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U.S. DEPARTMENT OF ENERGY

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YUCCA MOUNTAIN

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

# Report of the Peer Review Panel on the Early Site Suitability Evaluation of the Potential Repository Site at Yucca Mountain, Nevada

January 1992

Technical & Management Support Services

CONTRACT NO. DE-AC08-87NV10576

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# REPORT OF THE PEER REVIEW PANEL ON THE EARLY SITE SUITABILITY EVALUATION OF THE POTENTIAL REPOSITORY SITE AT YUCCA MOUNTAIN, NEVADA

JANUARY 1992


CORE TEAM MEMBERS

JEAN L. YOUNKER, WILLIAM B. ANDREWS, GREGORY A. FASANO, STEVEN R. MATTSON, ROBERT C. MURRAY, Science Applications International Corporation, Las Vegas, NV; LYNDEN B. BALLOU, MICHAEL A. REVELLI, Lawrence Livermore National Laboratory, Livermore, CA; ARTHUR R. DUCHARME, LES E. SHEPHARD, Sandia National Laboratories, Albuquerque, NM; WILLIAM W. DUDLEY, DWIGHT T. HOXIE, U.S. Geological Survey, Denver, CO; RICHARD J. HERBST, EDWARD A. PATERA, Los Alamos National Laboratory, Los Alamos, NM; BRUCE R. JUDD, Decision Analysis Company, Portola Valley, CA; JANET A. DOCKA, LARRY D. RICKERTSEN, Weston Technical Associates, Washington, DC; Assisted by: JEREMY M. BOAK, Yucca Mountain site Characterization Project Office, U.S. Department of Energy, Las Vegas, NV; JANE R. STOCKEY, Office of Geologic Disposal, U.S. Department of Energy, Washington, DC.

PEER REVIEW PANEL

STAN L. ALBRECHT, Brigham Young University, Provo, UT; WALTER J. ARABASZ, University of Utah, Salt Lake City, UT; JOHN H. BELL, University of Nevada, Las Vegas, NV; F. WILLIAM CAMBRAY, Michigan State University, East Lansing, MI; STEVEN W. CAROTHERS, SWCA, INC. Environmental Consultants, Flagstaff, AZ; JAMES I. DREVER, University of Wyoming, Laramie, WY; MARCO T. EINAUDI, Stanford University, Palo Alto, CA; DON E. FRENCH, Billings, MT; KIP V. HODGES, Massachusetts Institute of Technology, Cambridge, MA; ROBERT H. JONES, Los Gatos, CA; DAVID K. KREAMER, University of Nevada, Las Vegas, NV; WILLIAM G. PARISEAU, University of Utah, Salt Lake City, UT; THOMAS A. VOGEL, Michigan State University, East Lansing, MI; THOMPSON WEBB III, Brown University, Providence, RI.



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# INTRODUCTION

The U.S. Department of Energy (DOE) Yucca Mountain Site Characterization Project Office (YMPO) assigned Science Applications International Corporation (SAIC), the Technical and Management Support Services (T&MSS) contractor to the YMPO, the task of conducting an Early Site Suitability Evaluation (ESSE) of the Yucca Mountain site as a potential site for a high-level radioactive waste repository. First, the assignment called for the development of a method to evaluate a single site against the DOE General Guidelines for Recommendation of Sites for Nuclear Waste Repositories, 10 CFR Part 960. Then, using this method, an evaluation team, the ESSE Core Team, of senior YMP scientists, engineers, and technical experts, evaluated new information obtained about the site since publication of the final Environmental Assessment (DOE, 1986) to determine if new suitability/unsuitability findings could be recommended. The Core Team members are identified in Table 1. Finally, the Core Team identified further information and analyses needed to make final determinations for each of the guidelines. The results of these efforts are contained in a companion document: "The Report of Early Site Suitability Evaluation of the Potential Repository Site at Yucca Mountain, Nevada" (Younker et al., 1992).

As part of the task, an independent peer review of the ESSE report has been conducted. Expertise was solicited that covered the entire spectrum of siting guidelines in 10 CFR Part 960 in order to provide a complete, in-depth critical review of the data evaluated and cited in the ESSE report, the methods used to evaluate the data, and the conclusions and recommendations offered by the report. Fourteen nationally recognized technical experts (Table 2) served on the Peer Review Panel. The comments from the Panel and the responses prepared by the ESSE Core Team, documented on formal Comment Response Forms, constitute the body of this document.

## DIRECTION FOR THE ESSE PEER REVIEW

In his 1989 report to Congress, the Secretary of the U.S. Department of Energy committed to evaluate the suitability of the potential site for a high-level radioactive waste repository by focusing on a search for features that could indicate if the site is not suitable. Responding to this commitment, an activity plan (DOE, 1991a) was prepared under guidance from the Director, DOE Office of Civilian Radioactive Waste Management (OCRWM), to the Associate Director, Office of Geologic Disposal (OGD), to develop a general approach for evaluating site suitability.

The OGD activity plan described the background, defined the organization and management, and developed a general work plan for the task. The work plan described the nature of the work to be done and set forth strategies for developing the method and for conducting the evaluation. The strategy for preparing the ESSE included submitting the ESSE report to external peer review and revising the report based on the review comments.

In response to instructions from the Associate Director, OGD, to the T&MSS Project Manager, the ESSE Task Manager prepared an implementation plan (T&MSS, 1991a). The T&MSS implementation plan described the scope, schedule, and

Table 1. Members of Core Team for Early Site Suitability Evaluation

| Name | Organization | Guideline Evaluation/ Area of Expertise |
|---|---|---|
| | VOTING CORE TEAM MEMBERS | |
| Jean L. Younker | Technical & Management Support Services (T&MSS) | Team Lead |
| Lynden B. Ballou; Michael A. Revelli | Lawrence Livermore National Laboratory | Postclosure Rock Characteristics |
| William W. Dudley | United States Geological Survey | Postclosure Tectonics<br>Erosion<br>Surface Characteristics |
| Dwight T. Hoxie | United States Geological Survey | Climatic Change |
| Richard J. Herbst; Edward A. Patera | Los Alamos National Laboratory | Geochemistry<br>Dissolution<br>Preclosure Rock Characteristics |
| Larry D. Rickertsen; Janet A. Docka | Weston Technical Support Team | Postclosure System<br>Ease and Cost System Guideline |
| Arthur R. DuCharme | Sandia National Laboratories | Preclosure Hydrology<br>Preclosure Tectonics |
| Les E. Shephard | Sandia National Laboratories | Postclosure Geohydrology |
| Steven R. Mattson | T&MSS | Natural Resources |
| William B. Andrews | T&MSS | Transportation<br>Offsite Installations & Operations |
| Gregory A. Fasano | T&MSS | Preclosure Radiological Safety<br>Environmental Quality<br>Socioeconomic Impacts<br>Population Density<br>Meteorology<br>Site Ownership & Control |
| C. Charles Herrington | T&MSS | Licensing |

Table 1. Members of Core Team for Early Site Suitability Evaluation (continued)

| Name | Organization | Guideline Evaluation/ Area of Expertise |
|---|---|---|
| | VOTING CORE TEAM MEMBERS (continued) | |
| Robert C. Murray | T&MSS | General Geology and Deputy Team Lead |
| | OTHER NONVOTING PARTICIPANTS AND OBSERVERS | |
| Bruce R. Judd | Decision Analysis Company | Decision Analysis |
| John F. Lathrop | Strategic Insights | Decision Analysis |
| K. Michael Cline | Woodward-Clyde Federal Services | Tectonics |
| Jeremy M. Boak; Jane R. Stockey | Office of Geologic Disposal | U.S. Department of Energy Observers |

funding necessary to develop and execute a method for evaluating the suitability of a potential repository site against the siting guidelines in 10 CFR Part 960.

## IMPLEMENTATION OF THE PEER REVIEW

A peer review serves as a formal mechanism for incorporating expert judgment in assessing the adequacy of work performed within or for the DOE, in this case the development and application of a method for evaluating site suitability. A procedure (T&MSS, 1991b) prescribes the process for performing peer reviews of work assigned to and performed by T&MSS, including designs, plans, test procedures, research reports, materials choices, or site exploration. This procedure is consistent with the U.S. Nuclear Regulatory Commission's generic technical position on peer reviews (Altman et al., 1988).

