Enclosure 1

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NRC STAFF REVIEW OF

THE DEPARTMENT OF ENERGY'S JANUARY 8, 1988

CONSULTATION DRAFT SITE CHARACTERIZATION PLAN FOR

THE YUCCA MOUNTAIN SITE

FINAL POINT PAPERS

MAY 11, 1988

INTRODUCTION

Background

The Yucca Mountain area in southern Nevada is the proposed site of the nation's first geologic repository for high-level radioactive waste. The Department of Energy (DOE) is preparing a site characterization plan (SCP), required by the Nuclear Waste Policy Act (NWPA), to obtain the information necessary to determine the suitability of the Yucca Mountain site for a repository. As part of its development of the SCP, on January 8, 1988 the DOE issued the Consultation Draft Site Characterization Plan (CDSCP) for the Yucca Mountain Nevada Site for the information of and review by the NRC and the State of Nevada.

NRC Staff Review

The NRC staff has completed its technical review of the CDSCP in accord with the NRC Division of High Level Waste Management's "Draft Technical Review Plan for NRC Staff Review of DOE's Site Characterization Plans" (DTRP-SCP) and "Administrative Plan and Procedures for NRC Staff Review of DOE's Consultation Draft Site Characterization Plans" (APP-CDSCP) (December 18, 1987). Recognizing that the NRC staff review of the CDSCP was a limited review that focused on the logic and overall structure of the program presented in the CDSCP, some portions of the CDSCP have not been reviewed in detail, nor have all the CDSCP references been thoroughly reviewed. Hence, the lack of expressed concerns about a particular portion of the CDSCP should not be interpreted to mean that there are no problems in that portion. Rather, the concerns expressed in this transmittal should be examined by DOE from the point of view that these concerns may be relevant to other sections of the CDSCP.

Results of NRC Staff Review

The concerns identified in the NRC staff review were transmitted to DOE on March 7, 1988 in the form of draft point papers which served as the focus of workshops in March and April with DOE and which have now been finalized, with no significant changes from the draft point papers. Two new comments (109, 110) and four new questions (49, 50, 51, 52) have been added, and two questions (23, 30) have been deleted. Also, there are vertical lines in the right margin of the text to indicate where any change from the draft point papers has been made. In addition, an index to the point papers by technical discipline has been provided as one means of grouping related concerns. The ordering of the point papers within each level of concern (objections, comments, questions) is also designed to provide an orderly, easy-to-follow presentation of concerns, the order having been determined by the number of the section in chapter 8 of the CDSCP to which the concern pertains. The section number and name are provided as part of the heading for each concern.

The three levels of concern encompassed by the final point papers are defined as follows (and are more completely defined in the APP-CDSCP): (1) objections,

which are matters of such immediate seriousness to the site characterization program that NRC would recommend DOE not start work until they are satisfactorily resolved (e.g., potential adverse effects on repository performance; potential significant and irreversible/unmitigable effects on characterization that would physically preclude obtaining information necessary for licensing; or fundamental inadequacies in quality assurance (QA) programs); (2) comments, which are concerns with the program that would result in a significant adverse effect on licensing if not resolved (and hence needing early attention), but which would not cause irreparable damage if site characterization started before resolution; and (3) questions, which are major concerns with the presentation of the program in the CDSCP, such as missing information that should be in the CDSCP, inconsistencies, or ambiguities, which preclude understanding an important part of the program well enough for the NRC staff to be able to evaluate that part. Each objection, comment, and question contains a statement of the concern, a basis for the concern, and a recommendation for a suggested resolution.

The NRC staff's most fundamental technical objection (Objection 1) is the failure of the CDSCP to recognize the range of alternative conceptual models of the Yucca Mountain site that can be supported by the existing limited data base. The uncertainties in the data available and the gaps in the existing data base allow interpretations of the data that lead to a range of possible conceptual models that need to be considered in the development of site characterization programs. The NRC has previously raised this concern in connection with both the draft and final Environmental Assessments (EAs) for the Yucca Mountain site. Although efforts have been made in the CDSCP to identify more than one conceptual model of the Yucca Mountain site, the site characterization program presented appears primarily designed to gather evidence in support of a preferred conceptual model rather than to obtain a thorough understanding of the site and the data necessary to reduce the uncertainties about which conceptual model best portrays the Yucca Mountain site. The outcome of such an approach is that not only might not the necessary data be sought, but that until all the investigations needed to lessen uncertainties about possible conceptual models are identified, the CDSCP cannot adequately consider, in sequencing investigations, whether conducting one investigation would physically preclude conducting another investigation needed to obtain necessary information for licensing. This concern was the subject of the April 11-14, 1988 workshop on alternative conceptual models, during which the NRC staff recommended that the DOE provide in the SCP a systematic treatment of alternative conceptual models, integrated across technical disciplines, and suggested ways in which such information might be effectively presented in the SCP. DOE agreed to consider the NRC staff recommendations for dealing with alternative conceptual models and hypotheses during development of the SCP.

Another fundamental objection (Objection 5) is the status of the QA plans for site characterization activities. A number of QA plans and procedures are referenced in the CDSCP, but many of them are undergoing potentially significant revisions, have been the subject of NRC comments unaddressed by the

DOE to date, or have not undergone NRC staff review. The reliability and accuracy of any site characterization data collected before QA programs which meet the QA regulations in Part 60 are in place may be subject to challenge during NRC's licensing review. Hence, DOE should not start any new testing until QA programs which meet Part 60 QA requirements are in place. During the March 21-24, 1988 Draft Point Papers workshop, the DOE committed to not starting new work in an area until the NRC has reviewed the QA plan for that program area and confirmed its implementation through audits. DOE also committed to submit to NRC the Nevada Project Office QA plan within two or three weeks of that workshop and to meet with NRC in May to discuss all QA open items identified during the past and to provide a schedule for formal submittal to NRC of DOE contractor QA plans. These commitments are the necessary first steps toward resolution of the fundamental NRC QA concern. In addition, there are a number of QA comments (Comments 104-108) which express the NRC staff's lack of confidence that various facets of the DOE QA program are adequate and in accordance with 10 CFR Part 60. These comments also need to be resolved by DOE in a timely manner.

The three additional objections (Objections 2, 3, and 4) identified by the NRC staff involve the exploratory shaft facility (ESF). First, the CDSCP does not include the conceptual design information on the proposed ESF needed to allow evaluation of the potential interference of proposed investigations with each other or the interference of construction operations in the two exploratory shafts and drifts with these investigations (Objection 3). The second ESF-related objection (Objection 4) is that the CDSCP does not adequately consider the potentially adverse impacts that could result from the proposed locations of the exploratory shafts (and other shafts and ramp portals) in areas that may be subject to erosion and flooding. Adverse impacts could include (a) potentially significant and unmitigable effects on the waste isolation capability of the site and (b) affecting the ability to adequately characterize the site. The third ESF-related objection (Objection 2) is that the proposed shaft (ES-1) penetration into the Calico Hills unit and the proposed horizontal drifting through it may have significant negative impacts on the waste isolation capability of the site. The Calico Hills unit is an important barrier between the repository horizon level and the groundwater table, and DOE has not evaluated whether the activities proposed may irreparably damage its ability to function as a barrier.

Among the staff's other concerns are three comments which, while they do not meet the definition of objections, are especially significant in that they address DOE positions that are inconsistent with requirements in 10 CFR Part 60. These positions may result in DOE not having information needed at the time of license application submittal to adequately demonstrate compliance of the natural and engineered barriers with regulatory requirements. The first concern (Comment 3) is that the CDSCP's interpretation of the term "substantially complete containment" and the design objectives for performance of the waste package and for radionuclide release from the engineered barrier system are inconsistent with 10 CFR Part 60.113 and hence inappropriate to guide the waste package testing and design program. The second such concern

(Comment 64) involves the statement in the CDSCP that in situ testing to evaluate seal components and placement methods would not start until after the submission of the license application. That position will result in a lack of sufficient data for evaluating the license application. The third concern (Comment 103) is that there is a lack of information in the CDSCP about the performance confirmation program. 10 CFR 60.140 requires that the performance confirmation program be started during site characterization.

In addition to these inconsistencies with NRC requirements, there are several comments (Comments 36, 90, 92, and others) on inconsistencies relative to the EPA standard. Although the standard was vacated by the U.S. Court of Appeals for the First Circuit in July 1987, and the NRC recognizes that it is not currently in effect, it is NRC's understanding that DOE prepared the CDSCP based on the vacated standard. While NRC considers this approach to be reasonable, it has noted several instances involving departures from the standard that need to be reexamined by DOE.

Another concern that is reflected in a number of comments (Comments 22, 46, 67, 71, and others) relates to a lack of conservatism in assumptions upon which various investigations are based. The NRC staff has previously expressed its concern over a lack of conservatism in the draft and final Environmental Assessments. The staff's review of the CDSCP indicates that while there has been progress in this area, DOE still needs to take further steps toward adopting conservatism in its program. It has been noted earlier herein that the staff objected to the CDSCP because a conservative treatment of uncertainties in the existing limited data was not provided for by considering a full range of alternative interpretations (alternative conceptual models) in the development of the site characterization program. In addition, it has also been noted earlier that the design objectives for waste package containment established to guide the waste package design and testing program were not conservative, and thus may not allow sufficient margin for meeting performance objectives in 10 CFR Part 60.113. Furthermore, numerous specific examples from the earth sciences investigations--e.g., slip rate determinations on faults (Comment 37); zone of investigation for fault identification for facilities important to safety (Comment 50); use of the ten thousand year cumulative slip earthquake (Comment 52)--indicate that this is a serious concern to the NRC staff with regard to investigations designed to gain a basic understanding of the site. It is important that DOE consider areas where introduction of a greater degree of conservatism is needed in site characterization activities.

Yet another concern throughout the staff comments (Comments 26, 30, 47, and others) is that the site characterization program needs to be better integrated into a unified and focused effort towards obtaining the information needed to understand the site and evaluate its suitability for a repository. This integration of investigations needs to be across technical disciplines and also includes factoring performance assessment into the site characterization program to help direct site characterization activities, to identify important processes and parameters, and to assist in development and refining of conceptual models. One particular example of where integration seems to be

lacking across technical disciplines is the site characterization drilling program, where consideration of multiple tests in boreholes might reduce the number of holes and the corresponding potential for compromising the waste isolation capability of the site (Objection 1; Comment 27).

While the discussion above has focused on the NRC staff's most urgent concerns, DOE is encouraged to give full attention to all the attached point papers, since items which are comments and questions at this time may become objections if they are not resolved on a timely basis.

INDEX TO CDSCP FINAL POINT PAPERS BY TECHNICAL DISCIPLINE

DESIGN/ROCK MECHANICS:

Objections 2; 3; 4. Comments 1; 27; 29; 30; 42; 43; 44; 45; 46; 47; 48; 54; 55; 56; 57; 58; 59; 60; 61; 63; 64; 65; 66; 67; 68; 70; 72; 97; 98; 99; 100; 101; 102; 103. Questions 12; 14; 16; 17; 25; 26; 27; 34; 35; 36; 37; 38; 39; 40; 41; 42; 48; 49; 50; 51.

GEOCHEMISTRY:

Comments 14; 15; 16; 17; 18; 19; 20; 21; 22; 23; 24; 25; 71; 89. Questions 5; 6; 7; 8; 9; 10; 11; 47.

GEOLOGY/GEOPHYSICS:

Comments 26; 28; 34; 35; 36; 37; 38; 39; 49; 50; 51; 52; 53; 62; 69; 95. Questions 13; 15; 18; 19; 20; 21; 22; 23 (deleted); 29; 30 (deleted); 31; 32; 33.

HYDROLOGY:

Comments 5; 6; 7; 8; 9; 10; 11; 12; 13; 31; 32; 33; 40; 41; 86; 87; 88; 96. Questions 3; 4; 24; 28.

PERFORMANCE ASSESSMENT:

Objection 1. Comments 2; 4; 90; 91; 92; 93; 94. Questions 2; 43; 44; 46; 52.

QUALITY ASSURANCE:

Objection 5. Comments 104; 105; 106; 107; 108.

WASTE PACKAGE:

Comments 3; 73; 74; 75; 76; 77; 78; 79; 80; 81; 82; 83; 84; 85; 109; 110. Questions 1; 45.

OBJECTIONS

Chapter 8 Site Characterization Program

OBJECTION 1

The performance allocation process in the CDSCP does not directly address the investigations that would be needed to characterize the site with respect to the full range of alternative conceptual models and associated boundary conditions that are consistent with the existing data. An important consequence is that without identifying all potentially significant investigations it cannot be determined whether conducting one investigation would interfere with, possibly to the point of precluding, conducting another investigation needed to obtain information for licensing. In addition, the program may favor providing data that confirm the "preferred" model and boundary conditions rather than the data needed to determine what the "preferred" model and boundary conditions should be.

BASIS

- In the CDSCP, the conceptual models and associated boundary conditions relied on for performance allocation are also the bases for identifying site characterization investigations (see Section 8.1.2 of the CDSCP).

- These conceptual models and associated boundary conditions may change during site characterization. For example, the performance allocations for Issues 1.1-1.6 and 1.8-1.9 are based on a groundwater flow model and associated boundary conditions that are not uniquely supported by existing data. Additional information may require the adoption of a different conceptual model and boundary conditions.

- To avoid compromising the site characterization program, priorities for investigations must be established in consideration of whether conducting tests will interfere with or preclude conducting other tests that are important to licensing. This requires that all potentially significant investigations be identified and considered when testing priorities are established.

- Should a test be conducted that would interfere with or preclude conducting another test needed to obtain information necessary for licensing, there could be significant and irreversible effects on the site characterization program.

RECOMMENDATIONS

- A full range of alternative conceptual models and associated boundary conditions suggested by available preliminary evidence should be systematically and clearly identified, and should be the basis for any preliminary performance allocations.

- Investigations and information needs should take into account alternative conceptual models and associated boundary conditions.

- Investigations should be integrated across all disciplines. This integration should help to minimize the number of tests that could affect the waste isolation capability of the site (e.g., see Comment 27; Question 13).

- Based on the full array of the needed investigations, it should be determined which test(s) would interfere with or preclude conducting other tests that are important to the site characterization program. Such test(s) should be sequenced appropriately with other tests.

- High priority should be accorded investigations having the greatest potential for resolving issues associated with features, events, or processes that could lead to the site being considered unlicensable, or to substantial change in the site characterization program, insofar as conducting such investigations does not interfere with or preclude conducting other necessary investigations.

- One way to deal with these recommendations would be to include in Chapter 8 of the SCP a series of systematic tables (supported by discussions), integrated across all technical disciplines, that focus on the performance objectives of 10 CFR Part 60 and establish the following:

  (1) a description of what is known or thought to be the case about the present and future states of each element of the natural and engineered systems,

  (2) for each such element, a discussion of the uncertainties, including identification and influence of any assumptions made in the description,

  (3) for each such uncertainty, identification of and assessment of the significance of the alternative hypotheses, interpretations, or assumptions that are consistent with the existing data and the uncertainty associated with the existing data,

  (4) for each such hypothesis, information needs and investigations to discriminate between the alternatives, and

  (5) prioritization of the investigations based on avoidance of interference between tests and the need to resolve key issues early.

REVIEW GUIDES

4.2.2, 4.2.3, 4.2.4.5

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

OBJECTION 2

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

BASIS

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

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

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

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

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

RECOMMENDATION

° The SCP should consider plans for characterizing the Calico Hills unit to the extent necessary without having to penetrate and damage portions of this important barrier between repository horizon level and the groundwater table. If alternative plans cannot be developed, it should justify the need for destructive testing of the Calico Hills unit and analyze the consequences of possible pathway connections from the proposed waste emplacement areas to both the lower portion of the ES-1 and to the proposed drifts in the Calico Hills unit.

REFERENCES

Letter R.E. Browning, NRC to S. Kale, DOE, dated December 22, 1986, Subject, "NRC Staff comments on Final EA."

10 CFR 60.

REVIEW GUIDES

4.2.5; 4.3.16

Section 8.4.2: Underground Test Facilities

OBJECTION 3

The CDSCP does not include sufficient and consistent conceptual design information on the proposed ESF. This does not allow the evaluation of the potential interference of proposed investigations with each other and the interference of construction operations in the two shafts and long drifts with these investigations.

BASIS

- The conceptual design of the ESF needs to provide a level of detail that will allow evaluation of potential interference of planned in situ investigations with each other and with construction operations.
- Relative distances between test locations, and dimensions of boreholes and other excavations are needed to assess the interference potential.
- In planning the underground test facility, the overall performance confirmation testing program and the need for starting at least some of the performance confirmation tests as early as practicable during site characterization should be considered.
- The conceptual design of the ESF should take into account the need for preliminary information from in situ seal testing to be available at License Application submittal (Ref. 1).
- The information provided on the ESF is inconsistent. For example, the layout sketch provided in Figure 8.4-11 is significantly different from those shown in Figures 8.4-10, 8.3.1.4-11 and 8.4-30.

RECOMMENDATIONS

- The ESF conceptual design information should be included in the SCP in more detail and in a consistent fashion. A strategy to minimize potential interference between investigations should be discussed.

REFERENCES

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

10 CFR 60 (Subpart F).

REVIEW GUIDE

4.2.5

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

OBJECTION 4

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

BASIS

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

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

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

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

RECOMMENDATIONS

- Prior to finalizing the locations of the ES-1, ES-2, Man-and-Materials Shaft, Waste Emplacement Ventilation Exhaust Shaft, Muck Handling Ramp portal and Waste Handling Ramp Portal, consideration should be given to:

    (a) Effects of surface water infiltration and flooding,
    (b) Effects of vertical and lateral erosion,
    (c) Potential for seals (drainage) to become ineffective (clogged) during postclosure phase,
    (d) Future changes in the geomorphic processes due to tectonic events and repository-induced uplift/subsidence,

(e) Potential adverse impacts on the isolation capability of the site, and
(f) Potential impact on the ability to characterize the site.

REFERENCES

1. Memorandum from T.L. Johnson, NRC to R. John Starmer, dated July 22, 1987, Subject, "Report of Site Visit to NNWSI Project."

2. Purcell, Charles (Rus), "Geomorphic Evaluation of Proposed shaft and ramp locations, Yucca Mountain High Level Waste Site," Draft Report NO. LLNL/NRC-NNWSI-CRP-87/88-YM1, Lawrence Livermore National Laboratory, January 1988.

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

4. Squires, R.R., and Young, R.L., 1984, Flood Potential of Fortymile Wash and Its Principal Southwestern Tributaries, Nevada Test Site, Southern Nevada. USGS-WRI-83-4001, Water-Resources Investigations Report, U.S. Geologic Survey, Carson City, Nevada.

5. Letter from S. Coplan, NRC to D. Vieth, DOE, dated April 14, 1983, Subject, "Information Considered Necessary Regarding Exploratory Shaft Construction and Sealing."

6. Letter From J. Linehan, NRC to D. Vieth, DOE, dated April 21, 1986, Subject, "Review of Flooding Analyses Exploratory Shaft Performance Analysis Study, NNWSI."

REVIEW GUIDE

4.2.5

Section 8.6.1, Quality Assurance Plan Summary and Table 8.6-1, Organizations participating in the NNWSI Project and their Quality Assurance Program Plans (QAPPs)

OBJECTION 5

The CDSCP references a number of QA plans and procedures for DOE and its prime contractors, many of which are undergoing potentially significant revisions, or which have outstanding staff review comments, or which have not undergone staff review. Based on staff reviews to date, they do not fully comply with NRC's QA criteria. Data collected under these existing programs may not be usable in licensing.

BASIS

- In accordance with the requirements of 10 CFR §60.151 and §60.152 of Subpart G, DOE shall implement a quality assurance program for site characterization based on the applicable criteria of Appendix B to 10 CFR Part 50.

- The NNWSI Project Quality Assurance Plan, (NVO-196-17, NNWSI-SOP-02-01-QAPP) and the LANL QA plan have undergone formal NRC staff review. Requests for additional information were issued by the staff on August 25, 1986, November 21, 1986, and October 8, 1987 respectively. Although the staff has recently received responses to the August 25 and November 21, 1986 requests for additional information, revised plans which incorporate these responses have not yet been received. A response to the staff comments on the LANL Plan has also not been received.

- The WMPO NVO-196-18, SAIC, H&N, and REECO Quality Assurance Plans have not been submitted to NRC and consequently, have not been reviewed by the NRC staff.

- The USGS, SNL, LLNL and F&S QAPPs have been submitted and will be reviewed by the NRC staff. DOE should confirm, however, that the staff is reviewing the appropriate revision to these plans.

- Two sources for establishing the quality assurance requirements for the NNWSI Project are the OCRWM "Quality Assurance Management Policies and Requirements" document (DOE/RW-0032) and the "Quality Assurance Plan for High-Level Radioactive Waste Repositories," DOE OGR/B-3 document. The OGR/B-3 and OCRWM quality assurance documents are presently undergoing revisions by DOE and need to be reviewed for acceptability by the NRC staff for the geologic repository. These revisions could significantly affect the lower tier quality assurance plans referenced above at the NNWSI project.

- The NRC has informed DOE at meetings and through correspondence that an adequate quality assurance program should be in place prior to or at the time of site characterization. This would include the required quality assurance program and implementing procedures of the DOE and contractors. It would also include the NRC selectively verifying through the audit

process, that adequate quality assurance provisions are in place for items and activities important to safety and to the design and characterization of barriers important to waste isolation. The staff is planning on completing six audits of the DOE NNWSI QA program during the period from June 1987 through May 1988. This additional verification of the repository QA program is essential to the process of NRC obtaining confidence in the adequacy of the program.

- Consequently, in view of the above open items, and needed improvements which have been identified by the staff, there is an insufficient basis for the staff to have confidence in the adequacy of the program at this time. This condition could likely affect the eventual usability of site characterization data for licensing of the waste repository.

RECOMMENDATIONS

- DOE should furnish the latest revisions to project and OCRWM QA Plans for staff review. The staff will not review all QA procedures supporting the Plans, but will selectively examine several during the plan review. Those covering peer reviews (such as QMP-03-01 at WMPO) or qualification of existing data should be furnished to the staff. Others will be requested as needed.

- DOE should respond to outstanding staff comments on QA plans.

- DOE should facilitate NRC staff verification reviews such as audits, observation/audits, readiness reviews, etc.

- The staff recommends that DOE not start site characterization work until additional confidence is gained in the adequacy of the plans supporting new site characterization work.

REFERENCE

10 CFR Part 60, Subpart G

REVIEW GUIDE

4.2.7

COMMENTS

Chapter 8: General Design/Rock Mechanics Concern

COMMENT 1

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

BASIS

- Although a detailed rationale for development of basic information needs is presented, it is not sufficient to ensure the completeness and utility of those information needs. For example, "sensitivity studies" that can point out the potential areas of concern in rock mass performance and can be used to identify critical parameters to be measured in the laboratory and field have been used only in a limited way in identifying information needs.

- The testing program does not demonstrate an integrated approach between the field testing, design and performance assessment functions. Several examples from the CDSCP illustrate this point.

  The testing plan does not describe in situ testing aimed at providing a complete set of joint properties that would be needed as input to design and performance assessment models.

  Some data proposed to be collected during site characterization apparently cannot be utilized by codes currently under development for the NNWSI project--for example, time-dependent properties of intact rock and discontinuities (i.e., velocity-dependent joint friction, creep parameters).

  The testing plan does not attempt to relate individual tests to validation or verification of specific design or performance specifications. For example, the design of the heater testing described in Section 8.3.1.15 does not recognize the need to provide data which can verify whether or not retrievability design criteria regarding allowable curvature, closure and spalling of the emplacement boreholes can be met (e.g., Table 8.3.5.2-3).

  Individual, cumulative, or synergistic effects of proposed boreholes have not been considered in the evaluation of the potential impacts of exploratory shaft construction and testing on the waste isolation integrity of the site.

RECOMMENDATION

The SCP should clearly describe the link between proposed tests, present design, and repository performance in various sections of the write-up, and should provide rationale for development of basic information needs.

REVIEW GUIDE

4.2.2

Section 8.2 Issues
Section 8.3.5.9 Containment by Waste Package,
Section 8.3.5.10 Engineered Barrier System Release Rates, and
Section 8.3.5.13 Total System Performance

COMMENT 2

The performance allocations associated with scenario classes identified for the purpose of resolving Issue 1.1 (Section 8.3.5.13 of the CDSCP) may not have considered the effects of all anticipated processes and events and in that way may be inadequate for resolution of Issues 1.4 and 1.5 (Sections 8.3.5.9 and 8.3.5.10 of the CDSCP), particularly for parameters associated with tectonic events.

BASIS

- Section 8.3.5.10.3 of the CDSCP discusses the identification of scenarios for the purpose of resolving Issues 1.4 and 1.5 (corresponding to the waste-package lifetime and engineered barrier system release rate performance objectives of Section 60.113 of 10 CFR Part 60), and identifies input parameters from the scenarios developed in Section 8.3.5.13 of the CDSCP (as well as from other CDSCP Sections).

