided by the SCP apparently in an attempt to support a static view of the dynamics and climate in the Great Basin. REFERENCES: Hunt, C.B. and D.R. Mabey, 1966, Stratigraphy and structure, Death Valley, CA, U.S. Geological Survey Professional Paper 494-A.

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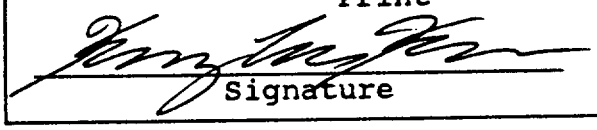
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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-12 p. 2 of 2 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.4.4 (3-111)	REFERENCES - continued Hooke, R.L., 1972, Geomorphic evidence for Late-Wisconsin and Holocene tectonic deformation, Death Valley, California: Geological Society of America Bulletin, v. 83, p. 2073-2098.

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TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-13 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.4.5 (3-111)	The statement that apparent ground-water ages indicate that much of the ground water within the tuffaceous rocks in the vicinity of Yucca Mountain ... was recharged ... about 10,000 to 18,000 yr ago, is highly questionable. All ground water is a mixture of water that enters the water table at different times. Sampling, especially considering the nature of the wells in the Yucca Mountain area, mixes the water even more. If there is water with an age of 10,000 years, then it is very possible that the sample contains water much less than 10,000 years old as well as water much older than 10,000 years.

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-14 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.4.5 (3-111)	The statement "According to Claassen (1985), 'little or no radiocarbon dilution probably occurred during the evolution of water in tuff or tuffaceous valley fill; therefore, the unadjusted ages are taken as true ages.'" is apparently included to support the available radiocarbon ages. In fact, all available ground water ages at Yucca Mountain are highly suspect. Not only is normal mixing along ground water flowpaths a problem, but additional mixing of water of different ages occurs when the existing wells are pumped. This problem is not adequately discussed in the SCP. To imply that the ages listed on pages such as 3-111 are "true ages" is deceiving. REFERENCE: Claassen, H.C., Sources and mechanisms of recharge for ground water in the West-Central Amargosa Desert, Nevada - A geochemical interpretation: U.S. Geological Survey Professional Paper 712-F, 22p.

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-15 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.4.5 (3-112)	The statement "Therefore, ground waters of about the same age as those beneath the upper zone of saturation near Yucca Mountain could have been emplaced 25 to 40 km downgradient." is unclear. It seems to imply some sort of static emplacement of ground water in the past, not a view of ground water as a dynamic system.

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DOCUMENT TITLE: Site Characterization Plan	
COMMENT NO.: 3-16 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.4.5 (3-112)	The absence of old waters (>15,000 yr B.P.) in the Amargosa Desert could simply be a result of the sampled intervals in the wells and the three-dimensional flow field beneath Yucca Mountain and the Amargosa Desert.
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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-17 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.4.5 (3-112)	Given the problems with sampling and highly uncertain knowledge of the three-dimensional flow field, deducing ground water velocities from the limited carbon-14 data is probably not possible.

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-18 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.4.6 (3-112)	Conclusion 1 paints a picture of long-term steady water table decline, which projected into the future means drier conditions and deeper ground water levels. Shorter pluvial cycles are superimposed on long-term changes and much of the changes in ground water levels that have been identified could be accounted for by these pluvial/non-pluvial cycles. The number of localities that have been studied and the number of reliable ages are very insufficient to assess the long-term character of climatic and hydrologic change with any certainty. Smith, 1968, provides evidence of cycles of pluviality over the past few million years in southeastern California. REFERENCE: Smith, G.I., 1968, Late Quaternary geologic and climatic history of Searles Lake, southeastern California: Means of correlation of Quaternary succession, v.8, p. 293-310.

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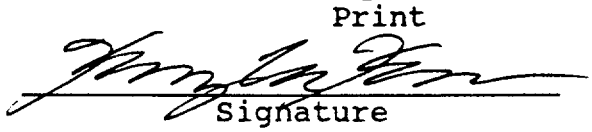

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-19 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.4.6 (3-113)	Pluvial lakes are expected to be highly variable in elevation and can leave only indistinct evidence of their past presence. The basins in the Yucca Mountain area should be studied very carefully to look for evidence of past pluvial lakes. This task is extremely difficult in this setting where the landscape is constantly being modified, by wind and occasional heavy storms.

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-20 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.7.4.6 (3-113)	Regarding conclusion 4, our knowledge of recharge in this setting is so sketchy at the present time, that the concept of recharge occurring only beneath the distributaries of Fortymile Wash should remain a hypothesis. Before ages can be interpreted the three-dimensional flow field needs to be much better determined as a basis for sampling. Then ages should be determined at specific locations along flowpaths to determine estimates of ground water velocity. If recharge is concentrated along Fortymile Wash, there should be a tendency for a mound or ground water ridge to develop, especially since the water table gradient is apparently very low in this region. However, no ground water ridge is apparent at this locality. Alternatively a ground water ridge might not be present because either little or no recharge occurs there, or recharge is distributed more widely and occurs in adjacent regions such as beneath Yucca Mountain.

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-21 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.8.1.4 (3-130)	Transmissivities are not provided in this section at wells J-12 and J-13. The "slight water level declines" associated with pumping imply that the transmissivities are fairly high here.

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DOCUMENT TITLE: Site Characterization Plan	
COMMENT NO.: 3-22 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.8.1.4 (3-130)	No information is provided on the distribution system or its source that is described in the statement: "water for site characterization activities would be drawn from wells J-12, J-13 until a distribution system could be constructed."
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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-23 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9 (3-136)	It is not clear and not explained how downward moisture flow could be offset by upward vapor flow and still have a significant and increasing percentage of saturation with depth in the unsaturated zone, as reported by Sass et al., 1988. REFERENCE: Sass, J.H., A.H. Lachenbruch, W.W. Dudley, Jr., S.S. Priest, and R.J. Munroe, 1988, Temperature, thermal conductivity, and heat flow near Yucca Mountain, Nevada: Some tectonic and hydrologic implications: U.S. Geological Survey, Open File Report 87-649.

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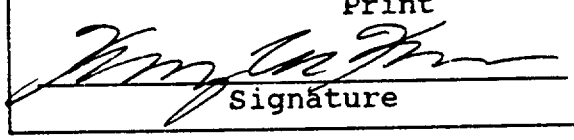

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-24 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9 (3-137)	Although our knowledge of the distribution and temporal variability of recharge in southern Nevada is very poorly understood, it is not appropriate to say 'if recharge occurs in southern Nevada.' Because there is a regional potentiometric gradient and discharge areas, there must be recharge areas, which are very poorly delineated. It should be presumed that recharge may be occurring at Yucca Mountain, and studies should investigate all possible mechanisms by which recharge occurs. To imply in a number of parts of the SCP that recharge is not occurring at Yucca Mountain, for example: "If any recharge occurs at Yucca Mountain...", diverts attention from the probability that it does occur.

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DOCUMENT TITLE: Site Characterization Plan	
COMMENT NO.: 3-25 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9 (3-137)	Recharge beneath Yucca Mountain would be better described as joining a three-dimensional saturated ground water flow field and flowing generally east or southeastward. However, the current understanding of the three-dimensional flow field is very poor.
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COMMENT NO.: 3-26 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9 (3-137)	From the water level altitudes for wells in the immediate vicinity of Yucca Mountain, the potentiometric or water table gradient slopes almost directly east. This is perpendicular to the direction of the structural features, the faults and orientation of the mountain, and may imply a strong connection between the hydrologic system and the tectonic setting.

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COMMENT NO.: 3-27 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9 (3-138)	Figure 3-25 and Table 3-22 portray standard geologic and hydrogeologic information in a usable format. However, in this setting where small structures or geologic deposits may be important to ground water movement, several representative diagrams of the detailed stratigraphy and structure at the site would be of use to the reader. These more detailed descriptions could be obtained from analysis of the core data, or from the trench data, and should present hydrogeologic diagrams, in addition to geologic diagrams. Figures 1-21 and 1-22 of the SCP provide some detail of vertical changes in the petrographic character of deposits in two boreholes. Detailed hydrogeologic descriptions are not provided in the SCP.

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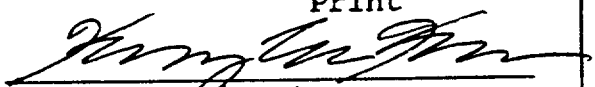

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-28 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9 (3-142)	The SCP states that "In general, k and K are assumed to vary stochastically within an otherwise homogeneous natural medium with mean values that are spatially invariant ..." This is one conceptual view of the natural variability. Stochastic models may be used to approximate the intrinsic natural variability. This distinction should be stated as such in the SCP. Alternative views should be considered, such as using a fractal model or a mixed stochastic-deterministic model to characterize the variability.

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TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-29 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9 (3-143)	I agree with the SCP that "It is not clear that these approximating representations are appropriate to indurated fractured tuffs, but they have been used in preliminary studies..." The SCP goes on to provide very limited evidence that the traditional soil science functional relationships apply. This paragraph emphasizes the limited understanding that is currently available on the hydrologic system where the repository will be placed. Basic and applied research, which, if done correctly is very time consuming, must be pursued to form a basis for characterizing the unsaturated zone hydrology of fractured tuff. In other words because the proposed repository is in a setting that has received only limited study, site characterization will take longer and probably be more costly than in other more easily characterized settings.

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-30 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9 (3-143)	I disagree with the statement: "A hydrogeologic unit, in this usage, is defined to be a functional unit composed of an interval or volume of rocks within which the mean hydrologic properties are effectively spatially invariant." There are probably trends in geologic or hydrologic properties, such as grain-size or composition, within one hydrogeologic unit. For example, a tuff becomes finer-grained with distance from sources (Lajoie, 1984). It is not spatially invariant. Besides requiring an adjustment in our conceptual model, spatial variability of the mean also requires modifications to sampling programs. Not only is there stochastic variability, but also deterministically understandable variability, which requires more sampling to adequately characterize. REFERENCE: Lajoie, J., 1984, Volcaniclastic rocks, in, Walker, R.G., ed., Facies models, second edition: Geoscience Canada, Reprint Series 1, Geological Association of Canada, Publications, Toronto, p. 39-52.

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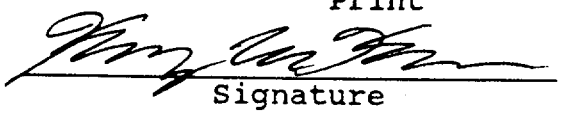

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-31 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9 (3-146)	The philosophy or approach for developing a conceptual model as stated on page 3-146 appears to be consistent with the overall structure and details of the Site Characterization Plan. However, by only pursuing <u>one</u> conceptual model, which is apparently the preferred model for siting a repository, it may be that alternative models are de-emphasized and thus understudied. The philosophy on page 3-146 should be augmented by Chamberlin's classic 1897 method of "multiple working hypotheses". Here several conceptual models of the hydrogeologic system or processes would be developed, coordinated, and evaluated simultaneously in an impartial manner.

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-32 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9 (3-146)	The current state of our knowledge regarding the hydrologic properties of faults as expressed by "...faults may act preferentially either as conduits for or as barriers against moisture flow." is quite amazing. The role of a key component of the hydrologic system of the proposed site is barely understood. The role of faults should probably have been determined before a site was proposed that has faults passing through the controlled area and the proposed repository itself.

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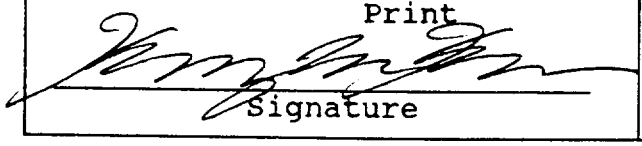

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-33 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1 (3-147)	Eight (8) or more additional water table wells are planned; however, the water table elevations are not well known at this time because the existing wells sample the hydraulic potentials over 60-75m of thickness of the geologic units. Packers should be placed in each water table well at about 1 meter beneath the currently measured water level. Monitoring should begin in the 1 meter section above the packer as well as in the lower intervals. These changes should be put in place so that monitoring of the actual water table can commence. Once the existing wells have been monitored for 3-5 years, the data should be reviewed as a guide for more-detailed investigations of the water table and for designing and siting additional wells.

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-34 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1 (3-147)	It is stated: "Based on available data, it can be concluded that seasonal variations in water levels probably are a fraction of a meter, and no long-term trends have been discerned yet." This sentence implies that long-term trends do not occur, or are so small they cannot yet be detected. In fact, the quality of the available water level data is poor and may not allow determination of trends or periodicities. The quality of the data is poor for two reasons. First, changes in measurement techniques, inadequate calibration methods, and drifting of transducers have called into question all available water level data. Second, the design and construction of water table wells and piezometers, means that composite or average hydraulic potentials are measured. These may show less variability or trends than measures of hydraulic head for thin intervals.

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COMMENT NO.: 3-35 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1.1.1 (3-150)	The fact that an apparent perched water zone was encountered in the drilling of borehole UZ-1, which was the first (relatively deep) borehole at the site drilled without water, is very interesting and should have received more attention. Many questions regarding this perched zone are not considered. The concentration of the drilling fluid polymer, its density and viscosity, the volume of fluid lost in comparison to the apparent volume estimated in the unsaturated zone, and the significant lateral transport distances are not discussed. Did the drilling fluid contaminate an already existing perched water zone and cause major changes in its flow field? If G-1 drilling fluid contaminated such a large region around a borehole, then it is also likely that this occurred around other boreholes. This constitutes significant disturbance of the unsaturated zone hydrology in the testing program and in the repository area. Can the site be adequately characterized with such disturbances? Do the disturbances alter the ability of the unsaturated zone to limit downward percolation in the repository area? The SCP only briefly describes the discovery of the water and implies it is all from the drilling of USW G-1.

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COMMENT NO.: 3-36 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1.1.1 (3-153)	The "...possible long-term drift of the pressure transducers, long equilibration times for the psychrometers placed in dry silica-flour columns, frequency of failure of the heat dissipation probes." again emphasizes the newness of this research and indicates that good quality research on unsaturated zone moisture conditions will take many years to accomplish. Changes in measuring techniques may be necessary to adequately understand the processes. A more systematic approach where all of the technologies were tried, **modified**, and proven on a limited scale prior to general application would provide more confidence in this program.

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COMMENT NO.: 3-37 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1.1.2 (3-156)	The piezometers in the Yucca Mountain area are 'unusual' piezometers that actually measure composite potentials, commonly over vertical intervals of hundreds of meters. Because of this fact (along with the great inadequacy in the number of piezometers) our current understanding of the three-dimensional flow field is in its infancy. Many additional piezometers that measure potentiometric head of thin intervals are required before much can be learned about the saturated flow system.

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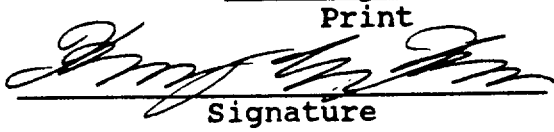

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COMMENT NO.: 3-38 p. 1 of 2 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1.1.2 (3-156)	The water level measurement errors are unsatisfactory. The measurement errors are roughly the same order of magnitude as the apparent variability in water levels, as determined with the available data (Robison et al., 1988). Thus the data do not permit the determination, with a high degree of confidence, of whether the water table fluctuations are real or are related to errors. Because individual water-level measurements are needed to calibrate the pressure transducer measurements, which are also subject to measurement problems, ("hydrographs of the limited data available might be imprecise and possibly misleading" p. 3-156) confidence in these measurements is even further weakened. Because of the seriousness of the matter for which these measurements are needed, improved technology for accurate water level measurement in deep boreholes should have been a first and high-priority item. It continues to be a high-priority need. I strongly encourage the DOE and USGS to support the development of new technologies in this area.