Under the T&MSS peer review procedure, the ESSE Task Manager received approval to initiate a peer review of the ESSE report from the T&MSS Project Manager and the Manager, Site Characterization Technical Support. The Task Manager then prepared a peer review plan (T&MSS, 1991c), as required by the peer review procedure, describing the ESSE task, the scope and objectives of the review, the necessary size and composition of the peer review panel, and the

Table 2. Peer Review Panel for the Early Site Suitability Evaluation of the Potential Repository Site at Yucca Mountain, Nevada

| NAME | ORGANIZATION | SPECIALTY |
|---|---|---|
| Stan L. Albrecht | Brigham Young University<br>Provo, UT | Socioeconomics |
| Walter J. Arabasz | University of Utah<br>Salt Lake City, UT | Preclosure Tectonics |
| John H. Bell | University of Nevada<br>Las Vegas, NV | Health Physics and Radiological Safety |
| F. William Cambray | Michigan State University<br>East Lansing, MI | Structural Geology, Tectonics |
| Steven Carothers | SWCA, Inc. Environmental Consultants<br>Flagstaff, AZ | Environmental Quality |
| James Drever | University of Wyoming<br>Laramie, WY | Geochemistry |
| Marco T. Einaudi | Stanford University<br>Stanford, CA | Economic Geology |
| Don E. French | Petroleum Geologist<br>Billings, MT | Petroleum Geology |
| Kip V. Hodges | Massachusetts Institute of Technology, Cambridge, MA | Tectonics, General |
| Robert H. Jones | Hazardous Material Systems, Inc.<br>Los Gatos, CA | Transportation Impacts |
| David K. Kreamer | University of Nevada<br>Las Vegas, NV | Hydrology |
| William G. Pariseau | University of Utah<br>Salt Lake City, UT | Rock Characteristics, Engineering Geology |
| Thomas A. Vogel | Michigan State University<br>East Lansing, MI | Tectonics-Volcanology |
| Thompson Webb III | Brown University<br>Providence, RI | Climatic Change |

method and schedule for preparing the peer review report. The reviewers were asked (1) to evaluate the adequacy of the methods and results in the report and (2) to determine if it presents an objective and technically defensible view of the suitability of the Yucca Mountain site. The plan called for a minimum of 12 experts representing the spectrum of technical disciplines specified in the 10 CFR Part 960 guidelines to review the ESSE report. Figure 1 presents the schedule for conducting the peer review. It starts with the request for peer review, then moves through the assembly of the Panel to the actual review and working sessions, and, finally, to the comment response process and revision of the ESSE report.

The fourteen invitees listed on Table 2 ultimately accepted positions on the Panel. Because of the diversity of the membership of the Panel, a nonvoting Chairman was appointed by the Task Manager to organize and coordinate the review and to fulfill the responsibilities of general secretary. The Panel was divided into two informal subpanels, which separated the geotechnical experts and those concerned mainly with environmental quality, transportation, socioeconomic impacts, and radiological safety. After accepting an invitation to participate in the peer review, the members of the Panel were placed under Consultant Agreements with SAIC. The Consultant Agreements were prepared and negotiated by the T&MSS Personnel and Contract Support Department and approved by the YMP Contract Officer.

The ESSE was designated non-quality-affecting in Quality Assurance Grading Report TESS-001. However, because the results of this effort, including the peer review, will be used by the DOE in public interactions and to assess future program planning, and because they may ultimately be used in the licensing process, the task is being subjected to the full rigor of all appropriate Quality Assurance controls. The Panelists were familiarized with the purpose and intent of the YMP Quality Assurance Program and maintained current training during the peer review through reading assignments for revisions to the relevant plans and procedures. Table 3 shows the revision schedule and status of these documents.

The formal YMP records package for this review contains copies of all comment resolution documentation in accordance with appropriate procedures (T&MSS, 1991b; 1991d). The records packages also include copies of the original request for peer review, the Peer Review Plan, and all other pertinent and appropriate documentation.

## INDEPENDENCE AND TECHNICAL QUALIFICATIONS OF THE PEER REVIEW PANEL

Members of the Peer Review Panel were selected on the basis of two primary considerations: (1) their independence from the YMP and (2) their recognized technical expertise in their respective fields. Panel members were chosen mainly from university faculties so that their professional, intellectual, and political independence could be maintained throughout the review. Independent consultants were retained in instances where specific technical expertise (such as the petroleum geology of the Great Basin physiographic province) was required for a comprehensive review of information on the Yucca Mountain site. In other instances where the required expertise was genuinely unique to the high-level waste program, such as spent-fuel transportation, persons with selective prior

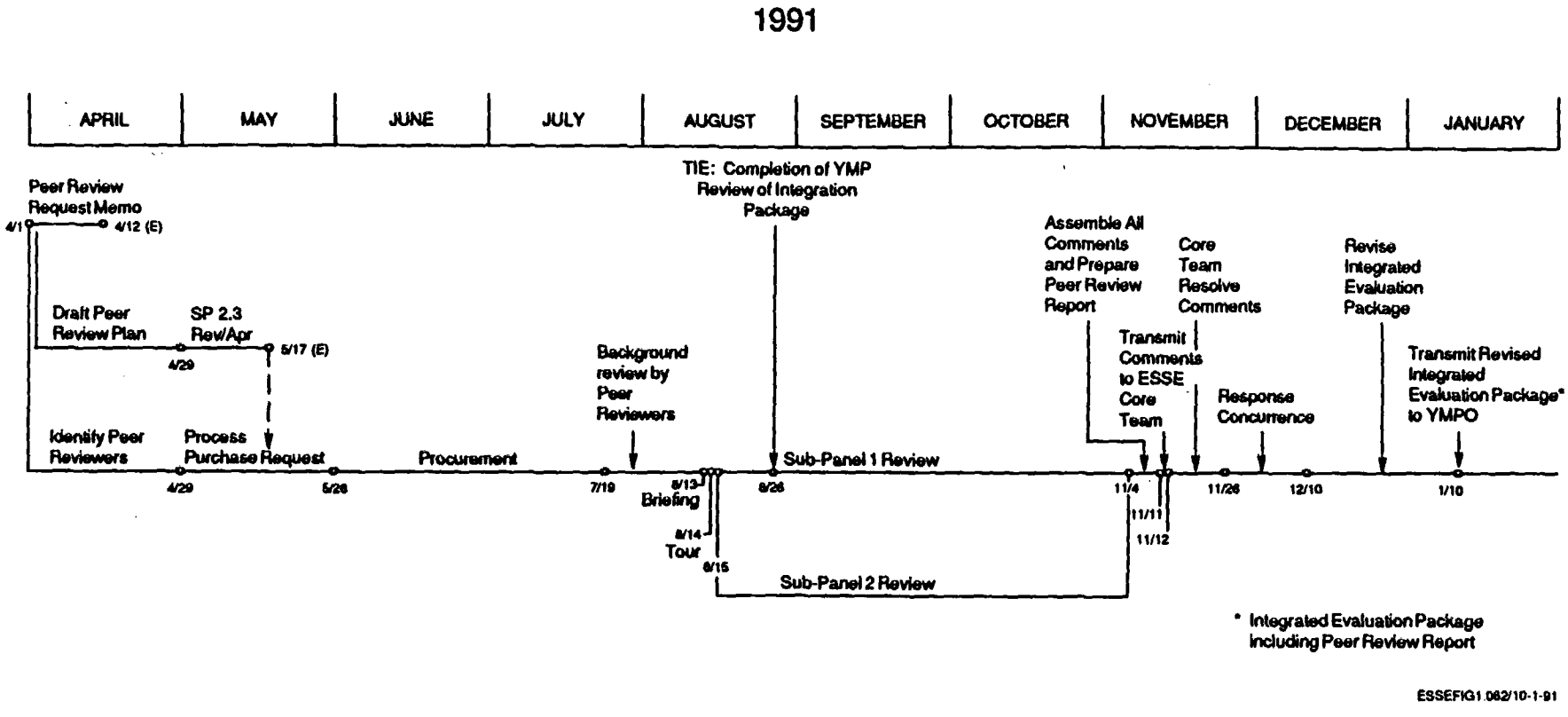


Figure 1. Early Site Suitability Evaluation (ESSE) Peer Review Schedule.

experience were asked to serve on the Panel. The technical qualifications and experience of the Panelists are documented in their resumes, which are presented in Appendix A of this report.

## PEER REVIEW WORKING SESSIONS

From August 13 to 14, 1991, the Panel convened in Las Vegas, Nevada, for working sessions with the ESSE Core Team and a tour of the Yucca Mountain site. The working sessions began with formal introductions of all those involved in the task and with overview presentations on the YMP and the high-level waste program, the development and status of the ESSE task, and the structure of the peer review. These topics were followed by brief introductions for each of the 10 CFR Part 960 guidelines by the report section authors, who reviewed the qualifying and disqualifying conditions, explained the issues with respect to the Yucca Mountain site, and provided a summary of the Core Team's evaluation. On August 14, 1991, the Core Team led the Panel on a field trip to the Yucca Mountain site to familiarize them with the site and to continue individual discussions between members of the Core Team and the Panel. Field trip stops at the top of Yucca Mountain for a regional overview, at Trench-14 (the site of the calcite-silica fault deposits), and at Midway Valley (the proposed location for the potential repository surface facilities) included explanatory talks by Core Team members and YMP scientific investigators.

During these working sessions it was explained to the Panelists that they would conduct their review under the T&MSS peer review procedure (1991b), and that the purpose of the review would be to determine whether the ESSE report presents an objective and technically defensible view of the suitability of the Yucca Mountain site. The Panelists were asked to focus their review on their respective areas of expertise, but to submit comments on any of the guidelines, as they felt appropriate. They were also asked to review the Executive Summary, Section 1 (Introduction), and Section 4 (Summary and Recommendations). During their review, the Panelists and Core Team members were encouraged to work closely together to clarify issues and to answer questions raised during the review. Copies of all the references cited in the draft ESSE report and any YMP documents were made available to the Panel upon request. Finally, the Panelists were urged to contact anyone and to request any information that they felt might help them with their review.

On August 28, 1991, the draft ESSE report was transmitted to the members of the Panel along with copies of the review procedure and the formal Comment Response Forms. Following delivery of the report, the Panelists were contacted to schedule individual meetings with Core Team members, T&MSS ESSE staff, and supporting technical experts. These meetings were held intermittently between September 9 and October 4, 1991, to discuss the text of the report, to answer questions, and to ensure that all necessary supporting information was being provided. Figure 2 shows the schedule of working sessions.