- The discussion in Section 8.3.5.10.3 and elsewhere assumes that the performance allocated to scenario parameters identified for the resolution of Issue 1.1 in Section 8.3.5.13 will also be adequate for the resolution of Issues 1.4 and 1.5.

- Although this may be the case, it is not necessarily so, particularly for anticipated processes and events that could lead to relatively rapid release of radionuclides from the engineered barrier system (EBS) that would violate the NRC's EBS release rate performance objective without necessarily violating the total system performance objective.

- An important class of this type of process and event is associated with tectonic disturbances of the waste package and EBS.

RECOMMENDATIONS

- The performance allocations for Issues 1.4 and 1.5 should include consideration of the effects of all anticipated processes and events (such as tectonic disturbances) on the waste package lifetime and the release rate for the EBS.

- If more severe performance goals are required to resolve Issues 1.4 and 1.5 than to resolve 1.1, these values should be chosen as the basis of the testing program.

REVIEW GUIDES

4.2.2, 4.2.4.1, 4.2.4.2

Section 8.2.2.1.1.4 Summary of waste package containment.
Issue 1.4: Will the waste package meet the performance objective for containment as required by 10 CFR 60.113?
Section 8.3.5.9 Issue resolution strategy for Issue 1.4: Will the waste package meet the performance objective for containment as required by 10 CFR 60.113?

COMMENT 3

The NNWSI CDSCP's interpretation of the term "substantially complete containment" and the three design objectives for performance of the waste package and for radionuclide release from the engineered barrier system (EBS) are inconsistent with 10 CFR 60.113 for "substantially complete containment" and inappropriate to guide the waste package testing and design program.

BASIS

- The NRC staff considers the design objectives to be nonconservative, inconsistent with the rulemaking record and the Commission's intent in requiring substantially complete containment during the containment period, and inappropriate to guide the waste package testing and design program.

- The Commission considers that a waste package design for containment in the range of 300 to 1000 years is reasonably achievable.

- The CDSCP objectives, if attained, would permit releases of radionuclides from the waste packages and from the engineered barrier system during the containment period which are substantially in excess of the radionuclide releases permitted during the post containment period.

- The first design objective would permit the waste in 20 percent of the waste packages to be exposed for release.

- The second design objective is unnecessary because it is less stringent than the third design objective. The purpose of this second objective is unclear as it is bounded and constrained by the third objective.

- The third design objective would permit larger releases from the EBS during the containment period than 10 CFR 60 permits during the post-containment period and this design objective, in the staff's view, does not satisfy the intent of "substantially complete containment."

- The NRC staff does not expect absolute proof that 100 percent of the waste packages will have 100 percent containment for 300 to 1000 years; however, it should be possible for NNWSI to establish conservative design objectives to guide a testing and design program which will lead to a package that meets the performance objective for substantially complete containment in 10 CFR 60.113. The staff expects substantially better containment than would be permitted by the proposed CDSCP design objectives.

RECOMMENDATIONS

- The NRC staff recommends that NNWSI establish conservative design objectives that are consistent with the rulemaking record.
- These design objectives should reflect the Commission's intent that performance of the waste package during the containment period be reliable and substantially better than that for the post-containment period.
- NNWSI should also provide a rationale and basis for the design objectives established to guide the waste package design and testing program.

REFERENCE

10 CFR 60.113

REVIEW GUIDES

4.3.24, 4.3.25, 4.3.30

Section 8.3 Planned Tests, Analyses, and Studies

COMMENT 4

The CDSCP indicates that subjective methods (e.g., formal use of expert judgement) will be extensively relied upon in site characterization investigations and analyses without stating any limits on their use.

BASIS

- The NRC staff agrees generally with the statement (page 8.3.5.8-6, last paragraph) that subjective methods must in many cases play an important role in the strategy for resolution of performance issues; the NRC staff considers, however, that preference should be given to objective methods (e.g., data collection) of resolving specific issues.

- During the licensing process, the formal use of expert judgement will not be accepted without question. The facts and reasoning used by experts to reach conclusions will be examined independently of the conclusions reached. Such an examination will include determining whether the subjective approach (1) was used only when more objective approaches were found to be unavailable and, (2) was used in a traceable, defensible manner.

- The CDSCP is unclear about whether subjective methods will be used consistently only when objective approaches are found to be unavailable. For example, statements on pages 8.3.5.20-6, (last paragraph), 8.3.5.20-8 (first paragraph), and 8.3.1.3-124 (fourth paragraph) call for extensive use of what is termed "peer review" in model validation and in establishing credibility of study results (see also the Question on clarification of terms regarding subjective methods).

RECOMMENDATIONS

- In developing plans for investigations and analyses, the use of subjective methods should be justified by

  (1) a general clarification, perhaps in Section 8.3.5.8, of how, when, and under what circumstances a specified subjective approach (professional judgement, peer review, or formal use of expert judgement) will be used, and

  (2) a commitment that subjective methods will be used only when other approaches and sources of information such as experimental data, quantitative analyses, and historical data are demonstrated to be infeasible or impractical.

REFERENCE

U.S. Nuclear Regulatory Commission, "Generic Technical Position on Peer Review for High-Level Nuclear Waste Repositories", Federal Register, Vol. 52, No. 131, July 9, 1987, 25932-25933.

REVIEW GUIDES

4.2.4.4, 4.2.4.8, 4.3.28

Section 8.3.1.2 Geohydrology

COMMENT 5

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

BASIS

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

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

RECOMMENDATION

- The results of the analyses of data collected in Yucca Mountain tuffs should be transferred to the alluvium at Fortymile Wash only after providing a technical basis for the transfer.

REVIEW GUIDE

4.3.16

Section 8.3.1.2.2 Investigation: Studies To Provide A Description Of The Unsaturated Zone Hydrologic System At The Site

COMMENT 6

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

BASIS

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

RECOMMENDATION

- Include a study activity describing the planned unsaturated zone percolation prototype testing program.

REVIEW GUIDE

4.3.16

Section 8.3.1.2.2.3.2 Activity: Site Vertical Borehole Studies

COMMENT 7

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

BASIS

° In Section 8.3.1.2.2.3.2 it is stated that "downhole sensors, consisting of pressure transducers, thermocouple psychrometers, heat dissipation probes, and thermal sensors will be installed in each of the 17 vertical boreholes." Further, "These will be monitored for an extended period of time (estimated at from 3 to 5 yrs.)" (page 8.3.1.2.-158, pgh. 4). The text also states that "drilling the holes will disturb the hydrologic system" and "it is not known if in situ conditions will return within the time period allotted for monitoring (3 to 5 yrs.)." Two potential problems are identified by these statements which could result in a loss of data or information needed to characterize the site: (1) there may not be enough time to complete long-term monitoring of the unsaturated zone and prototype testing of the instrumentation; and (2) many of the instruments may fail or drift out of calibration during the long period of monitoring.

RECOMMENDATION

° If long-term monitoring of unsaturated vertical boreholes is crucial to the characterization of the repository, reliable instrumentation must be developed and used. Also, alternative methods of collecting this information should be explored.

REVIEW GUIDES

4.3.16, 4.2.4.6.2

Section 8.3.1.2.2.3.2 Activity: Site Vertical Borehole Studies

COMMENT 8

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

BASIS

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

RECOMMENDATIONS

- Include a discussion describing how the vertical unsaturated zone boreholes have been located to provide a representative description of the proposed repository location.

- Integrate the hydrologic drilling program with the systematic drilling program for geologic and natural resource characterizations.

REVIEW GUIDE

4.3.16

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

COMMENT 9

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

BASIS

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

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

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

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

- It is also stated in the CDSCP that drifting will take place in the Topopah Springs Member to investigate the geology and hydrology of the Ghost Dance fault, the Imbricate-Normal fault zone, and beneath Drill Hole Wash. However, no study activities are described for these locations.

RECOMMENDATION

- Develop activities for geohydrologic testing in the drifts at the Ghost Dance fault, the Imbricate-Normal fault zone, and beneath Drill Hole Wash.

REVIEW GUIDE

4.3.16

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

COMMENT 10

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

BASIS

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

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

RECOMMENDATION

- Evaluate drilling effects of USW G-4 on planned hydrologic and geochemical tests at the exploratory shaft site.

REFERENCE

Water Waste & Land, Inc., 1986, Analyses of Observed Flow Between Test Wells USW G-4 and USW UZ-1, Mini-report #6, prepared for the USNRC

REVIEW GUIDES

4.3.16, 4.2.3, 4.2.12

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

COMMENT 11

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

BASIS

- Groundwater Travel Time and Total System Performance evaluations depend on the current conceptual model of fracture/matrix flow, which has not been experimentally demonstrated by tests on unsaturated fractured rock. The CDSCP states (Section 3.9.2.1, Page 3-170) that "Standard laboratory methods are not yet available by which to determine the moisture-characteristic relations for fractures and fractured rocks, and reliance must be made on theoretically based models and approximations." Further, the CDSCP states that (page 3-172) "the flow of liquid water within and across fractures is not yet well understood" and that "Theoretical models for liquid-water flow in single fractures have been developed, but have not been field or laboratory tested." In Section 8.3.1.2.2.4, planned tests are described to confirm the current moisture-characteristic relation concepts for fractures and dry fractured rocks in the exploratory shaft and drifts. The problem is that these tests will require new techniques and devices, which are unproven and experimental. Further, because these tests will be conducted in the exploratory shaft and drifts, they will be conducted at a late date in the exploratory program. If these tests fail, a fundamental premise of the hydrogeologic conceptual model will not have been demonstrated and the program could be significantly delayed. In addition, should these tests require revision to the current concept of fracture/matrix flow, the design of other tests may have to be changed at a date in the program when changes might be difficult or impossible.

RECOMMENDATION

- The current concept of moisture characteristic relations for fracture/matrix flow in unsaturated fractured rock should be demonstrated early in the program either by laboratory or field tests on dry fractured rock similar to that at Yucca Mountain.

REVIEW GUIDES

4.3.16, 4.2.6, 4.2.4.4

Section 8.3.1.2.2.5.1 Activity: Diffusion Tests In The Exploratory Shaft Facility.

COMMENT 12

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

BASIS

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

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

RECOMMENDATION

The diffusion test should be designed to eliminate or take into account capillary pressure gradient effects.

REVIEW GUIDES

4.3.16, 4.3.14

Section 8.3.1.2.3.1 Study: Characterization Of The Site Saturated Zone Ground-water Flow System

COMMENT 13

Activities presented for this study do not appear to be adequate for characterizing saturated zone hydrologic boundary conditions, flow directions and magnitudes.

BASIS

- West-dipping normal faults lie within and east of the repository block, and the block is bounded on the west by the Solitario Canyon Fault. The Solitario Canyon Fault is located on the high side of the site hydraulic gradient and the faults within and east of the repository block lie generally across the assumed groundwater flow path from the repository to the accessible environment. Because fluid flow can be influenced by faults (Section 8.3.1.2.3; page 8.3.1.2-292; paragraph 7), an important aspect of studies of the saturated zone at the site will be evaluating the imposition of structure on hydrologic boundary conditions (Section 8.3.1.2.3; page; 8.3.1.2-292; paragraph 5).

- "The objectives of the study are (1) to determine the internal and external boundary conditions that can be applied to the saturated zone model and (2) to determine the ground-water flow magnitudes and directions at the site" (Section 8.3.1.2.3.1; page 8.3.2-297; paragraph 4). Eight activities are described under the study to characterize the saturated groundwater zone flow system. One activity is designed to address the impacts of the Solitario Canyon Fault on the saturated groundwater flow system; impacts of the repository block and eastern faults on flow directions and magnitudes are not addressed by the other activities.

RECOMMENDATIONS

- The study to characterize the saturated zone should contain activities for addressing the influence of faults within and east of the repository block on flow directions and magnitudes.

- The study should be integrated with the geophysical program and the systematic drilling program for geologic characterization.

REVIEW GUIDES

4.3.16, 4.2.4.4, 4.2.4.5, 4.2.4.6

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

COMMENT 14

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

BASIS

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

RECOMMENDATION

° To determine the effect of matrix diffusion on the migration of tracers, it is recommended that various size particles or colloids be included in the C-hole tests.

REFERENCE

Cathles, L. M., Spedden, H. R., and Malouf, E. E., 1974, A tracer technique to measure the diffusional accessibility of matrix block mineralization, in Aplan, F. F., editor, Solution Mining Symposium, Society of Mining Engineers, American Institute of Mining, Metallurgical and Petroleum Engineers, New York.

REVIEW GUIDES

4.2.1, 4.2.2, 4.2.3, 4.2.4, 4.2.8, 4.3.14

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

COMMENT 15

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

BASIS

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

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

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

RECOMMENDATIONS

° The integration of the work described with work characterizing sorption in both the saturated and unsaturated zone described in the geochemistry program (8.3.1.3) should be clarified.

° Additional methods of obtaining information on radionuclide sorption should be considered in the SCP. One approach would be to attempt to gain information on radionuclide mobility under similar tuff-groundwater situations from the many bomb test sites at the Nevada Test Site.

REVIEW GUIDES

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

Section 8.3.1.3.1 Investigation: Studies to provide the information required on radionuclide retardation by precipitation processes along flow paths to the accessible environment water.

COMMENT 16

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

BASIS

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

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

RECOMMENDATION

° Consider running experiments in the presence of gamma radiation or include species expected in a high gamma flux environment to examine the potential importance of kinetics.

REVIEW GUIDES

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

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

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

COMMENT 17

Standard solubility approaches alone may not be sufficient for determining reliable thermodynamic properties of these phases. These parameters are needed to model mineral stability under repository conditions.

BASIS

° Zeolites are metastable in dilute aqueous solutions.

° Secondary phases could precipitate during the solubility tests, rendering the solution concentrations irrelevant to the thermodynamic properties of the solid of interest.

° Solubility tests could be performed at high concentrations of sodium and calcium where the phases are stable. Unfortunately, extrapolating the results to an ionic strength of zero to obtain standard thermodynamic properties is uncertain because of uncertainties in the activity correction schemes for high-ionic strength soultions.

RECOMMENDATION

° Consider the use of alternative techniques for determining the free energy of formation for these phases. For example, a combination of differential scanning calorimetry and solution calorimetry has been shown to be successful for determining properties of similar phases (Johnson et al. 1982, 1985).

REFERENCES

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

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

REVIEW GUIDES

4.2.1, 4.2.2, 4.2.3, 4.2.4, 4.2.6, 4.2.8, 4.3.13

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

COMMENT 18

None of the studies described includes the use of solutions directly from waste form leach tests or integrated waste package tests. Contaminated solutions migrating from the vicinity of the waste package may have inherited characteristics that do not respond to postulated equilibrium controls (page 8.3.1.3-60)

BASIS

- Groundwater chemistry and mineralogy do not necessarily control the speciation and oxidation state of dissolved waste elements as stated on page 8.3.1.3-60.

- Complex chemical systems such as those expected are notorious for behaving in a nonequilibrium manner (Lindberg and Runnells, 1984).

- The oxidation states and speciation of waste elements in a complex solution may be a mixture of disequilibrium states as a result of interactions near the waste packages.

- Waste package interactions may also produce colloids or particulates that may transport waste elements.

RECOMMENDATION

- Consider the use of sorption tests that use actual or simulated solutions from waste form leach tests and waste package interaction tests. These solutions should be well-characterized prior to use and care should be taken to preserve the chemical and physical characteristics of the solutions.

REFERENCE

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

REVIEW GUIDES

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

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

Section 8.3.1.3.4.1.5 Activity: Statistical analysis of sorption, and

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

COMMENT 19

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

BASIS

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

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

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

RECOMMENDATIONS

- The integration of this investigation with Activity 8.3.1.2.3.1.7, which will derive a more fundamental approach to explaining sorption, should be clarified.

- In the SCP additional methods of obtaining information on radionuclide sorption should be considered. Another approach would be to attempt to gain information on radionuclide mobility under similar tuff-groundwater situations from the many bomb test sites at the Nevada Test Site.

REFERENCE

Palmer, D. A., Shiao, S. Y., Meyer, R. E., and Wethington, J. A., 1981, Adsorption of nuclides on mixtures of minerals, Journal of Inorganic and Nuclear Chemistry, volume 43, number 12, p. 3317-3322.

REVIEW GUIDES

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

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

COMMENT 20

The Studies to be conducted under this Investigation do not include measurement of potential interactions between or among radionuclides, or evaluation of the effects of such interactions on radionuclide sorption.

BASIS

° Competition among radionuclides for sorption sites on the solid phase may occur. The need to measure such effects when evaluating sorption in geologic systems has been recognized in the literature (Serne and Relyea, 1981).

RECOMMENDATIONS

° The SCP should include, under this investigation, an evaluation of the effects of radionuclide interactions and sorption site competition on radionuclide sorption.

° Additional methods of obtaining information on radionuclide sorption should be considered in the SCP. One approach would be to attempt to gain information on radionuclide mobility under similar tuff-groundwater situations from the many bomb test sites at the Nevada Test Site.

REFERENCE

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

REVIEW GUIDES

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

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

COMMENT 21

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

BASIS

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

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

- From phase rule considerations, the number of restrictions placed on a system involving a precipitation/dissolution reaction must make the system invariant (Crerar et al., 1978). Otherwise, the solubility information acquired may not be reliable to extrapolate to repository conditions. Solids in contact with groundwater can buffer the solution and, thus, provide a means of restricting the system.

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

RECOMMENDATIONS

- The use of solid minerals in solubility experimentation should be considered as a means of constraining the system.

- Additional methods of obtaining information on radionuclide transport should be considered in the SCP. One approach would be to attempt to gain information on radionuclide mobility under similar tuff-groundwater situations from the many bomb test sites at the Nevada Test Site.

REFERENCE

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

REVIEW GUIDES

4.2.1, 4.2.2, 4.2.3, 4.2.4.5, 4.2.4.6, 4.2.4.7, 4.2.6, 4.2.8, 4.3.14

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

COMMENT 22

The conceptual model of matrix-dominated groundwater flow in the unsaturated zone drives the radionuclide retardation testing program. As a result, the determination of some parameters that may be important to site characterization are not planned.

BASIS

- 10CFR60 requires that radionuclide mobility be characterized in such a way that cumulative release over 10000 years can be evaluated with respect to both anticipated processes and events and unanticipated processes and events.

- Groundwater in the unsaturated zone is expected to flow in both the matrix and the fractures.

- Most of the geochemical retardation testing simulates conditions in the matrix, inasmuch as the DOE expects most of groundwater flow to occur in the matrix.

- Only some of the parameters needed to characterize radionuclide retardation will be determined in experiments simulating fracture flow.

- Speciation may be different in groundwater contacting crushed rock versus fractured rock, inasmuch as minerals associated with the fractures can be different from those in the matrix.

- The determination of speciation occurring in fractured rock is not planned.

RECOMMENDATION

- The SCP should include plans to determine speciation, colloids, matrix diffusion, and any other conditions or processes which may significantly affect radionuclide retardation in fractures.

REVIEW GUIDES

4.2.1, 4.2.2, 4.2.3, 4.2.4.1, 4.2.4.2, 4.2.4.3, 4.2.4.4, 4.2.4.5, 4.2.4.6 4.2.4.7, 4.2.6, 4.2.8, 4.3.14

Section 8.3.1.3.6.1 Study: Dynamic transport column experiments

COMMENT 23

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

BASIS

- In order to carry out fractured column tests of radionuclide transport, tuff samples containing fractures must be recovered from the rock units of interest.
- The plastering technique described in 8.3.1.2.2.4.1 provides evidence that the fractured core is not disturbed during the recovery phase but does not guarantee that the fractured core was not disturbed prior to recovery.
- Disturbances may produce changes in the physical properties (e.g. fracture aperture) or in the fracture surfaces that will be contacted by the test solutions (e.g. fresh mineral coatings on the fracture surfaces may be exposed).
- If such disturbances occur, these tests may produce results which are not characteristic of in situ repository conditions.

RECOMMENDATIONS

- Develop in situ tests which will serve as a source of data on colloid transport and matrix diffusion to confirm laboratory fractured column tests.
- Additional methods of obtaining information should be considered in the SCP. One approach would be to attempt to gain information under similar tuff-groundwater situation from the many bomb test sites at the Nevada Test Site.

REVIEW GUIDES

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

Section 8.3.1.3.6.1.3 Activity: Unsaturated Tuff Columns

COMMENT 24

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

BASIS

- Adsorption isotherms describe the effect of radionuclide concentration on Kd.
- The linear region of an adsorption isotherm indicates that there is no effect of radionuclide concentration on Kd.
- Changing the rock-water ratio can cause changes in the groundwater chemistry which can affect radionuclide sorption reactions and consequently Kd.
- By decreasing the rock-water ratio of a system it is possible to shift the position on the isotherm from the linear to the nonlinear region.
- Most of the mass of the rock in the repository could be discounted if groundwater is confined to fractures. As a result, the rock-water ratio of some flow systems of the repository may be less than that in crushed tuff experiments.

RECOMMENDATION

- It is recommended that the effect of rock-water ratio be considered in the sorption testing program.

REVIEW GUIDES

4.2.4.1, 4.2.4.2, 4.2.4.3, 4.2.4.4, 4.2.4.5, 4.2.4.6, 4.2.4.7, 4.3.14.

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

COMMENT 25

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

BASIS

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

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

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

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

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

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

RECOMMENDATION

- It is recommended that natural analogs be considered in determining the effects of time and scale on extrapolations of radionuclide migration experiments to repository conditions. Validation of models will require consideration of natural analogs.

REFERENCES

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

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

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

REVIEW GUIDES

4.2.4.5, 4.2.4.7, 4.3.7, 4.3.14.

Section 8.3.1.4 Rock Characteristics
Section 8.3.1.17 Preclosure Tectonics

COMMENT 26

Existing geophysical data supplemented by existing geological data do not appear to have been integrated for the purpose of developing a coherent plan for future geophysical investigations.

BASIS

- The geophysical programs of the CDSCP are generally noted in Tables 8.3.1.4-4, 8.3.1.17-7, and 8.3.1.17-8. The locations and scopes for the geophysical methods referenced in these tables are generally related only to specific geologic structural features or cover areas of limited extent as shown in figures 8.3.1.4-7, 8.3.1.4-8, 8.3.1.4-9, and 8.3.1.17-12.

- The integration of existing geological and geophysical data will provide a more complete understanding of the geologic system and will identify areas where further investigations are needed.

RECOMMENDATIONS

- Integrate and evaluate existing geophysical and geological data.

- Develop a preliminary 3-dimensional geophysical model based upon the existing integrated geophysical and geologic data.

REVIEW GUIDE

4.3.6

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

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

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

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

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

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

COMMENT 27

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

BASIS

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

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

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

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

  - Given the presently preferred shaft seal design of a simple shaft backfill, shaft deformations are to be expected over the time period of interest. Given the present preferred borehole seal design with

cement grouts, such seals for boreholes near ES-1 are likely to fracture.

- Horizontal holes are known to be difficult to seal.

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

RECOMMENDATION

° It is recommended that SCP broaden its analysis of the potential impact of exploratory shaft construction and testing on the waste isolation capability of the site. An analysis of the effects of proposed boreholes, trenches and characterization activities within the zone mechanically influenced by the exploratory shaft should also be included.

REFERENCES

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

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

REVIEW GUIDE

4.2.5

Section 8.3.1.4.2, Geologic Framework of the Yucca Mountain Site, p. 8.3.1.4-32.

COMMENT 28

The program of drifting and Systematic Drilling (designed to acquire site-specific subsurface information) outlined in the CDSCP appears unlikely to provide the lithologic and structural information necessary to construct a reliable three-dimensional geologic model of the repository block or insure that observations made will be representative of conditions and processes throughout the repository.

BASIS

- 10CFR60.122 provides generally that the DOE must demonstrate that the effects of potentially adverse conditions (e.g., faulting in the Quaternary) have been adequately studied to assure that the condition does not compromise the performance of the repository.

- Chapter 8.3.1.8 states that "If deformation was found to be significant enough that the requirements for waste package performance could not be met, the changes required in repository geometry may be such that the repository would no longer be able to accommodate the specified volume of waste " (p. 8.3.1.8-27).

- Section 6.1.2.1.4 notes that the subsurface expression of faults and fractures is important to underground design because they introduce uncertainty in the determination of the potential thermomechanical response.

- The area within the perimeter drift has been said to contain a significantly lower concentration of faults relative to surrounding areas (p. 8.3.1.4-33). However the southeastern part of the repository block is in the Abandoned Wash block which is described as containing many north-northwest striking fractures and faults which have displacements of 3 m or less and where beds have dips as steep as 70° (U.S.G.S, 1984).

- The Solitario Canyon fault borders the repository on the west and is a major block-bounding fault. The subsurface expression of this fault zone appears to be largely unknown.

Systematic Drilling Program:

- The description of Investigation 8.3.1.4.1 indicates that the integrated drilling program is dependent on satisfactorily resolving regulatory concerns about drilling within the boundaries of the repository perimeter drift.