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COMMENT NO.: 3-38 p. 2 of 2 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1.1.2 (3-156)	REFERENCE: Robison, J.H., D.M. Stephens, R.R. Luckey, D.A. Baldwin, 1988, Water levels in periodically measured wells in the Yucca Mountain area, Nevada, 1981-1987: U.S. Geological Survey Open-File Report 88-468.

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COMMENT NO.: 3-39 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1.1.2 (3-156)	With regard to the problem of pressure transducer measurements. At the very least a significant improvement in quality assurance of these measurements would be realized by utilizing redundancy. Two (or more) pressure transducers should be used to record water-level fluctuations in water table wells or piezometers. For example, two pressure transducers mounted exactly one-meter apart should record identical water-level fluctuations. Deviations between the pressure transducers would either have to be accounted for (perhaps one drifted as its battery voltage decayed) or if the records could not be reconciled then the value of the records is called into question.

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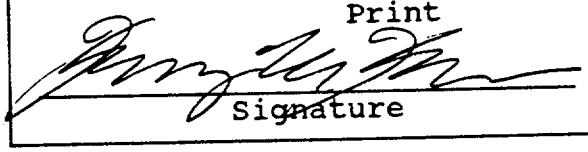

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-40 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1.1.2 (3-160)	The SCP emphasizes how important precise hydraulic gradient information is to the overall project, in that both ground-water flow direction and travel times are dependent on this information. However, the current lack of true water table wells or piezometers, and the serious problems with obtaining reliable measurements of water levels is in conflict with DOE's statement of the importance of this information.

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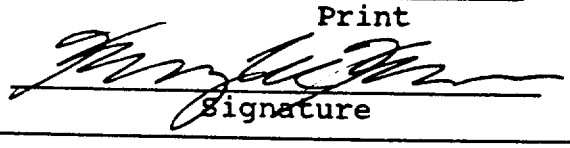

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COMMENT NO.: 3-41 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1.1.2 (3-160)	Comparisons of density, temperature, and chemistry are also complicated because samples of these properties are also composites drawn from thick geologic intervals. Density variation is assumed to be small, however, as recently pointed out by Oberlander (1989) density effects associated with variability in temperature and dissolved solids may be very significant in the Yucca Mountain area. The assumption that fluid potentials are being measured by the water-level measurements in the deep boreholes may be inaccurate. REFERENCE: Oberlander, P.L., 1989, "Fluid density and gravitational variations in deep boreholes and their effect on fluid potential": Groundwater, v. 27, n.3, p. 341-350.

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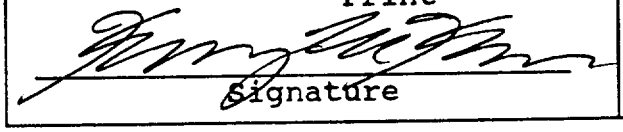

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COMMENT NO.: 3-42 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1.3 (3-165)	To determine temporal trends in hydrochemistry, samples should be collected at monthly to quarterly intervals. By sampling at irregular longer intervals any seasonal variations in hydrochemistry may not be discernable. In addition, samples should be collected from water table wells that penetrate only shallowly beneath the water table. The current water table wells probably do not allow detection of seasonal variability of water chemistry at Yucca Mountain.

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COMMENT NO.: 3-43 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1.3 (3-165)	It should be realized that the available major-ion data are for composite samples, which are withdrawn from a significant thickness of the geologic formations. These samples are mixtures of water that may have quite different original chemistries. Interpretations of the available and other forthcoming chemistry data from the wells at Yucca Mountain are very difficult to make. Determining whether the water appears to be super-saturated, undersaturated, or in equilibrium with specific minerals within the tuffs at a given level cannot be ascertained from composite samples. In addition, because kinetics may also play a role and the composite samples may include water of very different residence times, part of the water may have had time to reach equilibrium whereas other parts may not have had time to attain equilibrium.

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COMMENT NO.: 3-44 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1.3 (3-165)	The water chemistry of the lower-permeability zones in the tuffs may be different from the water chemistry of the higher-permeability zones. Selective sampling of the higher-permeability zones probably occurs when the wells are pumped to collect a sample.

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COMMENT NO.: 3-45 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1.3 Table 3-25	A column that indicates the depth interval from which the samples are taken should be included.

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COMMENT NO.: 3-46 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1.3 (3-168)	The delta carbon-13 values of ground water samples are negative and are consistent with recharge under very poorly vegetated conditions. This may suggest that water, even at significant depth, was probably recharged in the Holocene. During the maximum-Wisconsin (20,000-15,000 yr. B.P.), vegetation patterns deduced by paleobotanical methods are consistent with greater vegetation cover and less negative delta carbon-13 values are expected. During the early Holocene pluvial period the vegetation cover was probably greater than today, but may not have been as much as in the Pleistocene, because the vegetation composition does not appear to have changed much at this time.

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COMMENT NO.: 3-47 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1.3 (3-167) Table 3-25	Why are the values listed for HTO given as less than certain values rather than providing the measured value? This should be explained on the Table or in the text. Pre-1950 values of tritium are approximately less than 5 or 10 tritium units, whereas tritium levels after the major atomic tests (50's-60's) are commonly 1000's of tritium units. If the values listed as <62 tritium units are close to 50 or 60 tritium units, then this could indicate that the water contains some recent water. If the values are less than this then the water may be somewhat older or very old. The fact that water has tritium values apparently > 6.0 TU is significant. Because the half-life of tritium is 12.3 years and because the samples are typically composite samples of water, the existence of significant measurable tritium values may indicate that some relatively young water is being incorporated.

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COMMENT NO.: 3-48 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1.3 (3-168)	Because "methods are currently under development for extracting uncontaminated samples upon which to perform these [hydrochemical and isotopic] analyses", the ability to use geochemical information on pore water to assess the residence time and chemical evolution of water as it passes through the unsaturated zone remains in doubt. Once methods are developed and tested, which will most likely take at least several years, the actual sampling will need to proceed at a number of sites and depths. Thus it appears there will probably not be enough time to have gathered and analyzed the samples prior to the 1995 license application deadline.

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COMMENT NO.: 3-49 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.1.3 (3-168)	It should be clearly stated that the possible "downward gas-phase transport from the surface" is only implied at site UZ-1. The possible downward transport is unknown for the rest of Yucca Mountain. In other words the highly tentative interpretation of radiocarbon-activity profile at one site should be clearly stated as such. The SCP should not presume that data collected at one site is representative of the entire site.
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COMMENT NO.: 3-50 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.2.1 (3-169)	Tuffs may have crude bedding, oriented in a horizontal or subhorizontal manner, and thus may be somewhat anisotropic with respect to water flow. Measurements of hydraulic conductivity of samples from cores, which are vertically oriented, are probably underestimating the maximum matrix permeabilities.

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COMMENT NO.: 3-51 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.2.1 (3-170) Table 3-26	The normal or expected statistics, such as range or standard deviation of K values and the number of samples these values are based on are not provided for each unit. By only listing one value a sense that the value is accurately known is presented.

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COMMENT NO.: 3-52 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.2.1 (3-171)	Regarding: "Techniques for the measurement of relative hydraulic conductivity on very low permeability tuffs, such as welded tuff matrix material from TSw, are under development,..." Because detailed measurements of permeability in these tuffs are unavailable, understanding the flow of fluids in the unsaturated zone remains highly speculative. This data is important in understanding the mechanics of vadose zone flow. To obtain this important data, upon which other experiments will need to be designed, will take at least several years if it is possible. It appears the time needed for this work is insufficient. Proceeding with other experiments prior to the measurement of this property may result in improperly-designed field experiments.

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COMMENT NO.: 3-53 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.2.1 (3-171)	Regarding: "Standard field and laboratory methods are not yet available by which to determine the moisture-characteristics relations for variably saturated fractures and fractured rocks." The time to develop methods for understanding moisture characteristics of fractures and fractured rocks is insufficient. Once the methods are available they need to be applied across Yucca Mountain at various depths. Sampling and analyzing the results of measurements will require additional time. Because of the importance that fractures may play in transporting water in the unsaturated zone, this data is very important and should be known and available as a foundation for site characterization. It should not be a part of site characterization. This lack of understanding is an example that supports the site being **not** "readily characterized."

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COMMENT NO.: 3-54 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.2.1 (3-171)	The selection of Yucca Mountain as a potential repository site is based on theoretical concepts of how moisture may behave in the unsaturated zone in this setting. The SCP states that "Theoretical models for liquid-water flow in single fractures have been developed but have not yet been field or laboratory tested." In other words our understanding of the flow of water through this material is in its infancy.

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COMMENT NO.: 3-55 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.2.1 (3-174) [3-34]	This is a highly idealized figure. It may apply in steady-state, uniform flow conditions, but is untested in transient conditions or in examples of real fractures possessing variable apertures and connectiveness.

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COMMENT NO.: 3-56 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.2.1 (3-175)	Besides being dependent on the parameters listed, the net effective hydraulic conductivity may also be a function of the transient conditions.

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COMMENT NO.: 3-57 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.2.1 (3-178)	Porosities should ideally be determined on the same samples for which moisture contents are determined. The values of saturation should be taken as estimates. The range or confidence intervals should be provided. As the SCP states, these are very tentative results.

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-58 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.2.1 (3-178)	The discrepancy of TSw matric potentials measured in UZ-1 and estimated from moisture contents highlights the fact that we may not yet have reasonable conceptual models for the unsaturated zone water system.

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COMMENT NO.: 3-59 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.2.2.1 (3-181)	The SCP should be consistent and report hydraulic conductivity values in the same units, preferably m/s. Switching between m/s and m/d only makes comparisons more difficult.

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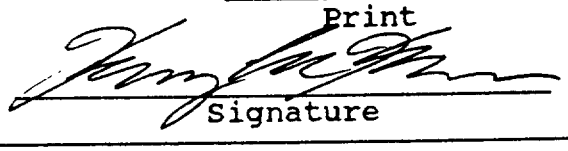

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COMMENT NO.: 3-60 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.2.2.2 (3-187 to 3-190) Table 3-28	The available values of hydraulic conductivity, reported on Table 3-28, may be unrepresentative of the true hydraulic conductivities, because of the biased sampling related to the respective orientation of the boreholes and the fractures, which are both oriented vertically. The permeable zones identified by the sampling program, may in fact be locations where fractures or fracture sets and boreholes intersect. Other levels may have higher conductivity, but fractures at those levels may not be intersected by a particular borehole.

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COMMENT NO.: 3-61 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.3 (3-193 to 3-197)	The conceptual model and hypotheses listed are biased towards a favorable model for repository siting. Alternative hypotheses should be listed and given fair consideration. The biggest concern with this approach is the danger that testing may be essentially restricted to these hypotheses and other concepts may not be investigated.

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COMMENT NO.: 3-62 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.3 (3-193 to 3-214)	Alternative models or aspects of models are not sufficiently discussed in Chapter 3. For example in section 3.9.3 possible linkages between changes in water tables or potentiometric levels and fault block movements are not considered. These are probably minor transitory effects, but the importance of such factors should be investigated. Another physical mechanism that is not discussed in Chapter 3, either in sections 3.9.3 or 3.7.4, is the possibility of changes in tectonic activity associated with changes in the hydrologic system. For example, when pluvial lakes form and when they disappear, the crust must isostatically adjust. By this mechanism greater earthquake activity and faulting may be expected as pluvial lakes form and as they wane. Thus present faulting rates may be less than the rates occurring at such times.

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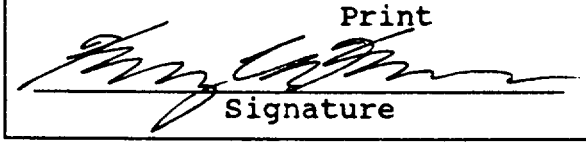

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COMMENT NO.: 3-63 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.3 (3-194) [3-40]	If hypothesis 3 is correct and water is less likely to flow into the matrix of TSw from PTn, then the offsets and hydraulic nature of the faults become very important. For example on Fig. 3-40, offsets of the PTn unit are shown that do and do not separate it from itself. If faults are transmissive features, then it is imperative the detailed geometries and offsets of these units are determined.

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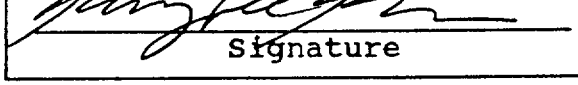

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COMMENT NO.: 3-64 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.3 (3-196)	A concept that may be important to the siting of a repository at Yucca Mountain, is that the non-welded units, eg. CHn, transport water essentially only by matrix flow. However, fractures do exist in these units and although they are less frequent, questions remain as to their role in water movement. First of all, are they continuous with fractures in the overlying and underlying units? Are there zones of greater concentration of fractures that serve as preferred pathways? Are fracture skins important in these units, as they may be in the welded tuff units?

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QAP-3.4
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NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-65 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.3 (3-197)	It is conceivable that ground water in the Yucca Mountain vicinity could have significant interaction with ground water of the lower carbonate aquifer. The SCP reports that a significantly-higher head in the carbonate aquifer has been discovered in one well on the east flank of Yucca Mountain, where the water table is relatively low and has a gentle gradient. However, the head relationship between the tuff and carbonate aquifers is unknown in the western and northern parts of Yucca Mountain where the water table is apparently much higher. Is recharge favored in these regions? Could there be a movement of water into the lower carbonate aquifer in this region?

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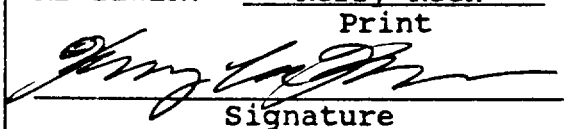
DOCUMENT TITLE: Site Characterization Plan	
COMMENT NO.: 3-66 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.3.1 (3-199)	This section seems to consider only vertical downward flow in the unsaturated zone. In a complex fracture network, the flow may have lateral components, which may become more important near perched-water zones.
REVIEWER: Kerry Keen Print  Signature	ORGANIZATION: L. Lehman & Associates, Inc. DATE: June 29, 1989

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COMMENT NO.: 3-67 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.3.2.1 (3-200)	Regarding: "Although the data show considerable variability, there is no well-defined systematic variation of matric potential with depth within hydrogeologic units, which is consistent with the supposition that the individual hydrogeologic units are relatively homogeneous in the vertical direction and that steady-state vertical moisture flow occurs under unit vertical hydraulic gradient." This statement is an example of the biased presentation of Chapter 3. This statement strongly over-interprets the data. Figures 3-30 and 3-31 indicate both significant vertical variability, as well as possible complicated patterns of changes in potentials over time. In addition, no details on the time response of the sensors are provided. Could rapid flow of a pulse of water in fractures be missed by this monitoring system?

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COMMENT NO.: 3-68 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.3.3 (3-203)	This section presents a biased or narrow, unsubstantiated view of moisture movement in the unsaturated zone. The statement: "Temporal variations of net infiltration are expected to be damped rapidly with depth in the uppermost few tens of meters of the unsaturated zone..." should be altered to read clearly as a hypothesis, not an expectation. Instead of the expectation that "slow temporal variation of moisture flux at any horizon" is a response to long-term climatic change, a more balanced set of hypotheses should be stated. These include the stochastic nature of infiltration as well as stochastic aspects of flow through the unsaturated zone. This section does not give fair consideration of other hypotheses. If flow through fractures is important, then the entire discussion of unsaturated flow must be changed.

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COMMENT NO.: 3-69 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.3.4 (3-208)	This section repeats many previously stated assumptions as "quasi-facts." There seems to be a pattern of introducing hypotheses early in Chapter 3 and repeating them several times later in the chapter. By the end of the Chapter, however, the conditional clauses may not appear with the hypothesis, which by this technique, is given more weight.