From October 23 to 24, 1991, in conjunction with the annual national meeting of the Geological Society of America, geotechnical subpanel working sessions were held in San Diego, California. A meeting of all those able to attend on October 23 was followed on October 24 by two separate discussions: one focused on seismic risk, tectonics, and rock properties and the other on geohydrology and geochemistry.

Table 3. Revisions to Peer Review Planning Documents

| Document | Document Number | Revision | Effective Date |
|---|---|---|---|
| Yucca Mountain Site Characterization Project Activity Plan for Development and Implementation of a Method for Early Evaluation of Site Suitability | YMP/91-1 | 0<br>1<br>2 | 1/31/91<br>10/3/91<br>In final signature |
| T&MSS Plan, "Implementation Plan for Developing and Implementing a Method for Early Evaluation of Site Suitability" | T&MSS/PM-91/001 | 0<br>1<br>2<br>3 | 1/30/91<br>6/13/91<br>7/31/91<br>10/17/91 |
| T&MSS Plan, "Peer Review Plan for Early Site Suitability Evaluation" | None | 0<br>1<br>2 | 6/14/91<br>8/23/91<br>10/15/91 |
| T&MSS Procedure, "Peer Review" | T&MSS SP-1.62 | 1 | 5/21/91 |

No formal subpanel working session was scheduled for the Panelists covering socioeconomic impacts, environmental quality, transportation, and radiological safety because these Panelists were concentrating on technically distinct guidelines. However, they were encouraged to communicate informally among themselves, as appropriate. Because of inevitable schedule conflicts, not all the Panelists were able to attend each of the appropriate working sessions. In these instances, special arrangements were made for them to come to Las Vegas and the Yucca Mountain site or to meet elsewhere.

## RESULTS OF THE PEER REVIEW

This peer review differed from several others conducted within the YMP in that no effort was made to reach formal consensus of the Peer Review Panel on the results and recommendations of the review. Because of the diversity of expertise needed on the Panel to provide a thorough examination of the method and substance of the 10 CFR Part 960 guideline evaluations in the ESSE report, it was determined that no comprehensive set of comments could be made in any one technical area. Numerous informal cross-disciplinary conversations occurred,

# ESSE MEETINGS
# SEPTEMBER - OCTOBER 1991

| MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY |
|---|---|---|---|---|
| 2<br>*LABOR DAY HOLIDAY* | 3 | 4 | 5 | 6 |
| 9 | 10<br>CAROTHERS (Flagstaff)<br>- Fasano - Murray | 11 | 12<br>OCRWM & EEI (DC)<br>- Younker - Murray<br>- Fogdall | 13<br>FRENCH (Billings)<br>- Mattson |
| 16<br>BELL (LV)<br>- Fasano - Andrews<br>HODGES (Cambridge)<br>- Mattson - Dudley<br>- Younker - Stockey<br>- Cline | 17<br>CAMBRAY & VOGEL (Lansing)<br>- Mattson - Dudley<br>- Murray - Younker | 18<br>KREAMER (LV)<br>- Hoxie - DuCharme<br>- Hopkins - Murray | 19 | 20<br>ARABASZ (LV)<br>- DuCharme - Cline<br>- Gibson - Younker<br>- Stockey<br>ALBRECHT (LV)<br>- Fasano - Kimble<br>- Murray |
| 23 | 24<br>DREVER (Laramie)<br>- Herbst - Canepa<br>- Murray | 25 | 26 | 27<br>WEBB (Providence)<br>- Hoxie - Murray |
| 30 | 1<br>EINAUDI (Stanford)<br>- Mattson - Stockey<br>- Younker | 2<br>JONES (Los Gatos)<br>- Andrews - Younker | 3 | 4<br>PARISEAU (SLC)<br>- Ballou - Revelli<br>- Herbst - Younker |

ESSECAL.075/1-24-92

Figure 2. Schedule of individual working sessions between Peer Review Panelists and Core Team authors and technical experts, September - October, 1991.

and common concerns arose during each of the working sessions. So, while the reviewers were free to comment on any section of the ESSE report as they felt appropriate, the comment record constituting the body of this report is largely the result of reviews by the fourteen independent technical experts. The focus of the ESSE task remains with the ESSE report itself, and the substantial points raised in this review have been incorporated into the final ESSE report.

The charter of each of the Panelists was to examine the method developed to evaluate the Yucca Mountain site against the siting guidelines in 10 CFR Part 960 and then to determine the adequacy of the technical information presented and the conclusions advanced on the basis of that information. The final ESSE report (Younker et al., 1992) has been modified on the basis of negotiated resolutions to these review comments. However, some of the responses to the comments included recommendations for future action beyond the scope of the ESSE task. These recommendations include specific commitments to modify test plans or strategies and more general commitments related to planning and decision-making by the DOE. At DOE direction, these commitments will be tracked through the appropriate administrative procedure (DOE, 1991b).

At the working sessions in San Diego, it became apparent that the geotechnical subpanel members, working independently, had identified several common concerns with the site characterization program. A brief consensus statement citing three concerns was prepared, circulated, and reviewed within the subpanel. Nine of the ten geotechnical subpanel members concurred with the statement (with one providing additional comments). The remaining panel member did not choose to participate in developing the consensus position. The statements were then submitted under signatures from each of the nine subpanel members to the ESSE Task Manager. They recommended (1) a comprehensive test prioritization to focus site characterization on determining if the site is in any way unsuitable, (2) a greater emphasis on interdisciplinary communication and coordination, and (3) a risk-based approach to quantify residual uncertainties associated with technical issues at the site. The full text of this statement is presented in Appendix B.

## NOTES ON THE CONTENTS OF THIS REPORT

The following general notes on organization, structure, and content of this report are provided to facilitate readability. The contents of this report are as follows:

- Introduction section

- Fourteen sections (one for each peer reviewer) each containing
  - Signed Comment Resolution Records
  - Formal Comment Response Forms, each containing the comment offered by the Peer Reviewer, the response developed by Core Team authors, and the comment resolution statement
  - List of references cited in comments and responses

- Appendices
  - Geotechnical Subpanel Consensus Statement
  - General Comments from Peer Reviewers
  - Resumes/Curricula Vitae for Peer Reviewers

In each of the sections containing comments offered by Peer Reviewers, the Comment Resolution Record is presented first to provide the reader with the summary concurrence/verification that the the reviewer's comments have been resolved. In reading each reviewer's section, please note that the text of a comment may continue to subsequent pages. An "END OF TEXT" statement will be found at the conclusion of each comment. Likewise, the response may continue on subsequent pages but begins after the end of the comment section. For each reviewer, a list of references cited in the text of the comments and responses is provided at the end. The page citations in these references refer to the August 1991 draft of the ESSE Report that was submitted to the Peer Review. As the ESSE Report has now been revised (Younker et al., 1992), these page citations may no longer be appropriate.

The Appendices contain the following additional materials:

- Geotechnical consensus statement (Appendix A)
- General comments (Appendix B) from some of the reviewers. (Note that the Peer Reviewers have agreed that these are general comments or opinions concerning the review and/or the program and are not submitted as comments to be resolved by the ESSE Core Team)
- Collection of resumes or curricula vitae for each of the Peer Reviewers (Appendix C)

REFERENCES

Altman, W. D., J. P. Donnelly, and J. E. Kennedy, 1988. Peer Review for High-Level Nuclear Waste Repositories, Generic Technical Position, NUREG-1297, U.S. Nuclear Regulatory Commission, Washington, DC.

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DOE (U.S. Department of Energy), 1991b. Disposition of Comments on the Site Characterization Program, Revision 1, Yucca Mountain Site Characterization Project Administrative Procedure AP-1.14, Las Vegas, NV.

T&MSS, 1991a. Implementation Plan for Developing and Implementing a Method for Early Evaluation of Site Suitability, T&MSS/PM-91/001, Yucca Mountain Site Characterization Project, Las Vegas, NV.

T&MSS, 1991b. Peer Review, Revision 1, Standard Procedure SP-1.62, Yucca Mountain Site Characterization Project, Las Vegas, NV.

T&MSS, 1991c. Peer Review Plan for Early Site Suitability Evaluation, Yucca Mountain Site Characterization Project, Las Vegas, NV.

T&MSS, 1991d. Records Management: Record Source Implementation, Revision 3, Standard Procedure SP-1.36, Yucca Mountain Site Characterization Project, Las Vegas, NV.

Younker, J. L., W. B. Andrews, G. A. Fasano, C. C. Herrington, S. R. Mattson, R. C. Murray, L. B. Ballou, M. A. Revelli, A. R. Ducharme, L. E. Shephard, W. W. Dudley, D. T. Hoxie, R. J. Herbst, E. A. Patera, B. R. Judd, J. A. Docka, and L. D. Rickertsen, 1992. Report of Early Site Suitability Evaluation of the Potential Repository Site at Yucca Mountain, Nevada, SAIC-91/8000, Las Vegas, NV.

DOE (U.S. Department of Energy), 1991a. Yucca Mountain Site Characterization Project Activity Plan for Development and Implementation of a Method for Early Evaluation of Site Suitability, YMP/91-1, Las Vegas, NV.