- Chapter 8.3.1.4 notes that core recovery from the unsaturated zone is typically poor (p. 8.3.1.4-39) and that careful analysis of core segments will not eliminate many sampling limitations inherent to the study of fractures in near-vertical coreholes (p. 8.3.1.4-73).

- Wilder and Yow (1984) have documented the difficulty of noting and understanding fault zones in drillcore.

- Section 8.3.1.4.2.2.3 states that careful reconstruction of core segments will not eliminate many of the sampling limitations that are inherent to the study of fractures in near vertical coreholes and that fracture dimensions will not be attainable from core due to the small sample size.

RECOMMENDATIONS

- Demonstrate that the program of drifting and systematic drilling will provide the information necessary to ensure that conditions and processes encountered are representative of conditions and processes throughout the site.

- If regulatory concerns about drilling as noted in 8.3.1.4.1 are not resolvable then the program for investigating potentially adverse conditions in the southern part of the repository appears inadequate. In this case, alternate methods of investigating potentially adverse conditions in the southern part of the repository should be outlined.

- Compare and evaluate the benefits and disadvantages between more extensive drifting during site characterization (including supplemental horizontal core drilling) and the surface-based systematic drilling program with respect to data derived and effects on performance assessment.

- Show that the goals and plans for the drifting and systematic drilling programs are integrated with the goals and plans for the geophysical exploration program.

REFERENCES

NRC, Letter from J. Linehan, NRC, to C. Gertz, DOE, Dated August 28, 1987, Subject "NNWSI Project: Drifting and Representativeness."

USGS (U.S. Geological Survey) (comp.), 1984, A summary of geologic studies through January 1, 1983, of a potential high-level radioactive waste repository site at Yucca Mountain, southern Nye County, Nevada: U.S. Geological Survey Open-File Report 84-792, 103 p.

Wilder, D.G., and Yow, J.L., Jr., 1984, Structural geology report Spent Fuel Test--Climax Nevada Test Site, Lawrence Livermore National Laboratory, UCRL-53381, 43 p.

REVIEW GUIDES

4.2.2, 4.3.4

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

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

COMMENT 29

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

BASIS

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

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

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

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

RECOMMENDATIONS

- The SCP should provide references indicating how and where fractal analysis has been used to successfully characterize three-dimensional fracture networks.

- The SCP should consider mapping and/or photographing floors and faces of shafts and drifts over short reaches to characterize fracture networks.

- The SCP should consider expanding the objective of fracture network analysis to support geomechanical and possibly other analyses.

- The SCP should integrate fracture studies proposed by various methods: fractal analysis, shaft/drift mapping, geologic mapping, systematic

drilling and core analysis, hydrologic tracer testing and geophysical surveying including borehole geophysics.

REVIEW GUIDE

4.3.20

Section 8.3.1.4.3.1 Study: Systematic acquisition of site-specific subsurface information, pg. 8.3.1.4-89/91

COMMENT 30

The required integration of site-specific subsurface information with repository design is not considered in this section (e.g., not even among the qualifying factors listed in the next to last paragraph on pg. 8.3.1.4-90).

BASIS

- 10 CFR 60.15(d)(3) requires that "To the extent practical, exploratory boreholes and shafts in the geologic repository operations area shall be located where shafts are planned for underground facility construction and operation or where large unexcavated pillars are planned."

- Considering the separation requirements between surface based holes and drifts of 15 m (pg. 8.3.3.2-28, second paragraph; more explicitly in Fernandez et al., 1987, pg. 6-52, next to last paragraph) and the repository layout (CDSCP Figures 6-62, 6-64), it seems clear that boreholes will have to be located with considerable restrictions, and that drilling will have to be quite accurate in order to meet the proposed separation requirements.

RECOMMENDATION

- The SCP should consider repository layout, location of emplacement holes and repository drifts in the drill site selection criteria and show that the systematic drilling program and the repository layout are integrated.

REFERENCES

Fernandez et al., 1987, SAND84-1895.

10 CFR 60.

REVIEW GUIDE

4.3.20

Section 8.3.1.5 Investigation: Studies To Provide The Information Required On Nature And Rates Of Change In Climatic Conditions To Predict Future Climates

COMMENT 31

Dendroclimatology is absent from the list of activity parameters included in evaluation of regional paleoclimatology. Although tree-ring studies are mentioned briefly in sections on literature review and modern regional climate (Sections 5.2.1.2.3 and 8.3.1.5.1.1.1, respectively), it is not specifically included in the proposed study plans as a separate activity.

BASIS

- Dendroclimatology is a major, and usually high-resolution, research tool for reconstructing the latest Holocene paleoclimatology at both local and regional scales (Bradley, 1985). Specifically, dendroclimatology is useful for estimating precipitation, temperature, and runoff data over time intervals that extend beyond historical or instrumental record (Fritts, 1976; Stockton, 1975). Techniques exist for cross-correlation and calibration of present precipitation, temperature, and runoff with time-correlative tree-ring indices. This can provide quantitative calibration for evaluating pre-historic tree-ring data and interpreting past climate over 100 to 1000 year time scales. Dendroclimatology can provide high-resolution proxy data for paleoclimatic interpretations of other proxy data, such as pollen, sedimentology, recent lake stands and paleofloods, that are already included in the paleoclimatology study.

RECOMMENDATION

- Dendroclimatology studies should be considered in this investigation.

REFERENCES

Bradley, R.S., 1985, Quarternary Paleoclimatology: Methods of Paleoclimatic Reconstruction (Chapter 10): Boston, Allen & Unwin, P. 330-375

Fritts, H.C., 1976, Tree Ring and Climate: London, Academic Press.

Stockton, C.W., 1975, Long-term Stream Flow Records Reconstructed From Tree Rings: Laboratory For Tree Ring Research, Paper 5, Tucson, University of Arizona Press.

REVIEW GUIDE

4.3.18

Section 8.3.1.5.1.5.1 Activity: Paleoclimate-paleoenvironment Synthesis

COMMENT 32

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

BASIS

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

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

RECOMMENDATION

- The full range of possible climatic variations (uncertainties) consistent with the basic data should be included as input to paleoclimatic and paleohydrologic modeling, as well as the assessment of the impact of future climatic variations on repository performance.

REFERENCE

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

REVIEW GUIDE

4.3.18

Section 8.3.1.5.2.1.1 Activity: Regional Paleoflood Evaluation

COMMENT 33

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

BASIS

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

RECOMMENDATIONS

- One way to overcome this problem is to identify and measure the occurrence of past storm and flood events over a larger area. These data can then be used in the determination of the probability of extreme flood events at the site.

- Paleoflood investigations should be conducted in other drainage basins in the site region. These data may be coordinated with ongoing regional and site-specific meteorological and erosional studies in order to derive probabilistic estimates of large storm events, as well as frequencies and magnitudes of storm-flood events at local and regional scales.

REFERENCE

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

REVIEW GUIDE

4.3.18

Section 8.3.1.6 Overview of erosion program

COMMENT 34

The CDSCP does not specifically address the evaluation of erosion/sedimentation at the surface facility locations.

BASIS

- Overall erosion programs are likely to result in an understanding of the potential future erosion in the Yucca Mountain area, but these programs are not likely to result in satisfactory evaluation of erosion/sedimentation potential at the proposed specific surface facilities such as portals and shafts.

RECOMMENDATION

- The SCP should present the specific data and analyses to be investigated with respect to erosion (Purcell, 1988) at the location of each of the following surface facilities: exploratory shafts (ES-1 and ES-2), men and materials shaft (MMS), waste emplacement ventilation exhaust shaft (WEVES), muck handling ramp and portal (MHR) and the waste handling ramp and portal (WHR).

REFERENCE

Purcell, C.R., 1988, Geomorphic evaluation of proposed shaft and ramp locations - Yucca Mountain High Level Waste Site: Lawrence Livermore National Laboratory report LLNL/NRC-NNWSI-CRP-87/88-YMI.

REVIEW GUIDES

4.3.1, 4.3.2, 4.3.4

Section 8.3.1.6 Overview of the erosion program

COMMENT 35

The overall erosion program does not include an evaluation of valley incision, sediment yield, uplift/subsidence, and escarpment retreat.

BASIS

- Hillslope erosion is only one aspect of the total erosion potential to be considered in site characterization. A complete erosion study should also evaluate valley incision, escarpment retreat, and sediment yield together with the impact of uplift and/or subsidence.

- The SCP should include valley incision rates and estimates of potential sediment yields which are necessary to completely assess the future loci of erosion and deposition in the Yucca Mountain area. These data, when combined with hillslope erosion rates and uplift/subsidence data, will provide estimates of the maximum future potential erosion/deposition in the site area (Purcell, 1986).

- Evaluations of escarpment retreat are necessary at the site to evaluate the potential for retreat of the west facing escarpment of Yucca Mountain and its relation to the integrity of the repository.

- All of these factors are necessary to estimate the overall future erosion/deposition potential at the Yucca Mountain site.

RECOMMENDATION

- An evaluation of the following parameters should be included in the erosion program to evaluate the overall future erosion/deposition potential required by the performance and design issue: 1) valley incision, 2) escarpment retreat, 3) uplift/subsidence, and 4) sediment yield.

REFERENCE

Purcell, C.R., 1986, Potential erosion at the Yucca Mountain nuclear waste site: Letter report from LLNL to NRC.

REVIEW GUIDES

4.3.1, 4.3.2, 4.3.4, 4.3.15, 4.3.18

Section 8.3.1.8 Overview of the postclosure tectonics program: Description of future tectonic processes and events required by the performance and design issues, Table 8.3.1.8-1(b), Investigation 8.3.1.8.1 - Studies to provide information required on direct release resulting from volcanic activity and Table 8.3.1.8-2(b), Investigation 8.3.1.8.2 - Studies to provide information on rupture of waste packages due to tectonic events

COMMENT 36

The NRC staff does not consider that meeting several of the tentative parameter goals listed in table 8.3.1.8-1(b) and 8.3.1.8-2(b) will demonstrate that the requirements of 40 CFR 191.13, as implemented in 10 CFR 60.112 have been met.

BASIS

- 40 CFR 191.13 requires that cumulative releases over 10,000 years to the accessible environment have a likelihood of less than one chance in 10 of exceeding the EPA ratio and less than one chance in 1000 of exceeding 10 times the EPA ratio as calculated in accordance with Appendix A to 40 CFR 191.

- The parameter goal for direct release resulting from volcanic eruption, as listed in table 8.3.1.8-1(b), is to demonstrate that less than .1% of the repository is disturbed with a conditional probability of less than .1 in 10,000 years. As .1% of the repository would contain approximately 18 canisters, direct release of this amount of radionuclides to the accessible environment would be approximately equal to an EPA ratio of 170, based on the radionuclide inventory presented in table 8.3.5.13-6. Even assuming radioactive decay through 10,000 years, the EPA ratio would exceed one (1) at all times and would probably exceed ten (10) if this amount of radionuclides was released to the accessible environment.

- A probability value in the range of 10^{-6} (the probability of less than 10^{-6} per year for penetrating the repository listed in table 8.3.1.8-1(b)), would require that the direct release volcanic eruption scenario be considered in calculating the CCDF to determine compliance with the EPA standard.

- If the conditional probability of less than .1 is to be applied to the 10^{-6} values, the resultant value of from 10^{-7} to 10^{-8} would still require consideration in calculating the CCDF to determine compliance with the EPA standard. However, it is recognized that when factored into the entire CCDF the probability contribution from the direct volcanic release scenario would require additional release scenarios to result in exceeding the EPA standard.

- The parameter goal for disruption of waste packages by igneous intrusion penetrating the repository, or for intersection of waste packages by a single fault is that less than .5% of the waste packages be disrupted. This would be equal to 90 waste packages. Utilizing the reference inventory in table 8.3.5.13-6, the radionuclides put at risk by such an event would equal an EPA ratio of over 830.

- While fault disruption, or igneous intrusion penetrating the repository but not resulting in direct release, would both require transport of the radionuclides to the accessible environment, the canisters in the fault zone would probably be badly broken and more susceptible to solution, whereas the canisters disrupted by a dike or other intrusion would be in an altered state.

- If it is assumed that water flow could occur along fault zones (See, for example, Montazer and Wilson, 1984, or Fernandez, et al., 1984), the zone of disruption would be a preferential transport path for material to move to the accessible environment. The area along a dike could also be an area of potential transport.

- While a complete analysis would be needed for the effect of either disruptive scenario, these scenarios could make a significant contribution to the CCDF and therefore potentially significantly affect the ability of the site to meet the EPA standard.

RECOMMENDATION

- The goals for the investigations should be set such that meeting the goals will aid in demonstrating that the site can meet the requirements of 40 CFR 191, as implemented in 10 CFR 60, for issuance of a license.

REFERENCES

Fernandez, J.A., Kelsal, P.C., Case, J.B. and Meyer, D., 1987, Technical basis for performance goals, design requirements, and material recomendations for the NNWSI repository sealing program; Sandia National Laboratories Report, SAND84-1895.

Montazer, P., and Wilson, W.E., 1984, Conceptual hydrologic model of flow in the unsaturated zone, Yucca Mountain, Nevada; U.S. Geological Survey Water Resources Investigation Report 84-4345.

REVIEW GUIDES

4.2.4.9, 4.2.3, 4.3.4

Sections 8.3.1.8 and 8.3.1.17 Postclosure and Preclosure Tectonics

COMMENT 37

Goals established for performance measures that rely on accurate slip-rate determinations for faults in and near the repository may be unachievable due to the large uncertainty about the performance parameter.

BASIS

- Performance parameters for pre and postclosure tectonics performance measures rely, in many cases, on characterization parameters that define a particular slip-rate for faults (e.g., Table 8.3.1.8-2(b), p. 8.3.1.8-8) in the vicinity of the repository.

- Attaining goals set for these performance parameters will be dependent on a thorough understanding of slip-rates which would include an understanding of the relationship between strike-slip and normal motion along faults.

- Existing data suggest that uncertainty about slip-rates in general and the amount of strike-slip motion on faults in particular could result in significant uncertainties in estimates of slip-rates on faults.

- Whitney and others (1986) were able to discern 10 cm of vertical Holocene offset on the Windy Wash fault; however, they were unable to estimate the age or amount of strike-slip offset.

- Swadley and others (1984, page 19) indicate that faults in the vicinity of the repository with a "few meters or less" of pure strike-slip movement in the Quaternary may be undetectable with current technology.

- Slip-rates of 0.001 mm/yr are considered "conservative" (p. 8.3.1.17-46) assuming an undetected component of strike-slip motion as large as the dip-slip movement. However, horizontal slip commonly exceeds vertical offset by several orders of magnitude. For example, estimates of offset along northwest trending faults at Yucca Mountain (Scott and others, 1984) range from 7-8 to 1 lateral versus vertical motion.

- The 10,000 year cumulative-slip earthquake proposed for assessing seismic risk is based on an estimated average Quaternary slip on faults. Underestimates of slip-rates on faults at Yucca Mountain due to uncertainties in the lateral component could result in underestimates of the magnitudes of expected earthquakes.

RECOMMENDATIONS

- Demonstrate that performance measure goals can be met given the uncertainties in slip-rates on faults in the vicinity of the repository, and/or

- Develop site characterization plans that will address uncertainties in slip-rate determinations.

REFERENCES

Scott, R.B., Bath, G.D., Flanigan, V.J., Hoover, D.B., Rosenbaum, J.G. and Spengler, R.W., 1984, Geological and geophysical evidence of structures in northwest-trending washes, Yucca Mountain, Southern Nevada, and their possible significance to a nuclear waste repository in the unsaturated zone: U.S. Geological Survey Open-File Report 84-567, 23 p.

Swadley, W.C., Hoover, D.L., and Rosholt, J.N., 1984, Preliminary report on late Cenozoic faulting and stratigraphy in the vicinity of Yucca Mountain, Nye County, Nevada: U.S. Geological Survey Open-File Report 84-788, 42 p.

Whitney, J.W., Shroba, R.R., Simonds, F.W., and Harding, S.T., 1986, Recurrent Quaternary movement on the Windy Wash fault, Nye County, Nevada: Geological Society of America Abstracts with Programs, p. 787.

REVIEW GUIDES

4.2.2, 4.3.4

Section 8.3.1.9.2.1	Natural Resource assessment of Yucca Mountain
Section 8.3.1.9.2.1.1	Geochemical assessment of Yucca Mountain in relation to the potential for mineralization.
Section 8.3.1.9.2.1.4	Assessment of hydrocarbon resources at and near the site.

COMMENT 38

- The program of investigations as presented in the CDSCP appears to be unsatisfactory for consideration of potential natural resources and natural resource models at the site and appears insufficient to assess the performance of the repository with respect to human intrusion.

BASIS

- No integrated conceptual model for natural resource occurrences or for the general geologic setting (as it pertains to resources) has been developed. Alternative resource models to include hosts other than tuffs appear not to be considered.

- Technical procedures to be employed in the evaluation of the likelihood of inadvertent human intrusion and the assessment of resources appear not to be specified.

- Proposed investigations appear to lack integration with other geological, geophysical, and geochemical investigations and pre-existing data.

- Information in Sections 1.7 and 8.3.1.9.2.1 does not reflect recent publications, models, and discoveries (NRC, 1986).

- The suite of elements proposed for geochemical analysis for economic minerals (Page 8.3.1.9-26) appears to be directed toward commodities known to occur in silicic tuff models and appears to exclude the possibility of other models related to hosts such as skarns, mineralized fault zones, calderas, veining, and carbonate rocks.

- The proposed geochemical sampling program appears to rely upon surface sampling and core drilling; however, "core recovery is typically poor in the unsaturated zone" (Section 8.3.1.4-39). Some precious metal deposits had no classic and/or surface geochemical anomalies (e.g., Manhattan deposit, Nevada) or may be hidden by thick alluvium/colluvium; therefore, results of the proposed geochemical program may have large inherent uncertainties.

- Drillholes proposed for other tests may not uniformly cover the controlled area (8.3.1.9-27) and may not be directed at features favorable to mineralization (e.g., fault zones and veins). For example, if mineralization is fault zone related there is a large degree of uncertainty that vertical drill holes would intersect vertical to near vertical faults/mineralized zones.

- Mineral and/or hydrocarbon resource potential of pre-Cenozoic rocks underlying volcanic rocks at Yucca Mountain cannot be adequately assessed based on surface samples. It is uncertain that planned drillholes will be favorably placed or extend to the depth necessary to provide adequate information to assess resource potential of the pre-Cenozoic rocks at and near the site, and drillhole UE-25P1 alone will not provide sufficient information to assess the resource potential.

RECOMMENDATION

- Consider and develop a program of planned technical procedures which integrate geological, geochemical, and geophysical studies in support of the resource assessment investigations, as well as those to be employed in the probability estimation of unidentified resources.

REFERENCE

NRC, 1986, NRC staff comments on the DOE final environmental assessments.

REVIEW GUIDE

4.3.5

Section 8.3.1.9.2.1.2 Activity: Geophysical/geologic appraisal of the site relative to mineral resources.

COMMENT 39

The existing geophysical data base for the site and the proposed coverage of geophysical profiling and measurements for surface, borehole, and airborne methods appears not to be comprehensive enough to provide satisfactory data for mineral resources appraisals.

BASIS

- It is stated under "Method and Technical Procedures" of this activity that "There are no procedures for Activity 8.3.1.9.2.1.2. Existing data will be used." Accordingly, the thoroughness/completeness of this activity is dependent on data from other activities.

- The geophysical programs of the CDSCP are generally noted in Tables 8.3.1.4-4, 8.3.1.17-7, and 8.3.1.17-8. The locations and scopes for the geophysical methods referenced in these tables are generally related only to specific geologic structural features or are of limited areal extent.

- Although some of the geophysical data from the activities listed in these tables will also be useful for activities to assess mineral resources, it is doubtful that complete suites of data capable of a comprehensive appraisal of mineral resources will be obtained.

RECOMMENDATIONS

- The SCP should provide in its complete geophysical program plan a subprogram designed specifically for mineral resources appraisal.

- This specific effort should be integrated with other comprehensive geophysical activity programs, such as the subprogram for volcanic/igneous considerations; however, all geophysical subprograms should be integrated to avoid duplication of geophysical coverage and to assure consistent interpretations.

- The geophysical program for mineral resources appraisal should be integrated with the drilling activities for mineral appraisal.

REVIEW GUIDES

4.3.5.2, 4.3.6.2, 4.3.6.3

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

COMMENT 40

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

BASIS

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

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

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

RECOMMENDATION

- Consider expanding the network to have a more dense raingage pattern (with electronic recording of data) and with radar augmentation. It is likely that one or more government agencies are operating radar systems that cover the region.

REVIEW GUIDE

4.3.18

Section 8.3.1.12.2	Investigation: Studies To Provide Data On Atmospheric And Meteorological Phenomena At Potential Locations Of Surface Facilities
Section 8.3.1.12.2.1	Study: Meteorological Data Collection At The Yucca Mountain Site.

COMMENT 41

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

BASIS

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

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

RECOMMENDATION

- The monitoring program, particularly the averaging period for the various meteorological parameters, should be determined by the anticipated use of the data. Bases for the averaging period should be developed prior to establishing any new meteorology stations. Averaging periods used at existing stations should be re-evaluated.

REVIEW GUIDE

4.3.18

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

COMMENT 42

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

BASIS

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

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

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

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

Issue 1.10 Waste Package Characteristics pg. 8.3.1.15-1

Issue 2.2 Worker Radiological Safety: Normal Conditions pg. 8.2-119, 2nd sentence of first paragraph

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

RECOMMENDATION

° The SCP should complete the proposed interaction (feedback) between Section 8.3.1.15 and all relevant Issues, in particular, consider the ones identified by the examples given above.

REVIEW GUIDE

4.3.20

Section 8.3.1.15 Overview of thermal and mechanical rock properties program, pg. 8.3.1.15-1/14

COMMENT 43

Section 8.3.1.15 does not present a clear testing rationale. Thermal and mechanical properties to be determined are not related to specific individual tests.

BASIS

- The CDSCP attempts to show the integration of the thermal and mechanical properties evaluations by relating the particular property to be measured to a specific information need (Table 8.3.1.15-1). However, it does not give sufficient rationale for information presented in this table and, furthermore, does not properly relate the measurement of properties to the individual tests. The parameters to be measured, the confidence required, and the type and number of tests need to be based on parametric performance calculations. Many examples can be cited from Table 8.3.1.15-1, where a tentative goal and confidence level are given for properties such as thermal expansion coefficient and deformation modulus; yet, no calculations are given or cited to show what effect an imperfect knowledge of the given property may have on repository design.

- The rationale for the testing and testing methods for a program of this scope needs to be based on analysis of the performance of the selected repository design. The NRC GTP on In Situ Testing During Site Characterization places particular emphasis on the need to provide a rationale for the In Situ Testing (NRC, 1985, Section 5.2).

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

RECOMMENDATION

- It is recommended that a testing rationale and performance calculations, aimed at demonstrating how the test program will meet the License Application information needs, be included or referenced in the SCP.

REFERENCE

NRC, 1985, GTP on In Situ Testing During Site Characterization for High-Level Nuclear Waste Repositories.

REVIEW GUIDE

4.3.20

Section 8.3.1.15 Overview of thermal and mechanical rock properties program, pg. 8.3.1.15-1/14

COMMENT 44

The testing program laid out in Section 8.3.1.15 is deficient in several respects. In some cases, important information that could be gained in testing is not identified. Also, some proposed tests are ill-defined, and others may not be able to provide required information.

BASIS

The testing plan shows that a large number of basic tests will be performed which have the potential to provide the data necessary for the geomechanical aspects of design and performance assessment. However, the text indicates that, in several cases, a particular test is not recognized as able to provide data important to the information needs. Furthermore, problems that may prevent certain tests from providing important data are not discussed. In addition, some tests are not clearly enough defined to establish whether they will obtain required information. The following are examples of these problems.

- The full-scale heater test will apparently not be used to determine the ultimate loading (i.e., temperature and spalling) potential of the boreholes. This test could be used to verify the retrieval concepts and limitations discussed in Section 8.3.5.2. There is no discussion of the need for measuring pressures on liners or curvature of holes in vertical or horizontal configurations, etc.--all design criteria set forth in Section 8.3.5.2.

- The "strength" of the rock mass is to be determined by an ill-defined test. A definition of the term "strength" is necessary because many interpretations are possible, each one requiring different parameters. The "strength" test should be developed using models to evaluate the validity of the basic constitutive laws presently considered for tuff.

- CDSCP Chapter 6 discusses several potential approaches (equivalent elastic model, ubiquitous joint, compliant joint), but the overall strategy for use of these models to help design tests, and then verify important aspects of the models is lacking.

- There is insufficient discussion of the effects of time, pressure, moisture and temperature on rock mass properties, and how they will be addressed through in situ testing.

- The proposed plate-bearing tests ignore potential effects of anisotropy introduced by joints. Plate-bearing tests may yield a much stiffer response than expected due to directional loading effects (not necessarily a lower bound as implied in the text, p. 8.3.1.15-62).