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COMMENT NO.: 3-70 p. 1 of 1	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.4.1 (3-216)	Ground water travel time calculations for the unsaturated zone are extremely premature, because conceptual models of flow mechanisms and patterns have not been compared with reality by field testing. Although it is interesting to calculate estimates of travel times, the possibility of rapid flow through fractures that may be contiguous for many meters or tens of meters means that the travel times (and range in estimated travel times) based on slow matrix flow may be very much larger than the actual travel time. A better approach would be to estimate travel times for a number of alternative scenarios, not just for the preferred matrix-flow model.
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COMMENT NO.: 3-71 p. 1 of 2 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.4.2 (3-219)	Regarding assumption 3: The available water level measurements are not detailed enough to provide reasonable estimates of the water table or hydraulic gradient because they are composite measurements. The gradient is probably underestimated in some areas. In addition the possibility of localized semi-perched water zones (see Winograd and Thordarson, 1975) and the interaction of this water with the water table surface is not discussed. Regarding assumption 4: Because vertical fractures exist, anisotropy may be very significant. Boreholes probably do not intersect a representative number of fractures and thus most likely underestimate both storativity and transmissivity. In addition, fracture aperture, density, and orientation are dependent on the tectonic stress field, which may vary spatially and temporally. Thus the system may be far from isotropic as assumed.

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COMMENT NO.: 3-71 p. 2 of 2 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.4.2 (3-219)	REFERENCE: 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: U.S. Geological Survey Professional Paper 712-C, p.C1-C126.

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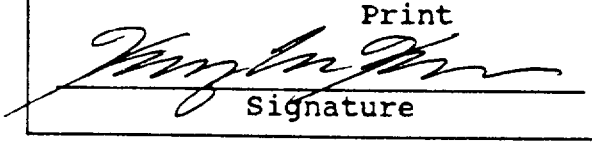

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COMMENT NO.: 3-72 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.8 (3-229)	It appears tnat zeolitization of tuffs is favored at or beneath the water table, and thus the lowest elevation of vitric tuff may allow determination of paleowater tables. This concept is interesting and could be quite useful if verified for the southern Nevada region. The lowest elevation of vitric tuff should be identified in other parts of southern Nevada to see if these surfaces could possibly approximate paleo-water levels. Investigations should also proceed to determine if zeolitization can occur in perched water zones. A much more thorough documentation of the three dimensional geometry of vitric versus de-vitrified zones may be necessary prior to concluding that this boundary may approximate the paleo-water table.

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COMMENT NO.: 3-73 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.9.8 (3-229)	The Czarnecki model and estimates of changes in recharge are valuable learning tools developed on the basis of the best available information. Although these modeling efforts are quite detailed and appear to be reasonable, we must remember that they are only one representation that approximates the actual hydrologic system. The results of the ground water modeling and recharge estimation are not substitutes for the actual processes or values. Czarnecki's model rests on a number of assumptions, which are subject to modification as new data are obtained. For example, the detailed timing and transient nature of infiltration over the Yucca Mountain surface in the past is unknown at this time. Significant recharge may have occurred along faults or beneath depressions on the mountain surface in the past.

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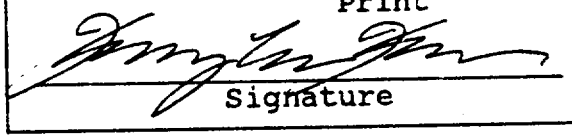

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-74 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.10.1 (3-235)	The modeling of flow in the unsaturated zone seems to apply circular reasoning. By presuming steady-state flow, the results show (as expected) that the flow through the unsaturated zone is steady and slow in the matrix. Investigations of stochastic or chaotic flow processes in the unsaturated zone are not reported here and realistic modeling of highly transient fracture flow has not been reported yet.

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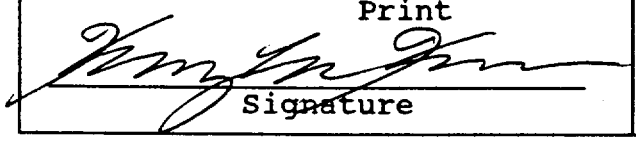

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COMMENT NO.: 3-75 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.10.1 (3-236)	The conclusions regarding the flow of water in the TSw unit are not conclusions, but rather are hypotheses developed from the available limited data.

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COMMENT NO.: 3-76 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.10.1 (3-236)	It may be necessary to analyze gas flow as a multicomponent system, Thorstenson and Pollock (1989), especially for radioactive daughter products. Fluxes may arise from small pressure differentials, which presents a problem because these are presently at the current detection limit for differences in gas pressures. REFERENCE: Thorstenson, D.C. and D.W. Pollock, 1989, Gas transport in unsaturated zones: Multi-component systems and the adequacy of Fick's Laws: Water Resources Research, v. 25, p. 477-507.

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COMMENT NO.: 3-77 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.10.1 (3-237)	Travel times are listed given the assumption that matrix flow dominates. The preliminary nature of these estimates should be emphasized. Travel times should also be estimated for other scenarios, including rapid transient fracture flow in preferred pathways via fracture networks.

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 3-78 p. 1 of 1 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.10.1 (3-237)	A value of 200 meters is listed here as the distance that the water table would have to rise to inundate the repository. From figure 3-41, a rise of 185 meters is needed to flood the lowest part of the repository, whereas a 135 meter rise would bring the level to the limit of the disturbed zone.

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COMMENT NO.: 3-79 p. 1 of 2 | CHAPTER NO.: 3

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.10.2 (3-238)	The SCP argues that if perched-water bodies are found at Yucca Mountain, they are not a major concern. No evidence or basis for this statement is offered. First of all, the presence of perched water bodies means fractures are saturated, which is exactly opposite of what the model of flow in the unsaturated zone is based on. This would be very serious and would indicate the preferred model may be flawed. Secondly, because flow through fractures is more rapid than through the matrix, the travel times through the unsaturated zone may be much less. It has not been established perched-water zones are static features with stagnant water. In fact, the variable discharge of perched-water springs as reported by Winograd and Thordarson, 1975, indicates perched water may be highly dynamic. If flow systems exist within perched-water bodies and if springs emerge from them now or in the future, this may be a rapid transport path for radionuclides to the accessible environment.

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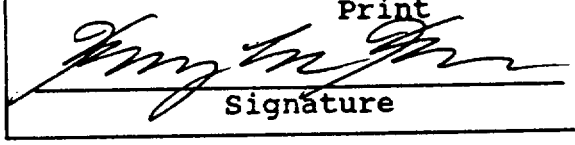

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DOCUMENT TITLE: Site Characterization Plan	
COMMENT NO.: 3-79 p. 2 of 2	CHAPTER NO.: 3
SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
3.10.2 (3-238)	REFERENCE: Winograd, I.J., and W. Thordarson, 1975, Hydrogeologic and hydrochemical framework, South-Central Great Basin, Nevada-California, with special reference to the Nevada Test Site: U.S. Geological Survey Professional Paper 712-C, p.C1-C126.
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SPECIFIC COMMENTS

Chapter 8

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TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 8-1 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.0 (8.0-5)	The preferred conceptual model for the site is used in this discussion. For example it is stated: "As explained in detail in Chapter 3, the currently available information suggests that only small amounts of water are available to percolate slowly downward through Yucca mountain." In reality very little field evidence is available for determining the actual rates at this time. A more balanced statement of this should be used at this time, which acknowledges the uncertainties in the current understanding of water movement in the unsaturated zone at Yucca Mountain.

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COMMENT NO.: 8-2 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.0 (8.0-8)	The preferred conceptual model is relied on too heavily in the discussion on the performance of the engineered barrier system. Whether or not an air gap around the containers will be effective in keeping water from contacting the containers is unknown. It depends on the nature of flow in the unsaturated zone, which at this time is highly uncertain. The role of transient fracture flow and the behavior of the perched water zones are essentially unknown at this time. The SCP is less credible or possibly flawed when it selectively adopts preferred conceptual views as a basis for its engineering design.

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TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 8-3 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.0 (8.0-8)	The statement: "Current evidence suggests that the travel time from the repository through the unsaturated units to the saturated zone is longer than 10,000 yr." should be modified to: "There is limited preliminary evidence, based on highly incomplete field study and modeling of matrix flow, that the travel time through the unsaturated units to the saturated zone is long, possibly greater than 10,000 years. Alternative models such as localized highly transient fracture flow are of concern because these could yield travel times that are much less than 10,000 years, especially given the uncertainty about future precipitation and recharge patterns." Again the SCP is assuming the most favorable conceptual model of flow and geochemical interactions in the performance of the natural barriers, and under-emphasizes the possibilities of rapid fluid transmission along fractures, the role of faults and tectonics, the behavior of perched water zones, etc.

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COMMENT NO.: 8-4 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.0 (8.0-9)	The statement: "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 flux is low and that the water in the unsaturated zone is tightly confined within the rock matrix." is a questionable strategy. Instead of "relying heavily" on one favorable model, there should be intensive investigations based on a variety of conceptual models to prove that other models do not apply or are not important. It is conceivable that by performing tests within the framework of one preferred conceptual model, the tests could all support the validity of the preferred model. However, tests of alternative models may explore aspects of the real system not previously considered, and may allow the detection of flaws in the original preferred conceptual model. Alternative conceptual models should not be relegated to "second place" concepts, or tucked in a short list of topics "that will also be studied." Alternative models should receive equal status.

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COMMENT NO.: 8-5 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.1.2 (8.1-5 thru 8.1.6) [8.1.1]	As presented in the figure on page 8.1-6, the Issue Resolution Strategy is missing an important feature. A feedback loop should extend from Step 9 "Establish That Information Needs Are Satisfied" back to Step 6 "Develop Testing Strategy, Identify Tests, Variables and Parameters to be Measured". This feedback loop is necessary in case it is determined during Step 9 that a particular information need has not been satisfied. Such situations are highly likely, particularly when dealing with subsurface investigations where unforeseen results are commonplace.

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 8-6 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.1.2.2 (8.1-7 thru 8.1-8)	The use of performance "goals" is questionable. The DOE defines these goals as guides which will have specific values consistent with licensing strategies. Once these "goals" are attained, then supposedly an issue will be resolved. The DOE however proceeds to caveat this rationale to the extent that it becomes useless. All goals do not have to be met, they are only preliminary, they can be changed. Once again, DOE has rendered a good idea useless. No steps have been outlined as to what happens when goals are not achieved within confidence limits. Does the DOE simply change the goal to meet the value?

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COMMENT NO.: 8-7 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.1.2.2 (8.1-8)	Typically confidence intervals are statistically rigorous quantities. DOE states that most of their confidence indicators are only qualitative expressions. DOE is trying to make a completely arbitrary process appear to be mathematically grounded.

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COMMENT NO.: 8-8 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.1.2.3 (8.1-8)	Again, DOE is setting a goal of a specific value for a parameter. Caveats are many; the goal does not have to be met, the goals are preliminary, etc. Again, this implies that if a parameter does not live up to expectations, expectations will simply be lowered. DOE should be required to have a strategy that if a parameter fails an expected goal, then other goals should be made much higher in order to compensate the failed goal. No such statements are made by DOE.

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COMMENT NO.: 8-9 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.2.1 (8.2-3) Table 8.2-2	The SCP lists the information needed for Key Issue 1.1.2 as: "A set of potentially significant release scenario classes that address all events and processes that may affect the geologic repository." This states that information is needed on a wide range of possible scenarios and emphasizes the importance of considering alternative conceptual models. This conflicts with other portions of Chapter 8 where the current preferred model is emphasized and alternative models receive little discussion.

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COMMENT NO.: 8-10 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.2.1.2 (8.2-21) thru (8.2-27) Table 8.2-3	Table 8.2-3 lists "concerns" along with corresponding "SCP cross-references", but a number of cross references are incomplete, or inadequately address the stated concerns. This table leads the reader to believe that the specific concern has been addressed or resolved as stated in the cross reference. The table should not state that the concerns are addressed, which implies some resolution of the concerns. Instead it should state that "...relevant discussion of the concern is included in the cross reference." A number of concerns are correlated with SCP sections that seem to discuss peripheral or slightly related issues. For example on page 8.2-23; major concern: Hydrogeologic properties; specific concern: Interrelationships of hydrogeologic properties; SCP cross-reference is 3.6 Regional hydrology. I interpret the stated concern to be about the detailed correlation between properties such as transmissivities, porosities, anisotropies, hydrogeologic formation geometries for specific units. This is not discussed in 3.6. Another example is on page 8.3-27 where a concern on groundwater migration in the Great Basin is correlated with SCP sec. 1.1, which is about Great Basin Geology not groundwater migration.

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COMMENT NO.: 8-11 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.2.1.2 (8.2-22) Table 8.2-3	Hydrothermal activity and its affects on flow paths does not necessarily require faulting and should not be correlated with an SCP section that discusses the effects of faulting.

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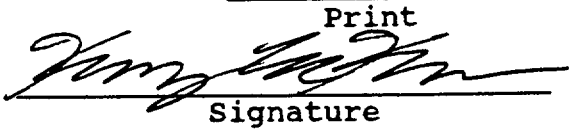

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COMMENT NO.: 8-12 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.2.2 (8.2-65) Table 8.2-6	The Potential for coupling of tectonic and hydrologic processes and events should be addressed by a Corresponding Issue in the SCP. Regulations supporting the study of this topic include 10 CFR 60.113 a(2) and 10 CFR 60.122 c(4).

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COMMENT NO.: 8-13 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.1 (8.3.1.1-4)	The geologic record does offer the opportunity of looking at long-term processes at Yucca Mountain. However, the statement that the mountain formed more than ten million years ago paints a static view of the site and is inaccurate. The volcaniclastic units were deposited at that time. The mountain itself is a dynamic feature of the present landscape.

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COMMENT NO.: 8-14 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.1 (8.3.1.1-5)	If an issue is "resolved" and then future information becomes available that sheds doubts about the previous resolution, there should be a mechanism for making an issue "un-resolved" again. This needs to be described in the SCP.

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COMMENT NO.: 8-15 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-3)	Restricting the development of the unsaturated zone hydrologic model to the site is unwise. A more comprehensive study of the regional unsaturated zone is definitely warranted. Analogs for the unsaturated zone at Yucca Mountain, especially those with a somewhat different hydrologic regime, such as higher annual precipitation and infiltration, should be identified and studied in detail. Because the unsaturated zone is relied on as the most important natural barrier, and because there are many questions regarding the hydrologic system in the unsaturated zone, this zone deserves intensive investigation. Hydrologic conditions will change over time at Yucca Mountain. Studies of the unsaturated zone in similar geologic media, but with higher precipitation, greater recharge, more extensive perched water zones, etc., may provide data that reduces the uncertainty regarding the behavior of water in the unsaturated zone.

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COMMENT NO.: 8-16 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-10) Table 8.3.1.2-1	The studies identified in Table 8.3.1.2-1 are valuable and definitely necessary. However, many of the studies listed, especially the meteorological and unsaturated zone studies, require many years of investigation to characterize the natural variability of the processes. The time allotted until the proposed submittal of the license application is too short for the level of research that is needed. If these studies had begun 10 years ago then perhaps there would be time to conduct high quality detailed research that can accommodate modifications as data is collected. The proposed studies can essentially only proceed as designed and there will be little or no time to modify or revise the approaches as preliminary data is collected.

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COMMENT NO.: 8-17 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-20) Table 8.3.1.2-1	Studies of three dimensional potential fields in the matrix and adjacent fractures, and also in and around perched water zones are not listed and should be included in the investigation of water potential in the unsaturated zone.