10 CFR Part 960 (Code of Federal Regulations), 1987. Title 10, Energy, Part 960, General Guidelines for Recommendation of Sites for Nuclear Waste Repositories, U.S. Government Printing Office, Washington, DC, pp. 518-551.

# Dr. Stan L. Albrecht

## SOCIOECONOMICS

Brigham Young University
Provo, UT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESOLUTION RECORD

Peer Reviewer's Statement:

I have reviewed the ESSE Integrated Evaluation Package in accordance with ESSE Peer Review Plan. My conclusions with respect to the review criteria of the ESSE Peer Review Plan are:

| Review Criteria | Adequate Yes: See Comment(s) Nos.* | No: See Comment(s) Nos. |
|---|---|---|
| In my areas of expertise: | | |
| A. The content of the ESSE Integrated Evaluation Package provides an unbiased and objective presentation of information relevant to the suitability issues covered by each guideline. | 1-24 | |
| B. The conclusions about the status of lower and higher-level findings on the siting guidelines are balanced and defensible. | 1-24 | |

Comments 1 through 24 are attached.

Peer Reviewer Stan L Albrecht Date 12-13-91

Comment Resolution Record

Yes X The revised ESSE Integrated Evaluation Package adequately addresses my comments.

No _____ The following comments have not been adequately addressed:

Peer Reviewer Stan L Albrecht Date 12-13-91

Comments not resolved between the Peer Reviewer and the ESSE Core Team have been noted by the T&MSS Task Manager.

T&MSS Task Manager Jean L Younker Date 12-13-91

* Note: May explain adequacy of comment(s) if needed.

ESSEFIG4.MISC/5-21-91

Figure B-3. Early Site Suitability Evaluation (ESSE) Comment Response Record.

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

***(Instructions on back of form)***

(Reviewer completes items 1 - 9.)

1. Comment 1 of 24
2. Date November 10, 1991
3. Reviewer Stan L. Albrecht
4. Organization Brigham Young University
5. Revision Draft/Date August 1991
6. Section 1.2.4
7. Page 1-12
8. Paragraph Figure 1-2

9. Comment

On the disqualifying condition portion where you ask if the conclusion could change, I would substitute "possibly" for "likely." You really don't believe the conclusion will change but, because it possibly could, additional data are called for.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

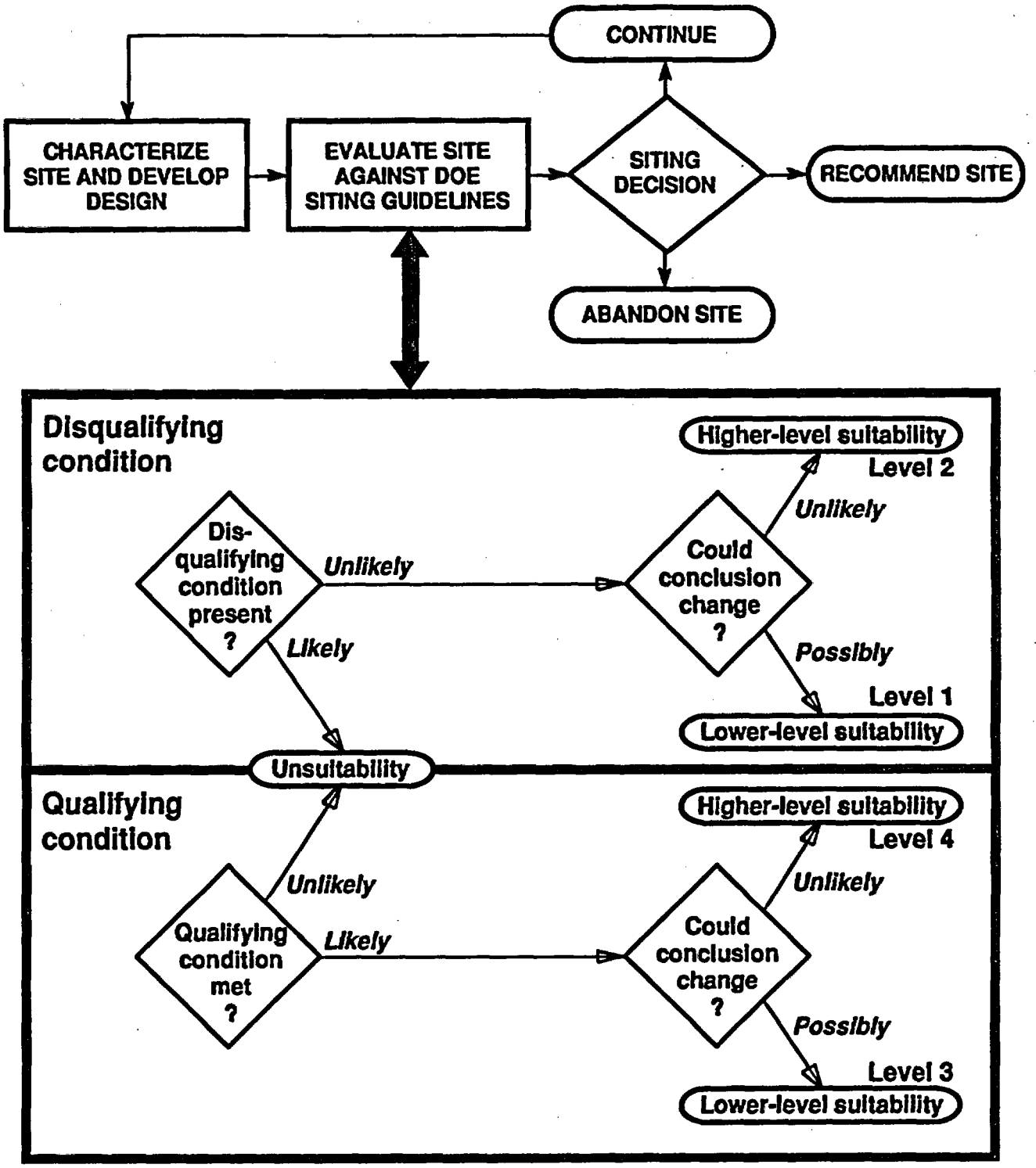
The reviewer makes a good point, which was also made in Dr. Hodges' Comment #2. The figure and its caption will be changed as shown on the attached figure (will be Figure 1-3).

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT




SITEGIDE.067/1-21-92

Figure 1-3. Decision logic for suitability and unsuitability findings, based on DOE Siting Guidelines. The primary distinction between lower- and higher-level suitability findings is the likelihood that further information will change conclusions about the suitability of the site for repository development. A higher-level suitability finding is supported when it is unlikely that additional data will change current conclusions; a lower-level suitability finding is supported when additional information could possibly change current conclusions.

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 2 of 24
2. Date November 10, 1991
3. Reviewer Stan L. Albrecht
4. Organization Brigham Young University
5. Revision Draft/Date August 1991
6. Section 3.2
7. Page 3-3
8. Paragraph 3, sentence 3

9. Comment

Reference is made here to measures that are available to mitigate unacceptable impacts. Should more be said about the kinds of measures that DOE has in mind?

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

While the discussion of potential environmental, socioeconomic, and transportation-related impacts and mitigation measures in Section 3.2 is general, the sentence in question will be modified to read as follows: "...the measures available to mitigate unacceptable impacts, such as avoiding the impacts altogether, minimizing impacts, rectifying impacts, and compensating for the impacts."

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 3 of 24
2. Date November 10, 1991
3. Reviewer Stan L. Albrecht
4. Organization Brigham Young University
5. Revision Draft/Date August 1991
6. Section 3.3.1.1
7. Page 3.3.1-2
8. Paragraph 2

9. Comment

Will pre-site characterization data continue to be collected to establish a baseline for project monitoring and mitigation efforts? I understand that regular monitoring reports are being prepared to document any project-related changes in the employment and population base. It might be helpful to note this in the ESSE document. The importance of the monitoring reports is increased because of the density of population issue that is raised in the disqualifying condition (10 CFR 960.5-2-1(d)), though it is extremely unlikely that this would ever become a factor.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

Data collection for the socioeconomic monitoring program will continue through the site characterization phase, but the information developed for the socioeconomic monitoring program is not sufficiently detailed to address the population density and distribution factors specified in the guidelines. However, demographic information developed in support of the radiological monitoring program does address the ongoing need to evaluate population density and distribution factors.

In response to comments from Dr. Bell, a paragraph will be added to the review of information obtained since the Environmental Assessment in Section 3.3.1.1.3 (page 3.3.1-4). That paragraph will include population density and distribution information from the radiological monitoring program to address the concern raised in this comment. (See proposed response to Dr. Bell's Comment #1.)

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

***(Instructions on back of form)***

(Reviewer completes items 1 - 9.)

1. Comment 4 of 24
2. Date November 10, 1991
3. Reviewer Stan L. Albrecht
4. Organization Brigham Young University
5. Revision Draft/Date August 1991
6. Section 3.3.1.1.4
7. Page 3.3.1-4
8. Paragraph 4

9. Comment

It will be important, of course, to confirm this with 1990 census data.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The discussion in the second paragraph of Section 3.3.1.1.4 indicates that data from the 1990 census will have to be evaluated in relationship to the population density and distribution factors incorporated in the disqualifying conditions.