- None of the potential difficulties or possible alternatives are described in this plan, e.g., the G-Tunnel heated block was plagued by horizontal

fracture propagation in the block (due to lack of vertical confinement) which may have affected results (Reference 1).

RECOMMENDATION

- The testing program for thermal and mechanical rock properties presented in the SCP should clearly identify and define all the required parameters that can be obtained by the tests and recognize potential difficulties that may prevent the tests from obtaining those parameters. Alternate tests should be proposed as backups in cases where a parameter may not be obtainable by the test initially proposed.

REFERENCE

1. Zimmerman R., et al., "Final Report: G-Tunnel Heated Block Experiment," SAND84-2620.

REVIEW GUIDE

4.3.20

Section 8.3.1.15.1 Investigation: Studies to provide the required information for spatial distribution of thermal and mechanical properties, pg. 8.3.1.15-18/26

COMMENT 45

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

BASIS

Some of the questions with the statistical approach proposed in the CDSCP are listed below.

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

- An acceptable way of determining test needs is to conduct sensitivity or parametric calculations of repository performance in which the various input parameters are varied and the response examined. It is not clear if such calculations have been performed.

- A certain property (e.g., deformation modulus) is given a "goal." It is not clear whether the design would be invalidated if the measured values do not fall within this "goal."

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

  - The properties to be determined are not evenly distributed throughout the mass.

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

  - Populations may not be normally distributed.

  - Sampling may be biased due to jointing, hole direction, etc.

- In general, there should be less concern about intact rock properties and more concern about rock mass properties. The CDSCP discussion appears to be more concerned with intact properties.

RECOMMENDATIONS

° The SCP should clarify and possibly refine the use of the proposed statistical approach to determine the number of tests required to determine various rock properties.

° The SCP should clarify the bases for assigning needed confidence levels of "low," "medium," or "high."

REVIEW GUIDE

4.3.20

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

COMMENT 46

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

BASIS

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

RECOMMENDATION

- At the conclusion of normal testing, consideration should be given to driving the system beyond the design heat loads and to evaluate potential failure mode(s). Also, consideration should be given to running tests on at least one hole for extended time periods (years) to check creep on joints and liner loads. Data from these tests can contribute to retrievability assessment.

REVIEW GUIDE

4.3.20

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

COMMENT 47

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

BASIS

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

RECOMMENDATION

- The confirmation and validation of models, and confidence in design should be the major driving force in designing this test. The SCP should discuss the application of the data from the proposed Activity to performance and design confirmation.

REVIEW GUIDE

4.3.20

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

COMMENT 48

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

BASIS

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

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

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

RECOMMENDATION

- The SCP should describe and justify the applicability of data from the activity proposed in Section 8.3.1.15.1.7.1 of the CDSCP as a suitable means of providing deformation properties to models. The SCP should examine potential problems in interpretation of the test due to the influence of joint structure on anisotropy of response.

- The SCP should discuss how results of the plate-load tests will be integrated into the overall program aimed at characterizing rock mass deformational relations and model validation.

REVIEW GUIDE

4.3.20

Section 8.3.1.17 - Preclosure tectonics
Section 8.3.1.8 - Postclosure tectonics

COMMENT 49

The geophysical studies program to investigate crustal structure in the area of Yucca Mountain appears to be insufficient in coverage to characterize the Yucca site and the geologic setting.

BASIS

- The geophysical activities that are useful for crustal study objectives are noted only for specific positions such as in Activity: 8.3.1.17.4.3.1. Lines of geophysical profiling and measurements that cross various features need to be augmented by additional lines generally in gridded patterns (as site and regional topography allow) to permit detection of unknown features if such features should exist within the rather extensive area of interest referenced in Figure 8.3.1.17-12.

- Some geophysical activities such as Activity: 8.3.1.17.4.7.8 indicate coverage that is isolated and not crossed or "tied" to other lines; also the nature of the coverage is shallow, and while useful by itself, it does not provide adequate depth penetration to allow understanding and evaluation of the deeper causes of the shallow observed (and yet to be detected) faults and scarps.

- A single long line such as a noted in Figure 8.3.1.4-7 is generally inconclusive and/or no definition of an anomalous trend is possible.

RECOMMENDATIONS

- The SCP should provide a geophysical investigation program plan that is comprehensive, integrated and sufficient to identify and understand the interrelationships of the deep crustal and shallow geologic structural features that are known to exist, and to assure that no significant structural features have gone undetected.

- Consider including a gridded program of exploratory surveys and measurements that would allow for cross-line correlations and more complete spatial definition of anomalies at the site and especially at the locations of the exploratory shafts.

- The overall geophysical investigation program should integrate relevant subprograms, such as volcanic and natural resources investigations and systematic drilling.

REVIEW GUIDES

4.3.6.2, 4.3.6.3

Section 8.3.1.17 Overview of preclosure tectonics: Description of tectonic and igneous events required by performance and design requirements
Table 8.3.1.17-3(a) Design and performance parameters related to surface facilities and preclosure fault displacement
Table 8.3.1.17-3(b) Characterization parameters related to surface facilities and preclosure fault displacement
Pages 8.3.1.17-32 to 35, Consideration of fault displacement

COMMENT 50

The NRC staff does not consider that the basis and rationale for the design and performance parameters proposed in the CDSCP for fault displacement, in particular the zone of investigation for fault identification for facilities important to safety (FITS), represent reasonably conservative goals which reflect the uncertainty in the understanding of faulting within the geologic setting.

BASIS

- 60.131(b)(1) requires that "The structures, systems and components important to safety shall be designed so that natural phenomena and environmental conditions anticipated at the geologic repository operations area will not interfere with necessary safety functions."

- Table 8.3.1.17-3(a) lists two design or performance parameters as "identification of any fault within 100 meters of facilities important to safety (FITS) with greater than 1 chance in 100 of producing more than 5 cm of surface offset during the pre-closure period," and "total probability of exceeding 5 cm fault displacement at location proposed for FITS."

- Table 8.3.1.17-3(b) lists characterization parameters as "Identification and characterization of faults within 100 m of FITS that have apparent Quaternary slip rates greater than .001 mm/year or that measurably offset materials less than 100,000 years old" and "estimates of total probability for greater than 5cm displacement beneath FITS, considering known and possibly concealed faults and tectonic interrelationships among local faults."

- Several faults within the area of the site, such as the Solitario Canyon, Bow Ridge, Paintbrush Canyon and the Windy Wash fault, have evidence of Quaternary activity.

- The various tectonic models proposed for the site area, such as are presented in CDSCP Section 1.3.2.2.1, could result in either normal or strike-slip fault movement.

- Stress measurements at Yucca Mountain suggest that movement on favorably oriented faults may occur under the present stress regime. (see CDSCP sections 2.3.2.1 and 1.3.2.3).

° Within Nevada the following surface offsets have been observed in historical events: (See Bonilla, 1970, or D'Appolonia, 1978)

-Pleasant Valley, 1915, Richter magnitude 7.6, maximum vertical offset of 4.6 meters, maximum distance of 150 meters from the center to the outer limits of the main fault zone, maximum offset on secondary faults of .9 meters, secondary faulting observed at a maximum distance of 4 kilometers from center of main fault.

-Cedar Mountain, 1932, Richter magnitude 7.3, maximum displacement of 1.2 meters of vertical offset and .9 meters of right-lateral slip, fault is a series of discontinuous traces scattered over a belt 6.4 to 14.5 km wide and 61 km long.

-Rainbow Valley, 1954, two events, Richter magnitude 6.6 and 6.8, maximum vertical offset of .8 meters, maximum distance of 320 meters from center to outer limits of main fault zone, secondary faults with up to .05 meters of offset at a maximum distance of .5 km from main fault.

-Dixie Valley, 1954, Richter magnitude 6.8, greater than 2.1 meters vertical offset with 4.6 meter scarp, maximum distance of 900 meters from center to outer limits of main fault zone, secondary faults with maximum displacement of up to .6 meters, secondary faults up to 4 kilometers from the center of main fault.

-Fairview Peak, 1954, Richter magnitude 7.1, maximum vertical offset of 3.7 meters with scarps up to 7 meters high, maximum right-lateral offset of 4.3 meters, up to 800 meters from center to outer limits of main fault zone, up to .9 meters of vertical offset on secondary faults, secondary faults up to 6.4 kilometers from centerline of main fault.

RECOMMENDATIONS

° In light of the historic record for ground rupture from faults within the Great Basin within Nevada, and in the case of the Cedar Mountain event, within the Walker Lane, the SCP should provide a technically defensible rationale as to why the investigations proposed would be sufficient to produce a design that is safe and performance parameters for fault displacement that are reasonably conservative.

° Such discussion should specifically address deterministic versus probabilistic criteria and appropriate stand-off distance of facilities important to safety from faults which have a potential for ground rupture. The discussion on probabilistic criteria should consider how information, such as the information on the existing stress regime, would be factored into probabilistic evaluations.

REFERENCES

Bonilla, M.G., 1970, Surface faulting and related effects, in Wiegel, R.L., Ed., Earthquake Engineering: Prentice-Hall Inc., Englewood Cliffs, N.J.

D'Appolonia, 1978, Summary of historical observations, ground disturbance and faulting: report prepared for the International Atomic Energy Agency, Vienna, Austria.

REVIEW GUIDES

4.3.4, 4.2.3, 4.2.4.10

Sections	8.3.1.17.1	Studies to provide information on volcanic activity that could affect repository design or performance
	8.3.1.8.1	Investigation: Studies to provide information required on direct releases resulting from volcanic activity
	8.3.1.8.5.1	Study: Characterization of volcanic features
	8.3.1.8.5.2	Study: Characterization of igneous intrusive features

COMMENT 51

No specific geophysical program appears to be planned to identify volcanic/igneous features and their lateral extent under or close to the site.

BASIS

- The geophysical investigations that will be used for volcanics considerations are generally adapted from the needs for other objectives (pre- and postclosure tectonics), that are primarily directed toward linearly oriented geologic features; however, geophysical investigations for volcanics considerations should also be directed toward three dimensional geologic features, and accordingly would require broader areal scope and coverage.

- On page 8.3.1.17-105 it is stated that the seismic reflection studies will be preceded by a seismic reflection test to determine usefulness of the technique in the Yucca Mountain area. If the preliminary test is a success, then high-resolution reflection surveys and supplemental gravity and magnetic surveys would be run (p. 8.3.1.17-108). This implies that the planned high-resolution survey, gravity survey, and low-level magnetic survey would not be run if the preliminary seismic reflection test is a failure, thus reducing the amount of data available to adequately characterize subsurface volcanic/igneous (and other) features at the site.

- Objectives of the planned studies (p. 8.3.1.17-94) and their design appear less than optimal to detect magma bodies. Only the planned magnetotelluric survey appears to be unrelated to the success or failure of the seismic reflection test; however, magnetotelluric survey data alone may be ambiguous without additional geophysical support.

- Section 8.3.1.17.4.7 presents a geophysical study of the subsurface geometry and concealed extension of Quaternary faults at Yucca Mountain. Most of the activities in this study are either not suited to detect magma bodies or are evaluatory in nature.

RECOMMENDATION

- The DOE should include and integrate into its complete geophysical program a subprogram designed specifically for volcanics considerations, considering, for example, seismic survey lines augmented by an expanded gravity and magnetic survey program (NUREG/CR-4957, 1987).

REFERENCE

NUREG/CR-4957, 1987, Survey of Geophysical Techniques for Site Characterization in Basalt, Salt and Tuff.

REVIEW GUIDES

4.3.4.2, 4.3.5.2, 4.3.6.2, 4.3.6.3, 4.3.6.4

Section 8.3.1.17.3.1.2 Activity: Characterize 10,000-year cumulative slip earthquakes for relevant seismogenic sources (p. 8.3.1.17-63)

COMMENT 52

When the definition of 10,000-year cumulative slip earthquakes for Quaternary faults is applied to the calculation of magnitudes for examples of Yucca Mountain-vicinity faults, the results yield magnitudes that are significantly lower than those derived from accepted fault rupture length-magnitude and displacement-magnitude relationships.

BASIS

- The adverse conditions described in §60.122(c) concerning earthquakes all require an adequate knowledge of the magnitudes of earthquakes that may affect the site.

- The premise that low earthquake recurrence rates could lead to misleading deterministic estimates of magnitude for a given fault, when fault length or displacement are used to develop these estimates, is unsupported. This premise appears to be in conflict with methodologies presented in Section 1.4.2.1 that use fault length or displacement relationships to determine potential maximum earthquake sizes for faults in the Yucca Mountain vicinity. This premise also appears to be in conflict with the initial statement of the following paragraph on page 8.3.1.17-63 that implies that mapped fault lengths and displacement will be used, together with other pertinent geologic data, to evaluate 10,000-year cumulative slip earthquakes.

- If the data for the upper limit of the aggregate fault lengths of the Paintbrush Canyon, Bare Mountain, and Windy Wash faults, which are presented in Table 1-8 of this site characterization plan and on page 78 of materials provided at the DOE/NRC meeting of September 22, 1987 in Las Vegas, Nevada (DOE/NNWSI, 1987), are used in the rupture length-magnitude relationship of Bonilla et al (1984) for western North America, the resultant magnitudes are 7.01, 6.83, and 6.75 respectively.

- If the post-Qta vertical displacement data from the same sources and for the same faults noted above are used to determine the average Quaternary displacements for earthquakes occurring on these faults every 10,000 years (the average Quaternary displacement is determined here by dividing the post-QTa vertical displacement by 100, which is the number of 10,000-year earthquakes in one million years, the conservative estimate of QTa age) and these <u>average</u> Quaternary displacements are used in the displacement-magnitude relationship of Bonilla et al (1984) for western North America, the resultant magnitudes are 5.95, 6.59, and 5.20 respectively.

RECOMMENDATIONS

- The manner in which the rate of earthquake recurrence affects the utility of fault length or displacement in the determination of estimated magnitude for a given fault should be elucidated.

- Preliminary estimates of 10,000-year cumulative slip earthquake magnitudes, based on existing data, for some of the relevant sources in the Yucca Mountain vicinity should be included in the SCP, and an example of how these estimates are determined should also be included. It is recognized that estimates presented in the SCP would be for exemplary purposes only and most likely would be subject to revision during site characterization.

- The technical basis that supports the concept of the 10,000-year cumulative slip earthquake should be established, and that it yields reasonably conservative results/parameters should be demonstrated.

REFERENCES

Bonilla, M.G., Mark, R.K., and Lienkaemper, J.J., 1984, Statistical Relations Among Earthquake Magnitude, Surface Rupture Length, and Surface Fault Displacement: Bulletin of the Seismological Society of America, vol. 74, no. 6, p. 2379-2411.

DOE/NNWSI, 1987, Meeting With the Nuclear Regulatory Commission (NRC) to Summarize the Seismic/Tectonic Strategies Presented in the Consultation Draft of the Nevada Nuclear Waste Storage Investigations (NNWSI) Project Site Characterization Plan (SCP): unpublished material provided to participants of the DOE/NRC meeting of September 22, 1987 in Las Vegas, Nevada.

REVIEW GUIDES

4.3.3, 4.3.4

Section 8.3.1.17.4 Preclosure Tectonics Data Collection and Analysis

COMMENT 53

The program of activities outlined for study of northeast trending faults in the area of Yucca Mountain appears insufficient to determine the significance of some of these features.

BASIS

- The Spotted Range-Mine Mountain Structural zone is currently seismically active and has a long history of tectonic activity (Carr, 1984). The Mine Mountain fault in the Spotted Range-Mine Mountain zone is one of several major northeast-trending faults within this zone and could be within approximately 15 km of the site.

- Activity 8.3.1.17.4.4.2 (Evaluate the Mine Mountain fault system) indicates that the activity will only synthesize and evaluate data collected as an adjunct to the NTS weapons program.

- A large portion of the existing data on the Mine Mountain fault has already been synthesized by McArthur and Burkhard (1986) who noted that this feature was a major fault system that trends toward Yucca Mountain.

- The Mine Mountain fault zone is the locus of substantial normal faulting and possibly detachment faulting (McArthur and Birkhard, 1986). Detachment faulting and its relation to north-trending normal faults is an unresolved issue at Yucca Mountain.

- Left-lateral offset of the Timber Mountain tuff along the Mine Mountain fault is 1 km (Chapter 1-114). Quaternary movement has been noted along the Mine Mountain fault (McArthur and Birkhard, 1986) but the amount of offset and exact timing are unknown.

- The Mine Mountain fault is comparable to the Bare Mountain fault in length, offset, and proximity to the site, but the Bare Mountain fault has a much more extensive program of investigation.

RECOMMENDATION

- The level of effort in the investigation of the potentially significant Mine Mountain fault should be justified, or the level of effort of investigation should be commensurate with the apparent significance of the Mine Mountain fault zone.

REFERENCES

Carr, W.J., 1984, Regional structural setting of Yucca Mountain, southwestern Nevada, and Late Cenozoic rates of tectonic activity in part of the southwestern Great Basin, Nevada and California: U.S. Geological Survey Open-File Report 84-854, 109 p.

McArthur, R.D., and Burkhard, N.R., 1986, Geological and Geophysical Investigations of Mid Valley: Lawrence Livermore National Laboratory, UCID-20740, 92 p.

REVIEW GUIDE

4.3.4

Section 8.3.2.1.4.1.1 Geomechanical Analyses, p. 8.3.2.1-21

COMMENT 54

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

BASIS

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

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

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

RECOMMENDATION

- The SCP should develop a more rigorous approach to constitutive model selection and/or development.

REFERENCES

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

Gerrard, C. (1983). "Rock Bolting in Theory--A Keynote Lecture," in Proceedings of the International Symposium on Rock Bolting (Abisko, Sweden), pp. 3-32.

Singh, B. (1973). "Continuum Characterization of Jointed Rock Masses: Part I--Constitutive Equations," Int. J. Rock Mech. Min. Sci. & Geomech. Abst., 10, 311-335.

REVIEW GUIDE

4.3.20

Section 8.3.2.1.4.1.1 Geomechanical Analyses, pg. 8.3.2.1-21

COMMENT 55

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

BASIS

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

- System element 1.2.1.2, drift construction, recognizes the need for designing ground support to accommodate the long-term thermal considerations. However, consideration of thermal effects is limited to thermally-induced stresses in the rock mass, not in support components.

RECOMMENDATION

- Geomechanical analyses should include consideration of the effects of emplaced support, as well as analysis of the effect of elevated temperature on the support components.

REVIEW GUIDE

4.3.20

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

COMMENT 56

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

BASIS

- Contrary to the second sentence of the last paragraph on pg. 8.3.2.2-55, product 1.11.3-1 does not list site data required to perform such assessments.

RECOMMENDATIONS

- The SCP should consider incorporation of long term performance requirements within the contingency procedures.

- Identification should be made of site data that will be needed to perform such assessments.

- Methods that can be used for system performance studies for off-normal conditions, with particular attention to the primary long-term repository performance requirements of containment and isolation, should be identified.

REVIEW GUIDE

4.3.20

Section 8.3.2.2.6 Information Need 1.11.6 Drift scale analyses, pg. 8.3.2.2-81

COMMENT 57

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

Given the proposed loose backfill and only partial filling of the drifts, this effect may be quite limited.

BASIS

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

RECOMMENDATION

- If a mechanical function is to be assigned to the backfill, it is recommended that the function be designed on the basis of a comprehensive and realistic mechanical analysis of drift-backfill interaction, backfill compaction characteristics, and initial compaction density.

REVIEW GUIDE

4.3.20

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

COMMENT 58

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

BASIS

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

RECOMMENDATION

- The SCP should recognize the limitations of limit equilibrium methods and justify the appropriateness of these methods for complex loadings.

REVIEW GUIDE

4.3.20

Section 8.3.2.2.6 Information Need 1.11.6, Far-Field Analyses, pg. 8.3.2.2-82

COMMENT 59

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

BASIS

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

RECOMMENDATION

- Potential for thermally induced movement along faults and fractures should be investigated.

REVIEW GUIDE

4.3.20

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

COMMENT 60

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

BASIS

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

Examples:

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

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

RECOMMENDATION

° Consequences of drift caving should be evaluated before treating it as an obviously acceptable design approach. Remedial action prior to backfilling that minimizes the potential for drift cave-in should be considered.

REVIEW GUIDE

4.3.20

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

COMMENT 61

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

BASIS

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

RECOMMENDATIONS

- Consideration should be given to adding studies of the heat transfer coefficients for moisture and heat from rock mass to ventilation air.

REVIEW GUIDE

4.3.20

Section 8.3.2.5, Preclosure Design And Technical Feasibility, pg. 8.3.2.5-13

COMMENT 62

The performance measure, measure goal and performance parameter for System Element 1.1.2, "Sites for underground facilities," do not appear to provide assurance that the function of the system element defined by this measure will be sufficiently addressed.

BASIS

- The performance measure for "Sites for underground facilities" is not a "physical quantity that describes the performance of the component in meeting the licensing strategy."
- The performance measure basically restates the System Element.
- The term "Potentially active faults" used in the measure goal is not defined in the glossary and, therefore, whether the goal is physically reasonable or achievable cannot be determined.
- Siting Criteria in 10CFR60.122 require that processes operating during the Quaternary be evaluated to determine if they will affect the geologic repository's ability to isolate waste. The use of the term "late Quaternary" in the performance parameter for this measure suggests that faults without documented "late Quaternary" movement would not be considered. This suggests that the Siting Criteria outlined in 60.122 for Quaternary processes would not be adhered to.

RECOMMENDATIONS

- A performance measure which can be measured or analyzed should be developed.
- The terms "Potentially active faults" and "late Quaternary" should be defined.
- The expected value should reflect the uncertainty that exists with faulting in the repository block.

REVIEW GUIDES

4.2.2, 4.3.4

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

COMMENT 63

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

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

BASIS

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

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

RECOMMENDATIONS

- SCP should provide a basis for the goal.

- SCP should provide assurance that the goal will be met with high degree of confidence.

REVIEW GUIDE

4.3.20

Section 8.3.3.1 Overview of the Seal Program, pg 8.3.3.1-1 and 8.3.3.1-2

COMMENT 64

The CDSCP does not include details of the in situ testing of the proposed seal design concepts. This information is necessary to evaluate the effects of seal testing activities on the ability of the site to meet the performance objectives (10 CFR 60.112 and 10 CFR 60.113).

In addition, the CDSCP states that in situ testing to evaluate seal components and placement methods would not start until after the submission of License Application. In view of the uniqueness of the proposed seal design concepts and the associated uncertainties with the long-term performance of the seals, the NRC staff considers that the proposed start date of in situ testing for evaluation of seal components and placement methods will result in a lack of sufficient data for evaluating the license application.

BASIS

- The performance confirmation requirements of 10 CFR 60 (Subpart F) include requirements for in situ design testing of such features as borehole and shaft seals and starting of performance confirmation during site characterization.

- The Safety Analysis Report to be submitted by the DOE for License Application is required to include an evaluation of the performance of the proposed geologic repository after permanent closure (10 CFR 60.21(c)(1)(ii)(C)). Figure 8.3.3.1-1 of the CDSCP shows that the DOE plans to complete the performance analysis without results of any in situ tests on seals. Preliminary results of verification of seal design with in situ test results should be available to demonstrate in the License Application that the seals for shafts, ramps and boreholes have been adequately designed to meet the overall system performance requirements.

- The current postclosure sealing design concepts (Fernandez and Freshley, 1984) as presented in the CDSCP do not provide sufficient confidence in the ability of the seals to meet 10 CFR 60 regulatory requirements. A specific concern with the drainage concept is potential for deposition of minerals in fractures and pores with time thereby reducing free drainage.

RECOMMENDATION

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

REFERENCES

10 CFR 60 (Subpart F).

U.S. Nuclear Regulatory Commission, Generic Technical Position on Borehole and Shaft Sealing of High-Level Nuclear Waste Repositories.

Fernandez, J.A., and M.D. Freshley, 1984, Repository Sealing Concepts for the Nevada Nuclear Waste Storage Investigations Project. SAND83-1778.

REVIEW GUIDE

4.2.21

Section 8.3.3.1 Overview of Seal Program, page 8.3.3.1-1 second paragraph

COMMENT 65

The CDSCP states that "The lack of aquifer above the waste emplacement horizon at the Yucca Mountain site, makes it unnecessary to install either permanent or temporary shaft or ramp seal components at the time of access construction."

No evidence or substantiation is presented for the statement that neither operational nor permanent seals will be required.

BASIS

- The shafts and ramps are located in areas where they may be subject to surface water flooding. Also, the shafts and ramps may intersect faults that may allow inflow, e.g., from wash flash flooding. The existence of perched water can not be ruled out at this time. The repository horizon may be intersected by faults that may be water conduits.

RECOMMENDATION

- The SCP should either describe contingency plans for providing seals, if substantial water is encountered at the time of access or during the rest of ESF construction, or provide reasonable assurance, by analysis or by reference, that no operational seals will be necessary.