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 8-18 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-22) Table 8.3.1.2-1	Studies of temperature variations after heavy rainfall events are not listed and should be included. Pulses of cool water from winter rains may be detected relatively easily in the unsaturated zone.

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COMMENT NO.: 8-19 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-28) Table 8.3.1.2-1	The boundary conditions for the unsaturated zone flow and solute transport numerical models do not include variable or non-steady boundary conditions, but these may be important and should be included.

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COMMENT NO.: 8-20 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-49)	The statement that "... and hydrologic processes are slow and difficult to measure." can characterize certain processes, but is extremely inaccurate in the characterization of storm precipitation, runoff, and in certain settings, infiltration and recharge. The statement follows the overall pattern in the SCP of characterizing the hydrologic system in a favorable light for repository siting.

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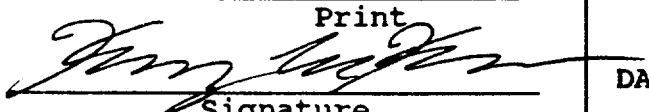

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COMMENT NO.: 8-21 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-52 thru 8.3.1.2-87) Tables 8.3.1.2-2a thru 8.3.1.2-2b	Commonly, the listing of the "current representation" and the "alternative hypotheses" on tables 8.3.1.2a and 8.3.1.2b are equally uncertain. In a number of instances the only distinction appears to be that the current representation is preferable for repository siting. This strategy is not balanced or fair. A better approach would be to list all hypotheses as "hypotheses", rather than subjectively selecting the "current representation" and "alternative hypotheses."

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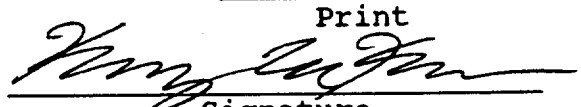

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 8-22 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-52) Table 8.3.1.2-2a	The uncertainty regarding the definition of the unsaturated zone should be considered to be greater because perched waters or semi-perched waters, similar to those described by Winograd and Thordarson (1975), may exist at the site. This would complicate distinguishing between the saturated and unsaturated zone. REFERENCE: Winograd, I.J. and Thordarson, W., 1975, Hydrogeologic and geochemical framework, South-Central Great Basin, Nevada-California, with special reference to the Nevada Test Site: U.S. Geological Survey Professional Paper 712-C, p. C1-C126.

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 8-23 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-52) Table 8.3.1.2-2a	The alternative hypothesis for the stratigraphy model element may characterize the stratigraphy as well as the current representation does. These should both be stated as alternative hypotheses rather than listing the preferred representation as the current representation. The uncertainty here is medium or high. As stated on page 8.3.1.2-89 of the SCP, clearly defined hydrogeologic units have not been established. These units are dependent on a detailed geologic process/depositional model and hydrogeologic model for the site, which are not available. The need to reduce uncertainty should be high, not low. The system is difficult to define because of complex depositional processes. Stochastic or other statistical characterization of hydrogeologic properties will only partially succeed in approximating the true deterministic system. Other representations, for example applying fractal mathematics, may be preferred over traditional statistical methods.

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COMMENT NO.: 8-24 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-53) Table 8.3.1.2-2a	The uncertainty of the transient, non-equilibrium flow of water in open fractures and faults should be listed as high not medium at this time. Although some modeling suggests that this is not an important process, field evidence that is consistent with more rapid transmission of water through the unsaturated zone indicates that this topic may be highly uncertain.

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COMMENT NO.: 8-25 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-53) Table 8.3.1.2-2a	Although there is low uncertainty that fractures and fracture systems are conduits for air and water-vapor flow in fractured tuffs, there is high uncertainty regarding the spatial and temporal variability of this flow. It is unknown if there are zones of enhanced gas flow or zones of diminished gas flow.

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COMMENT NO.: 8-26 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-53) Table 8.3.1.2-2a	An overall criticism of Table 8.3.1.2-2a, especially the structural features section, is that the alternative hypotheses are inadequate or overly simplified. More complex, but realistic hypotheses are not provided, for example: preferred pathways, combination of transient conditions and preferred pathways, heterogeneity of moisture conditions, which reduce air/vapor flow locally. We cannot rely on average conditions to understand the entire range of processes acting in a system.

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COMMENT NO.: 8-27 p. 1 of 2 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-54) Table 8.3.1.2-2a	Regarding the lateral flow of liquid related to eastward dipping fault blocks; lateral flow in the unsaturated/variably saturated zone could be strongly controlled by the structural dip of the geologic units, but could also be enhanced near and within perched water or semi-perched water zones. Because there is a possibility that springs could emerge from such perched water bodies, as identified elsewhere in southern Nevada (eg. Winograd and Thordarson, 1975), and because this could be a pathway for radionuclides to the accessible environment, the need to reduce the uncertainty regarding three-dimensional flowfields and interaction with perched water bodies is very high. The SCP states (p. 8.3.1.2-54) that "a complete description of this process probably is beyond the scope of the site characterization program." This is a serious weakness or omission of the site characterization program. To not study a possible transport mechanism or an aspect of a process, which conceivably could play a major role in allowing radionuclides to reach the accessible environment, is of major concern and indicates a selective approach to the study of potential problems. This is

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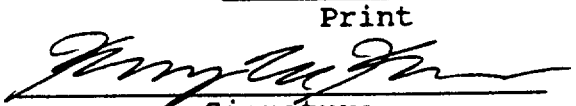
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COMMENT NO.: 8-27 p. 2 of 2 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-54) Table 8.3.1.2-2a	contrary to the intent of 40 CFR 191.12(q) and if not investigated will not allow the assessment of containment as required in 40 CFR 191.13(a). This weakens the credibility of the Site Characterization Plan. REFERENCE: Winograd, I.J. and Thordarson, W., 1975, Hydrogeologic and geochemical framework, South-Central Great Basin, Nevada-California, with special reference to the Nevada Test Site: U.S. Geological Survey Professional Paper 712-C, p. C1-C126.

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COMMENT NO.: 8-28 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-55) Table 8.3.1.2-2a	I disagree with the lower boundary condition's assigned uncertainty. Because we do not have "true" water table wells at the site the current understanding of the water table configuration is very uncertain. In addition if saturated perched water zones connect with the water table then the description of the true water table could be very complicated. The lateral boundary conditions may be more important if lateral flow is important under current or future hydrologic regimes and the need to reduce the uncertainty in their definition could be significantly higher.

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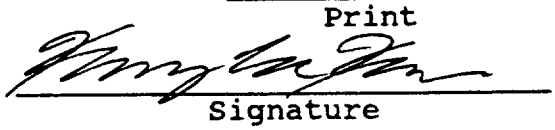

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COMMENT NO.: 8-29 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-56) Table 8.3.1.2-2a	Another category should be included that states that Darcy's law is applicable to the matrix of the geologic units, whereas non-linear (or other non-Darcian) flow may be important in fracture flow. Not considering alternative hypotheses is not prudent to careful site characterization.

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COMMENT NO.: 8-30 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-56) Table 8.3.1.2-2a	Concern regarding the release of radioactive gases, such as those containing Carbon-14, should raise the importance and sensitivity of the nature of gas flow.

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COMMENT NO.: 8-31 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-60) Table 8.3.1.2-2a	Regarding the current representation of perched-water bodies; it is unclear why perched water bodies are considered to be only temporary features. The sensitivity should be high. Perched water zones exist in analog sites, such as Rainier Mesa, and studies to identify these at Yucca Mountain are just beginning. The need to reduce uncertainty should be high, because the behavior of perched water bodies under present, former, and future situations is extremely important. For example, could relatively rapid growth and coalescence of smaller perched water zones, under an increased precipitation regime, rapidly change the groundwater travel time?

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COMMENT NO.: 8-32 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-66) Table 8.3.1.2-2a	Evaluation of the steady-state characterization of the hydrologic system below the Paintbrush nonwelded unit is very important. If transient conditions prevail in that part of the hydrologic system, then the ground water travel time to the accessible environment could be shorter than the required 10,000 years. Thus the needed confidence in defining the system dynamics should be high not medium for this aspect.

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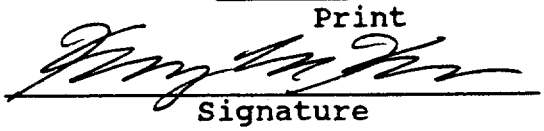

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COMMENT NO.: 8-33 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-67) Table 8.3.1.2-2a	The SCP states that tests to date have failed to identify definitive hydrostratigraphic units in the saturated zone (8.3.1.2-89). Because similar geologic processes formed the units in the unsaturated zone, it is not clear why unsaturated zone hydrogeologic units can be defined and characterized whereas saturated zone units cannot. In reality complex geometries and hydrogeologic properties are expected in this volcaniclastic geologic setting. These may be better defined by more extensive sampling and geophysical testing and development of a depositional geologic model linked to a hydrogeologic model. This model could also have geostatistical characterization overlaid onto it. The need to reduce the uncertainty regarding the representation of the hydrogeologic properties of the unsaturated zone is at least medium, not low.

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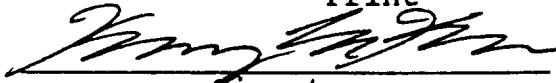

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COMMENT NO.: 8-34 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-70) Table 8.3.1.2-2b	The connection between the Tertiary units and the underlying carbonate aquifers is very poorly known. If the current representation is based only on one drillhole, then the uncertainty should be listed as being high.

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COMMENT NO.: 8-35 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-72) Table 8.3.1.2-2b	I disagree with the assessment that the uncertainty regarding the description of the water table is low. The uncertainty is higher because of the possible existence of semi-perched water zones, which could make the description of a single gently sloping water table surface difficult.

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COMMENT NO.: 8-36 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-73) Table 8.3.1.2-2b	The alternative recharge hypothesis should include: percolation following preferred fracture and fault pathways resulting in relatively rapid areally-distributed recharge.

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COMMENT NO.: 8-37 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-75) Table 8.3.1.2-2b	It is not clear that the base of the saturated system is the base of the Tertiary units. It may be necessary, especially considering the risk of radionuclide releases, to include more of the saturated geologic units, especially the Paleozoic carbonate aquifer. It has not been proven that there is no interaction between these units.

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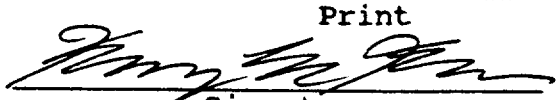
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COMMENT NO.: 8-38 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-77) Table 8.3.1.2-2b	The site hydrogeologic system should not be restricted to the controlled area, instead the boundaries should be defined based on the best available understanding of the saturated zone flow field at the time. It may be necessary to model a larger region so that boundary conditions or other aspects of the model can be better specified. For example, it may be easier to specify the upgradient boundary along a fault rather than the irregular boundary of the controlled area.

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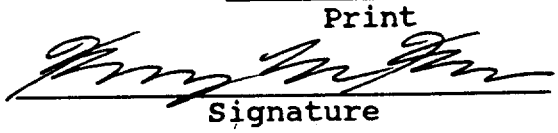

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COMMENT NO.: 8-39 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-77) Table 8.3.1.2-2b	Our current understanding of the temporal changes of the flow field is very poor. The apparent existence of much larger water table gradients northwest of the site and our brief monitoring of the groundwater system make the uncertainty fairly high in characterizing the system geometries.

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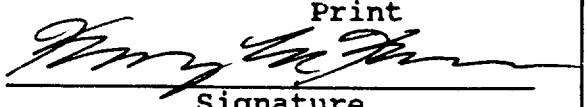

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COMMENT NO.: 8-40 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-85) Table 8.3.1.2-2b	It is questionable that "inverse modeling has been used successfully in the past to characterize ground-water flow beneath Yucca Mountain and vicinity", because extremely little good data is available to confirm or deny any model's results. The lack of true water table wells and only a crude sense of the three-dimensional distribution of heads means that past or current flow models cannot be accurately tested and determinations of success of modeling cannot be performed. The uncertainties and needs to reduce uncertainty are much higher, especially because of the complexities inherent in fractured volcaniclastic deposits.

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COMMENT NO.: 8-41 p. 1 of 2 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-89 and 8.3.1.2-91)	The SCP correctly describes the present high uncertainty about fractures and their connectiveness in the saturated zone. In addition it states that definitive hydrostratigraphic units have not been identified by production surveys or hydraulic tests of the saturated zone (page 8.3.1.2-89). These statements conflict with the portrayal of the current understanding of the unsaturated zone on page 91. There it is stated: "...characterization of flow ..., for all hydrostratigraphic units." If hydrostratigraphic units cannot be adequately defined for the saturated zone, then it seems unlikely that similar rock types in the unsaturated zone can be identified, and thus modeling of the unsaturated zone becomes even more formidable. This emphasizes the need for linking a detailed study and development of a geologic depositional model for the site with a hydrogeologic model of the site. The SCP does not include plans for studies to develop a linked geologic depositional model and hydrogeologic model for the site similar to the approach proposed by Anderson (1989).

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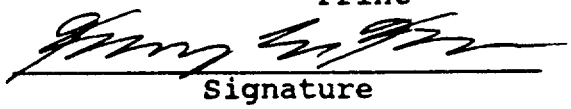

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COMMENT NO.: 8-41 p. 2 of 2 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-89 and 8.3.1.2-91)	REFERENCE: Anderson, M.P., 1989, Hydrogeologic facies models to delineate large-scale spatial trends in glacial and glaciofluvial sediments: Geological Society of America Bulletin, v. 101, p. 501-511.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2 (8.3.1.2-91)	Vapor movement in the unsaturated zone may increase the moisture tension in regions near fractures or faults where moisture may be channeled. Another scenario is also conceivable and should be considered. If preferred pathways for percolation exist, then depending on their geometry, the transmissive properties, the hydrologic inputs, and the presence of water at pinched zones, the gas permeability could be significantly reduced locally and moisture tensions may remain low in those regions.

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COMMENT NO.: 8-43 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1 (8.3.1.2-94)	In the northern half of the subbasin, the water table is reported to be at great depths. However, this is also the region where recharge is primarily supposed to occur in the mountainous areas. If recharge is occurring in the northern half of the subregion, as it must, then the significant thickness of the unsaturated zone by itself should not be viewed as a limitation for recharge occurring. Thus Yucca Mountain could likewise serve as a significant recharge feature depending on hydrologic inputs.

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COMMENT NO.: 8-44 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1 (8.3.1.2-96)	The studies of runoff and streamflow at Yucca Mountain probably need at least 10-20 years of detailed records to begin to assess the probabilities and characteristics of maximum floods. This may even underestimate the data needs in this environment where storm characteristics are highly variable. Streamflow studies are linked to infiltration and runoff investigations, which are essential for predicting the input of water to the unsaturated zone where the waste will be stored. Skimping on these studies and not being able to collect data over a long enough period weakens the understanding of the hydrologic system and causes concern that events of low probability but high impact may not be adequately assessed during site characterization.

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COMMENT NO.: 8-45 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1 (8.3.1.2-96 and 8.3.1.2-99) [8.3.1.2-6]	For a study of such importance, where accurate measurements of the inputs to the unsaturated zone hydrologic system are currently poorly known, the number and areal coverage of continuously-recording precipitation gauges should be significantly increased. Better coverage, including gauges at higher altitudes, will also prevent underestimation of the natural variability in time and space of storm rainfall. The location of the proposed rain gauges are not adequately distributed. For example, precipitation gauges are needed on the crest of Yucca Mountain, the higher northern parts of Yucca Mountain, west of the Solitario Canyon Fault, on the upland east of Beatty, and one on Timber Mountain. In general the coverage of rain gauges is adequate east and southeast of the site, but more should be continuously-recording devices.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1.2.1 (8.3.1.2-104)	Because no "analog" streamflow records exist for Yucca Mountain, these data will have to be collected over a number of years. The time remaining for measuring and characterizing streamflow at Yucca Mountain prior to the license application in 1995 is too short.