Additionally, in response to this comment and comments from Dr. Bell, a paragraph will be added to the review of information obtained since the Environmental Assessment in Section 3.3.1.1.3 (page 3.3.1-4). That paragraph will include an evaluation of the preliminary information from the 1990 census in terms of the closest highly populated area and the closest 1 mile by 1 mile area with a population of 1,000 or more individuals. (See proposed response to Dr. Bell's Comment #1.)

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes Items 1 - 9.)

1. Comment 5 of 24
2. Date November 10, 1991
3. Reviewer Stan L. Albrecht
4. Organization Brigham Young University
5. Revision Draft/Date August 1991
6. Section 3.3.2
7. Page 3.3.2-1
8. Paragraph 1

9. Comment

Since reference is made to protecting the public and the environment from all potential impacts, it seems that a case can be made for greater reference to specifically social and perception-based concerns that might flow from the project. Even if such work is not done by the SAIC team in this phase of the project, relevant work done by others should be acknowledged.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The third, fourth, and fifth sentences in the third paragraph of Section 3.3.2.2.3 (page 3.3.2-13) will be replaced with the following text: "The State of Nevada has initiated a comprehensive socioeconomic assessment program, which includes evaluation of potential economic and demographic effects, as well as potential effects on public services and facilities. A major focus of the State's socioeconomic program is on potential sociocultural impacts and on potential perception-based impacts on tourism and economic development. While the complete results of these assessments are not yet available, the State of Nevada has produced reports regarding particular components of its program and an interim report (Mountain West Research, 1989) that summarizes the results of its entire socioeconomic program. In those reports, the State of Nevada has indicated that population-related impacts on public infrastructure and fiscal capacity are expected. The reports also suggest that perception-based impacts on tourism and economic development are anticipated,

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 5 of 24

2. Page 2 of 2

3. Name Stan L. Albrecht
(Print Name)

4. Date November 10, 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

10 Proposed Resolution ( continued )

but the extent of those effects is not yet fully understood."

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 6 of 24
2. Date November 10, 1991
3. Reviewer Stan L. Albrecht
4. Organization Brigham Young University
5. Revision Draft/Date August 1991
6. Section 3.3.2
7. Page 3.3.2-1
8. Paragraph last

9. Comment

When will the types of impacts that are to be addressed be defined?

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The discussion in Section 3.3.2 (last paragraph) indicates that the "...types of impacts that will need to be evaluated for this group of guidelines have not yet been fully defined..." The discussion in the previous paragraph also indicates that while those impacts have not been defined, "...the impacts that are likely to be of concern can be identified." For clarification, the following text will replace the last sentence on page 3.3.2-1: "The ongoing programs to address environmental quality, socioeconomic, and transportation issues and concerns indicate that some types of impacts have been identified and are being assessed. However, additional information concerning the environmental characteristics of the site and repository design, as well as ongoing input from State and local officials and from residents of Nevada, is necessary to fully define the types of impacts that are to be addressed."

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

***(Instructions on back of form)***

(Reviewer completes items 1 - 9.)

1. Comment 7 of 24
2. Date November 10, 1991
3. Reviewer Stan L. Albrecht
4. Organization Brigham Young University
5. Revision Draft/Date August 1991
6. Section 3.3.2.2
7. Page All
8. Paragraph

9. Comment

In a typical study of large-scale developments, demographic change is perceived as the prime drive of social impacts associated with the project. It is important to acknowledge that demographically-driven changes are important, as are the social infrastructure impacts that follow from the demographic changes, but it is also important not to ignore or downplay other categories of impacts, such as perceptions of the hazards and risks associated with nuclear waste storage.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The second paragraph of Section 3.3.2.2.2 (page 3.3.2-12) will be modified to include (following the first sentence): "Typically the socioeconomic impact assessment for a project of this magnitude includes an evaluation of potential local and regional economic and demographic effects and the resulting changes in public infrastructure requirements, as well as the social effects that may occur both as a direct result of the project and as a result of the involvement of special interest groups. An evaluation of the potential effects that may result from public response to the controversial nature of the project and the public perception of the risks associated with the transportation and storage of high-level nuclear waste may also be necessary because the extent and duration of many economic, demographic, and social changes are related to public perception. The possibility that many of these potential social and economic effects could be long term and may extend beyond the operational life of a repository will need to be addressed in the final assessment of

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 7 of 24

2. Page 2 of 2

3. Name Stan L. Albrecht
(Print Name)

4. Date November 10, 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

10 Proposed Resolution ( continued )
socioeconomic impacts."

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

***(Instructions on back of form)***

(Reviewer completes items 1 - 9.)

1. Comment 8 of 24
2. Date November 10, 1991
3. Reviewer Stan L. Albrecht
4. Organization Brigham Young University
5. Revision Draft/Date August 1991
6. Section 3.3.2.2
7. Page All
8. Paragraph

9. Comment

This project is quite unlike anything that has ever been done before. The uniqueness of the project--its focus, size, timeframe, and national scope--really demands an assessment process that may be quite unlike the kinds of things that normally are done in social assessment efforts. Much of the methodology that is drawn on is designed for more "normal" development projects rather than for very highly sensitive projects which will continue to attract national and even international attention. Part of the challenge is not the adjustment of a community--local residents and their governmental infrastructure--to an influx of new workers, but local, county, and state reaction to the federal government and its various representatives, and to the prospect of siting an extremely controversial repository for highly dangerous materials.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

In response to this comment and several of the other comments provided by this reviewer, the second paragraph of Section 3.3.2.2.2 (page 3.3.2-12) will be modified to better explain the socioeconomic impact assessment for the potential repository. The changes to that paragraph (see response to Dr. Albrecht's Comment #7) address this comment.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 9 of 24
2. Date November 10, 1991
3. Reviewer Stan L. Albrecht
4. Organization Brigham Young University
5. Revision Draft/Date August 1991
6. Section 3.3.2.2
7. Page All
8. Paragraph

9. Comment

Important social psychological, interpersonal, and psychological factors come into play in this arena. While most of the [work] on these issues is apparently being delayed until the EIS process, I would at least acknowledge the fact that these issues will require some attention before the project is completed. An "accident" at the site or along a transportation route would have very substantial implications. In addition, it is a very long-term project with possible impacts that extend well past construction, operation, and even closure. The implications of this for the social assessment process should be noted.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

In response to this comment and several of the other comments provided by this reviewer, the second paragraph of Section 3.3.2.2.2 (page 3.3.2-12) will be modified to better explain the socioeconomic impact assessment for the potential repository. The changes to that paragraph (see response to Dr. Albrecht's Comment #7) address this comment.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 10 of 24
2. Date November 10, 1991
3. Reviewer Stan L. Albrecht
4. Organization Brigham Young University
5. Revision Draft/Date August 1991
6. Section 3.3.2.2
7. Page All
8. Paragraph

9. Comment

Where will regional consequences be addressed? If they are to be addressed in a format other than the EA process or the ESSE summary (Younker et al., 1992), this should be noted.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

In response to this comment and several of the other comments provided by this reviewer, the second paragraph of Section 3.3.2.2.2 (page 3.3.2-12) will be modified to better explain the socioeconomic impact assessment for the potential repository. The changes to that paragraph (see response to Dr. Albrecht's Comment #7) address this comment.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 11 of 24
2. Date November 10, 1991
3. Reviewer Stan L. Albrecht
4. Organization Brigham Young University
5. Revision Draft/Date August 1991
6. Section 3.3.2.2
7. Page All
8. Paragraph

9. Comment

In recognition of the fact that there will be some very active interest groups following the progress of the project, it might be a good idea to acknowledge their potential role in the public participation phase of the effort. The environmental and anti-nuclear social movements are likely to play a very active role before all is said and done. To the extent to which this is the case, the whole political process associated with nuclear waste storage becomes a legitimate focus of the social assessment process.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

In response to this comment and several of the other comments provided by this reviewer, the second paragraph of Section 3.3.2.2.2 (page 3.3.2-12) will be modified to better explain the socioeconomic impact assessment for the potential repository. The changes to that paragraph (see response to Dr. Albrecht's Comment #7) address this comment.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

***(Instructions on back of form)***

(Reviewer completes items 1 - 9.)

1. Comment 12 of 24
2. Date November 10, 1991
3. Reviewer Stan L. Albrecht
4. Organization Brigham Young University
5. Revision Draft/Date August 1991
6. Section 3.3.2.2
7. Page 3.3.2-11
8. Paragraph 1 & 2

9. Comment

I find the disconnection between the qualifying and the disqualifying conditions to be interesting. In most other instances in the report, disqualifying conditions are typically the obverse of the qualifying conditions. Here the qualifying conditions are quite specifically socioeconomic in nature, while the disqualifying condition has to do with water quality. Should this receive further explanation in the body of the report?

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The following sentence will be inserted in the second paragraph of Section 3.3.2.2.1 (page 3.3.2-11) (following the second sentence): "The discussion in 10 CFR Part 960 indicates that the disqualifying condition could have been included in the guideline for natural resources, but was added here because the DOE believes that the most serious effects of a significant degradation of major water sources would be socioeconomic effects."

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes Items 1 - 9.)