REVIEW GUIDE

4.3.21

Section 8.3.3.1 Overview of the Seal Program, page 8.3.3.1-1, second paragraph, last sentence

COMMENT 66

The CDSCP states that "The shaft liner can be removed to emplace seal components later."

This statement, without reference to an evaluation, analysis or justification, appears to imply that it is a straightforward matter to remove a shaft liner, and that such a procedure has no implications for the isolation capability of the site.

BASIS

- Removing a concrete liner cast in place against the rock is very likely to disturb the adjacent rock. Depending upon the length of time for which the liner has been in place, and the amount of stress that has developed in it, such removal could significantly affect the waste isolation capability of the site.

RECOMMENDATION

- It is recommended that the SCP evaluate the consequences of removing a shaft liner, specifically the risk of developing a zone of enhanced fracturing at a seal location, as a result of stress redistribution following liner removal.

REVIEW GUIDE

4.3.21

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

COMMENT 67

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

BASIS

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

RECOMMENDATION

- It is recommended that the SCP incorporate a decision making strategy that includes adequate consideration of gaseous radionuclide migration and of thermally driven or disturbed water flow paths. Also the SCP should provide detailed information (e.g., location, depth, and distance from the site boundary) on boreholes that are not planned to be sealed and the reasons for the decision.

REVIEW GUIDE

4.3.21

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

COMMENT 68

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

BASIS

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

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

RECOMMENDATION

- It is recommended that SCP evaluate whether a sufficient safety or uncertainty margin has been allowed between the Maximum Allowable and the Design Basis performance goals; e.g., whether uncertainty associated with the curves leaves sufficient margin of error to preclude possible crossing of the two curves for anticipated and unanticipated processes and events.

REFERENCE

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

REVIEW GUIDE

4.3.20

Section 8.3.3.2 Issue resolution strategy for Issue 1.12: Have the Characteristis and configurations of the shaft and borehole seals been adequately established to (a) show compliance with the postclosure design criteria of 10 CFR 60.134 and (b) provide information for the resolution of the performance issues, page 8.3.3.2-24 to 27 Step D: Performance and design goals

COMMENT 69

The performance and design goals for the sealing subsystem do not consider a comprehensive set of anticipated processes and events and unanticipated processes and events.

BASIS

- 60.112 requires that ..... the shaft and boreholes and their seals shall be designed.....with respect to both anticipated processes and events and unanticipated processes and events.

- Processes and events considered in Section 8.3.3.2. for the sealing subsystem do not appear to be as complete as the scenarios and categories of processes and events considered in CDSCP Section 8.3.5.13.

- This section does not consider the effects of such anticipated processes and events and unanticipated processes and events as faulting on the performance of the sealing subsystem, on the status of the waste package and engineered barrier system, and the interrelationship of the waste package, engineered barrier system and seal system on the total performance of the repository.

- This section does not appear to account for the effects on the natural system caused by the perturbations of waste emplacement.

- This section, and the referenced report, considers that only 62 cubic meters of water per year can contact the waste under anticipated processes and events and 5600 cubic meters per year under unanticipated conditions (Fernandez et al., 1984, pages 5-4 and 5-5).

- Thordarson (1965) estimated 30 to 50 million gallons discharge over a five year period in tunnel U12e at Rainier Mesa. The very large difference in the estimated inflow values in U12e and estimated values of water that can potentially contact the waste package in Yucca Mountain do not appear justified, despite the recognized differences in the hydrological conditions at Rainier Mesa and Yucca Mountain.

- Rush and others (1984) noted 14 zones of water inflow in the unsaturated zone in borehole H-1. While the source of this water is unidentified, the possibility that the water is perched water cannot be discounted, at present.

- This section only assumes 1 mm per yer infiltration even though Montazer and Wilson (1984) estimated that net infiltration, under present conditions, is between .5 to 4.5 mm per year.

- This section does not appear to account for the nonuniformity in which precipitation events occur within the Yucca Mountain geologic setting.

- This section does not consider the effects of either potential "anticipated climatic changes" or "unanticipated climatic changes" and the potential change in net infiltration such processes and events could cause.

RECOMMENDATIONS

- The design and performance parameters should account for the various scenarios considered to be applicable during the post-closure period, such as presented in section 8.3.5.13 of the CDSCP.

- The processes and events considered should account for anticipated processes and events and unanticipated processes and events as defined in 10 CFR 60.2.

REFERENCES

Fernandez, J.A., Kelsal, P.C., Case, J.B. and Meyer, D., 1987, Technical basis for performance goals, design requirements, and material recommendations for the NNWSI repository sealing program; Sandia National Laboratories Report, SAND84-1895.

Rush, F.E., Thordarson, W. and Pyles, D.G., 1984, Geohydrology of test well H-1, Yucca Mountain, Nye County, Nevada; U.S. Geological Survey Water Resources Investigation Report 84-4032.

Thordarson, W., 1965, Perched ground water in zeolitized-bedded tuff, Rainier Mesa and vicinity; Nevada Test Site, Nevada, Report No. TEI-862, U.S. Geological Survey, Denver CO.

Montazer, P., and Wilson, W.E., 1984, Conceptual hydrologic model of flow in the unsaturated zone, Yucca Mountain, Nevada; U.S. Geological Survey Water Resources Investigation Report 84-4345.

REVIEW GUIDES

4.2.4.2, 4.2.2, 4.2.4.1, 4.2.4.9

Section 8.3.3.2.1 Information Need 1.12.1, Technical Basis for Addressing the Information Need, Parameter 8, page 8.3.3.2-32/33.

COMMENT 70

It is unclear whether a reasonably conservative design approach has been used to determine required backfill hydraulic conductivity.

BASIS

- The determination of the required backfill hydraulic conductivity (10^{-2} cm/s) appears to be driven by comparisons of relative flow (i.e., allowable shaft inflow as a fraction of total flow, e.g. Fernandez et al., 1987, p3-22, top paragraph). The basic reference design chart (Fernandez et al., 1987, Fig F-10) is developed for the case where the hydraulic conductivity of the rock mass is taken as 10^{-2} cm/s. It is not clear why a broad range of possible hydraulic conductivities of the rock mass is not considered in determining the required backfill hydraulic conductivity.

RECOMMENDATION

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

REFERENCE

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

REVIEW GUIDE

4.3.20

Section 8.3.4 Waste Package Program

Section 7.4.2.6.5 Environmental considerations in localized corrosion initiation

COMMENT 71

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

BASIS

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

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

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

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

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

RECOMMENDATION

° In determining the geochemical environment of the waste packages, alternative conceptual models should be considered that lead to the production of corrosive groundwaters.

REFERENCE

Morales, A. R., 1985, Technical correspondence in support of the final environmental assessment, Sandia Report, SAND85-2509, p. 1-10.

REVIEW GUIDES

4.2.1, 4.2.2, 4.2.3, 4.2.4.1, 4.2.4.2, 4.2.4.3, 4.2.4.4, 4.2.4.5, 4.2.6, 4.2.8, 4.3.10

Section 8.3.5.2 Issue Resolution Strategy for Issue 2.4, pg. 8.3.5.2-1/63

Section 8.3.5.5 Issue Resolution Strategy for Issue 2.3, pg. 8.3.5.5-1/33

COMMENT 72

In evaluating potential effects of credible accidents on projected radiological exposures, the CDSCP has not sufficiently considered retrieval operations.

BASIS

- Potential credible accidents during retrieval may result in radiological exposures that could be of concern.

RECOMMENDATION

- The SCP should adequately consider retrieval operations in evaluating the effects of credible accidents. A realistic representation of the thermal and stress environment at retrieval time is important.

REVIEW GUIDE

4.3.22

Section 8.3.5.9 Containment by Waste Package
Section 8.3.5.10 Engineered Barrier System Release Rates

COMMENT 73

The issue resolution strategies and testing programs for design of the waste package (Section 8.3.5.9 of the CDSCP) and engineered barrier system (Section 8.3.5.10 of the CDSCP) do not take into account the full range of reasonably likely natural conditions ("anticipated processes and events") that, with current understanding of the site, might be expected to affect performance of these barriers.

BASIS

- Waste package and engineered barrier system (EBS) testing programs do not include the possibility that nearly vertically oriented faults and fractures may be highly effective pathways for vertical groundwater flow at high flux rates (e.g., see Table 8.3.1.2-2 on page 8.3.1.2-46 of the CDSCP), subjecting portions of the repository and at least some of the waste packages to a much wetter environment than suggested in the expected or bounding cases, which were developed using estimates of spatially averaged water inflow.

- Testing programs for design of the waste package and EBS do not explicitly account for the full range of possible anticipated processes and events that may affect waste package and EBS performance, including covolcanic activity (such as hydrothermal processes), faulting within and near the repository block, earthquake-induced vibration, and more extreme geochemical conditions than those suggested by the currently limited data available for the site.

- As a specific example, the proposed designs of the waste package and EBS inadequately consider significant uncertainties concerning slip rates on faults in and near the repository block.

RECOMMENDATION

- Consider all anticipated processes and events in developing issue resolution strategies and testing programs for the waste package and EBS, using criteria provided in Review Guide 4.2.4.2.

REVIEW GUIDES

4.2.4.2, 4.3.4

Section 8.3.5.9.1 Information Need 1.4.1: Waste Package Design Features that Affect the Performance of the Container.

COMMENT 74

There is no description of the development and use of standardized test methods.

BASIS

- Standardized test methods are needed for determining the stability and durability of the nuclear waste and the waste package materials.
- Standardized test methods are those developed and approved by an appropriate cross-section of producers, users, and academics.
- The tests must be acceptable in terms of reliability and reproducibility.

RECOMMENDATIONS

- Describe what use will be made of the Materials Characterization Center (MCC), which was established by the DOE in 1980 to ensure that qualified materials data would be available on nuclear waste and waste package materials. Meeting this goal must include development of acceptable standardized test methods.
- Indicate whether MCC test method development and approval procedures would be used as a first step in obtaining acceptable compliance data.
- Include a section in the site characterization plan describing the development and approval procedure for all standardized test methods and data reliability, precision and accuracy.

REFERENCES

As stated in Review Guides 4.2.4.11, 4.3.25

REVIEW GUIDES

4.2.4.11, 4.3.25

Section 8.3.5.9.1.1.2 Microstructural Properties

COMMENT 75

Metallographic and microscopic characterization techniques given in this section for copper, copper-based alloys, and austenitic stainless steels are insufficiently described.

BASIS

- Some microstructures cannot be observed using conventional metallographic techniques.
- Grain boundary structure, precipitate formation, and dislocation structures affect material properties and stability, and these features should be viewed at high magnifications using electron microscopy.
- Advanced analytical techniques are needed to analyze for oxygen, hydrogen, or other elemental diffusion into metals.

RECOMMENDATIONS

- Establish standard procedures for studying microstructures of materials being considered for use in nuclear waste storage.
- Provide the bases for selection of the specific methods used for characterizing microstructures of a given material.
- Methods should be specified for the material and microstructural considerations in question.

REFERENCES

As stated in Review Guides 4.3.25

REVIEW GUIDE

4.3.25

Section 8.3.5.9.1.1.2 Microstructural Properties
(Phase stability in austenitic stainless steels)

COMMENT 76

Data are not presented to show that structural stability of the container will be maintained after prolonged exposure to 100 to 250°C temperatures (p.7-42).

BASIS

- Microstructures of austenitic stainless steels are unstable in terms of transformation to martensite, precipitation of sigma or other embrittling phases and sensitization.
- Small amounts of martensite increase the steel's susceptibility to stress corrosion cracking.
- Embrittling phases provide initiation sites for cracking and increase susceptibility to cracking.
- Sensitization or carbide formation may be enhanced by initial high temperatures and by extended elevated temperatures of the repository. Beneficial effects of carbide forming alloying elements such as titanium and of specified cooling rates during manufacture could be negated by the extended time at temperature after emplacement.
- Phase precipitation causes chemical changes in the microstructure which may result in decreased resistance to localized corrosion such as pitting and stress corrosion cracking.

RECOMMENDATIONS

- The microstructure and associated properties should be established to be stable in given repository conditions before selecting the material for use in the repository. Any metastability should be characterized and demonstrated to not adversely affect predicted performance. This may require proof that transformation will not occur over the projected life of the components made from this material.
- Data should be collected under simulated repository conditions to show microstructural changes which will and will not occur.
- Effects on sensitization of alloy composition and time at repository temperatures should be determined.

REFERENCES

As stated in Review Guide 4.3.25

REVIEW GUIDE

4.3.25

Section 8.3.5.9.1.1.4 Subactivity 1.4.11.4. State of Stress in the Container

COMMENT 77

The site characterization plan does not take into account temporal changes in the state of stress due to corrosion of the container.

BASIS

- This section states that changes in the state of stress with time and temperature will be evaluated at a number of locations, but it does not specifically state that corrosion damage is included in this evaluation.
- Wall thinning due to corrosion processes will alter the stress state.
- Corrosion processes can alter the geometry of the wall by reducing the wall thickness and by promoting the formation and growth of stress concentrating flaws.
- If localized corrosion (pitting, crevice corrosion, etc.) occurs, it will result in the formation and growth of flaws which act as stress concentrators.

RECOMMENDATIONS

- Provide an analysis of the state of stress at various locations in the container and changes in the state of stress with time to account for the influences of corrosion and temperature.
- Provide analyses that account for the probability of formation of stress concentrating flaws and the expected rate of growth of these flaws.

REFERENCES

As stated in Review Guide 4.3.25

REVIEW GUIDE

4.3.25

Section 8.3.5.9.1.1.5 Characterization and inspection of weld integrity

COMMENT 78

The effect of microstructure and chemistry on weld integrity has not been sufficiently treated.

BASIS

- o Welds are areas of chemical inhomogeneity, and effects of this inhomogeneity under repository conditions should be established.
- o Welds of austenitic stainless steels are areas subject to sensitization that may lead to failure.
- o Weld solidification shrinkage can result in localized increases in stress that can promote stress corrosion cracking and other cracking.
- o Weldments have the potential for contamination and local segregation, either of which may promote premature failure.
- o Welded areas are potential sites for galvanic corrosion and localized corrosion.

RECOMMENDATIONS

- o Establish, for each material considered for repository storage, the metallurgical and microstructural properties that result after welding.
- o Conduct studies of the metallurgical aspects of weldments that involve exposure of weldments to simulated repository conditions.
- o Evaluate data in terms of long-term stability and durability.
- o Conduct tests to determine effects of residual stress, welded microstructures and weldment chemistry on corrosion behavior.
- o Effects of composition, welding conditions and repository environment should be established.

REFERENCES

As stated in Review Guides 4.3.25

REVIEW GUIDE

4.3.25

Section 8.3.5.9.2.2 Degradation Modes Affecting Candidate Copper-Based Container Materials

COMMENT 79

There is no discussion of the basis and reasons for choosing three specific copper-base alloys as candidate container materials.

BASIS

- 3 materials--CDA 102, CDA 613, and CDA 715--are going to be tested.
- Other copper-based alloys could perform as well or better than the three listed.
- Except for these 3 materials, no tests, not even scoping tests, have been performed on other potential, or candidate copper-base alloys.

RECOMMENDATIONS

- A program for screening or preliminary testing of a broad spectrum of copper-base alloys should be provided.
- A justification for the selection of the above copper-base alloys as candidate materials should be made.

REFERENCES

As stated in Review Guides 4.3.25, 4.3.28

REVIEW GUIDES

4.3.25, 4.3.28

Section 8.3.5.9.2.2.1 Subactivity 1.4.2.2.1:S Assessment of Degradation Modes Affecting Candidate Copper-Based Container Materials

COMMENT 80

The basis for degradation modes of copper-base alloys given in the CDSCP does not appear to agree with scientific literature. Future testing plans may therefore be improperly designed.

BASIS

- Only T-SCC (transgranular stress corrosion cracking) is being considered. However, I-SCC (intergranular SCC) is known to occur for many copper-base alloys, in particular α-brass in the presence of an oxide film, in aqueous NH_3 solutions.
- The role of NH_3 in the electrolyte is assumed to be that of dissolving a protective film. However, T-SCC in pure copper, for instance, requires the presence of a film.
- In Table 8.3.5.9-4, NH_3 is singled out as a potential cause for SCC, while nitrites are not. However, it is well known that NO_2 causes SCC, even in pure copper. See for instance Reference 1.
- Since T-SCC in some copper-base alloys has been observed in conditions where copper was not being dissolved, the existence of critical electrical potentials for SCC prevention seems rather doubtful. See Reference 2.
- There is no convincing evidence that selective leaching (dealloying) occurs exclusively through a dissolution-precipitation mechanism.

RECOMMENDATION

- The section (p. 59-79) should be expanded to reflect a fuller treatment of the technical literature and current theories for degradation modes of copper base alloys.

REFERENCES

1. Pednekan, S.P., A.K. Agrawal, H.E. Chaung, and R.W. Strahle, J. Electrochem. Soc. 126, 701 (1979).

2. Bertocci, V., F.J. Thomas, E.N. Pugh, Corrosion 40, 439 (1984).

REVIEW GUIDES

4.3.25, 4.3.28

Section 8.3.5.9.2.3.2 Subactivities 1.4.2.3.2. - 1.4.2.3.9. Laboratory Test Plan for Austenitic Materials

COMMENT 81

Investigation of the effects on the corrosion behavior of the containers that may result from any metallurgical changes associated with fabrication in large sections is not identified as a specific topic of a test program.

BASIS

- The influence of fabrication in large section on the corrosion behavior of the container is not identified as a specific topic of a test program.
- The size of the section and the welding procedures govern metallurgical conditions and thus alter the corrosion behavior.
- Other fabrication processes and procedures (such as surface peening) may alter the surface and metallurgical condition of the container and thereby alter the corrosion behavior of the container.
- Residual stresses present in large vessels after post-weld stress-relief heat treatment can be significant.

RECOMMENDATION

- The impact of metallurgical changes associated with fabrication in large sections on the corrosion behavior of full size containers should be evaluated.

REFERENCES

As stated in Review Guides 4.3.25

REVIEW GUIDE

4.3.25

Section 8.3.5.9.2.3.2 Subactivities 1.4.2.3.2. - 1.4.2.3.9. Laboratory Test Plan for Austenitic Materials

COMMENT 82

The possibility that the container may come into contact with dissimilar metals (resulting in galvanic corrosion) is not addressed in this section.

BASIS

- The container may come into contact with various alloys in the repository (spacers and base plates, etc.) or with the fuel rods inside the container.

RECOMMENDATIONS

- The possibility of galvanic coupling should be identified as an area of concern.
- Potential couples and procedures to avoid galvanic coupling should be identified.
- Where galvanic coupling cannot be avoided, experimental and modeling programs should be established to address this possibility and the expected results of the various conceivable couplings.

REFERENCES

As stated in Review Guide 4.3.25

REVIEW GUIDE

4.3.25

Section 7.4.5.4.6 Corrosion Model
Section 8.3.5.9.3 Information Need 1.4.3: Scenarios and models needed to predict the rate of degradation of the container material

COMMENT 83

The corrosion models described in the CDSCP are not specific and/or adaptable to specific metals, environmental conditions, and forms of corrosion.

BASIS

- The electrode potential of a metal or a phase within an alloy and the repository environment will control initiation or absence of corrosion. Electrode potentials should be known for various possible conditions and for expected times of exposure.

- Changes in water chemistry such as pH and/or ionic content will affect the electrode potential of the exposed metal.

- Surface film formation on a given metal as related to composition, electrode potential and corrosion rate must be established.

- Localized stresses, brittle phases, precipitates, different phases and other microstructural variations will result in variations in electrode potential and corrosion processes.

- Corrosion processes expected should be correlated with the material and environment.

RECOMMENDATIONS

- Use standard testing methods to determine and verify corrosion behavior of candidate repository materials in repository environments.

- Measure electrode potentials associated with given corrosion reactions in the repository environment.

- Set up corrosion data base for each material, environment, temperature and condition.

- Set up corrosion data base for previously determined corrosion data that will be used as a basis for projecting corrosion rates or behavior. (Note: There is a lot of scatter in some corrosion data, and this must be dealt with for modeling or predicting.)

REFERENCES

As stated in Review Guides 4.2.4.4, 4.3.9, 4.3.10, 4.3.25

REVIEW GUIDES

4.2.4.4, 4.3.9, 4.3.10, 4.3.25

Section 8.3.5.9.3.2.1 Subactivities 1.4.3.2.1 Metallurgical Aging and Phase Transformations

COMMENT 84

The resistance of an alloy to corrosion, intergranular corrosion, and stress-corrosion cracking is a function of the combined effects of radiation, temperature, stress, and time on the metallurgical stability of the alloy. These combined effects are not sufficiently discussed in the CDSCP.

BASIS

- Changes in the metallurgical condition of metastable austenitic materials can have dramatic effects on the resistance of these materials to degradation by chemical as well as mechanical processes.

RECOMMENDATION

- This section should address the effect of metastability of austenitic or other candidate materials on the resistance of these materials to degradation by chemical (corrosion), and combined chemical and mechanical (stress-corrosion) processes, as well as purely mechanical processes.

REFERENCES

As stated in Review Guide 4.3.25

REVIEW GUIDE

4.3.25

Section 8.3.5.10 Corrosion of Zircaloy

COMMENT 85

The tests discussed in this section of the CDSCP are insufficient in that they do not account for the previous history of the Zircaloy, all modes of hydrogen embrittlement, and other types of localized corrosion.

BASIS

- The type of reactor exposure, the composition of the residue that collects on the fuel rods, and the manner in which the fuel rods were cleaned will affect corrosion of Zircaloy.
- Residue deposits that contain copper have especially destructive effects on Zircaloy's protective oxide film, and local corrosion or pitting may result.
- Zircaloy, in reactor service, is subject to stress corrosion cracking from the fuel side of the cladding due to fission products such as iodides.
- Examples of hydrogen embrittlement failures in Zircaloy cladding have been reported.
- Zircaloy is not immune to pitting corrosion; and pitting can occur in hydrochloric acid containing ferric or cupric ions and in the presence of all the halogens either in liquid or gaseous form.

RECOMMENDATIONS

- Conduct corrosion studies to measure electrode potentials for Zircaloy in the repository environment, and to determine effects of varying temperature, ions present, water and oxygen.
- Use standardized tests to determine the susceptibility of Zircaloy to stress corrosion cracking in the repository environment.
- Study structural formation of the oxide film, and determine effects of wetting, drying and other conditions of the repository.
- Use standardized tests to determine susceptibility to hydrogen embrittlement and cracking.
- Conduct standardized tests to determine pitting susceptibility of Zircaloy.
- Study effects of final container closure welding on the corrosion behavior of Zircaloy.

REFERENCES

As stated in Review Guides 4.3.25

REVIEW GUIDE

4.3.25

Section 8.3.5.12 Groundwater Travel Time

COMMENT 86

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

BASIS

- The CDSCP states that the performance measure for groundwater travel time is the probability or frequency distribution expressed as a cumulative distribution function (cdf) of calculated groundwater travel times for each hydrogeologic unit (Section 8.3.4.12; page 8.3.5.12-17; paragraph 1). The amount of spreading or flattening of the cdf's of groundwater travel time results from the following interrelated factors:

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

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

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

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

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

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

RECOMMENDATION

- The strategy for resolving Issue 1.6 should be developed to meet the regulation by addressing the concerns presented in this comment.

REVIEW GUIDES

4.3.16, 4.2.2

Section 8.3.5.12 Groundwater Travel Time

COMMENT 87

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

BASIS

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

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

RECOMMENDATION

The performance parameters should be correlated with the tests described in Sections 8.3.1 to 8.3.1.16.

REVIEW GUIDES

4.3.16, 4.2.2

Section 8.3.5.12 Ground-Water Travel Time

COMMENT 88

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

BASIS

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

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

RECOMMENDATION

- Include a plan which incorporates parameters, activities, logic and schedules/milestones for formulating and establishing the credibility of conceptual flow models into the process of providing information need 1.6.1. The NRC staff considers that such a plan will measure and derive flow parameters and incorporate different kinds of information including, but not necessarily limited to, geochemistry, independent field or laboratory research on flow processes and validation of prototype testing technology. Formal use of expert judgement and peer review may be an integral part of such a plan. All technical concerns related to uncertainty in conceptual models need to addressed though the issue resolution process.

REVIEW GUIDES

4.3.16, 4.2.2, 4.2.4.4, 4.2.4.5, 4.2.4.8

Section 8.3.5.13 Total System Performance

COMMENT 89

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

BASIS

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

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

RECOMMENDATION

- The SCP should provide the criteria to be used in the determination of chemical retardation factors required for individual radionuclides under site-specific conditions.

REVIEW GUIDES

4.2.1, 4.2.2, 4.2.3, 4.2.4, 4.2.6, 4.2.8

Section 8.3.5.13 Total System Performance (pages 9, 78, 80 and 84, Figures 8.3.5.13-3A, 3C and 3G) and
Section 8.3.5.17 NRC Siting Criteria (potentially adverse condition 2, page 20)

COMMENT 90

Pages 8.3.5.13-70, 80 and 84 of the CDSCP imply that in developing a Complementary Cumulative Distribution Function (CCDF) to demonstrate compliance with the total system performance standard (Section 191.13 of 40 CFR Part 191, Section 60.112 of 10 CFR Part 60), it will be permissible to exclude the effects of certain significant scenarios or scenario "classes". In particular, it is suggested elsewhere (pages 8.3.5.13-9 and 8.3.5.17-20) that those scenario classes involving human intrusion will be excluded.