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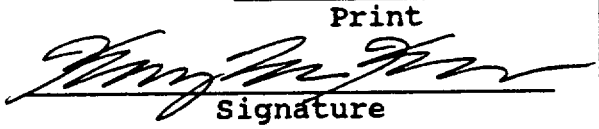

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1.2.1 (8.3.1.2-105)	If studies are just starting to monitor the meteorological and streamflow systems in adjacent areas, there will not be enough time to measure these components prior to the license application. It is necessary to fully understand the processes acting now to make predictions for the future hydrologic system at Yucca Mountain.

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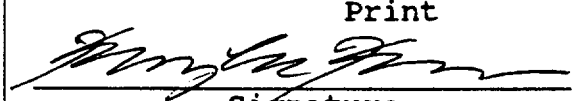

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1.3.1 (8.3.1.2-115)	Two-dimensional, regional flow models have been developed for the Yucca Mountain area. Examples of these include Czarnecki, 1985; Rice, 1984; Czarnecki and Waddell, 1984; and Waddell, 1982. The SCP should acknowledge that work has been done in this area, and indicate if any of this previous work will be utilized in this activity. REFERENCES: Czarnecki, J.B., 1985. Simulated Effects of Increased Recharge on the Ground-Water Flow System of Yucca Mountain and Vicinity, Nevada-California, USGS-WRI-84-4344, Water-Resources Investigations Report, U.S. Geological Survey, Denver, CO. Czarnecki, J.B., and R.K. Waddell, 1984. Finite-Element Simulation of Ground-Water Flow in the Vicinity of Yucca Mountain, Nevada-California, USGS-WRI-84-4349, Water-Resources Investigations Report, U.S. Geological Survey, Denver, CO.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1.3.1 (8.3.1.2-115)	REFERENCES - (continued) Rice, W.A., 1984. "Preliminary Two-Dimensional Regional Hydrologic Model of the Nevada Test Site and Vicinity", SAND83-7466, Sandia National Laboratories. Waddell, R.K., 1982. Two Dimensional, Steady-State Model of Ground-Water Flow, Nevada Test Site and Vicinity, Nevada-California, USGS-WRI-82-4085, Water-Resources Investigations Report, U.S. Geological Survey, Denver, CO.

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COMMENT NO.: 8-49 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1.3.2 (8.3.1.2-118) [8.3.1.2-8]	Although the areal coverage of observation wells is quite good, it appears that another well or two are needed in Crater Flat south of WT 22. From the limited available data, it appears that flow across Southern Yucca Mountain is from west to east; thus more wells are needed southwest of the repository to better define the flow field.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1.3.2 (8.3.1.2-119)	Activity 8.3.1.2.1.3.2 needs substantial modification so that "true" water table wells are constructed and monitored. These wells need to penetrate as little beneath the water table as is possible. Currently these wells penetrate 50-70 meters below the water table and thus measure a composite head over this interval, not the true water table. Packers should be installed about 2 meters beneath the current water table or below the uppermost level where sufficient fractures are located. The new wells should be drilled so that they only penetrate the water table a few meters. The measurements must be calibrated, repeatable, and the design for deep-well water level measurements should be improved. Robison et al. (1988) report numerous inconsistencies and problems that exist with the available water level measurements. REFERENCE: Robison, James H., et al, 1988, Water Levels in Periodically Measured Wells in the Yucca Mountain Area, Nevada, 1981-87: U.S.G.S. Open-File Report 88-468, 132 p.

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COMMENT NO.: 8-51 p. 1 of 2 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1.3.2 (8.3.1.2-122)	A very important aspect of the regional potentiometric analysis that is the foundation of that entire study is the correct design and installation of the water table wells and piezometers. The correct determination of the water table and the representative sampling of geologic units rests on the correct design of water table wells and piezometers. Technical procedures for constructing and installing water table wells and piezometers are not listed in the methods for this section and apparently do not exist. Explanation of why water table wells penetrate so far beneath the water table, which is contrary to accepted hydrologic practice, and why intervals spanning up to hundreds of meters are packed off rather than installing piezometers so that only thin intervals are sampled is not provided in the SCP. Without technical procedures, wells, which are very costly, may be installed that do not measure or sample what they are supposed to sample. This casts serious doubts about the data that has been collected by the entire saturated zone monitoring program and continues to be a major weakness. There is insufficient time before the license application to redesign

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1.3.2 (8.3.1.2-122)	the study, install new wells, restart the monitoring of water level fluctuations, and collect data over a long enough period for analysis of short-term and long-term fluctuations.

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COMMENT NO.: 8-52 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1.3.3 (8.3.1.2-127)	Because pulses of infiltrating water may move very quickly (order of minutes to hours if the alluvium is coarse) through the upper unsaturated zone, the use of neutron probes to monitor the moisture movement may be inadequate. Continuously-monitored soil moisture sensors should also be used in this study.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1.3.4 (8.3.1.2-136)	The evapotranspiration studies appear to be well designed and should supply important answers to questions about the discharge of water. Considering the size of the playa, it may be necessary to have more than 30 piezometer and tensiometer nests. Without adequate coverage of monitoring devices and determination of areas of shallow ground water, the discharge flux for the sub-basin will be underestimated. At one or two sites, both the Bowen-ratio and Eddy-correlation techniques should be used. A thorough investigation aimed at identifying and mapping phreatophytes around Franklin Lake playa and elsewhere, for example in the Amargosa Valley, is needed.

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COMMENT NO.: 8-54 p. 1 of 2 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1.4.1 and 8.3.1.2.1.4.2 (8.3.1.2-137) to (8.3.1.2-144)	Although the approach of updating Waddell's 1982 regional ground water flow model is reasonable especially in terms of being efficient, it also has drawbacks. The assumptions and biases that are inherent in any model (in this case Waddell's) are perpetuated in later versions. In other words, this and future modeling efforts are constrained and may not be able to assess a full range of realistic conditions. To avoid this, one or possibly two independent modeling teams should also be assembled. Preferably, these teams will be composed of members of the international hydrogeologic community who have no experience with the Yucca Mountain site. These teams should be supplied with all of the necessary data and pertinent references for the site, but not with the details of the previous (Waddell's) model grid, boundaries, boundary conditions, parameters, etc. These teams should be well-supported and encouraged to assess a wide range of modeling scenarios. After the results are obtained, a conference should be held to evaluate and discuss the

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1.4.1 and 8.3.1.2.1.4.2 (8.3.1.2-137) to (8.3.1.2-144)	differences in methods, model parameters and results, with the intent of developing an improved basis for the site hydrogeologic model and the three-dimensional model. The end result of this process would be a much more defensible assessment of the ground water flow system and travel time calculations.

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COMMENT NO.: 8-55 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1.4.3 (8.3.1.2-142)	The cross-sectional modeling is a necessary component of the overall modeling effort. Unfortunately, little detailed data is available on the three-dimensional distribution of hydraulic head, especially the heads in the lower carbonate aquifer. Available data seems to indicate that flow is almost directly east across Yucca Mountain. This places the proposed cross-section line at a significant angle to the flow direction. Another problem with this activity is that the flow direction in the lower aquifer may be different than near the water table and thus selection of a cross-section line may be difficult. Validation of this model will be nearly impossible without better control on hydraulic head at depth.

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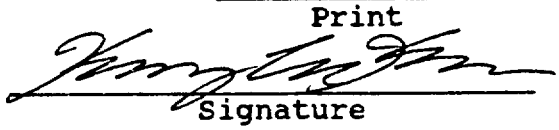

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.1.4.4 (8.3.1.2-146)	The anisotropic properties of the formations should be determined in some detail. The SCP states these are assumed to be unimportant and will be ignored. Without evaluation of the properties, how can they be assumed unimportant? It should be noted, however, that this particular model is so unrefined that specifying the units to be isotropic or anisotropic may not affect the results.

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COMMENT NO.: 8-57 p. 1 of 2 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2 (8.3.1.2-151)	DOE acknowledges in this section of the SCP how little is known regarding unsaturated flow in fractured rock environments. This situation applies to vapor-phase as well. Given the short time period allowed for Site Characterization, it cannot be realistically expected that this lack of knowledge can be overcome. Basic lab and field investigations cannot be successfully carried out until research is done on what methods might be feasible towards performing these investigations. Rigorous theoretical progress will be necessary as well in order to interpret collected data. Given the extremely long time scales that scientific research normally requires, it is unlikely that a significant amount of information can be generated during Site Characterization. It seems much wiser to consider sites where traditional porous-media flow occurs. Ground water flow in such areas has been studied successfully for decades. While such sites may or may not be inferior to Yucca Mountain, they will clearly decrease the amount of uncertainty involved in performance assessment evaluations.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2 (8.3.1.2-151)	Given the extreme hazard of high-level waste, reducing uncertainty is of the highest priority.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.1.2 (8.3.1.2-164)	It is unclear why the particular six "parameters" are listed in the fashion on page 8.3.1.2-164. While there is nothing inappropriate about such a list, neither does it appear particularly profound. These six terms relate to infiltration in one way or another. However, they do not seem to have encompassed every possible variable relevant to infiltration, nor do they seem to suggest six broad aspects of infiltration. This particular list simply confuses the reader. Such lists are ubiquitous in the SCP.

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COMMENT NO.: 8-59 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.1.2 (8.3.1.2-165)	The discussion of the neutron moisture logging study does not specify the average depths that existing and future access holes will be surveyed over, nor is it mentioned if any holes are planned to be emplaced subhorizontally. Subhorizontal boreholes would probably be preferable in monitoring fractures. It is unclear if the boreholes will or do extend into bedrock. Also, the frequency of measurements is not stated. Furthermore, a brief summary of the data gathered to date would be helpful in order to evaluate the value of this study. Most importantly, there is no discussion of exactly how the results will be used to calculate infiltration rates. It seems logical that changes in water content will be integrated over time at the various depths to calculate cumulative infiltration, however this is not stated in the SCP. Given the short duration of time for site characterization, these details need to be established immediately. Interpreting the data as it is collected will allow problems to arise at a time early enough for their mitigation. This data should not just be archived until some later time. If this latter procedure is followed, it is more and more likely that the data will never be reduced and analyzed.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.1.2 (8.3.1.2-165)	It is not stated in the SCP how many tritium samples will be analyzed in this study nor to which borehole locations they correspond. It must be realized that when dating matrix pore water in a fractured rock environment, it may be possible that younger fracture water may bypass old matrix water during precipitation events. Therefore, results of tritium analyses of matrix water must be interpreted carefully.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.1.2 (8.3.1.2-169)	As is acknowledged in the SCP, it is well established that water balance studies where the error in precipitation rate and/or evapotranspiration rate is larger than the infiltration rate, are useless. It is very likely that the prototype water balance study proposed for the USGS will reveal nothing new. In light of these observations, it would not be a good investment of time and resources to pursue this water-balance pilot study.

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COMMENT NO.: 8-62 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.1.3 (8.3.1.2-172 to 8.3.1.2-179)	The evaluation of artificial infiltration provides a rough overview of a series of four field investigations and states that: "each type of study increases in complexity and builds on the results of previous studies (p. 8.3.1.2-173). These studies, if well designed and executed, could provide significant results on the infiltration process. However, it appears unrealistic that these studies could be completed (or possibly even begun) by the time of the license application. No anticipated time line is offered for these studies, which are only roughly outlined. The technical procedures listed are incomplete and do not provide assessment of the details of these studies.

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COMMENT NO.: 8-63 p. 1 of 2 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.1.3 (8.3.1.2-173)	DOE plans a series of double ring infiltration tests to be performed on the surface of Yucca Mountain in order to "characterize infiltration rates" spatially. On page 8.3.1.2-173, the SCP states, "The term infiltration rate is defined here as the infiltration flux resulting when water, at atmospheric pressure, is made freely available to the unconsolidated material surface." From this definition, and the lack of references and detail regarding the double-ring method, it appears that DOE does not adequately understand infiltration nor what the method involves. First of all, infiltration rate is not a constant. Upon introduction of a thin, ponded surface to the soil profile, the infiltration rate will be at a maximum, as time goes on this infiltration rate will decrease and approach the saturated hydraulic conductivity of the soil. Because early-time vertical hydraulic gradients can be substantially larger than

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.1.3 (8.3.1.2-173)	unity, the early infiltration rate can be significantly higher than the final value. Therefore, the definition of "infiltration rate" in the SCP is flawed because actual infiltration rates depends on the length of the test. If the test is to be conducted until the infiltration rate levels off at a minimum value, then what is truly being measured is the saturated hydraulic conductivity. It is not clear that DOE realizes this judging by the SCP.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.1.3 (8.3.1.2-174)	If the organic dye tracer test is successful and its distribution on or adjacent to fracture surfaces can be identified, it would be very beneficial to do the excavation in increments from one side to the other. Detailed mapping of the exposed vertical surface would then permit a three-dimensional assessment of the fluid paths. This would be much superior to a determination based on only one exposed surface.

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JANUARY 20, 1989

NEVADA NUCLEAR WASTE PROJECT OFFICE
TECHNICAL REVIEW COMMENT FORM

DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 8-65 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.1.3 (8.3.1.2-174)	The SCP mentions several parameters and variables that are to be evaluated during the ponding experiments using a neutron moisture meter. These parameters include infiltration rate, flow velocities, matrix/fracture relationships, and unsaturated hydraulic conductivity as a function of water content. Unfortunately, only the last of these parameters include a reference in the SCP as to what method will be used to interpret and analyze the data (Libardi et. al., 1980). Unless similar references to published techniques are established, it is very unlikely the data collection activities will be successfully planned and executed. REFERENCES: Libardi, P.L., K. Riechardt, D.R. Nielsen and J.W. Diggar, 1980. "Simple Field Methods for Estimating Soil Hydraulic Conductivity", SSSAJ:44 (3-7).

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COMMENT NO.: 8-66 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.1.3 (8.3.1.2-175)	As is the case for much of the infiltration studies described in the SCP - there are no references made to which techniques will be used to perform these studies. The SPRS studies are expected to "determine the complex relations between rainfall, thickness and properties of unconsolidated rock or soil and the development of perched water tables" (p. 8.3.1.2-175). Because the fractured rock properties are not to be evaluated in these studies, numerous techniques are available from the soil science disciplines to undertake these studies, yet none of these are referenced. It will not be necessary, nor likely worthwhile, in this case to undertake research into these techniques given the existing level of knowledge in soil physics. It is paramount to performing the SCP activities in an efficient and timely manner that such references specifying analysis techniques and instrumentation be established immediately.

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 8-67 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.3 (8.3.1.2-183)	The SCP states, "No natural perched water has been observed in holes drilled in Yucca Mountain. However, circulating drilling fluid that was last in hole USW G-1 was observed in USW UZ-1, 335m distant." The tone of this statement indicates that it is an established fact that the perched water is a result of the loss of drilling fluid in hole USW G-1. In Chapter 3 (p. 3-150) of the SCP it is stated, "...because the water was contaminated with drilling fluid polymer used to drill drillhole USW G-1...it was speculated that the perched-water horizon was not natural but a result of drilling drillhole USW G-1...". The first quote implies that there is no question the perched water is <u>completely</u> due to drilling fluids, while the second only speculates about this. Even if drilling polymer was found in the well water, it is possible that some of this perched water was natural and was supplemented by the drilling water. Until more evidence is revealed, it should be considered that natural perched water may have contributed to this occurrence.