1. Comment 13 of 24
2. Date November 10, 1991
3. Reviewer Stan L. Albrecht
4. Organization Brigham Young University
5. Revision Draft/Date August 1991
6. Section 3.3.2.2
7. Page 3.3.2-11
8. Paragraph 5

9. Comment

Substantial work has been completed since the Environmental Assessment. It is my impression that significantly more attention has been given to that work in other parts of the ESSE than in the socioeconomic section. It is noted in the Peer Review Plan, for example, that "Non-DOE efforts have... contributed to this information base, including studies supported by the State of Nevada..." I have reviewed the very extensive list of studies and reports prepared by the State of Nevada Nuclear Waste Projects Office and believe that a number of them are relevant to the issues at hand. Most of these studies have now been released for public consumption and so are readily accessible. At the least, it would seem important to acknowledge the existence of this body of work and to summarize the major findings that are relevant to the conclusions reflected in the ESSE. For example, might it not be a good idea to cite the attitudinal and community studies conducted by the State? While you may be operating under the assumption that DOE is not required by statute to do this kind of work, at least until the EIS process begins, I think it would be a mistake to ignore the

10. Proposed Resolution *(To be completed by ESSE Core Team)*

In response to Dr. Albrecht's Comment #5, the third paragraph of Section 3.3.2.2.3 (page 3.3.2-13) will be modified to indicate that the State of Nevada has initiated a comprehensive socioeconomic program, which includes evaluations of potential sociocultural effects and perception-based impacts on tourism and economic development. That response also addresses the concerns expressed in this comment (see response for the modification).

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 13 of 24

2. Page 2 of 2

3. Name Stan L. Albrecht
(Print Name)

4. Date November 10, 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

9 Comment ( continued )

fact that a significant amount of work is being done on socioeconomic issues independent of the SAIC effort.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

***(Instructions on back of form)***

(Reviewer completes Items 1 - 9.)

1. Comment 14 of 24
2. Date November 10, 1991
3. Reviewer Stan L. Albrecht
4. Organization Brigham Young University
5. Revision Draft/Date August 1991
6. Section 3.3.2.2.1
7. Page 3.3.2-11
8. Paragraph 1

9. Comment

It is important to emphasize that while demographic changes will drive many of the other socioeconomic changes that occur, particularly the infrastructure needs, there are other types of impacts that are also important. These should not be ignored. This seems particularly relevant since Section 3.1.2 notes that lifestyle, social and esthetic values are pertinent areas of concern in the project.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

In response to this comment and several of the other comments provided by this reviewer, the second paragraph of Section 3.3.2.2.2 (page 3.3.2-12) will be modified to better explain the socioeconomic impact assessment for the potential repository. The changes to that paragraph (see response to Dr. Albrecht's Comment #7) address this comment.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 15 of 24
2. Date November 10, 1991
3. Reviewer Stan L. Albrecht
4. Organization Brigham Young University
5. Revision Draft/Date August 1991
6. Section 3.3.2.2.1
7. Page 3.3.2-11
8. Paragraph 3

9. Comment

Impacts can result from project-driven changes in the social environment, as well as from public perceptions of possible impacts. In this case, the latter may be equally as important as the former. In fact, public response will likely be affected as much by perceived impacts as by actual changes that are linked to the project. This deserves at least some mention.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

In response to this comment and several of the other comments provided by this reviewer, the second paragraph of Section 3.3.2.2.2 (page 3.3.2-12) will be modified to better explain the socioeconomic impact assessment for the potential repository. The changes to that paragraph (see response to Dr. Albrecht's Comment #7) address this comment.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 16 of 24
2. Date November 10, 1991
3. Reviewer Stan L. Albrecht
4. Organization Brigham Young University
5. Revision Draft/Date August 1991
6. Section 3.3.2.2.2
7. Page 3.3.2-11 & 3.3.2-12
8. Paragraph para. 1 of 3.3.2.2.2

9. Comment

Should more be said about the kind of negotiation process that will occur with affected political entities? This will be such an important part of the decision-making process that it may deserve some further, if only brief, mention.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The second paragraph of Section 3.3.2.2.2 (page 3.3.2-12) will be modified by replacing the second sentence with the following new paragraph:

"The guideline indicates that the qualifying condition will be addressed through '...a process of analysis, planning, and consultation among the DOE, affected State and local government jurisdictions, and affected Indian tribes.' The DOE has continued efforts to accomplish this coordination with affected parties by developing the Yucca Mountain Site Characterization Project Socioeconomic Plan (DOE, 1991e). That document, which was prepared in consultation with the State of Nevada and affected counties, specifies a process of consultation, communication, and coordination between the DOE and the affected parties to ensure that socioeconomic issues and concerns are identified, potential socioeconomic effects are evaluated, and appropriate impact mitigation strategies are developed and

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 16 of 24

2. Page 2 of 2

3. Name Stan L. Albrecht
(Print Name)

4. Date November 10, 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

10 Proposed Resolution ( continued )

implemented. The process of interaction between the affected parties and the DOE requires coordination of their respective socioeconomic programs to avoid unnecessary duplication of efforts and is designed to be sufficiently flexible to respond to changes in social and economic issues associated with the project."

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes Items 1 - 9.)

1. Comment 17 of 24
2. Date November 10, 1991
3. Reviewer Stan L. Albrecht
4. Organization Brigham Young University
5. Revision Draft/Date August 1991
6. Section 3.3.2.2.2
7. Page 3.3.2-11
8. Paragraph 5

9. Comment

It is important to recognize that this is not a "study" using an approved "method." Rather, it is an ongoing process that must be flexible and adaptive to a changing social and political environment. The project will change as it develops, as will the public reaction to it. This makes the task of the social science researcher even more difficult than it might otherwise be.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

In response to this comment and several of the other comments provided by this reviewer, the second sentence in the second paragraph of Section 3.3.2.2.2 (page 3.3.2-12) will be expanded into a new paragraph that explains the process of analysis, planning, and coordination specified in the qualifying condition. The changes to that paragraph (see response to Dr. Albrecht's Comment #16) address this comment.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 18 of 24
2. Date November 10, 1991
3. Reviewer Stan L. Albrecht
4. Organization Brigham Young University
5. Revision Draft/Date August 1991
6. Section 3.3.2.2.2
7. Page 3.3.2-12
8. Paragraph 1

9. Comment

Should there be more on the kinds of coordination that has occurred and that will occur with the state, tribes and communities as specified in NWPA?

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

In response to this comment and several of the other comments provided by this reviewer, the second sentence in the second paragraph of Section 3.3.2.2.2 (page 3.3.2-12) will be expanded into a new paragraph that explains the process of analysis, planning, and coordination specified in the qualifying condition. The changes to that paragraph (see response to Dr. Albrecht's Comment #16) address this comment.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 19 of 24
2. Date November 10, 1991
3. Reviewer Stan L. Albrecht
4. Organization Brigham Young University
5. Revision Draft/Date August 1991
6. Section 3.3.2.2.2
7. Page 3.3.2-12
8. Paragraph 2

9. Comment

It should be noted that if further socioeconomic analysis is delayed until the EIS, the baseline for the EIS will be a characterized site. A great deal of consequence will obviously have happened prior to that point. It will be important that a good baseline be established prior to any impacts associated with the project, particularly in a socioeconomic environment that is changing as rapidly as it is in the Clark County area.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The third paragraph of Section 3.3.2.2.3 (page 3.3.2-13) will be modified to better explain the socioeconomic study area and to address the temporal issues raised by this comment. (See the response to Dr. Albrecht's Comment #21.)

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

***(Instructions on back of form)***

(Reviewer completes items 1 - 9.)

1. Comment 20 of 24
2. Date November 10, 1991
3. Reviewer Stan L. Albrecht
4. Organization Brigham Young University
5. Revision Draft/Date August 1991
6. Section 3.3.2.2.3
7. Page 3.3.2-12
8. Paragraph 1

9. Comment

The guiding legislation requires that any socioeconomic impacts associated with the project can be mitigated. I believe that this will be the case. Unless there are impacts substantially greater than those identified in the Environmental Assessment, in the Section 175 report, or in other studies that have been done, I believe that the requirements for mitigation can be met. However, it will be important to make it clear that the mitigation package will be a negotiated package with significant involvement from state and local officials, as well as DOE. Strategies for mitigating typical impacts associated with demographically-driven infrastructure needs are well-known. Strategies for dealing with potential impacts on tourism and economic development are less-well understood. It might be a good idea to acknowledge this fact.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

Section 3.3.2.2.2 (page 3.3.2-12) will be modified to include the following paragraph (prior to the last paragraph of the section):

"The guideline also requires that socioeconomic impacts '...induced in communities and surrounding regions by repository siting, construction, operation, closure, and decommissioning can be offset by reasonable mitigation or compensation...' The Nuclear Waste Policy Act (NWPA, 1983) requires the DOE to avoid or minimize adverse socioeconomic impacts to the maximum extent practicable and gives the DOE the authority to provide financial and technical assistance to mitigate unavoidable impacts. The Section 175 Report (DOE, 1988) and the Socioeconomic Plan for the Yucca Mountain Site Characterization Project (DOE, 1991) both indicate that the process of identifying socioeconomic impacts and developing appropriate mitigation strategies requires communication and cooperation between the DOE and

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 20 of 24

2. Page 2 of 2

3. Name Stan L. Albrecht
(Print Name)

4. Date November 10, 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

10 Proposed Resolution ( continued )

the affected parties. While the strategies for mitigating population-related impacts on public services and facilities are relatively well known, methods for addressing potential social impacts and perception-based impacts are less clearly understood. The DOE will need to work with the affected parties to determine which socioeconomic effects are considered adverse impacts and how they can most efficiently be addressed with reasonable mitigation or compensation."