BASIS

- As described in Section 8.3.5.13.5 of the CDSCP and elsewhere, it is intended to use the CCDF in a license application as evidence of compliance with the total system performance standard.
- For the CCDF to be used in this way, all significant events, processes, and combinations thereof, i.e., scenario classes, must be included.
- In addition, each scenario class must be comprehensive in its consideration of potentially significant categories of events and processes.
- Finally, the individual scenario classes must be so constructed as to form a mutually exclusive set.
- Because human intrusion (e.g., drilling) is an event that can occur along with other events and processes, it is not mutually exclusive and therefore must not only be included in deriving the CCDF, but must also be included additively with other events and processes when scenarios are being developed and evaluated.

RECOMMENDATIONS

- A methodology should be developed and described that will ensure that all significant scenario classes are included in the CCDF, and that the individual scenario classes are comprehensive and mutually exclusive.
- The effects of human intrusion must be considered in addition to those associated with all other potentially significant events and processes in developing the CCDF.
- In cases where it is not possible to collect sufficient information about a particular event, process, or scenario class to include it in the CCDF, another basis should be developed for including it in the CCDF, for example through the use of bounding calculations.

REVIEW GUIDES

4.2.4.1, 4.2.4.2, 4.2.4.8, 4.2.4.9

Section 8.3.5.13 Total System Performance (pages 9-14 and elsewhere)

COMMENT 91

The CDSCP implies that conceptual model uncertainty can be dealt with appropriately by developing more than one scenario class for undisturbed performance or, in the case of unexpected features, by developing additional disturbed-case scenario classes.

BASIS

- This approach confuses uncertainties associated with future states of the repository system (i.e., scenarios) with uncertainties associated with conceptual models of the site.

- If legitimate distinguishable conceptual models are supported by the available information, reasonable assurance in the validity of neither model has been obtained.

- If information cannot be obtained that will distinguish among alternative conceptual models, the model associated with the greatest releases should, in general, be used in evaluating compliance with regulations.

- Unexpected features are an intrinsic part of the uncertainty associated with the conceptual model on which undisturbed as well as disturbed performance calculations are based.

RECOMMENDATIONS

- Provide high priority in the characterization program to testing of alternative conceptual models.

- Develop a single undisturbed scenario class that conservatively includes model uncertainty (in addition to data uncertainty).

REFERENCE

B. Ross, "A first Survey of Disruption Scenarios for a High-Level-Waste Repository at Yucca Mountain, Nevada", Sandia National Laboratories Report SAND85-7117, December 1987.

REVIEW GUIDES

4.2.4.1, 4.2.4.5, 4.2.4.9

Section 8.3.5.13 Total System Performance (page 33 and elsewhere)

COMMENT 92

The CDSCP implies that the significance of a scenario class to the CCDF can be evaluated by considering the product of total releases (in the form of the "EPA sum"*) and probability over 10,000 years for that scenario class (the "EPPM," or expected partial performance measure). This interpretation is inconsistent with how the NRC staff interprets the EPA standard (40 CFR Part 191).

BASIS

- Section 191.13 of 40 CFR Part 191 (Section 60.112 of 10 CFR Part 60) requires that cumulative releases over 10,000 years to the accessible environment have a likelihood of less than one chance in 10 of exceeding the EPA sum and less than one chance in 1000 of exceeding 10 times the EPA sum.

- Generally, categories of events and processes that can be shown to have probabilities less than 10^{-4} over 10,000 years do not need to be included in a CCDF developed to evaluate compliance with Section 191.13.

- In developing the CCDF, the EPA sum for a scenario or scenario class is not plotted directly against the probability for that scenario or scenario class. Rather, the EPA sum for a particular scenario or scenario class is plotted against the cumulative probability of scenarios having an EPA sum greater than that for the scenario or scenario class of concern. Thus, cumulative releases for the total system, including those arising from all significant scenarios or scenario classes, must first be considered.

- Only after developing the entire CCDF, using the set of all significant mutually exclusive scenario classes, can the full effect on the CCDF of individual scenario classes be ascertained.

- All scenarios that could lead to an EPA sum greater than 1 and that do not contain categories of events or processes that can be shown to have a probability less than 10^{-4} over 10,000 years need to be considered in developing the CCDF, unless a technical basis can be provided that the remaining probability distribution of cumulative releases would not be significantly changed by such omissions.

- Low-probability scenario classes that lead to an EPA sum greater than 10 (much less 10,000) could be significant if there are enough mutually exclusive scenario classes leading to similar or greater values of summed normalized releases. There are "enough" such classes if the sum of the probabilities for these classes leads to a value greater than 10^{-3} (one chance in 1000) over 10,000 years. For example, assume there are 10 or more mutually exclusive scenario classes that lead to EPA sums greater than 10 and each of these classes has a probability of occurrence of about 10^{-4} over 10,000 years. In this example, after summing the probabilities

for individual scenario classes, the total system would exceed the release limits specified in Section 191.13 ("... cumulative releases over 10,000 years... less than one chance in 1000 of exceeding 10 times the EPA sum," see above); consideration of individual scenario classes alone, however, would not indicate that this might be the case.

RECOMMENDATIONS

- Revise the SCP on page 8.3.5.13-33 and elsewhere (e.g., the discussion under disturbed-case scenario classes A-1 and A-2) to conform better to the EPA standard (40 CFR Part 191).

- The NRC staff recognizes that the EPPM concept may be useful as a guide to where available resources for site characterization should be focused; the EPPM should not, however, be used as a measure of the significance of a scenario class to the CCDF or in scenario screening.

REFERENCE

R. L. Hunter, R. M. Cranwell, and M. S. Y. Chu, "Assessing Compliance with the EPA High-Level Waste Standard: an Overview", USNRC Report NUREG/CR-4510, 1986.

REVIEW GUIDES

4.2.4.1, 4.2.4.9

*Summed releases normalized to limits specified in Appendix A of 40 CFR Part 191.

Section 8.3.5.13 Total System Performance (pages 27-33, equations 19, 20, and 22)

COMMENT 93

No basis has been provided in the CDSCP for the use of a "waiting time", T_e (equations 21 and 22, page 31), selected from an exponential distribution (page 33) in evaluating the significance of scenario classes (equation 19, page 27) for the purpose of scenario screening.

BASIS

- No physical basis has been provided for the assumption on page 33 of the CDSCP that the first occurrence of any event (initiating a disturbed-case scenario class) will be exponentially distributed in time.

- Because it is impossible to know a priori precisely when a particular disturbing event will actually occur, a conservative consequence analysis for the purpose of scenario screening would assume that any disturbed-case scenario class under evaluation occurs immediately or relatively soon after repository closure.

RECOMMENDATIONS

- Equation 22 should not in general be used (T_e should be set to zero) for the purpose of scenario screening, that is, the scenario class should be assumed to occur immediately subsequent to repository closure; if waiting time is used to eliminate a scenario from consideration (or to estimate cumulative releases for the purpose of developing a CCDF), this use should be technically justified.

- In particular, one or more sections on probability should be developed that include (1) a statement of why probabilities are needed, (2) a description of what probabilities are needed (i.e., for which events and processes), (3) an explanation of how the probabilities will be used, (4) a description of what technique(s) will be used to estimate probabilities of events and processes, (5) the criteria required for the use of each technique, (6) alternative approaches for estimating probabilities when little or no data are available, and (7) consideration of how uncertainties in the scenario probabilities will be incorporated in the CCDF.

REVIEW GUIDE

4.2.4.3

Section 8.3.5.13 Total System Performance (pages 17-50)

COMMENT 94

Several potentially significant scenario classes have not been presented under the sub-Section entitled "Technical discussion of the release-scenario classes"; thus, the performance allocation provided inadequately addresses Issue 1.1, and the site characterization program may have substantial gaps.

BASIS

- The discussion does not account for the possibility that future occurrences of hydrothermal activity may affect repository performance.
- The discussion does not account for the possibility that natural runoff or floods may enter the repository through shafts and boreholes.
- The discussion does not account for the possibility that gaseous radionuclides may exit the repository and be transported to the accessible environment through shafts and boreholes, particularly if seal failure occurs.
- The discussion does not account for the possibility that boreholes, shafts, their seals, the engineered barrier system, or the waste package may be disrupted by some process or event.
- The discussion does not account for the possibility that perturbations to the natural system caused by the repository could contribute to radionuclide releases to the accessible environment.
- While some of these concerns are addressed in other Sections of the CDSCP, in developing a CCDF to resolve Issue 1.1, all potentially significant scenario classes must be considered, and the final set of scenario classes used must be complete, comprehensive, and mutually exclusive.
- The omissions may have particularly substantial repercussions if currently unidentified tests need to be conducted where the potential interference with other tests is an important consideration.

RECOMMENDATIONS

- A methodology for scenario development and screening should be developed and described that (1) is systematic, (2) provides assurance that all significant events and processes have been considered in the development of scenarios, (3) contains explicit criteria, with justification for these criteria, for screening events, processes, and scenarios, (4) ensures the compatibility of scenarios developed for the various components of an overall performance assessment, and (5) clearly identifies the areas where formal use of expert judgement is applied.

- The technical discussion of release-scenario classes should be expanded to include consideration of all potentially significant events, processes, and scenarios, including but not necessarily limited to those noted above.

- The performance allocation for Issue 1.1 and the site characterization program should be modified to include consideration of all potentially significant scenario classes.

REVIEW GUIDES

4.2.2, 4.2.4.1, 4.2.4.2

Section 8.3.5.13 Issue resolution strategy for Issue 1.1: Will the mined geologic disposal system meet the system performance objectives for limiting radionuclide release to the accessible environment as required by 10 CFR 60.112 and 40 CFR 191.13 Page 8.3.5.13-42 Disturbed case (A-1): direct release in basaltic volcanism

COMMENT 95

The expected partial performance measure (EPPM) presents a misleading representation of how basaltic volcanism could influence the final shape of the CCDF. In addition, other information presented in this section appears to indicate that the scenario of basaltic volcanism is not being analyzed in a way which will determine its complete effect on the ability of the site to meet the EPA standard.

BASIS

- The partial performance measure (PPM) as presented in equation 8.3.5.13-6, is calculated in an approximately equivalent manner as the method recommended for calculating the EPA ratio in Appendix A to 40 CFR 191. Equation 8.3.5.13-31 gives a PPM (approximating the EPA ratio) of 104 if basaltic volcanism were to occur during the early stages of post-closure, if all other assumptions in this section were to remain constant.

- It is recognized by the NRC staff that during different times after post-closure the radionuclide inventory would decrease due to radioactive decay; however, at all times the ratio released would be over 1 (and probably over 10 during most of the post-closure period) if all other assumptions in this section were to remain constant. An EPPM of 4.16×10^{-2} does not portray the fact that the above values could result in the CCDF being exceeded.

- While in the above case the EPPM of 4.16×10^{-2} comes from a release of 104 associated with a probability of 4×10^{-4}, this value could be obtained from a release of 10.4 and a probability of 4×10^{-3} or a release of 1.04 and a probability of 4×10^{-2} or a probability of 4×10^{-1} associated with a release of .104. The EPPM does not tell the reader if either the probability or release parameter is significant.

- Many of the assumptions in this section are unconservative or do not reflect a complete range of phenomena or scenarios which need to be considered. For example:

  -The assumed value of 11 canisters represents an average value; the potential number of canisters is much higher.

  -The assumptions in this section, and elsewhere in the SCP, do not include the possibility of hydrovolcanic activity (See, for example, CDSCP Section 1.5.1.2.1), which could disrupt a larger area than the calculations assume.

-The calculations in this section do not account for the effects of co-volcanic phenomena, such as hydrothermal effects.

-The calculations in this section do not include the effect of disruption of the engineered barrier system and waste package.

-The calculations in this section utilize the procedures of Link et al.(1982). The method used by Link et al., gives a summation of the area of canisters intercepted based on the size of the assumed dike, size of canister and area of the repository. If one quarter of 4 canisters were intercepted, this formula would indicate the interception of only one canister. Statistical calculations which provide the number of canisters "hit" can provide numbers of canisters intercepted ranging several times higher.

-While it is recognized that investigations are being conducted to better understand the phenomena of basaltic volcanism, the calculations presented in the section neglect the potential effects of structural control.

° Only after producing the entire CCDF using complete, comprehensive and mutually exclusive scenarios can it be determined what the effect of basaltic volcanism on the CCDF would be; however, depending on the relative probability of the event, the relative position of the event in the CCDF and the time of release, release of the inventory from 11 canisters could make a very significant contribution to the CCDF. Modification of the base scenario by consideration of all potential phenomena and scenarios could make an even more significant contribution.

RECOMMENDATIONS

° The NRC considers that the PPM or the EPA ratio provides an acceptable description of the effects of a scenario. As is shown in the scenario for basaltic volcanism, the use of the EPPM may provide a misleading representation of the effects of a scenario on the CCDF, therefore its use for this purpose should be discouraged.

° Scenarios developed for basaltic volcanism (as well as other scenarios) need to be complete, comprehensive and mutually exclusive.

REFERENCES

Hunter, R.L., Cranwell, R.M., and Chu, M.S.Y., 1987, Assessing compliance with the EPA High-level waste Standard: An overview; NUREG/CR-4510, SAND86-0121, Sandia National Laboratories, Alburquerque, New Mexico.

Link, R.L., Logan, S.E., Ng, H.S., Rockenback, F.A., and Hong, K.J., 1982, Parametric studies of radioactive consequences of basaltic volcanism; SAND81-2375, Sandia National Laboratories, Alburquerque, New Mexico.

U.S. Nuclear Regulatory Commission, 1987, Letter from John J. Linehan Division of High-Level Waste Management, USNRC, to Mitchell Kunich, Waste Management Project Office, U.S. Department of Energy, Subject: Concerns related to volcanic intrusion into the repository at NNWSI.

Code of Federal Regulations, 40 CFR Part 191, Title 40, "Protection of Environment," Part 191, "Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes," United States Enviromental Protection Agency, 1986.

REVIEW GUIDES

4.2.4.9, 4.3.4

Section 8.3.5.14 Individual Protection

COMMENT 96

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

BASIS

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

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

RECOMMENDATION

- Include the presence or absence of "significant sources" of groundwater into the resolution strategy as an information need. A decision point should also be incorporated into the logic diagram with a related milestone/schedule to close out the question.

REVIEW GUIDE

4.3.17

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

COMMENT 97

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

BASIS

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

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

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

RECOMMENDATIONS

- In addition to mapping of unanticipated and significant structural or hydrological features and stratigraphic contacts, it is recommended that provisions be made to:

  - Photo log after each round of blasting, and

  - Develop criteria for deciding when to require detailed mapping.

REVIEW GUIDE

4.2.5

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

COMMENT 98

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

BASIS

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

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

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

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

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

RECOMMENDATIONS

- An analysis of potential hydrological interference should be conducted, including anticipated fluids in ES-2 (e.g., drill water, dust suppression water, ventilation air, and blast fumes) as well as unanticipated releases.

- Potential adverse effects of the construction of ES-2 using the drill and blast method on the ability to obtain required data in ES-1 and adjacent test areas should be addressed and mitigated.

REFERENCE

NRC Comments on the DOE's Draft Environment Assessment for the Yucca Mountain site, March 20, 1985.

REVIEW GUIDE

4.2.5

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

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

COMMENT 99

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

BASIS

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

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

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

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

RECOMMENDATIONS

- The NRC staff recommends that the SCP Section 8.4.2.1.1 and other sections pertaining to shaft construction procedures be revised to make them consistent with the procedures and requirements proposed by DOE in Reference 1, which outlines a reasonable strategy for minimizing shaft wall damage.

- Procedures on smooth wall blasting, test blasting and vibration monitoring should be developed early to allow the NRC staff to evaluate the potential impact of shaft construction on long-term isolation capability of the geologic repository.

REFERENCES

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

° 10 CFR 60.

° NRC, 1986, GTP Borehole and Shaft Sealing of High-Level Nuclear Waste Repositories.

REVIEW GUIDE

4.2.5

Section 8.4.2.4 Exploratory Drifts, page 8.4-35, paragraph 3 and 4

COMMENT 100

The extent of site exploration described in the CDSCP indicates that the DOE plans to explore only a small portion of the underground repository block through underground testing and drifting. Substantially more drifting may be necessary to reduce uncertainties about the presence of faults and other geologic and hydrologic conditions. In the CDSCP no exploratory drift is planned to cross the main waste storage area to the southern portions of the the block, which based upon existing information appears to contain more faults and fractures than other parts of the block. Borehole penetrations into the main waste storage area (boreholes from the surface, horizontal core drilling or other means) may not provide the representative information needed to construct a reliable three-dimensional geologic model of the repository block and to evaluate ranges of parameters that could affect repository performance.

BASIS

- The exploration, as proposed in CDSCP, covers only a relatively small and peripheral area in the north east portion of the block. The proposed drifting and testing has not been demonstrated as being sufficient to establish the ranges of the parameters required by the site characterization as defined in 10 CFR 60.2. See also Reference 2.

- Exploratory drifting across the entire proposed facility has been used in the past in other repository projects (Ref. 3). A similar approach at Yucca Mountain site is likely to yield valuable information about the range of variability of site parameters and will substantially reduce uncertainties.

RECOMMENDATIONS

- The SCP should show that the proposed underground exploration and testing together with surface-based site characterization, would sufficiently establish the geologic conditions and the ranges of important geomechanical, hydrologic and other needed parameters across the entire repository block. Alternatively, additional drifting to yield a more complete and representative characterization of the repository block should be proposed.

REFERENCES

1. 10 CFR 60.2

2. Letter from J. Linehan, NRC to C. Gertz, DOE, dated August 28, 1987, Subject "NNWSI Project: Drifting and Representativeness."

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

REVIEW GUIDE

4.2.5

8.4.2.4 Exploratory Drifts, pages 8.4-35 and 36

COMMENT 101

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

BASIS

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

RECOMMENDATION

° Potential remedial measures that may be needed to isolate and stabilize the target structures should be discussed in the SCP.

REFERENCE

Summary of DOE/NRC Meeting on Proposed changes to the NNWSI Exploratory Shaft Facility, April 14-15, 1987.

REVIEW GUIDE

4.2.5

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

COMMENT 102

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

Aside from the potential technical difficulties associated with the feasibility of drilling such holes, this raises questions about the reliability of the permeability values thus obtained.

BASIS

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

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

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

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

RECOMMENDATION

- Prototype testing is recommended to alleviate doubts about permeability measurements in air drilled holes.

REVIEW GUIDE

4.2.5

8.4.2.5.2: Performance Confirmation Tests, Page 8.4-55, para 4
8.3.5.16 Performance Confirmation, Page 8.3.5.16-1

COMMENT 103

The performance confirmation program has not been sufficiently well defined, and appropriate details are not included in the CDSCP. The discussion concerning confirmation, Issue 1.7, has not presented the strategy or a plan to meet the requirements set forth in Subpart F of 10 CFR Part 60.

BASIS

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

- 10 CFR 60.140(b) (Ref. 1) requires that the performance confirmation program shall have been started during site characterization.

- The Annotated Outline for the SCP (Ref. 2, page xiii) states that one of the objectives of the SCP is to provide details of the performance confirmation testing program. This information is needed to allow evaluation of the effects of performance confirmation activities, in particular, the ability of the natural and engineered barriers of the repository system to meet the performance objectives.

- The USNRC Generic Technical Position on In Situ Testing During Site Characterization for High-Level Nuclear Waste Repositories, Section 5.6 (Ref. 3) states that "DOE should identify in its test plan which tests will be completed at the time of construction authorization application, and which tests and long-term monitoring activities will continue after that."

- Due to uncertainties associated with performance allocation and anticipated site conditions, parameters for long-term performance confirmation should be identified before exploratory shaft sinking and drifting.

RECOMMENDATION

- The performance confirmation discussion in the SCP should be augmented to include as a minimum (1) recognition of key parameters needed for validating the conceptual and mathematical models proposed for use in the performance assessment program to show compliance with Sections 60.112 and 60.113 of 10 CFR Part 60, (2) identification of those parameters for which it is necessary to initiate performance confirmation testing as early as practicable during site characterization, and (3) a program for performance confirmation testing.

REFERENCES

10 CFR 60.

DOE's Annotated outline for the Site Characterization Plan.

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

REVIEW GUIDE

4.2.4.11

Section 8.6.1 Quality Assurance Plan Summary

COMMENT 104

This section states that activities controlled in accordance with QA Level II requirements can be justified to support QA Level I data through the peer review process. This section also states that data or data interpretations generated as a result of activities controlled in accordance with QA Level II or III programs may be used in the licensing process as corroborative information. The staff believes it is prudent to classify future QA Level II and III data collection activities as QA Level I if there is a possibility that the subject data may be relied on in licensing.

BASIS

- NRC regulations (10 CFR 60, Subpart G) require that a QA program be implemented for all systems, structures and components important to safety, to design and characterization of barriers important to waste isolation and to activities related thereto. These activities include the development of site characterization data which will be used in support of the license application.

- Data used in support of the license application that are related to items important to safety or barriers important to waste isolation and not originally collected under the QA requirements of 10 CFR 60, Subpart G should be qualified to meet these requirements. The staff's "Generic Technical Position on Qualification of Existing Data for High-Level Nuclear Waste Repositories" defines methods for qualifying data for licensing.

- As described in Section 8.6.2, the QA requirements for QA Levels II and III do not meet the QA requirements of 10 CFR 60, Subpart G or the above Generic Technical Position.

RECOMMENDATION

Data which may be relied on in the licensing process that are related to items important to safety or barriers important to waste isolation should be Quality Level I.

REFERENCE

U.S. Nuclear Regulatory Commission, "Generic Technical Position on Qualification of Existing Data for High-Level Nuclear Waste Repositories," Federal Register, Vol. 52, No. 131, July 9, 1987, 259-25933.

REVIEW GUIDES

4.2.7, 4.3.27

Section 8.6.4.1 Quality Assurance During Site Exploration.

COMMENT 105

The acceptance review process for data collected after August 1980 (the date when the NNWSI Project QA Plan, NVO-196-17, was first issued) appears to be insufficient.

BASIS

- NRC regulations (10 CFR 60, Subpart G) require that a QA program be implemented for all systems, structures and components important to safety, to design and characterization of barriers important to waste isolation and to activities related thereto. These activities include the development of site characterization data which will be used in support of the license application. Data used in support of the license application that are important to safety or waste isolation and not originally collected under the QA requirements of 10 CFR 60, Subpart G should be qualified to meet these requirements.

- The NNWSI QA plan (196-17) has not been found acceptable by the NRC. A number of outstanding comments remain. An unacceptable or unimplemented QA program could jeopardize the use of data collected under such a QA program in licensing.

- For example, Section 8.3.1.4.2.1.5 refers to specific drill core samples, collected after the August 1980 date, which will be used to measure magnetic properties and consequently, to make stratigraphic correlations. However, numerous concerns have been identified by the NRC staff related to the handling and logging of core collected for the NNWSI project. These data were generated under the NNWSI QA program but may not be defensible in licensing. These data must also be "qualified" to meet the requirements as described in 10 CFR 60, Subpart G.

- NNWSI procedure SOP-03-03, Rev. 0 "Acceptance of Data or Data Interpretations Not Developed Under the NNWSI QA Plan," dated January 31, 1986 describes a process for qualifying data collected after August 1980. According to this procedure, all data or data interpretations generated by the NNWSI participants after the NNWSI QA Plan implementation date (August 1980) will be processed as a nonconformance. This approach may be acceptable to the NRC staff if the proposed corrective action consists of the data qualification methods described in the NRC's "Generic Technical Position on Qualification of Existing Data for High-Level Nuclear Waste Repositories," or some other method proposed by DOE and accepted by NRC. However, to treat "unqualified data" under the traditional nonconformance system - which has less rigor than the methods in the GTP - does not appear adequate.

RECOMMENDATION

- Data collected after August 1980 should be reexamined, and when necessary, qualified based on guidance found in the NRC's "Generic Technical Position

on Qualification of Existing Data for High-Level Nuclear Waste Repositories," or some other method proposed by DOE and accepted by NRC.

REFERENCE

U.S. Nuclear Regulatory Commision, "Generic Technical Position on Qualification of Existing Data for High-Level Nuclear Waste Repositories," Federal Register, Vol 52, No. 131, July 9, 1987, 25932-25933.

REVIEW GUIDES

4.2.7, 4.3.27

Section 8.6.4.2 Quality Assurance during site characterization Section 8.3.5.5 Preclosure performance

COMMENT 106

The lists of items and activities covered by the 10 CFR Part 60 Subpart G quality assurance programs are incomplete and the analysis provided for their identification is non-conservative in some areas.