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 8-68 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.3.1 (8.3.1.2-183 thru 8.3.1.2-191)	The USGS conducted a test to determine effects of wet versus dry drilling techniques in tuff in G-Tunnel. The results of these experiments showed that drilling fluids penetrated into the removed core and replaced as much as 40% of the pore fluids. Conversely, dry drilling dried out the core somewhat. In either case, extrapolation of hydraulic or geochemical parameters from laboratory analyses of cores will not give an accurate representation of the unsaturated zone. Therefore, more pressure is placed on the in-situ field experiments to yield representative results.

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 8-69 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.3.1 (8.3.1.2-189)	In order to most efficiently perform the testing for moisture-retention curves, relative permeability, and saturated permeability; a comprehensive literature survey is recommended to identify which of the various techniques might be most applicable to tuff. It is commonly the case that when a particular testing procedure is developed, only one soil or rock type was utilized as the tested medium. Eventually, several methods become available yet very few are applicable to the entire range of possible porous media. It would be advantageous to focus only on those techniques developed on a soil or rock with similar characteristics to tuff, rather than perhaps a coarse sand for example.

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COMMENT NO.: 8-70 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.3.1 (8.3.1.2-190 thru 8.3.1.2-191)	The SCP includes numerous references to established techniques that will be used to measure matrix hydrologic properties. Given the short duration for the Site Characterization Program - it is very possible that this phase of the program will be the only one completed. Very few of the other hydrologic investigation techniques have been established or apparently even speculated upon. DOE should have in-place, some type of fall back position in case they cannot gain any insight into fracture-flow processes at Yucca Mountain. If this occurs, little more will be known about the site than is known now and placing high-level waste at Yucca Mountain would be a highly speculative undertaking.

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COMMENT NO.: 8-71 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.3.2 (8.3.1.2-202)	Inspection of Figure 8.3.1.2-14 reveals that no vertical boreholes exist or are planned in the northern 3/4 of the perimeter drift area. An obvious concern arises in that no coverage of this large area is planned. Unless there is some overriding issue, boreholes should be installed in that area to gain an insight into the hydrologic character of that area and its subsurface.

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COMMENT NO.: 8-72 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.3.2 (8.3.1.2-207)	The SCP states that multiple test zones will be selected for each hydrogeologic unit for packer nitrogen-injection testing. As part of the Site Characterization Plan, the criteria for selection of these zones should be stated. In other words, will the sampling be planned to assure regular spacing to support statistical analyses? Or will the irregularities be focused upon in order to support worst-case scenarios that might be used to compensate for uncertainty? In any case, how these intervals will be selected should be established.

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COMMENT NO.: 8-73 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.3.2 (8.3.1.2-210)	Montazer (1986) calls into question the adequacy of the current vadose zone monitoring regarding soil-water potential due to effects from gravel packs, and silica flour columns in USW UZ-1. Planned borehole completions should be based on the results of previous monitoring in that hole. Gravel packs appear particularly burdensome in regards to monitoring matric potential. Direct contact of monitoring devices with the host rock is obviously preferable although, admittedly, not always possible. DOE's approach to this problem should be outlined in the SCP. REFERENCES: Montazer, P., 1986. "Application of Hydrologic Techniques in Characterization of Unsaturated, Fractured Rocks" AGU Fall Meeting, San Francisco, CA, 1986.

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COMMENT NO.: 8-74 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.3.2 (8.3.1.2-207, 8.3.1.2-210)	None of the descriptions of the various pneumatic (gas) and liquid-phase testing planned for the vertical boreholes and clusters include any references to fractured-rock testing techniques and data analysis methods developed for the petroleum or geothermal industries or from previous waste disposal applications. It is acknowledged that established techniques in this field are few in number. However, a starting point is needed, even for the prototype testing. These references should be established to the extent possible before further data collection activities are planned.

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DOCUMENT TITLE: Site Characterization Plan

COMMENT NO.: 8-75 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.3.3 (8.3.1.2-223)	The SCP states that air will be used as the drilling medium in order to preserve the ambient moisture content of the recovered core and cuttings and of the in situ rock mass. While using air is preferable to water, and is therefore the best choice, it must be realized that the introduction of air into the fractured rock mass will likely perturb the ambient conditions, most notably by lowering the relative humidity in the immediate vicinity of the borehole. It is acknowledged that such a situation is unavoidable, however the monitoring results should be interpreted with this phenomenon in mind.

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COMMENT NO.: 8-76 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.3.3 (8.3.1.2-223)	In order to collect perched or other free water in the unsaturated zone via the Solitario Canyon horizontal borehole study, delicate instrumentation will likely be necessary. The report "Characterization of Infiltration into Fractured, Welded Tuff Using a Small Borehole Data Collection Technique" by W. Linderfelt of the Desert Research Institute, University of Nevada may provide valuable information towards planning this instrumentation. In this study, infiltrating water was successfully sampled from fractures following precipitation events.

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COMMENT NO.: 8-77 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.4.1 (8.3.1.2-241)	The SCP suggests the performance of tracer tests on laboratory samples of fractured tuff in order to investigate matrix diffusion processes. In order to confidently interpret results, tracer tests should be run using two different types of tracers. One tracer should be amenable to matrix diffusion (a standard solute), and the other should be an inert, relatively large particle tracer (such as silica spheres) that will not exhibit diffusive behavior. Comparison of break-through curves of the two different tracers under equal flow conditions will reveal the possibility of matrix diffusion. Care must be taken that moisture conditions in the cores are representative of Yucca Mountain.

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COMMENT NO.: 8-78 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.4.1 (8.3.1.2-242)	An obvious omission in terms of previous studies that could be utilized in studying channelization in fractures, are those described in Neretnieks, 1985. These pioneering studies represent invaluable planning resources for the studies described in this section of the SCP. REFERENCES: Neretnieks, I., 1985. "Transport in Fractured Rocks" in Hydrogeology of Rocks of Low Permeability - Proceedings of a Symposium Tucson, AZ. January, 1985. International Association of Hydrogeologists.

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COMMENT NO.: 8-79 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.4.2 (8.3.1.2-254)	The SCP briefly describes planned tests to be conducted on core samples including fracture location and geometric parameter logging as well as hydraulic property testing of the rock matrix. The concern here is the implied ease in which this experiment is apparently expected to entail. Retrieving core long enough for instrumenting experiments can sometimes be difficult. Some of these complications should be addressed in the SCP.

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COMMENT NO.: 8-80 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.4.7 (8.3.1.2-301)	It can reasonably be expected that near saturation conditions will occur in the host rock near any seeps encountered by the exploratory shaft. The SCP states that psychrometers will be used to measure soil-moisture potential in the boreholes installed at these seeps. Unfortunately, psychrometers are not useful in measuring near-saturation soil moisture potential, but rather they can be used at pressures below -2 bars (Hillel, 1980). Use of psychrometers in the vicinity of seeps should therefore be reconsidered. REFERENCES: Hillel, D., 1980. Fundamentals of Soil Physics, 413 pp. Academy Press, New York, New York.

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COMMENT NO.: 8-81 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.5.1 (8.3.1.2-321)	The SCP states the results of the diffusion test (tracer concentrations as a function of radial distance in the host rock surrounding a borehole) will be analyzed under the assumption that fluid flow does not occur. Inasmuch as the host rock will be initially unsaturated upon introduction of the tracer solution in the borehole, it would appear that fluid flow will occur outward from the free-standing liquid in the borehole. The plans to assume no fluid flow should therefore be re-evaluated. If fluid flow is neglected as planned, it would appear that diffusivity would be over-estimated.

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COMMENT NO.: 8-82 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.9 (8.3.1.2-350)	The "plans" for modeling ground water flow and radionuclide transport in the unsaturated zone as presented in the SCP are essentially generic to any sophisticated modeling study. In other words, DOE is so far from actually performing any technically defensible modeling, that it is unlikely it will ever be done.

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COMMENT NO.: 8-83 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.2.9.2 (8.3.1.2-353 thru 8.3.1.2-355)	This section on selection and development of hydrologic modeling computer codes is noticeably lacking in specific references to existing codes. The SCP speaks of available codes, but none are specifically named. The selection and modification of codes to model conditions in the unsaturated zone is a complicated undertaking. The SCP should already contain a list of models under consideration if this task is expected to be completed in a timely manner.

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COMMENT NO.: 8-84 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.3 (8.3.1.2-369)	This section of the SCP discusses several of the large areas of uncertainty in performing and interpreting hydraulic stress-testing in fractured media. A "catch-22" situation exists in this area in that pre-test analyses (modeling) of the test are sometimes necessary to design the tests adequately. A conceptual model of fracture flow (e.g. channel flow, parallel plate, etc.) must be available as a basis for such a pre-test analysis. However, without pump tests and similar field investigations, it is very difficult to develop a conceptual model. DOE appears to have an appreciation for such situations as reflected in this saturated-zone section of the SCP. Unfortunately, preceding sections of the SCP regarding gas-phase "pump" tests in the unsaturated zone present the plans for these tests as if they are routine. This is hardly the case, particularly so for fractures that may contain two phases (gas and liquid). The unsaturated zone section of the SCP should be presented with the same appreciation for uncertainty as this section.

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COMMENT NO.: 8-85 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.3 (8.3.1.2-371)	The presentation in this section of the SCP does not make reference to the regional and sub-regional flow modeling section. Those modeling efforts are intended to provide technical bases (e.g. boundary conditions) for the site saturated zone modeling. Therefore, the site saturated zone modeling should occur after the regional modeling. The SCP should reflect such a chronology.

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COMMENT NO.: 8-86 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.3.1.1 (8.3.1.2-372)	The SCP suggests placing observation wells W-8 and W-9 on the opposite (west) side of the Solitario Fault from the pumping well USW-H7. While these wells may prove useful, detecting flow boundaries from pump tests are typically accomplished by having the observation well(s) on the same side of the boundary as the pumping well. A deviation from "normal" drawdown measured in the observation well would then be the indicator of the behavior of the boundary. For example, if the semi-log drawdown slope doubles, or otherwise greatly increases, a flow barrier is indicated. DOE should plan to install an additional observation well(s) between the pumping well and the fault.

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COMMENT NO.: 8-87 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.3.1.3 (8.3.1.2-385)	The SCP suggests a theoretical model describing flow in the fractured system at the site will be selected that most closely matches the behavior observed in previous pump tests. While this is a good approach, provisions should be made for the need to consider more than one theoretical model. One model may reflect some aspects better while a different theory may better support other observed behavior. In such a situation, it may be necessary to incorporate the more conservative model due to the large amount of uncertainty that will surely exist regarding fracture flow analyses.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.3.1.5 (8.3.1.2-401)	The SCP states that tracer tests will be used at the C-holes site to possibly investigate matrix diffusion. While matrix diffusion can be used to explain the behavior of the "tails" of breakthrough curves of diffusing, conservative tracers; the DOE should consider using non-diffusing tracers also. Comparing results from a diffusing tracer test repeated with a non-diffusing tracer test may provide the best evaluation of matrix diffusion.

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COMMENT NO.: 8-89 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.3.1.6 (8.3.1.2-411)	The SCP suggests a location immediately southwest of the repository block for multiple-well testing if single-well tests are determined to be inadequate. The approach is to select rocks significantly different from those of the C-holes location. Apparently, the reasoning here is to provide a range of values representative of the entire Yucca Mountain area. It may also be important to DOE to avoid drilling an abundance of drill holes in the down gradient area of the site (the southeast). On the other hand, the properties of the rocks to the southwest may be irrelevant to the performance of the site. For the purposes of performance assessment, a location immediately to the southeast would be better. In addition, completing the wells near the water table may be more useful than 300m below it, as suggested in the SCP. In the area immediately adjacent to the repository, radionuclides will more likely migrate near the water table. Whatever rationale is behind the suggested location of a second multiple well site should be clearly stated in the SCP.

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COMMENT NO.: 8-90 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.3.1.7 (8.3.1.2-417)	The SCP neglects to mention the significant amount of sorption data (mostly from laboratory batch experiments) available from previous studies. While this section does state literature reviews and consultations with experts will be undertaken as a first step, other portions of the SCP reflect a more-prepared state of knowledge within DOE. This section needs to be fortified with citations to the important, comprehensive data bases on sorption such as those mentioned by Siegal, et al (1987). REFERENCES: Siegal, M., S. Phillips, J. Leckie and W. Kelly, 1987. "Development of a Methodology for Geochemical Sensitivity Analysis for Performance Assessment" Proceedings of DOE/AECL Conference Geostatistical Sensitivity and Uncertainty Methods for Ground-Water Flow and Radionuclide Transport Modeling, San Francisco, CA, September 1987.

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COMMENT NO.: 8-91 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.3.2.3 (8.3.1.2-432)	No specifics are provided as to sample collection relating to parameter preservation. Retrieving representative samples from great depths is a difficult task. If these results are to be meaningful, sample collection methods must consider depth factors.

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COMMENT NO.: 8-92 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.2.3.3.2 (8.3.1.2-438)	Within a fracture flow system, large zones of highly conductive fractures may exist at a scales equal to the scale of interest (kilometers). For this reason, there simply may not be a useful representative elementary volume that can be incorporated into an equivalent porous media (EPM) model. If DOE wishes to pursue the EPM approach, it should be done parallel to other approaches that address discrete zones as well, in case the EPM method proves unworkable.

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COMMENT NO.: 8-93 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.6 (8.3.1.6-1 thru 8.3.1.6-6)	In a letter dated March 13, 1987, from DOE to Mr. Robert Loux of the Nevada Nuclear Waste Project Office, DOE states that, "Chapter 8 of the SCP contains a description of the plans for site characterization activities." DOE, however consistently uses Chapter 8 to present hypotheses established elsewhere without also presenting adequate technical data to justify the conclusions. For example, the hypothesis that erosional processes are not expected to effect waste isolation during the post closure period is repeated five times from page 8.3.1.6-1 to 8.3.1.6-6 without proper data presentation or referencing. In fact, the SCP admits a total lack of data on page 8.3.1.6-6: "...very little site-specific information is available that would allow for the quantification for the erosional processes at Yucca Mountain." This type of undocumented hypothesis presentation not only unjustly establishes conclusions in the readers' (and DOE's) mind, but also downplays the importance of the planned site characterization activities. Chapter 8 should refrain from presenting undocumented hypotheses and concentrate on future characterization needs.