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

***(Instructions on back of form)***

(Reviewer completes items 1 - 9.)

1. Comment 21 of 24
2. Date November 10, 1991
3. Reviewer Stan L. Albrecht
4. Organization Brigham Young University
5. Revision Draft/Date August 1991
6. Section 3.3.2.2.3
7. Page 3.3.2-13
8. Paragraph 1

9. Comment

I continue to have questions about what constitutes the study area. I acknowledge that political factors may force the inclusion of counties that would, on the basis of empirical data, not normally be included. Nevertheless, I recommend that most of the effort be concentrated on Nye and Clark counties and, to the extent that something must be done beyond that, that it be limited to contiguous counties. Exceptions might occur when looking at potential impacts along major transportation routes.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The third paragraph of Section 3.3.2.2.3 (page 3.3.2-13) will be modified to include (following the first sentence): "Because of the rapidly changing socioeconomic environment of the area, particularly in Clark County, and the need to develop a complete data base of information for use in preparation of the Environmental Impact Statement, the DOE has already initiated many components of the socioeconomic program for the Yucca Mountain Site Characterization Project. The socioeconomic studies conducted by the DOE primarily have focused on Nye, Clark, and Lincoln counties, and on the State of Nevada as a whole (See Section 3.3.2.1.3.1 for a description of the program to address Native American concerns). As circumstances require, socioeconomic studies will be needed to examine other potentially affected areas, such as counties or communities that may experience socioeconomic effects related to potential rail and highway access routes to the Yucca Mountain site."

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 22 of 24
2. Date November 10, 1991
3. Reviewer Stan L. Albrecht
4. Organization Brigham Young University
5. Revision Draft/Date August 1991
6. Section 3.3.2.2.4
7. Page 3.3.2-14
8. Paragraph (Discussion)

9. Comment

A significant and quite unique feature of the Nuclear Waste Policy Act is the requirement for coordination and consultation between the federal government and the affected states, Indian Tribes, and communities. It would be helpful if some additional information on just how this is to be done is included, at least in a footnote to the report. For example, I know that SAIC and its consultants have been involved in quite extensive work with Native American groups. I would urge that this work be reviewed and summarized. As I understand it, some of this work is designed to assess the meaning and value the study area holds for Native Americans. It is my impression that this is an important effort and should be reflected in the ESSE, at least in summary form. While there are no Native American reservations that will be directly affected, the sensitivity to these concerns that is reflected in the work that is being done should be demonstrated in the report.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

In response to this comment and several of the other comments provided by this reviewer, the second sentence in the second paragraph of Section 3.3.2.2.2 (page 3.3.2-12) will be expanded into a new paragraph that explains the process of analysis, planning, and coordination specified in the qualifying condition. The changes to that paragraph (see response to Dr. Albrecht's Comment #16) address this comment.

The DOE has an extensive program to involve Native American groups in the evaluation of the Yucca Mountain site. However, those studies are components of the environmental program and are addressed in Section 3.3.2.1.3.1. A parenthetical reference to the Native American work has been included in the paragraph added in response to Dr. Albrecht's Comment #21.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 23 of 24
2. Date November 10, 1991
3. Reviewer Stan L. Albrecht
4. Organization Brigham Young University
5. Revision Draft/Date August 1991
6. Section 3.3.2.2.4
7. Page 3.3.2-14
8. Paragraph 2

9. Comment

Should there be more detail on the types of mitigation that might occur? I agree with the Core Team that impacts that are likely to be associated with the project will be mitigatable. This is particularly true of the typical infrastructure impacts that follow from demographic change in the affected communities. As noted earlier, it is less clear that effective mitigation mechanisms are available for addressing the more social and perception-based impacts.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

In response to Dr. Albrecht's Comment #20, Section 3.3.2.2.2 (page 3.3.2-12) will be modified to include a paragraph that describes the process of identifying socioeconomic impacts and developing appropriate mitigation strategies. That response also addresses this comment.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes Items 1 - 9.)

1. Comment 24 of 24
2. Date November 10, 1991
3. Reviewer Stan L. Albrecht
4. Organization Brigham Young University
5. Revision Draft/Date August 1991
6. Section 3.3.2.3
7. Page 3.3.2-15
8. Paragraph All OF 3.3.2.3

9. Comment

It is important for someone to be examining the socioeconomic impacts that might be associated with transportation of waste materials to the site. It is not clear that that is being done.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

In response to Dr. Albrecht's Comment #21, the third paragraph of Section 3.3.2.2.3 (page 3.3.2-13) will be modified to include a discussion of the geographic scope of DOE's socioeconomic studies, including the assessment of potential socioeconomic effects resulting from development of transportation access routes. The modified text is given in that response which also addresses this comment.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

## REFERENCES FOR DR. STAN L. ALBRECHT

DOE (U.S. Department of Energy), 1986. Final Environmental Assessment: Yucca Mountain Site, Nevada Research and Development Area, Nevada, 3 volumes DOE/RW-0073 Office of Civilian Radioactive Waste Management, Washington, DC.

DOE (U.S. Department of Energy), 1988b. Section 175 Report: Secretary of Energy's Report to the Congress Pursuant to Section 175 of the Nuclear Waste Policy Act, As Amended, DOE/RW-0205, Office of Civilian Radioactive Waste Management, Washington, DC.

DOE (U.S. Department of Energy), 1991e. Socioeconomic Plan, Revision 0, YMP/91-21, Yucca Mountain Site Characterization Project Office, Las Vegas, NV.

Mountain West Research, 1989. Yucca Mountain Socioeconomic Project An Interim Report on the State of Nevada Socioeconomic Studies, NWPO-SE-022-89, State of Nevada Agency for Nuclear Projects/Nuclear Waste Project Office, Reno, NV.

NWPA (Nuclear Waste Policy Act), 1983. Nuclear Waste Policy Act of 1982, Public Law 97-425, 42 U.S.C. 10101-10226, Washington, DC.

Younker, J. L., W. B. Andrews, G. A. Fasano, C. C. Herrington, S. R. Mattson, R. C. Murray, L. B. Ballou, M. A. Revelli, A. R. Ducharme, L. E. Shepard, W. W. Dudley, D. T. Hoxie, R. J. Herbst, E. A. Patera, B. R. Judd, J. A. Docka, and L. D. Rickertsen, 1992. Report of Early Site Suitability Evaluation of the Potential Repository Site at Yucca Mountain, Nevada, SAIC-91/8000, Las Vegas, NV.

10 CFR 960 (Code of Federal Regulations), 1984. Title 10, Energy, Part 960, General Guidelines for the Recommendation of Sites for Nuclear Waste Repositories, U.S. Government Printing Office, Washington, DC.

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# *Dr. Walter J. Arabasz*

## PRECLOSURE TECTONICS

University of Utah
Salt Lake City, UT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESOLUTION RECORD

Peer Reviewer's Statement:

I have reviewed the ESSE Integrated Evaluation Package in accordance with ESSE Peer Review Plan. My conclusions with respect to the review criteria of the ESSE Peer Review Plan are:

| Review Criteria | Adequate Yes: See Comment(s) Nos.* | Adequate No: See Comment(s) Nos.† |
|---|---|---|
| In my areas of expertise: | | |
| A. The content of the ESSE Integrated Evaluation Package provides an unbiased and objective presentation of information relevant to the suitability issues covered by each guideline. | 15, 16, 21, 26, 29 | 1-14, 17, 20, 22-25, 27, 28, 30<br>† *Most of these comments are minor or editorial.* — *WJA* |
| B. The conclusions about the status of lower and higher-level findings on the siting guidelines are balanced and defensible. | 18, 19, 31 | |

Comments 1 through 31 are attached.

Peer Reviewer Walter J. Arabasz Date November 12, 1991

Walter J. Arabasz

Comment Resolution Record

Yes ✓ The revised ESSE Integrated Evaluation Package adequately addresses my comments.

No _____ The following comments have not been adequately addressed:

Peer Reviewer Walter J. Arabasz Date December 8, 1991

Walter J. Arabasz

Comments not resolved between the Peer Reviewer and the ESSE Core Team have been noted by the T&MSS Task Manager.

T&MSS Task Manager Jean L Younker Date 12-8-91

* Note: May explain adequacy of comment(s) if needed.

ESSEFIG4.MISC/5-21-91

Figure B-3. Early Site Suitability Evaluation (ESSE) Comment Response Record.

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

***(Instructions on back of form)***

(Reviewer completes items 1 - 9.)

1. Comment 1 of 31
2. Date November 12, 1991
3. Reviewer Walter J. Arabasz
4. Organization University of Utah
5. Revision Draft/Date August 1991
6. Section Executive Summary
7. Page E-6 ff.
8. Paragraph

9. Comment

(editorial)

The section entitled, "Findings Based on Site-suitability Evaluations," outlines the logic for the designation of findings in a confusing way for the executive summary. The confusion stems from describing higher and lower levels only for suitability findings. Appendix III of 10 CFR Part 960 outlines higher and lower levels for unsuitability findings too (as later explained in section 1.2.2 of the Introduction). The concept of higher versus lower level is distinct from, and should be explained separately from, the concept of suitability versus unsuitability.