BASIS

- The spent fuel analysis (see the Conceptual Design Report, Section 5.1.1.1) used an average burnup for a 10 yr old fuel assembly to calculate the source term and consequently the amount of radiation available to expose the public. It is stated in Section 7.3.1.1.1 of the CDSCP that 5 year old high burnup spent fuel will be stored in the repository. A subsequent reanalysis using 5 yr old spent fuel would have shown an approximate doubling of the available source term.

- In addition, Part 60 requires that items that mitigate the effects of an accident are to be classified as important to safety. The accident analyses in Appendix F and L of the CDR take credit for several mitigation features (e.g. the hotcell and HEPA filters). The CDSCP (see 5.1.4, p 6-79) states that the analyses were re-examined to remove any reductions from mitigating features and that no Q-list items resulted from this re-examination. However, other than this statement, no analyses are presented or referenced. In addition, the doses resulting with mitigation features as shown in Figure 6-9 of Appendix F of the CDR, suggests mitigating features are needed to keep within the dose identified by DOE.

- DOE has utilized a probability cut-off of 10^{-5}/year for screening events and accident scenarios. However, no basis is provided for this number.

- A criticality event has not been considered in the analyses for developing the scope of the quality assurance program. 10 CFR 60.131(b)(7) requires the repository to be designed to ensure that a nuclear criticality accident is not possible. To provide reasonable assurance that a criticality accident would not occur this work should either be covered by the QA regulations in 10 CFR 60, Subpart G and items which prevent criticality added to the Q-list or alternatively, it should be shown that an event would not lead to doses in excess of the .5 rem criterion for important to safety.

- The DOE Annotated Outline Section 8.6.4.2 specifies that a list of activities covered by the QA program be provided in the SCP. This is also emphasized in the Q-list TP and SCP Review Plan Section 4.3.30. Section 8.6.4.2 of the CDSCP states that data collection activities associated with tests in 8.3 that will produce primary data are on the Activities List. However, Section 8.3 does not identify which tests produce primary data and it is therefore not possible to determine which fall under the Subpart G QA program.

- Also, development of design aspects for the underground facility which could affect the performance of the Q-listed engineered barriers (such as spacing of emplacement boreholes) should be included on the Activities List.

- Performance assessments are not included on the Quality Activities List.

RECOMMENDATIONS

- Reanalyze the "Preliminary Preclosure Radiological Safety Analysis" using conservative design assumptions and provide a list of all items that belong on the Q-list, including necessary mitigation features.

- Apply Subpart G, Part 60 quality assurance measures to criticality control analyses, equipment, etc. Alternatively, demonstrate that the consequences of a criticality event are within regulatory limits and describe the QA measures to assure this.

- Include necessary activities in 8.3 on the Activities List. Alternatively, list quality Level I study plans on Activities List in SCP and SCP updates.

- Add design aspects of the underground facility to the Activities List.

- Add performance assessment activities to the Activities List.

REFERENCES

10 CFR Part 50, Appendix B and 10 CFR 60, Subpart G 10 CFR 60.131(6)(7)

U. S. Nuclear Regulatory Commission "Generic Technical Position on Items and Activities in the High-Level Waste Geologic Repository Program Subject to Quality Assurance Requirements." U. S. DOE Annotated Outline for site characterization plans (OGR/B-5)

REVIEW GUIDES

4.3.30, 4.2.7

Table 8.6-2, Quality assurance plans and procedures in effect during site exploration and Table 8.6-3, NNWSI Project procedures generic to site characterization tasks.

COMMENT 107

The plans and procedures listed in Table 8.6-3 do not appear to address all of the applicable criteria of Appendix B to 10 CFR Part 50 for the NNWSI Project office and contractors.

BASIS

- In accordance with the requirement of 10 CFR 60.152, "DOE shall implement a quality assurance program based on the criteria of Appendix B of 10 CFR Part 50 as applicable...."

- The NRC staff recognizes that all of the 18 criteria of Appendix B to 10 CFR Part 50 do not apply to each participant involved in the NNWSI Project. However, in the NRC staff review of Tables 8.6-2 and 8.6-3, and the associated CDSCP descriptions for these tables, the CDSCP does not address why certain parts of the Appendix B criteria have not been covered by the quality assurance plans and procedures in Tables 8.6-2 and 8.6-3, (e.g. the USGS quality assurance plans and procedures referenced in Table 8.6-2 do not appear to address the Appendix B to 10 CFR Part 50 criteria for inspection, test control, calibration and nonconformances.) Similarly, the H&N quality assurance plans and procedures in Table 8.6-3 do not appear to address the Appendix B criteria for procurement; instructions, drawings and procedures; document control; control of purchased material; equipment and services; and test control.

RECOMMENDATION

- The SCP should justify why certain criteria in Appendix B to 10 CFR Part 50 do not apply for particular project participants.

REFERENCE

10 CFR Part 60.152

REVIEW GUIDE

4.2.7

Section 8.6.6 Table 8.6.3 Nevada Nuclear Waste Storage Investigations Project procedures generic to site characterization tasks.

COMMENT 108

NNWSI procedure, "Acceptance of Data or Data Interpretations not developed Under the NNWSI Project QA Plan," number NNWSI-AP-5.9Q, should be formally submitted to the NRC staff for review. Data which are important to safety or waste isolation and which are not collected under a QA program based on 10 CFR 60, Subpart G, must be qualified to meet the NRC's QA requirements. (See Comment Section No. 8.6.4.1 for a related comment).

BASIS

- NRC regulations (10 CFR 60, Subpart G) require that a QA program be implemented for all systems, structures and components important to safety, to design and characterization of barriers important to waste isolation and to activities related thereto. These activities include the development of site characterization data which will be used in support of the license application. Data used in support of the license application that are important to safety or waste isolation and not originally collected under the QA requirements of 10 CFR 60, Subpart G should be qualified to meet these requirements.

- For example, Section 8.3.1.2.1.3.2 refers to borehole cuttings collected by a "mining company" during exploration. Many important parameters will be measured from the subject borehole cuttings. If these data are to be relied on in licensing, they should be qualified to meet 10 CFR 60, Subpart G. If not, the measured parameters derived from the cuttings may not be defensible in the licensing process.

RECOMMENDATION

- Formally submit procedure number NNWSI-AP-5.9Q to the NRC staff for review and evaluation.

- Another option is to adopt methods equivalent to those found in the NRC's "Generic Technical Position on Qualification of Existing Data for High-Level Nuclear Waste Repositories."

REFERENCE

U.S. Nuclear Regulatory Commission, "Generic Technical Position on Qualification of Existing Data for High-Level Nuclear Waste Repositories," Federal Register, Vol. 52, No. 131, July 9, 1987, 25932-25933.

REVIEW GUIDES

4.2.7, 4.3.27

Section 8.3.5.9 Performance Allocation, Waste Package and Engineered Barrier System.

COMMENT 109

The performance allocation and associated performance measures and goals for waste package containment are inconsistent with the Commission's intent in 10 CFR Part 60.113 for "substantially complete containment" of high level waste within the waste package during the containment period.

BASIS

- The performance allocation and associated performance measures and goals for waste package containment are based on established design objectives for performance of the waste packages.

- The three design objectives for performance of the waste package and for radionuclide release from the engineered barrier system (EBS) are inconsistent with the Commission's intent in 10 CFR Part 60.113 for "substantially complete containment." (See Comment 3 of these Point Papers.)

- The tentative goals allocated for the performance measures (Table 8.3.5.9-1) and for their respective parameters (Tables 8.3.5.9-2, 8.3.5.9-3, and 8.3.5.9-4) are not completely consistent with the Commission's intent in 10 CFR Part 60.113 for "substantially complete containment."

RECOMMENDATIONS

- Establish conservative design objectives, as recommended in Comment 3 of the Point Papers, which are consistent with the Commission's intent in 10 CFR Part 60.113 for "substantially complete containment."

- Guided by the design objectives, establish tentative goals for performance measures and their respective parameters that are consistent with the performance objectives for waste package containment.

REFERENCE

10 CFR 60.113

REVIEW GUIDES

4.3.24, 4.3.25, 4.3.30

Section 8.3.5.10.2 Information need 1.5.2; material properties of the waste form. Technical basis for addressing the information need.

COMMENT 110

The effect of oxidation on the leaching of spent fuel has not been sufficiently addressed in relation to meeting the performance objectives for radionuclide releases.

BASIS

- The solubility or leachability of spent fuel will be enhanced if it is oxidized in a repository environment.
- The rate of spent fuel oxidation has not been determined.
- The leaching behavior of oxidized spent fuel has not been determined.
- The leach rate of fission products may be greatly increased depending on their distribution in the spent fuel. For example, if fission products concentrate in grain boundaries and oxidation along grain boundaries is the dominant mechanism, leach rates may be greatly increased.
- Radionuclide release, because of spent fuel oxidation, may result in an unexpectedly high source term to the engineered barrier system.

RECOMMENDATIONS

- Leach characteristics of oxidized spent fuel should be determined.
- Mechanism of oxidation and distribution of fission products in spent fuel should be determined.

QUESTIONS

Section 6.2.6 Subsurface design
Section 7.3.1.3 Reference waste package design
Section 7.4.1.3 Figure 7-5 Example of temperature histories of thermal waste package components and host rock for a vertically emplaced spent fuel container

QUESTION 1

Is the site characterization testing related to thermal loading for the site based on the maximum waste package and areal design loadings?

BASIS

- The subsurface design is using a design basis areal power density of 57 kw/acre, based on an average waste package heat input of 3.03 kw. The maximum design heat output of a waste package is 5 kw. Figure 7-5 shows typical modeled thermal histories of a vertically emplaced spent fuel waste package and its immediate surroundings with waste package average power of 3.3 kw.

- Design basis information should include the maximum design case.

- The areal power density and the maximum heat output of a waste package can be exceeded if 5 year old high burnup fuel is consolidated and placed in boreholes of close proximity to other 5 year old high burnup fuel.

- Any analysis must consider the margins of safety under normal conditions and anticipated operational occurrences (10 CFR 60.21(c)(ii)(F)(3)).

RECOMMENDATION

- Either use maximum design basis conditions for site characterization testing related to thermal loading or provide justification for the design basis.

REFERENCE

U. S. Nuclear Regulatory Commission "Generic Technical Position on Items and Activities in the High-Level Waste Geologic Repository Program Subject to Quality Assurance Requirements."

REVIEW GUIDES

4.2.7, 4.3.25, 4.3.30

Section 8.3 Planned Tests, Analyses, and Studies

QUESTION 2

Terms such as "professional judgement," "expert judgement," and "peer review" are used extensively throughout the CDSCP and in key supporting references. What precisely is meant by them, and has a basis been developed for how, where, when, and under what circumstances it would be appropriate to use such subjective methods during site characterization?

BASIS

- The NRC staff agrees with the general thrust of the statement on pages 8.3.5.8-6 through 8.3.5.8-7 of the CDSCP that (what the NRC terms) the "formal use of expert judgement" and "peer review" (variously described in the CDSCP as "expert, professional judgement," "peer review," and "expert judgement through peer review") must in many cases play an important role in the overall strategy for resolution of performance issues.

- Pages 8.3.5.13-11 and 8.3.5.13-101 of the CDSCP call, respectively, for "professional judgement" to be used as a guide in the development of scenario classes, and for "judgement" to be used in constructing the joint distribution of state variables required for development of the CCDF.

- Pages 8.3.5.17-12 through 8.3.5.17-14 of the CDSCP call for "expert professional judgement" and "expert review" to be used as a basis for determining the significance of potentially adverse conditions.

- Pages 8.3.5.20-1 and 8.3.5.20-6 through 8.3.5.20-8 of the CDSCP variously call for "peer review," "formalized peer review," "expert judgement," "professional judgement," and "expert review...through peer review" to be used extensively as a basis for model validation and performance assessment.

- The Conceptual Design Report (MacDougall et al., 1987), referenced on page 8.3.5.5-20 of the CDSCP, calls variously for a "panel of experienced engineers" (page 3-22), a "panel of experienced facility designers" (page 3-26), and "engineering judgement" (page 4-13) to be used for screening preclosure-phase initiating events and estimating their probabilities.

- Numerous other examples in the CDSCP and in key supporting references could be provided.

RECOMMENDATIONS

- At a minimum, a distinction should be made in the SCP between "peer" review" and what may be termed the "formal use of expert judgement" (as distinguished from the routine use of expert judgement that is part of any scientific or engineering investigation). The distinction should bring out:

(1) the "formal use of expert judgement" as a highly structured approach to drawing inferences from sparse data and assessing the uncertainty of those inferences, and

(2) "peer review" as an independent critique of the way data and information are analyzed or of conclusions drawn from those analyses.

° Whatever terms are eventually used in the SCP, they should be carefully defined and distinguished from one another.

° A basis should be presented for the "formal use of expert judgement" and for the use of "peer review."

REFERENCES

H.R. MacDougall, L.W. Scully, and J.R. Tillerson, "Site Characterization Plan Conceptual Design Report," Sandia National Laboratories Report, SAND84-2641, 1987.

U. S. Nuclear Regulatory Commission, "Generic Technical Position on Peer Review for High-Level Nuclear Waste Repositories", Federal Register, Vol. 52, No. 131, July 9, 1987, 25932-25933.

REVIEW GUIDES

4.2.4.8, 4.3.28

Section 8.3.1.2.1.2.1 Surface Water Runoff Monitoring

QUESTION 3

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

BASIS

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

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

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

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

RECOMMENDATION

- It is recommended that the SCP clearly and thoroughly identify how surface-water data transfer between sub-basins will be achieved.

REVIEW GUIDES

4.3.15, 4.3.18, 4.2.3, 4.3.1, 4.3.2

Section 8.3.1.2.3.2.2 Activity: Hydrochemical Characterization Of Water In The Upper Part Of The Saturated Zone At The Site

QUESTION 4

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

BASIS

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

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

RECOMMENDATION

- Water samples should be collected from the upper several meters of the water table for age determination. The samples should be analyzed for carbon-14, tritium, iodine-129, and chlorine-36 at a minimum.

REVIEW GUIDES

4.3.16, 4.2.3

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

Section 8.3.1.3.1.3 Schedule and milestones

QUESTION 5

What information will be obtained through Activity 8.3.1.2.2.2.2?

BASIS

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

- Activity 8.3.1.2.2.2.2 is not described anywhere in the CDSCP.

RECOMMENDATION

- Clarify whether Activity 8.3.1.2.2.2.2 should have been included in the CDSCP, or if the reference to Activity 8.3.1.2.2.2.2 in Investigation 8.3.1.3.1 is in error.

REVIEW GUIDES

4.2.1, 4.2.2, 4.2.3, 4.2.4, 4.2.6, 4.2.8, 4.2.12

Section 8.3.1.3.4.3 Study: Development of sorption models (isotherms)

QUESTION 6

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

BASIS

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

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

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

RECOMMENDATION

° The SCP should provide further information on how iso-beta and iso-K_d maps will be used in performance assessment tasks to determine sorption in the matrix and fractures.

REVIEW GUIDES

4.2.1, 4.2.2, 4.2.3, 4.2.4.5, 4.2.4.6, 4.2.6, 4.2.8, 4.3.14

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

QUESTION 7

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

BASIS

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

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

RECOMMENDATION

° The sequence of milestones for 8.3.1.3.4.3, Study: Sorption modeling (isotherms) should be clarified.

REVIEW GUIDES

4.2.1, 4.2.2, 4.2.3, 4.2.6

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

QUESTION 8

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

BASIS

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

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

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

RECOMMENDATION

° The assumptions that will be used in defining an Eh for the model calculations should be explicitly stated and justified.

REFERENCES

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

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

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

REVIEW GUIDES

4.2.1, 4.2.2, 4.2.3, 4.2.4.4, 4.2.4.5, 4.2.6, 4.2.8, 4.3.9, 4.3.12, 4.3.14

Section 8.3.1.3.5.1 Activity: Speciation Measurements

QUESTION 9

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

BASIS

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

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

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

RECOMMENDATION

- The SCP should consider backup positions in the event that the proposed method cannot be developed in the expected time frame.

REFERENCE

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

REVIEW GUIDES

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

Section 8.3.1.3.5.2 Study: Colloid behavior

QUESTION 10

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

BASIS

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

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

° The tetravalent actinide ions undergo extensive hydrolysis in solutions with near-neutral values of pH, leading to polymers of high molecular weight which can disperse as colloids. These processes have been studied extensively for thorium, largely because of its availability and stability of the (IV) oxidation state (Ahrland, Liljenzin, and Rydberg, 1973). In view of its well known chemical tendency to form high polymers, thorium colloids might provide a means for affecting radionuclide transport.

RECOMMENDATION

° The SCP should address the question of colloid formation by other elements in addition to plutonium and americium. If a decision is made to eliminate these additional elements from the study of colloid behavior, those elements considered and the basis for eliminating them from the plan should be clearly stated.

REFERENCE

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

REVIEW GUIDES

4.2.1, 4.2.2, 4.2.3, 4.2.4.7, 4.2.6, 4.2.8, 4.3.9, 4.3.14

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

8.3.1.3.7.1 Study: Retardation sensitivity analysis

8.3.1.3.7.1.3 Activity: Transport models and related support

QUESTION 11

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

BASIS

- The goal of this activity is to "...verify and validate computer codes...."
- To comply with the Quality Assurance procedure NNWSI-SOP-03-02: Software Quality Assurance, and NRC requirements, the codes being used under this study must be verified and validated.
- The activity gives no information on code validation.

RECOMMENDATIONS

- These sections should provide a description of the validation procedure which will be used in the investigation. It is not clear from the description how code validation will be successfully accomplished.
- One approach would be to partially validate using information on radionuclide mobility under similar tuff-groundwater situations from the many bomb test sites at the Nevada Test Site.

REVIEW GUIDES

4.2.1, 4.2.2, 4.2.3, 4.2.4.4, 4.2.4.5, 4.2.6, 4.2.7, 4.2.8, 4.3.9

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

QUESTION 12

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

BASIS

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

RECOMMENDATION

- The SCP should provide more explicit definitions of aperture and length. In doing so, a more explicit integration with flow measurements (hydrology), which, presumably, will provide hydraulic apertures should be considered. A terminology that is consistent across disciplines is highly desirable.

REVIEW GUIDE

4.3.20

Section 8.3.1.4.1 Integrated drilling program

QUESTION 13

Discussions of the integrated drilling program are unclear. How will drilling or tests be coordinated so as to prevent possible interference; how will various studies be integrated; how will data from various holes be used in support of different studies; how will uncertainity in core retrieval and data analysis be handled; and how will the large volume of existing information be used to plan the drilling program? Explain.

BASIS

- Activities associated with proposed drillholes listed in Table 8.3.1.4-2 reflect a concern with the impact of drilling and drilling media upon the saturated zone and hydrologic characterization of the unsaturated zone, but consideration should also be given to the impact of drilling upon tests to be conducted or in progress in surrounding holes.

- It is not clear whether data obtained from holes conducted for one particular investigation or discipline will be utilized as possible input into other investigations (e.g., data from water level drilling as input to geologic studies).

- It is unclear to what extent the proposed program will be implemented. For example, page 8.3.1.4-37 states that "three additional continuously cored holes may be drilled."

- Information from core may be limited with respect to mineral fillings, fractures, and faults due to the small sample size and the difficulty in recognizing certain features in core. Vertical holes may not intersect many major rock discontinuities such as near vertical faults and fractures.

- Difficulties may arise in interpretation of core, as "core recovery is typically poor in the unsaturated zone" (Page 8.3.1.4-39).

RECOMMENDATIONS

- The integrated drilling program should supply relevant data from drillholes to all investigations and clearly state the proposed program of exploration.

- Drill core may be inadequate to provide information on many parameters; the SCP should propose alternative methods for determination of parameters.

- Some angled drillholes should be considered.

- At an early stage in planning the drilling program, qualified existing information should be integrated and evaluated to identify information still needed.

- Planned drilling programs should be integrated with planned drifting and geophysical programs.

REVIEW GUIDES

4.3.5, 4.3.6

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

QUESTION 14

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

BASIS

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

RECOMMENDATION

- The impact of all drilling should be included in the subject investigation and evaluation of waste isolation integrity of the site.

REFERENCE

10 CFR 60.

REVIEW GUIDE

4.3.20

Section 8.3.1.4.1.3 Ongoing Integration of the NNWSI Project Drilling

QUESTION 15

What are the types and sources of data, and what is the interpretation of geologic and geophysical data used in identifying the limits of the region of investigation around the site? Explain.

BASIS

- On page 8.3.1.4-33 it is stated that "The northern, eastern, and southern limits of a region of investigation around the site are selected primarily on the basis of differences in structural styles inferred from existing geologic and geophysical data."

- The boundary of the tectonic region/region of investigation is one of the parameters needed in calculating probabilistic seismic hazard. The response to this question will provide valuable information which will be used in the seismic hazard analysis.

RECOMMENDATION

- Provide adequate information which supports the delineation of the limits of the region of investigation.

REVIEW GUIDES

4.3.4, 4.3.6

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

QUESTION 16

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

BASIS

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

RECOMMENDATION

- The SCP should define roughness, roughness coefficient, and a distinction between the two. Consistent terminology should be used throughout the SCP.

REVIEW GUIDE

4.3.20

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

QUESTION 17

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

BASIS

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

RECOMMENDATION

° The SCP should expand the discussion presented to address this question.

REVIEW GUIDE

4.3.20

Section 8.3.1.5.1.4 Climate

QUESTION 18

In addition to the regional climatic influences on erosion and deposition at the site, how have local variables such as uplift, subsidence, and stream piracy been considered?

BASIS

° The climatic model developed for the Yucca Mountain area should correspond/correlate well with regional models of the Great Basin, but, in addition, the model also needs to evaluate local variables in order to provide an understanding of the history of erosion and deposition at the site.

RECOMMENDATIONS

° Clarify statements in Section 8.3.1.5.1.4 that imply that if preliminary climatic responses at Yucca Mountain are synchronous with those of the rest of the Great Basin, the study will be complete.

° Even if the climatic responses at Yucca Mountain are synchronous with those of the Great Basin, effects of local variables will need to be considered (Purcell, 1986).

REFERENCE

Purcell, C.R., 1986, Potential erosion at the Yucca Mountain nuclear waste site: letter report from LLNL to NRC.

REVIEW GUIDES

4.3.1, 4.3.2, 4.3.4, 4.3.15, 4.3.18

Section 8.3.1.6 Erosion

QUESTION 19

What is the source for hillslope erosion rates (page 8.3.1.6-7) and attendant uncertainties? Explain.

BASIS

° Substantiation of average downwasting rates over the last 1 to 5 million years should be provided.

RECOMMENDATIONS

° Reference the sources of long-term average upland and hillslope erosion rates of the southern Great Basin.

° Provide appropriate references to substantiate the discussion of average downwasting rates over the last 1 to 5 million years.

REVIEW GUIDES

4.3.1, 4.3.2, 4.3.4, 4.3.15, 4.3.18

Section 8.3.1.8 Postclosure Tectonics, p. 8.3.1.8-36

QUESTION 20

What is the basis for statements made in 8.3.1.8.1 about the migration of and structural boundaries to volcanism in the Yucca Mountain area?

BASIS

- The probability of the products of volcanic activity intersecting the repository or the controlled area in such a manner as to affect isolation is a concern at Yucca Mountain (p. 8.3.1.8-102).
- No references to a southwestward migration of volcanism are present in Sections 1.3.1.1.2, 1.5.1.2.1, 1.5.1.2.2, or 1.5.1.2.3.
- Dates and locations supplied in Table 1-6, Characteristics of Basaltic Volcanism Fields in the Yucca Mountain area, do not appear to support a southwestward migration of basaltic volcanism.
- On Page 1-202, a statement is made that indicates that the temporal and spatial patterns of volcanism in the Death Valley-Pancake Range zone are not well defined.
- No evidence is found in Chapter 1 that supports the preliminary conclusion that the Bare Mountain fault is no longer a structural boundary for the localization of basaltic activity.

RECOMMENDATION

- Statements/interpretations pertaining to volcanism should be fully supported.

REVIEW GUIDE

4.3.4

Section 8.3.1.8.3 Investigation: Studies to provide information required on changes in unsaturated and saturated zone hydrology due to tectonic events (p. 8.3.1.8-61)

QUESTION 21

- The CDSCP states that initiating events considered in investigation 8.3.1.8.3 "probably will have no significant impact on respository performance because of the very low rates at which the related tectonic processes operate at Yucca Mountain." What is the basis for this low level of effort with respect to assessment of initiating events?

BASIS

- Significant effects on the groundwater regime have been observed to occur during earthquakes of the size and type anticipated at the proposed Yucca Mountain HLW repository vicinity.

- These effects, which have lasted up to several months in some cases, could possibly adversely affect the capability of the underground facility to limit the release of radionuclides.

RECOMMENDATION

- A higher level of effort for activities concerning earthquakes and faulting than the level of effort for activities concerning tectonic processes such as uplift, subsidence, and folding should be considered.