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COMMENT NO.: 8-94 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.6 (8.3.1.6-2)	The SCP states that the "average maximum downwasting rate was estimated to be 2 cm/1000 years (Section 1.1)." Yet on page 8.3.1.6-6 the SCP also states "very little site-specific information is available that would allow for the quantification for erosional processes at Yucca Mountain". DOE's lack of data has led them to speculate on the downwasting rate, which may prove to be inaccurate. Many geomorphologists believe that mountains in the semiarid climates have the most rapid rates of downwasting found anywhere on earth. This is supported by Langbein and Schumm, 1958, who report areas with 15 cm/year of precipitation (as Yucca Mountain) should downwaste an average of 6 cm/1000 years. This dramatically increases the downwasting rates presented by DOE. REFERENCE(S): Langbein, W.B. and S.A. Schumm, 1958. Yield of sediment in relation to mean annual precipitation. American Geophys. Un. Trans. v. 39, pp. 1076-84.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.6.1.1.1 (8.3.1.6-10)	To place a lot of value on this study seems unwarranted at this time due to the extreme alteration of deposits which has occurred over the past several years from exploratory operations. Roads run along the top of the mountain and much leveling has occurred for drilling platform construction. Much of the area of concern has been drastically altered by man and may not be representative of pre-man conditions.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.6.2 (8.3.1.6-15)	The SCP addresses "average erosion rates in the region surrounding Yucca Mountain." If the SCP focuses research on obtaining only average regional erosion rates, the results could produce an inaccurate geomorphological scenario of the area. Erosion is not a uniform process and cannot be accurately depicted through average values. Any breach of a repository through erosion will not result from uniform downwasting but severe localized erosion. This type of scenario, not average erosion, should be the focus of the SCP's plans.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.6.2 (8.3.1.6-16)	The SCP introduces models aimed at forecasting future erosion rates relative to future climatic, tectonic and hydrologic trends. Included in these scenarios should be human effects upon erosion. Human activity as an agent in promoting erosion on and around Yucca Mountain could be profound. Foot and motor vehicle traffic tends to loosen overburden and accelerate erosion. This increased rate of erosion will be a function of the amount and type of human activity and will tend to augment the natural erosionary processes.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.6.3.1 (8.3.1.6-22 thru (8.3.1.6-23)	The emphasis of study 8.3.1.6.3.1 is to assess the component of total erosion due to tectonics. This emphasis seems misplaced. Rather the issue is if renewed tectonic activity occurs, what are the effects on repository stability and groundwater transport. Erosion effects should be a low priority endeavor, given a renewed tectonics scenario.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.12.1 (8.3.1.12-8)	The SCP states that since some of the data will only be available as several-year summaries, only general trends and averages for certain regions will be derived. The SCP does not get specific as to what these regions are and which data will be trends or averages. This should be known in advance, since independent researchers may have different needs for analysis. Affected parties should have more specific information as to what data will be generated.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.12.1 (8.3.1.12-9)	Will other population centers that may not be as large as Las Vegas have impacts calculated, such as Pahrump? The SCP should list areas where impacts will be calculated.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.12.2.1.2 (8.3.1.12-23)	The SCP states that one year's worth of hourly sequential meteorological data will be used as input to calculate x/Q values at each designated receptor. This could be problematic if the year's worth of data are not representative, i.e., a dry year or a wet year as opposed to an average year.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.16.1 (8.3.1.16-8 and (8.3.1.16-12)	To be effective, the log-Pearson approach should have a long historical record. How long a record is available in areas of concern?

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.16.1.1.1 (8.3.1.16-11)	It is usually assumed some debris will be transported during a severe flood. However, to try and quantify the amount and assess a separate damage from the debris versus the flood seems unwarranted. The DOE admits that they do not really know how to go about it yet, since no standard techniques exist. Large forests are not present which could bring a large number of trees or logs into the facility. Rather, we are asking how much sediment do we have to contend with? It would appear that a worse case should be assumed, perhaps equal to flood stage, since such a scenario may still be acceptable, thereby ending this line of analysis. It is more likely that erosion would be more prevalent rather than deposition at Yucca Mountain. It seems unlikely that hazards would be very sensitive to the amount of sediment in the flood.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.1.16.2.1.4 (8.3.1.16-24)	The objectives should include effects on water supplies of downstream users such as the Amargosa area which is dependent on continuing water supplies for farming.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.3.1.2 (8.3.3.1-5)	The current concept for borehole seals is that the principal seal component in the borehole will be used only in the tuffaceous beds of the Calico Hills. The remainder of the borehole may be filled with a granular material or a cementitious material as needed to control possible water inflow from the surface or gaseous movement of radionuclides from the repository. This may be a satisfactory approach, if the hydrologic system is static. However, the ground water system is dynamic and water levels could rise in the future. Therefore, tight seals should be designed and installed in the Topopah Springs unit as well.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.2 (8.3.5.2-3)	The role of affected Parties in the issue resolution strategy is largely undefined. However, it is of utmost importance that states play a role in establishing performance goals and in any modification of these goals which may occur at later stages.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.2 (8.3.5.2-10)	The SCP formulates goals that are intended to ensure reentry into the non-operational areas for the purpose of waste retrieval. These goals call for temperatures not exceeding 50°C for up to 50 years beginning after waste emplacement is initiated. These reentry goals do not correspond to another SCP goal, usability for a period of 84 years after waste emplacement is initiated. The lack of uniformity among these goals will result in a 34 year retrieval period where the shafts and drifts will be physically usable, but the severe environment will not permit reentry to commence retrieval operations. The SCP should clarify this discrepancy.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.2 (8.3.5.2-19)	The host rock is not a component of the waste package and cannot be counted on to provide shielding during the waste package removal.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.2 (8.3.5.2-19)	The SCP states "Numerous analyses of the performance and design of the transporter will be needed . . ." This is an obvious assumption. Specific requirements for operator exposure to radiation and other safety features should be listed.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.2.5 (8.3.5.2-45)	The SCP discusses the design issues of waste transport underground and unloading at the surface, but does not specifically address the vertical transport of the waste from the repository to the surface together with the accompanying weight limitations. The SCP should present the information needs of the vertical transport system.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.3 (8.3.5.3-16)	These analyses are for normal operating only. What assumptions will be made in these analyses? For example, what is a worse case scenario? Is the analysis to assume no releases from canisters? What about accidents involving dropped canisters?

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.3 (8.3.5.3-17)	The SCP states that maximum public-dose exposure will evaluate releases from routine operation of the repository and offsite facilities. DOE should also include background radiation in this determination. The combined exposure of all three components should be within applicable limits. This is the only way to truly assure total public exposure is below allowable thresholds.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.5 (8.3.5.5-18)	Question one reads: "What are credible accident sequences and their respective frequencies . . ."This statement should include credible "worst case" accidents. In order to adequately construct ventilation systems, and safeguards for workers and the public, DOE should perform its accident exposure analyses on the credible worst case scenario. The present wording allows analyses to be based on "credible accidents", which based on DOE's optimism regarding repository performance, may produce unrealistic accident exposure analyses.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.8 (8.3.5.8-8)	If one assumes a dry environment, then possibly this mechanism can be considered to be minimal. However, current models assume water influx controlled waste-package-release. The high temperature gradients between the waste package and surrounding county rock will almost certainly cause some thermal diffusion effects.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.8 (8.3.5.8-8 and 8.3.5.8-9)	To assume a very small steady state flux within the matrix only has potentially serious ramifications. It has been pointed out many times by various reviewers that reliance on diffusion into the matrix is not well founded for fractured materials such as welded tuff. While this argument may have validity in granitic or other crystalline terrains, it has not been shown valid for tuff. An effort must be made to determine fracture transport conditions. This investigation must be carried out during site characterization. An approach which tries to disprove the steady state assumption should be part of the strategy, rather than a confirmatory approach.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.8 (8.3.5.8-8 and 8.3.5.8-9)	The last paragraph on page 8 and first paragraph on page 9 make many assumptions regarding flow behavior under differing flux conditions. There are no data offered in support of these assumptions.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.8 (8.3.5.8-9)	Radionuclides are assumed to be retarded by the combined effects of sorption, diffusion into the matrix, mineral precipitation and ion exchange. Current work by AECL, presented at Waste Management '89, indicates these assumptions should be re-examined. AECL lysimeter tests indicated species which have had assumed high K_d values may move dominantly as colloids.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.9 (8.3.5.9-1 thru 8.3.5.9-4)	This discussion leads one to believe that during the Site Characterization process DOE will develop a test program which will provide the data needed to select a packaging material. This is not true. DOE plans, by their own admission (ACNW meeting, January 1989), to select a material and one alternate by summer of 1989. This is prior to the commencement of Site Characterization.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.9 (8.3.5.9-44)	With respect to long-term metallurgical changes during disposal, unresolved issues include strain aging in and near welds, and for the metastable austenitic stainless steels for the tuff repository, martensite may form or low temperature sensitization may occur.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.9 (8.3.5.9-45)	The synergistic interaction of stress with corrosion is potentially the most catastrophic failure mode. Residual stresses arising from welding operations or from long-term phase transformation as well as stresses generated thermally or by external forces can interact with hydrogen absorbed by the metal from the cathodic partial of the corrosion process and/or from the radiolysis of water to produce embrittlement of steel, especially at or near the welds. In addition, hydrogen degradation of annealed steel has been found to occur, presumably because of the induced impurity segregation at grain boundaries. In the earlier portion of the storage life of the waste package, sufficiently high temperatures will be obtained to make hydrogen attack in steel a possibility. The formation of methane and the attendant grain boundary porosity embrittles the steel. Another synergism between stress and environment can develop when water solutions contact the metal, especially stress corrosion cracking of the austenitic steels in the presence of chlorides.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.9 (8.3.5.9-45)	It has been found through noted experimentation that where, "metal temperatures are high enough to cause concentration of chlorides on the metal surface, cracking may occur even where the chloride concentration in the surrounding media is only a few parts per million" (Perry et al., 1963). This stress corrosion cracking occurs only for a specific temperature range of greater and solute concentration range. Except for copper, every alloy considered for waste package use undergoes stress corrosion cracking in some environment. It follows that each alloy must be examined in all credible solutions and temperature ranges, and if the radiation level is to be appreciable, because of relatively thin wall thickness, at the outer surface of the overpack, the effect of radiation on stress corrosion cracking should also be examined. As much understanding of this very complex failure mode should be developed to maximize life prediction ability.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.9 (8.3.5.9-45)	REFERENCE: Perry, Robert H., Cecil H. Chilton, Sidney Kirkpatrick, 1963. Chemical Engineers' Handbook. McGraw-Hill, New York, NY. p. 23-3.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.9 (8.3.5.9-46)	Localized corrosion can occur wherever there exist differences between one region of the overpack and another. These may be built in the metal in the form of grain boundary segregation, composition inhomogeneities or second phases, or they may result from the operating conditions in the repository. For example, temperature differences at the metal-backfill interface due to the geometry of the container and/or differences in contact conditions, differences in the chemical composition of moisture contacting different portions of overpack surface arising from the water having percolated through different minerals in the surrounding tuff differences in porosity or in degree of adherence of solid corrosion products, any of these may produce enhanced corrosion at one locality, pitting, or crevice corrosion. These effects are insidious and difficult to characterize and measure. Difficulty of prediction is compounded by the mineralogical diversity at the tuff site and by the variability of composition and of processing of

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.9 (8.3.5.9-46)	the commercial alloys designated today as reference and as alternate materials. Localized corrosion in all its manifestations needs very careful study to develop sufficient understanding that predictive models can be developed. The effect of radiation on localized corrosion needs more investigation, as does the question of microbial corrosion. Even in a gamma radiation field, microbial corrosion does not have a zero probability, since it is now known that some microbes can withstand amazingly high levels of radiation.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.9 (8.3.5.9-47)	Another set of problems may develop at a much later stage in the waste disposal history if it should happen that the overpack is breached by some corrosion failure mode. Then the inner container will be attacked by the corrosive environment, and since the inner container and the overpack will be in metallic contact, galvanic effects will occur to increase the anodic reactions at one metal and the cathodic reaction at the other. When the relatively thin inner container is breached, the corrosive environment will suffer a change of chemistry because the waste form will dissolve (in the case of vitrified wastes) or corrode (in the case of clad spent fuel rods). In the latter case the zirconium cladding will absorb hydrogen from the corrosion reaction and it is likely that the hydrides formed thereby will hasten the liberation of radionuclides by virtue of the stresses generated. The modified water chemistry will change the corrosion rate of the

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.9 (8.3.5.9-47)	overpack and the inner container, which will affect the rate of widening of the breach, and hence the access of radionuclides to the backfill. The transport of radionuclides to the host rock will at this stage be controlled by the characteristics of the backfill after the temperature, radiation, and water intrusion history that it has undergone. It is known that steam treatment at high-temperatures can reduce the swelling capacity of bentonite and can increase its permeability. Channeling is a real possibility, whereby transport to the host rock can be considerably increased in rate.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.9.1.1.4 (8.3.5.9-55)	This paragraph states that, "When possible or feasible, the analysis will be supplemented by actual stress measurements on prototype canisters." This sentence should be rephrased to indicate that actual measurements must be done as a verification of what appears to be a computer analysis. These measurements must be made on actual canisters, not just prototypes or scale models.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.9.2.1.1 (8.3.5.9-68)	The near field environmental and thermal degradation modes should include the effects of microbial and radiological effects upon the waste package. It is known that certain microbes can withstand high levels of gamma radiation, so the possibility of microbial corrosion should not be ruled out. Additionally, the radiolytic generation of hydrogen, oxygen and other species due to gamma radiation may affect corrosion as well. The criteria for containment objectives should therefore include two addition items: g. Resistance to microbial corrosion h. Resistance to corrosion caused by the radiolytic generation of hydrogen, oxygen and other species.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.9.3.2.4 (8.3.5.9-101)	Localized electrochemical attack occurs and progresses preferentially along the grain boundaries of an alloy, usually because the grain boundary regions contain material that is anodic to the central region of the grains. It is now generally accepted in the case of the austenitic stainless steels that some of the chromium combines with the carbon to form chromium carbide which is precipitated at the grain boundaries when the alloy is heated or cooled slowly. The rate and extent of the formation of the chromium carbide are functions of time, temperature, and carbon content. It occurs during welding in the base metal adjacent to the deposited metal. As a result of the localized impoverishment of chromium at the grain boundaries, preferential corrosion may occur at the grain boundaries in some environments. Although the SCP addresses the carbide precipitation, it should also discuss intergranular attack as a function of chromium carbide formation at the weld/base metal boundaries.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.9.3.2.5 (8.3.5.9-103)	The SCP fails to identify one important hydrogen-induced degradation mechanism of the austenitic stainless steel waste package. Hydrogen may attack stainless steel when it reacts with iron carbides in the steel to form methane. This degradation mechanism is not considered corrosion and occurs most commonly under dry conditions at elevated temperatures and pressures. Resistance to this type of degradation increases with chromium concentration because of the greater stability of chromium carbides. The SCP should discuss hydrogen induced methane production and its effects upon the waste package.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.9.3.2.7 (8.3.5.9-106)	The SCP states on pages 8.3.5.9-106, "The concentration of oxygen, nitrate and other oxidizing species is expected to influence the critical chloride level for crack initiation." The SCP should also address the sources of oxidizing species, since some will be native to the near field environment and some could be generated radiolytically due to gamma radiation. Since the radiolytic generation of oxidizing species could influence the concentration of chloride, the rates of which these species are produced should be examined.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.10 (8.3.5.10-37)	The SCP states that a performance goal of the spent fuel dissolution rate will be "no more than one part in 100,000/year." This grossly contradicts the Yucca Mountain EA on page 6-373, which reports figures of five parts in 100,000/year from two separate studies. The SCP should adopt the established results of the scientific studies or present data and discussion which justifies its lower estimates.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.10.2.1.2 (8.3.5.10-46)	The SCP references various sources such as Einziger (1985) and Smith (1985) without adequately documenting the citation. The SCP should provide complete citations of all references at a convenient location for the reader.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.10.2.2.1 (8.3.5.10-52)	The SCP reports that, "Water dripping onto and off glass" is an example of radionuclide release. The SCP tends to concentrate on the chemical degradation of the waste form by leaching water, however, and fails to mention an important mode of degradation mechanical erosion. The consistent dripping of water upon a breached waste canister will have a definite mechanical, as well as chemical erosionary effect upon the waste form. This mechanism should be included in the leach testing.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-3)	Should not fastest pathway include water vapor movement?

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-3)	How will vapor flux be considered in determining liquid travel time? Needs an explanation.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-6)	By assigning a designation "Barrier" to establish a defense in depth approach is really meaningless if fracture flow is the dominant mechanism. Currently, flow times can be shown to be a few years to a million years depending upon assumptions such as percent of flow in fractures vs. matrix. It is unlikely we will know the answers to key questions in the time allocated for Site Characterization.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-6)	The DOE strategy states, "If any combination of a single unit and set of processes could be shown to meet the goal of 1,000 years, the issue will be considered resolved." This is on the surface a logical statement and if all affected parties are in agreement on the assumptions used in the analysis, it would be reasonable. However, it should be pointed out that this will probably become a major issue. First of all, the testing proposed for the unsaturated zone is on an accelerated schedule. It is very likely that all information needs will not be satisfied to an acceptable degree of uncertainty. Herein lies the problem, DOE probably will not know the degree to which various processes operate and contribute to the velocity term. Instead, DOE will probably assert that matrix flow is the only feasible flow regime in the unsaturated zone. This will lead to the conclusion that the Topopah Spring member itself will meet the GWTT criteria, and therefore the issue is resolved. Affected

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-6)	parties, however, may argue that the data do not conclusively indicate that fracture flow is insignificant, which would argue against the issue being resolved. Without substantial guarantees laid out in the IRS for state technical issue resolution, such situations will become commonplace.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-7) [8.3.5.12-3]	DOE intends to estimate relative probabilities for alternative conceptual models. It is likely these probabilities will be nothing but guesses, highly skewed toward matrix flow. Process for assigning probabilities needs to be examined as to who will be allowed to participate in assigning values.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-10)	Darcian flow assumptions for substantial continuous fracture flow must be evaluated. It may not be valid to make these assumptions now.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-13)	The fastest ground water flow path may be interpreted as being present at the northeast corner of the current facility design since the vitric unit of the Calico Hills tuff is thin or absent in this area. This has prompted the DOE to consider relocating the current repository design position, to avoid this area. This appears to be a good move, but more data regarding what this does to size, loadings, and proximity to faults would be required before the State could agree with such a move.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-13)	The SCP states that because of uncertainty, "...flow from the entire disturbed zone boundary over the entire site may be included in the distribution of travel time relevant to this issue." This approach is inconsistent with the intent of the Ground Water Travel Time requirement specifying the "fastest path" of likely radionuclide travel. By including the entire disturbed zone as a starting point, the cumulative distribution function (CDF) for travel time would be inappropriately skewed to the large travel times. The CDF should only be based on the "fastest path" as determined from Site Characterization.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-14) [8.3.5.12-5]	Isochron maps of travel times do not account for ranges which are possible under current data. Ranges should be shown.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-17)	The SCP states that the effects of matrix diffusion (between the fractures and the matrix) will be considered in the Ground Water Travel Time calculation. It should be realized that matrix diffusion processes may be very difficult to support technically as is stated by the U.S. NRC in the following quote: "The mechanisms of matrix diffusion are difficult to evaluate in the field. Without direct measurements of the appropriate coefficients, estimates of the effect of matrix diffusion would have to be based on mathematical models which are largely untested, using parameters which are difficult or impossible to substantiate" (Codell, 1986). Furthermore, the Site Characterization program is only allowed a relatively short time for its completion. As described in the SCP (Chapter 8.3.1.2 - Geohydrology), the planned activities do not even include references to using non-diffusing tracers in comparison with diffusing tracers to investigate the

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-17)	possibility of matrix diffusion. In other words, the planned site characterization investigations do not appear to be adequate in order to support reliance on a process the NRC has stated may be virtually impossible to substantiate. REFERENCE(S): Codell, R., 1986. "Draft Generic Technical Position on Ground Water Travel Time" U.S. Nuclear Regulatory Commission, Division of Waste Management. June, 1986.

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COMMENT NO.: 8-142 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-20)	It cannot be said that the current estimate of flux is conservative. Quite the opposite - it is not conservative. Valid ranges for flux and effective porosity have not been established. Effective porosities for welded units appear very high.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12.1 (8.3.5.12-28 thru 8.3.5.12-33) Table 8.3.5.12-3	The desired levels of confidence for the fracture properties would appear to be ranked too low given the importance of determining the extent of fracture flow occurring at the site. If significant recharge is occurring through the unsaturated zone at Yucca Mountain, it is probably occurring via transient, fracture flow episodes. The isolation capabilities of the site are heavily based on the assumption that very little recharge occurs through the unsaturated zone. This assumption would appear to hold if only matrix flow is occurring due to the low hydraulic conductivity of the tuff matrix. However, it is not known if fracture flow occurs. Therefore, determining the fracture flow parameters in Table 8.3.5.12.3 should be given "high" priority.

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COMMENT NO.: 8-144 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-39)	Not all sparsely sampled parameters will be corrected to more densely sampled ones. Leaving the true range up for grabs. This range will undoubtedly be assigned a value based on "expert judgement", which may be heavily biased.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-41)	Reference is made to several models which are being developed to generate unsaturated porous-media properties from detailed structural and physical concepts. Detailed references should be provided, i.e. whose doing the work, its funding source and its status.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12.2 (8.3.5.12-42)	It would appear the composite medium approach of Klavetter and Peters (1986) may be appropriate for steady-state simulations but not for transient cases, especially so for unsaturated flow. As part of the SCP, the DOE should consider what approach will be taken if better models do not become available. REFERENCE(S): Klavetter, E.A. and R.R. Peters, 1986. "Fluid Flow in a Fractured Rock Mass". SAND85-0855 Sandia National Laboratories for the U.S. DOE.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-42)	Limiting the travel time studies to only equivalent porous media approaches is not conservative. We recognize that DOE and USGS want to believe flow is matrix dominated. However, the jury is not in yet, so dual porosity approaches should not be prematurely ruled out based on DOE's "current beliefs".

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COMMENT NO.: 8-148 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-43)	Simplifications may be required in overall performance assessments. When they occur, they must be backed by thorough knowledge of the processes being simplified. To eliminate pressure terms, assume flux and divide this flux by moisture content to get velocity is premature in light of our rudimentary understanding of the processes.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12.2 (8.3.5.12-43)	It should be realized by the DOE that the Wang and Narasimhan simulations were only successful for steady-state or near steady-state flow <u>across</u> fractures at low levels of saturation. Flow <u>along</u> fractures was not simulated adequately. A substantial amount of work needs to be done regarding transient flow conditions in fractures in the presence of partially-saturated matrix, before conclusions can be made regarding infiltration through the unsaturated zone at Yucca Mountain. REFERENCE: Wang, J.S.Y. and T.N. Narasimhan, 1985. "Hydrologic Mechanisms Governing Fluid Flow in Partially Saturated, Fractured, Porous Tuff at Yucca Mountain." SAND84-7202 Sandia National Laboratories for the U.S. Department of Energy. Wang, J.S.Y. and T.N. Narasimhan, 1986. "Hydrologic Mechanisms Governing Partially Saturated Fluid Flow in Fractured Welded Units and Porous Non-Welded Units at Yucca Mountain." SAND85-7114 Sandia National Laboratories.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12.2.1.1 (8.3.5.12-45)	The fact that development of a mathematical representation of flow at the site has not yet been adequately accomplished, indicates the rudimentary understanding of ground water flow at the site on the part of the DOE. To provide reasonable assurance, as required by the U.S. NRC regarding issues such as satisfying the ground water travel time requirement at Yucca Mountain, will require a much longer period of time for site characterization than is allowed for in the current schedule. Because of the complexity of fluid flow and energy transport processes in unsaturated rocks makes quantitative studies more difficult and less certain than for some other media, the relative favorability of Yucca Mountain as a repository location must be considered diminished.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12.2.2.2 (8.3.5.12-46)	This section is entitled 8.3.5.12.2.2.2 Subactivity 1.6.2.2.2: Validation of Models. This section is misrepresentation at best, and is misguided. Misrepresentation of what is to occur is serious in and of itself. The title leads one to believe that model validation procedures will be laid out. However, after reading the section, validation will not be done and is so stated in the first full paragraph of page 8.3.5.12-48. Further, the work described is calibration, not validation. It is designed to allow model calibration of parameters as needed to match a single core sample imbibition experiment. First, DOE must try to validate models of physical processes we are trying to simulate. Of major concern is whether or not fracture flow dominates in the unsaturated zone. This is what is needed to assess the validity of travel time distributions.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12.2.2.2 (8.3.5.12-46)	It does not appear useful to use a matrix-flow type of imbibition experiment to arrive at "validated" input parameters for travel time calculations. This is because the main question is assumed answered, i.e. you have matrix flow only. This section should be deleted or redone to specify calibration not validation. A true validation procedure must also be developed.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12.2.2.2 (8.3.5.12-49)	Paths of likely radionuclide travel are to be determined directly and by modeling. The focus is obviously on the modeling. This emphasis should be changed to include more direct observation. The examples cited do not indicate if these observations are to take place underground in the shaft or drifts. The discussion, in fact, leads one to believe this will not be done in situ, since the following statement appears: "This evaluation will involve examination of what is known about the features at the site." Only when shafts and lateral drifts are completed and reach an equilibrium conditions will many of the flow paths be discovered.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-51)	A two-dimensional approximation for the saturated zone if the ground water travel time is the only concern. However, for an overall performance assessment and to address Szymanski's concerns, a three-dimensional model will need to be developed.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-55)	This limited definition, i.e. changes in intrinsic permeability, is troublesome. The regulation requires the evaluation of effects caused by thermal output of waste. This thermal envelope may affect the rock and water to depths greater than 50 meters. Consequently, changes in hydraulic conductivity need to be evaluated because of thermal changes to water density and viscosity. Do not limit change to intrinsic permeability, include the water as well as the media.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12.5 (8.3.5.12-56)	Pages 8.3.5.12-40 thru 44 discusses models to be used to predict groundwater travel times between the disturbed zone and the accessible environment for the purpose of determining pre-waste-emplacement of groundwater travel time. It appears DOE will only be using a matrix flow code to assess groundwater travel time instead of the dual porosity (special case) code as described earlier (Klavetter and Peters, 1986). This calculation should be done using both methods to determine the more conservative approach.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12.5 (8.3.5.12-57)	The SCP suggests that at Yucca Mountain, the boundary of the disturbed zone will be much less than 50m from the edge of the underground opening. It is clear from this section of the SCP that this assertion is based only on stress-redistribution calculations. It does not take into account thermochemical processes such as hydration/dehydration, phase change, and dissolution of geologic material. Such processes are likely to be important in an unsaturated flow system such as that at Yucca Mountain.

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COMMENT NO.: 8-157 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.4.12-58)	Thermal hydrologic properties needs to be added to the list of processes considered in determining the boundary of the disturbed zone. Not just matrix properties, but fluid properties as well.

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COMMENT NO.: 8-158 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-58)	We object to the approach used to determine the disturbed zone because: (1) it considers only matrix flow and (2) it considers only media properties, not fluid properties.

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COMMENT NO.: 8-159 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-61)	Item #15 and #16 indicate that perhaps hydraulic conductivity will be assessed. If this is the case, the word permeability should be replaced with hydraulic conductivity and the word intrinsic permeability changed as well in the previous discussion.

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COMMENT NO.: 8-160 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.12 (8.3.5.12-65 thru 8.3.5.12-68) Table [8.3.5.12-6]	Major events and planned completion dates for activities in Issue 1.6 (Ground Water Travel Time). The ground water travel time (GWTT) and pathways analysis will take place largely without any underground testing (shaft). This table indicates that validation of models will largely occur from lab studies. Identifications of flow paths will be a computer exercise calculation of pre-emplacement GWTT will be from interim Site Characterization data based on information available as of 7/91. (Keep in mind the shaft will be down by 2/91, an optimistic estimate.) Complete updating of calculations of pre-emplacement GWTT will occur 9/93 and post-emplacement GWTT on 9/92.

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COMMENT NO.: 8-161 p. 1 of 2 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.13 (8.3.5.13-55) Table [8.3.5.13-3]	Rapid fracture flow should be used as a means for partial failure of the unsaturated zone barriers (supercategory (C)). Investigations to date regarding the unsaturated zone at Yucca Mountain have not established whether periods of rapid, fracture flow occur as a recharge mechanism. Downward water velocities in excess of 60 meters/year were calculated by Tyler (1986) based on the work of Clebsch (1961) at Rainier Mesa, also on the Nevada Test Site. Tyler (1986) concludes: "... a large number of studies have indicated that soil water movement in the alluvial valleys of the NTS and surrounding areas receiving periodic inundation. Studies in fractured rock environments, although far less in number, indicate the potential for rapid fluid migration is high. Human activities requiring isolation from the underlying groundwater system should be designed with this data in mind."

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.13 (8.3.5.13-55) Table [8.3.5.13-3]	Based on studies such as Tyler (1986) and Clebsch (1961), and the lack of understanding regarding fracture flow at the Nevada Test Site, episodic fracture flow through the unsaturated zone should be considered to have a probability of greater than 0.1. Therefore, it should be an anticipated process in performance assessments at Yucca Mountain until conclusive evidence indicating otherwise becomes available. At this point, such evidence has clearly not been established. This scenario is different, although the consequences may be similar, from an "altered" hydrogeologic system when, for example, a wetter climate is assumed to exist.

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COMMENT NO.: 8-162 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.13 (8.3.5.13-73)	The SCP states "In those cases where the calculation proves difficult or time consuming, t_p may conservatively be set to zero." While this is reasonable, care must be taken that a large number of parameters are not set this way. This would decrease the validity of the model, leaving it open to criticism of being overly conservative. DOE should clarify "difficult or time consuming" to avoid using this statement as an default loophole.

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COMMENT NO.: 8-163 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.13 (8.3.5.13-75) Table [8.3.5.13-18]	It is not clear how these scenarios can be lumped or described by one model when different processes come into play. Many simplifying assumptions will have to be made to assess effects of faulting or tectonic movements on groundwater flow fields, etc.

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COMMENT NO.: 8-164 p. 1 of 1 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.15 (8.3.5.15-6)	The SCP assigns a medium level of confidence that contamination from the emplaced waste will not impact the three site aquifers in 1000 years. The current understanding of fluid flow in the unsaturated zone does not warrant "medium" confidence. Rapid rate fracture flow remains a possibility and a recent report by Jerry Szymanski of the DOE raises further uncertainties on isolation abilities of the unsaturated zone. REFERENCE: Szymanski, Jerry, 1987. "Conceptual Considerations of the Death Valley Groundwater System with Special Emphasis on the Adequacy of This System to Accommodate the High-Level Nuclear Waste Repository". U.S. DOE, Nevada Operations Office.

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SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.15.1.1 (8.3.5.15-7)	The description given for activities in this section are not complete. The SCP states parameters will be extracted from other investigations and analyzed. No mention is given as to how much data will be synthesized or even how this will be accomplished. It appears the DOE is not sure of how to proceed in satisfying regulatory requirements of 40 CFR 191.16.

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COMMENT NO.: 8-166 p. 1 of 2 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.20.2 (8.3.5.20-2)	The SCP states that performance assessment models will be validated (establishing that the code and parameters adequately represent the site) and an explanation of these activities will be provided during licensing. Whereas it would be highly desirable for all codes to be validated, more realistically this validation stage will not be realized for the vast majority unsaturated zone flow and transport codes. This is due to the complexity that the dual porosity tuff media (fractures and matrix), coupled with unsaturated conditions in an arid environment with episodic precipitation, presents. Furthermore, it is not evident that the Site Characterization program can obtain the necessary input parameters. The vast majority of the planned site characterization tests are novel, and do not even have an established technique(s) to be implemented. In light of this, numerical simulation of ground water and gaseous phase flow and accompanying radionuclide transport in unsaturated, fractured tuff under

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COMMENT NO.: 8-166 p. 2 of 2 | CHAPTER NO.: 8

SEC. NO. (PAGE NO.) [FIG. NO.]	COMMENT
8.3.5.20.2 (8.3.5.20-2)	non-isothermal conditions will remain largely a guess. This is particularly true given the short duration allowed in the Nuclear Waste Policy Act for data collection and modelling.

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