REVIEW GUIDES

4.3.3, 4.3.4, 4.3.16

Section 8.3.1.8.3.1.5 Activity: Assessment of the effects of faulting on flux rates and Section 8.3.1.8.3.2.6 Activity: Assessment of the effect of faulting on water-table elevation (p. 8.3.1.8-73 and p. 8.3.1.8-83)

QUESTION 22

What is the basis for considering that significantly large, or significant cumulative, offsets are those offsets that are greater than two meters?

BASIS

- According to studies by Bonilla et al (1984), an average displacement of one meter is the equivalent of a magnitude 7 earthquake in western North America.

- Earthquakes of magnitude 7 may have a significant effect on flux rates and water-table elevation.

RECOMMENDATION

- Justification of the significance criteria of two meters should be provided.

REFERENCE

Bonilla, M.G., Mark, R.K., and Lienkaemper, J.J., 1984, Statistical Relations Among Earthquake Magnitude, Surface Rupture Length, and Surface Fault Displacement: Bulletin of the Seismological Society of America, vol. 74, no. 6, p. 2379-2411.

REVIEW GUIDES

4.3.3, 4.3.4, 4.3.16

QUESTION 23 OF DRAFT POINT PAPERS DELETED

Section 8.3.1.12.2.1.1 Activity: Site Meteorological Monitoring Program

QUESTION 24

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

BASIS

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

RECOMMENDATION

- Provide justification for the number and location of stations to be included in the network.

REVIEW GUIDE

4.3.18

Section 8.3.1.13.2.4 Activity: Evaluate the impact of ground motion from nuclear testing activities at the NTS, pg. 8.3.1.13-13

QUESTION 25

What methods will be used to determine whether there is any impact of ground motion from underground nuclear explosions on repository design?

BASIS

- The only statement in this section related to evaluation of the impact of ground motion from nuclear testing is: "This activity is addressed in the resolution of Investigation 8.3.1.17.3." However, the referenced investigation relates only to determining vibratory ground motion. The impact of ground motion is discussed in Section 8.3.2.1.4.1.2, Seismic analysis. Item 5 on page 8.3.2.1-25 states that "Ground motion at any point in the repository horizon will be analyzed to determine its effect on the state of stress and deformation, and the stability of underground openings." Analysis methods are not discussed.

RECOMMENDATION

- The SCP should evaluate whether or not existing methods can be used or modified to evaluate whether there is any impact of vibratory ground motion from underground nuclear explosions on repository design.

REVIEW GUIDE

4.3.20

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

QUESTION 26

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

BASIS

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

RECOMMENDATION

° The heated block test should be used primarily for constitutive model development or confirmation. Model validation needs to include comparison to excavation-scale problems.

REVIEW GUIDE

4.3.20

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

QUESTION 27

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

BASIS

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

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

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

RECOMMENDATION

- The proposed investigations, including large-scale in situ rock mass strength experiments, should be analyzed and discussed from an applications point of view. The need for these investigations should be adequately justified in the SCP.

REVIEW GUIDE

4.3.20

Section 8.3.1.16.1.1 Site Flood And Debris Hazard Studies

QUESTION 28

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

BASIS

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

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

RECOMMENDATION

- The proposed field evaluation of debris-flow hazard should be augmented by other methods of evaluation. Laboratory modeling should simulate susceptibility to site-specific debris movement for Yucca Mountain using maximum precipitation (PMP) conditions.

REFERENCE

Campbell, Russell H., Soil slips, debris flows and rainstorms in the Santa Monica Mountain and vicinity, Southern California, U.S. Geologic Survey professional paper 851, 1975.

REVIEW GUIDES

4.3.15, 4.2.3, 4.3.1

Section 8.3.1.17 Preclosure Tectonics

QUESTION 29

How will studies of rock varnish dating be integrated with other data for site characterization?

BASIS

- The use of rock varnish dating is not tied to other studies in the CDSCP.
- Rock varnish dating is a viable instrument to aid in determining the age of a surface. However, it should be used in conjunction with various other parameters, such as degree of dissection, desert pavement development, and soil profile development.

RECOMMENDATION

- The SCP should include how the desert varnish data will be combined with other data developed during the site characterization process and refer to the appropriate sections of the SCP to show the plans to develop other data that should be combined with the rock varnish dates to provide a final interpretive picture of geomorphic surfaces.

REVIEW GUIDE

4.3.4

QUESTION 30 OF DRAFT POINT PAPERS DELETED

Section 8.3.1.17.3.1.1 Activity: Identify relevant earthquake sources (p. 8.3.1.17-61)

QUESTION 31

What is the process used to develop the example of a conceptual approach to determining relevancy criteria and what is the basis for it?

BASIS

- The adverse conditions described in §60.122(c) concerning earthquakes all require a consideration of which earthquakes are relevant to the condition described.
- The relevancy criteria illustrated appears to depend upon source distance and 10,000-year cumulative slip earthquake magnitude.
- If a commonly used attenuation relationship such as that of Campbell (1981) is applied to various points along the line defining the relevancy limit (Fig. 8.3.1.17-6), the resulting values of peak ground acceleration, estimated at the mean plus one standard deviation, range from nearly 0.7g at one kilometer from the site to 0.12g at one hundred kilometers distance.
- Additional parameters or a significantly different attenuation relationship apparently were incorporated into the relevancy criteria example.

RECOMMENDATION

- Even though the material presented is meant to represent one conceptual approach to the development of relevancy criteria, further explanation of the processes that established the minimum threshold magnitude, the 3-kilometer distance criterion for choosing between the magnitude models, and the magnitude-distance relationship for sources beyond three kilometers, would help to clarify intended procedures for defining the actual relevancy criteria to be used in site characterization.

REFERENCE

Campbell, K.W., 1981, Near-Source Attenuation of Peak Horizontal Acceleration: Bulletin of the Seismological Society of America, vol. 71, no. 6, p. 2039-2070.

REVIEW GUIDES

4.3.3, 4.3.4

Section 8.3.1.17.3.4 Study: Effects of local site geology on surface and subsurface motions. (p. 8.3.1.17-66)

QUESTION 32

How will the data obtained from instrumental recordings of ground motion described in Sections 8.3.1.17.3.4.1 and 8.3.1.17.4.2 be sufficient to meet the objectives of this study? Explain.

BASIS

- The provisions of §60.122(c)(14) require an investigation into the degree to which the local effects of an earthquake compare with those typical of the area in which the geologic setting is located.

- The objective of this study is to develop local correction factors for ground motion with respect to regional values by comparing ground motion parameters obtained from a more densely-spaced network of seismic instruments in the site area with those from a less densely-spaced regional network.

- The parameters listed under Activity 8.3.1.17.4.1.2 that are applicable to the determination of local correction factors, such as peak ground acceleration and velocities, durations, and spectral amplitudes, will only be compiled for the larger (M greater than or equal to 5.5) earthquakes. Since earthquakes of this size are not common in the Yucca Mountain vicinity, considering the period of time alloted for characterization of the site, no regional data may be collected except for data from underground nuclear explosions.

- From the descriptions presented in Sections 8.3.1.17.3.4.1 and 8.3.1.17.4.1.2 the local array of seismic instruments in the Yucca Mountain vicinity could consist of as few as three surface and two downhole instruments, located chiefly in Midway Valley.

RECOMMENDATIONS

- Appropriate data should be determined for earthquakes of lower magnitude than that proposed in order that a sufficient body of data for local-regional comparisons can be made.

- The local array of seismic instruments should be more extensive and include sites both on the surface above the proposed underground facility and within the exploratory shaft and drifts, as well as surface and borehole sites in the proposed surface facility area in Midway Valley.

REVIEW GUIDE

4.3.3

Section 8.3.1.17.4.3.1 Activity: Conduct and evaluate deep geophysical surveys in an East-West transect crossing the Furnace Creek fault zone, Yucca Mountain, and the Walker Lane.

Section 8.3.1.4.3.1 Rock Characteristics

QUESTION 33

In tables 8.3.1.4-4, 8.3.1.17-7, and 8.3.1.17-8, it is indicated in several places that the decision to proceed with the surveys will be made after evaluation of preliminary tests. If some survey methods are not implemented, what are the alternatives? Explain.

BASIS

- Tables 8.3.1.4-4, 8.3.1.17-7, and 8.3.17-8 are not specific as to which planned exploration programs will be implemented.
- The CDSCP states that "...as many as 15 seismic reflection profiles may be performed..." (Page 8.3.1.4-46).
- Geophysical methods mentioned in the CDSCP are pertinent to the site characterization. If these methods are not implemented, complete characterization of the site may be lacking.

RECOMMENDATIONS

- The SCP should clearly state the program of exploration which will be performed.
- Programs which may not be performed, or will only be performed under certain conditions should be clearly identified.
- Contingencies to gather data if the primary technique is not implemented need to be described.
- Geophysical programs should be integrated with planned drilling programs.

REVIEW GUIDES

4.3.6.2, 4.3.6.3

Section 8.3.2.2.3 Information Need 1.11.3, Product 1.11.3-4: Drainage and moisture control plan (pg. 8.3.2.2-54)

QUESTION 34

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

BASIS

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

RECOMMENDATION

- The SCP should provide for adequate interaction between Information Need 1.11.3 and Issue 1.12 (Sealing).

REVIEW GUIDE

4.3.20

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

QUESTION 35

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

BASIS

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

RECOMMENDATION

- The SCP should specify where the referenced information is given. Where appropriate, it should be recognized that specific data requirements may not have been developed fully.

REVIEW GUIDE

4.3.20

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

QUESTION 36

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

BASIS

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

RECOMMENDATION

° The SCP should identify specific excavation criteria and the data requirements for excavation.

REVIEW GUIDE

4.3.20

Section 8.3.2.3 Table 8.3.2.3-3 Parameters required for Issue 2.7 (radiological safety), pg. 8.3.2.3-30

QUESTION 37

Some concerns exist as to whether the list of parameters for performance goal C2 (rock radiation shielding) given on pg. 8.3.2.3-30 is comprehensive. For example, does the expected pre-emplacement saturation value of 65% represent the expected post-emplacement saturation value?

BASIS

- Particularly for vertical emplacement, given the proximity of the package to the floor, the influence of vertical jointing and of a damaged rock zone around the emplacement drift might need to be considered. It is unlikely that a 65% saturation will be maintained in this zone.

RECOMMENDATION

- The SCP should evaluate whether all aspects that might influence rock radiation shielding have been considered.

REVIEW GUIDE

4.3.20

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

QUESTION 38

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

BASIS

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

RECOMMENDATION

° Consistency should be assured among various SCP sections that discuss excavation technology to be considered.

REVIEW GUIDE

4.3.20

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

QUESTION 39

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

BASIS

- Pg. 8.3.2.4-13 limits air velocities to less than 1,500 ft/min (supply) and less than 2,500 ft/min (return). On the other hand, pg. 8.3.2.5-23 limits air velocities to less than 2,000 ft/min (both supply and return).

- According to pg. 8.3.2.5-23 no site characterization data is required for ventilation routing. However, according to Section 8.3.2.4.1.2, Design activity to verify air quality and ventilation (pg. 8.3.2.4-30), parameters needed to properly design the ventilating system include wall roughness, in situ moisture, formation gas, dust generation, etc.

RECOMMENDATION

- Discrepancies among these sections should be either reconciled or the differences should be explained.

REVIEW GUIDE

4.3.20

Section 8.3.2.5 Table 8.3.2.5-5 Preliminary performance allocation for System Element 1.2.1.3, borehole construction, pg. 8.3.2.5-24

QUESTION 40

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

BASIS

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

RECOMMENDATION

- The SCP should provide justification for the statement referenced above.

REVIEW GUIDE

4.3.20

Section 8.3.3.2 Issue Resolution Strategy for Issue 1.12, pg. 8.3.3.2-6/26

QUESTION 41

There are many inconsistencies in this section when compared with the details given in other sections of the CDSCP and reference documents. What are the potential impacts of such inconsistencies?

BASIS

A few examples of the inconsistencies are as follows:

- It appears that the seal design performance analysis may have been based on four holes (Fernandez et al., 1987, pg. 3.23), while the CDSCP implies the presence of five holes (pg. 8.3.3.2-6). A more fundamental inconsistency is that the borehole seal design requirements are based on existing holes only, and do not consider the relatively large number of additional holes to be drilled during further site characterization.

- Performance goals in CDSCP page 8.3.3.2-30, first paragraph, last sentence and Fernandez et al., 1987, pg. 6-3.

- CDSCP Table 8.3.3.2-5, page 8.3.3.2-26 indicates that the design basis performance goal for shafts and ramps for the first 400 years is 0 m^3/year. CDSCP Table 8.3.3.2-1, page 8.3.3.2-8, Item 1 shows that the tentative design goal would be 1,700 m^3/year from 0 to 500 years. Item 3 shows that the tentative design goal for quantity of surface and subsurface water to inflow through the station plugs would be 1,000 m^3/year from 0 to 500 years.

RECOMMENDATION

- The CDSCP should be reviewed to remove inconsistencies between referenced sections and documents. When referenced analyses have been performed based on information which differs from current information (e.g., as presented in the CDSCP), it is recommended that the analyses be updated, or, as a minimum, that the possible implications of such changes be discussed.

REVIEW GUIDE

4.3.21

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

QUESTION 42

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

BASIS

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

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

  In Underground facility sealing components - fault seals.

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

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

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

RECOMMENDATION

- The SCP should clarify the items included in Table 8.3.3.2-1 in more detail and explain why certain items are not included in the said Table.

REVIEW GUIDE

4.3.21

Section 8.3.5.5.1 Information Need 2.3.1: Determination of credible accident sequences and their respective frequencies applicable to the repository

QUESTION 43

The magnitude of the dose to members of the public during accident conditions (and consequently the Q-list) is highly dependent upon the numbers of fuel assemblies (or waste canisters) assumed to be breached in those accidents. What are the bases for the assumed numbers of breached assemblies or canisters?

BASIS

- As indicated in paragraph 2, page 5-16, Section 5.1.3 of the CDR, Fuel Pellet and HLW Glass Pulverization Factors: "Estimating the airborne source term from impact accidents is a major requirement in performing realistic dose assessment calculations."

- As indicated in equations 5.18 and 5.22, pages 5-48 and 5-49, Section 5.3 of the CDR, Approach for Event Tree Scenario Quantifications, the magnitude of the dose (to both workers and to the public) is directly proportional to the number of fuel assemblies and high-level waste canisters that are assumed to be breached.

- Dose is also used to determine those structures, systems and components important to safety in accordance with 10 CFR Part 60.2.

RECOMMENDATION

- The SCP should provide a rationale for the numbers of fuel assemblies (or waste canisters) breached in the accidents considered.

REFERENCE

H. R. MacDougall, L. W. Scully,and J. R. Tillerson, "Nevada Nuclear Waste Storage Investigations Project, Site Characterization Plan Conceptual Design Report", SAND84-2641, Volume 4, Appendix F, September 1987: Section 6.1.2.1 (page 6.1) General Assumptions and Discussions.

REVIEW GUIDES

4.2.4.10, 4.3.23, 4.3.30

Section 8.3.5.5.1 Information Need 2.3.1: Determination of credible accident sequences and their respective frequencies applicable to the repository

QUESTION 44

The CDSCP does not identify whether additional data are needed to establish particulate source terms for the waste package, particulate retention factors by containing vessels, or plateout or gravitational settlement factors for the geologic repository operations area during accident conditions in the preclosure phase. What investigations are planned?

BASIS

- Several statements in Sections 5.1.2-5.1.5 of the CDR seem to indicate that better bases for waste package source terms and releases from the geologic repository operations area are needed.

- The CDSCP does not discuss the need for investigations to characterize the magnitude (or particle sizes) of radionuclides that could be released from the waste package when subjected to impacts (such as a crane falling on a fuel assembly) nor does it discuss the need for investigations to develop realistic radionuclide retention fractions for containment systems and structures.

RECOMMENDATIONS

- The SCP should address existing information on the source terms for the waste package and plateout and retention factors for the geologic repository operations area in the preclosure phase in terms of the need for additional information (e.g. data gathering, models, etc.) to be obtained during site characterization.

- If new information is to be obtained, the investigations should be discussed.

REFERENCES

H. R. MacDougall, L. W. Scully,and J. R. Tillerson, "Nevada Nuclear Waste Storage Investigations Project, Site Characterization Plan Conceptual Design Report", SAND84-2641, Volume 4, Appendix F, September 1987: Section 5.1.2 Release Factors for Gap Radioactivity; Section 5.1.3 Fuel Pellet and HLW Glass Pulverization Factors; Section 5.1.4 Particulate Retention Factors for Fuel Cladding, Casks, DHLW Canisters, and Waste Disposal Containers; Section 5.1.5 Particulate Retention Factors by Building and Hot Cells.

P. A. Haris, D. M. Ligon, and M. G. Stamatelatos, GA Technologies, Inc., "High-Level Waste Preclosure Systems Safety Analysis, Phase I, Final Report," USNRC Report NUREG/CR-4303 (July 1985).

REVIEW GUIDES

4.2.4.6, 4.2.4.10

Section 8.3.5.9.2.3.2 Subactivities 1.4.2.3.2. - 1.4.2.3.9. Laboratory Test Plan for Austenitic Materials

QUESTION 45

The experimental approach for each possible degradation mode to be tested should be designed and evaluated prior to testing. How will "more severe" environments be identified and proven to be "more severe" for a given failure mode?

BASIS

- Since the design of an experiment can influence the outcome, each experiment should be thoroughly evaluated as to its appropriateness for testing a possible failure mode or for yielding information for use in a given model.

- Various investigators will disagree as to the value of experimental designs, and their differences need to be considered and then resolved or accommodated.

- The relative severities of environments can be difficult to evaluate and quantify. Proving that a given environment is "more severe" may become difficult.

RECOMMENDATION

- A procedure should be established to evaluate the appropriateness of test conditions so as to establish whether the test can be used in (1) evaluation of a possible failure mode, or (2) providing information to be used in a model and (3) for identifying and justifying "more severe" environments for a given failure mode.

REFERENCES

As stated in Review Guide 4.3.25

REVIEW GUIDE

4.3.25

Section 8.3.5.13 Total System Performance (pages 100-103 and elsewhere)

QUESTION 46

The methodology to be used to develop a CCDF is unclear; in particular, how will scenario class probabilities be evaluated and accounted for in developing the CCDF?

BASIS

- Used as evidence of compliance with the total system performance standard, the CCDF must show the total probability of exceeding various levels of cumulative radionuclide releases over 10,000 years.
- To do so, scenario class probabilities must ultimately be used in combination with scenario class release estimates in assessing release probabilities (Hunter et al., 1986).
- Section 8.3.5.13.5 of the CDSCP, concerning the information needs and activities for probabilistic scenario class release estimates, does not discuss the evaluation or use of scenario class probabilities in developing the CCDF.
- On the other hand, elsewhere in Section 8.3.5.13, it is indicated that the partial performance measures being generated for each scenario class will incorporate the scenario class probability.
- It is unclear how a CCDF can be calculated on the basis of partial performance measures alone.

RECOMMENDATIONS

- Various parts of Section 8.3.5.13 (e.g., Section 8.3.5.13.5, pages 100-103) dealing with development of the CCDF need to be greatly clarified, perhaps by including discussions of simple examples.
- In particular, one or more sections on probability should be developed that include (1) a statement of why probabilities are needed, (2) a description of what probabilities are needed (i.e., for which events and processes), (3) an explanation of how the probabilities will be used, (4) a description of what technique(s) will be used to estimate probabilities of events and processes, (5) the criteria required for the use of each technique, (6) alternative approaches for estimating probabilities when little or no data are available, and (7) consideration of how uncertainties in the scenario probabilities will be incorporated in the CCDF.

REFERENCE

R. L. Hunter, R. M. Cranwell, and M. S. Y. Chu, "Assessing Compliance with the EPA High-Level Waste Standard: an Overview", USNRC Report NUREG/CR-4510, 1986.

REVIEW GUIDES

4.2.4.3, 4.2.4.9

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

Overview of the performance assessments for this issue

3. Technical discussion of the release-scenario classes

Nominal case (E): gas-phase releases

QUESTION 47

What assessments have been done to show that the vapor pressure of iodine will be low enough such that gaseous iodine cannot be formed in the repository system and transported in the vapor phase to the accessible environment?

BASIS

- The CDSCP states that the transport of gaseous iodine will not be a concern because iodine is extremely reactive and likely to be released in a liquid or solid phase.

- Section 7.4.3.1.1, Spent fuel dissolution studies, however, suggests that iodine could have been lost to the air during spent fuel dissolution testing.

RECOMMENDATION

- The SCP should further substantiate the basis for eliminating iodine as an important radionuclide which can be transported in the gaseous phase.

REFERENCE

Binnall, E. P., S. M. Benson, L. Tsao, H. A. Wollenberg, T. K. Tokunaga, and E. M. Didwall, 1987, Critical parameters for a high-level waste repository, volume 2: tuff, NUREG/CR-4161, UCID-20092, volume. 2, p. 68.

REVIEW GUIDES

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

Section 8.4: Planned Site Preparation Activities

QUESTION 48

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

BASIS

A few examples of inconsistencies are as follows:

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

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

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

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

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

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

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

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

RECOMMENDATION

- The CDSCP should be thoroughly reviewed to remove inconsistencies between referenced sections and documents. Possible implications of such inconsistencies should be evaluated and results incorporated in the SCP.

REFERENCES

Fernandez, J.A., P.C. Kelsall, J.B. Case, and D. Meyer, 1987, "Technical Basis for Performance Goals, Design Requirements, and Material Recommendations for the NNWSI Repository Sealing Program," SAND 84-1895.

NRC, 1985, NRC Comments on DOE Draft Environmental Assessment for the Yucca Mountain site, March 20.

REVIEW GUIDE

4.2.5

Section 8.3.1.4.1.1.1 Activity: Develop a Position on Drilling Within the Boundaries of the Repository Perimeter Draft, p. 8.3.1.4-24

QUESTION 49

Site characterization investigations should be planned based on the total area that may be needed for repository development. Is this the case for the drilling program laid out in the CDSCP?

BASIS

The development of a proposed position on drilling references the area within the boundary of the repository perimeter drift shown in CDSCP Figure 8.3.1.4-2 (page 8.3.1.4-23). The CDSCP states that the area needed for repository development is judged to be 1,420 ± 210 acres, based on uncertainty in the aerial power density of 40 to 80 kw/acre (page 6-226). Furthermore, as much as 300 additional acres may be needed to ensure availability of adequate area for contingency (page 6-227). Therefore, the final repository may encompass up to 1,930 acres. It is not specified in the CDSCP how much area is contained within the repository perimeter drift shown in Figure 8.3.1.4-2.

RECOMMENDATION

The SCP should consider the total area requirement, including the area required for adequate flexibility in repository development, in planning the site investigation program.

Section 8.3.1.4.3.1.1 Activity: Systematic Drilling Program, pp. 8.3.1.4-89 to 8.3.1.4-95

QUESTION 50

It is difficult to tell from various depictions in the CDSCP what are the actual boundaries of the area that may be involved in repository development and that therefore may need to be characterized intensively. What are these actual boundaries?

BASIS

Figure 6-88 presents an outline of the "revised usable portion of the primary area and expansion areas." Figure 8.3.1.4-2, Figure 1-71, and others depict the "repository perimeter drift." The outlines of the figures do not appear to be the same.

RECOMMENDATION

There should be one figure in the SCP clearly delineating the boundaries of the area that needs to be characterized intensively.

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

QUESTION 51

Which activity in Table 8.3.1.15-1 is planned to investigate the effects of radiation on thermal and mechanical rock properties?

BASIS

- The CDSCP (page 6-206) states that "the effects of radiation on thermal and mechanical rock properties have been identified as needed information in issue 4.4." However, the activity planned to investigate this information does not appear to have been included in the CDSCP.

RECOMMENDATION

The SCP should clarify how the effects of radiation on thermal and mechanical rock properties will be investigated.

Section 8.3.5 Performance Assessment Program

QUESTION 52

How will performance assessment be integrated into the site characterization program?

BASIS

- The NRC staff considers performance assessment as a process that should be done iteratively throughout site characterization to aid in understanding the regulatory value of data collected, to assist in focusing the site characterization program on key areas of uncertainty, and to refine models as data are collected.

- In addition to its use as a primary tool in evaluating compliance with the numerical criteria of 10 CFR Part 60, performance assessment should be used in directing site characterization activities, in identifying important processes and parameters, and in assisting in development of conceptual models.

- Performance assessment models must be based on a sound understanding of the physical, chemical, and biological phenomena involved, must reflect gains in knowledge resulting from site characterization programs, and must employ data that are as representative of actual in situ conditions as is practicable to obtain. Also, site characterization programs should be directly linked to the data needs of models and computer codes.

- The CDSCP does not address the issue of how performance assessment has been integrated into the site characterization program.

RECOMMENDATION

- Include one or more sections in Chapter 8 of the SCP that describe how performance assessment will be integrated into the site characterization program.

REVIEW GUIDES

4.2.2, 4.2.4