In Tables E-3 and E-4, the reader encounters "Lower-level finding" and "Higher-level finding"--dissociated from the word suitability, as earlier connected at the top of page E-7. Hence, initial confusion results in trying to understand the seemingly contradictory meaning of a "higher-level (suitability) finding" for a "disqualifying (unsuitable) condition." A better

10. Proposed Resolution *(To be completed by ESSE Core Team)*

Text of the executive summary will be substantially revised.

To clarify the logic for the designation of findings, the text beginning with the fourth paragraph on page E-6 will be revised to read as follows:

"The Siting Guidelines specify two levels of suitability findings, depending on the likelihood that new information could change current conclusions about the site. These levels are designated "lower-level" and "higher-level" suitability findings in this report and are defined as follows:

| | |
|---|---|
| Lower-level Suitability Finding | A lower-level suitability finding can be supported when (1) a disqualifying condition does not appear to be present, but additional information could change the conclusion; or (2) a qualifying condition appears to be present, |

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 1 of 31

2. Page 2 of 2

3. Name Walter J. Arabasz
(Print Name)

4. Date November 12, 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

9 Comment ( continued )

introductory summary of the complicated logic will help many readers unfamiliar with Appendix III of 10 CFR Part 960. (See also Comment 4.)

END OF TEXT

10 Proposed Resolution ( continued )

but additional information could change the conclusion, and thus, the site could subsequently be found to be unsuitable.

Higher-level Suitability Finding

A higher-level suitability finding can be supported when (1) a disqualifying condition is not present and additional information is unlikely to change the conclusion; or (2) a qualifying condition is present and additional information is unlikely to change the conclusion. This finding would be supported if there is high confidence in the conclusion based on current information.

A higher-level suitability finding for a particular disqualifying or qualifying condition does not necessarily mean that all remaining uncertainties regarding the conditon have been resolved. Rather, a higher-level suitability finding means that gaining additional information to resolve the remaining uncertainties is <u>unlikely to change the present conclusion</u> about the suitability of the site."

The footnotes to Tables E-3 and E-4 will be revised as follows:

Table 3:

LLF: Lower-level suitability finding is supported
HLF: Higher-level suitability finding is supported

Table E-4:

HLF: Higher-level suitability finding is supported
LLF: Lower-level suitability finding is supported

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 2 of 31
2. Date November 12, 1991
3. Reviewer Walter J. Arabasz
4. Organization University of Utah
5. Revision Draft/Date August 1991
6. Section Executive Summary
7. Page E-7
8. Paragraph 3

9. Comment

(minor)

The section entitled, "Summary of Evaluation Results," may be an appropriate place for the authors to elaborate on the concept of "consensus" and their team approach to reaching agreement on qualifying versus disqualifying conditions.

It was particularly helpful for me (1) to understand that a higher-level finding required absolute unanimity among the technical specialists making up the core team (explained later on p. 1-16 of the Introduction) and (2) to be informed that the team was more conservative in voting on qualifying conditions than on disqualifying conditions.

I was given to understand that--consistent with language in 10 CFR Part 960--disqualifying conditions were held to be less important than qualifying conditions and were perceived to be intended as a tool for site screening. If

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The text at the end of the first paragraph in the section entitled "Summary of Evaluation Results" will be modified to read as follows:

"... The consensus of the Core Team is that the new information corroborates the findings of the EA that the site is suitable for characterization. In some cases, the evidence supports stronger findings regarding suitability for repository development. The consensus findings by the Core Team are summarized in Tables E-3 and E-4."

In addition, text will also be added to the previous section (two paragraphs earlier) to explain that a "consensus" has a special meaning with regard to support for a higher-level suitability finding. In this instance, consensus means that the conclusions are supported by every member of the Core Team.

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 2 of 31

2. Page 2 of 2

3. Name Walter J. Arabasz
(Print Name)

4. Date November 12, 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

9 Comment ( continued )

true, this perspective is important for readers to be aware of when considering, say, the relative merits of a higher-level finding for a disqualifying condition when only a lower-level finding is supported for the corresponding qualifying condition.

END OF TEXT

10 Proposed Resolution ( continued )

A response to the reviewer's remark about understanding that "the team was more conservative in voting on qualifying conditions than on disqualifying conditions" is included in the following response to paragraph 3 of this comment. See also the perspective given in the response to Dr. Arabasz's Comment #3, where the intent of disqualifying and qualifying conditions, respectively, is described.

There may have been a miscommunication or misunderstanding between the ESSE Core Team members and the reviewer on this issue. The Core Team did not give greater importance to qualifying conditions relative to disqualifying conditions.

The intent of 10 CFR Part 960, as described in Section IV(A), was that disqualifying conditions should be conditions that are "so adverse as to constitute sufficient evidence to conclude, without further consideration, that a site is disqualified." The text further states that the presence or absence of 10 of 17 of the disqualifying conditions can be verified at a site without extensive data gathering or complex analysis, and thus, can be applied early in the siting process. A site must also be disqualified if it fails to meet any one of the qualifying conditions. However, according to Section IV(A), failure to meet a qualifying condition can usually only be determined after site characterization and concurrent environmental and socioeconomic investigations.

Rather than reflecting relative importance of the qualifying and disqualifying conditions as suggested in this comment, the distinction appears to be related to the amount of site-specific information needed to determine if the condition is present. Because more site data and analysis are required for some of the qualifying conditions compared to 10 of the 17 disqualifying conditions, Core Team members may have been "more conservative" on those qualifying conditions.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 3 of 31
2. Date November 12, 1991
3. Reviewer Walter J. Arabasz
4. Organization University of Utah
5. Revision Draft/Date August 1991
6. Section Executive Summary
7. Page E-12, -13
8. Paragraph NA

9. Comment

(editorial)

The section entitled, "Ease and Cost of Siting, Construction, Operation, and Closure," includes seemingly contradictory statements that can be better worded to avoid confusion. Regarding disqualifying conditions and higher-level findings, the report first states that, "Hazards due to...seismic conditions...are not expected to require engineering measures that have not been applied and proven elsewhere in similar facilities." In terms of qualifying conditions, the same section goes on to say (p. E-13, paragraph 2), "However, uncertainty exists about the ability to accommodate seismic conditions at the site using reasonable available technology. Specifically, ground-motion or surface-rupture conditions on which repository designs are based are not yet known well enough to support a higher-level suitability finding."

Suggestion: Underline "expected" in the first part (last sentence of

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The text will be revised as suggested in this comment. This comment illustrates a difficulty faced by the ESSE Core Team in evaluating qualifying and disqualifying conditions with very similar wording. The background material for 10 CFR Part 960 explains that disqualifying conditions were intended to be evaluated earlier in the siting process, and thus, on the basis of less complete site information. Conversely, qualifying conditions were intended to be evaluated later in the siting process and, thus, more stringent requirements for a thorough data base would be applied. On this basis, the Core Team concluded that a higher-level suitability finding could be supported for the disqualifying condition, but not for the qualifying condition. However, the confusing wording identified by the reviewer resulted from this conclusion. We believe the revised text greatly improves the clarity of the presentation of this section.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 3 of 31

2. Page 2 of 2

3. Name Walter J. Arabasz
(Print Name)

4. Date November 12, 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

9 Comment ( continued )

paragraph 4 on p. E-12). Reword paragraph 2 on p. E-13 to read: "Current evidence also continues to support the lower-level suitability finding for the qualifying condition for Preclosure Tectonics. Although ground-motion and surface-rupture conditions on which repository designs are to be based are not expected to exceed the ability of reasonably available technology to accommodate them, those seismic conditions are not yet known well enough to support a higher-level suitability finding."

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 4 of 31
2. Date November 12, 1991
3. Reviewer Walter J. Arabasz
4. Organization University of Utah
5. Revision Draft/Date August 1991
6. Section 1.2.2 (general comment)
7. Page 1-9 ff.
8. Paragraph

9. Comment

(minor)

The authors have made commendable efforts to simplify the logical propositions spelled out in Appendix III of 10 CFR Part 960 (referred to hereafter as Appendix III). However, because Appendix III provides the definitive regulatory guidelines for site qualification or disqualification, rigor demands that serious readers be able to correlate conclusions in the ESSE Report with the original propositions outlined in Appendix III. It would be straightforward--and greatly helpful--in this section to relate the simplified logic about types of findings to the original propositions in Appendix III---indexed as 1(a), 1(b),...4(b).

Because the logic of 10 CFR Part 960 permeates the ESSE Report, it seems appropriate to reproduce the original propositions of Appendix III verbatim. Admittedly, Table 1-3 makes some attempt in this direction, but the language represents "translation," and tracing back to the original propositions of

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The ESSE Core Team will modify Table 1-3 to cross-reference the original eight propositions. This is in lieu of reproducing the wording of Appendix III verbatim or including the cross-reference indices in Figure 1-2. We believe that cross-referencing Table 1-3 will provide the needed link for readers who are thoroughly familiar with Appendix III, without unnecessarily complicating the picture for those with a less thorough knowledge of that appendix. The proposed Table 1-3 is reproduced at the end of this comment response.

To help clarify the table, the following sentence will be added at the end of first paragraph of Section 1.2.2 on page 1-9: "Each level is further subdivided into parts (a) and (b). Part (a) of each level specifies conditions for a suitability finding. Part (b) specifies conditions for an unsuitability finding."

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

Table 1-3. Definitions of Findings Specified by DOE's Siting Guidelines

| Conclusion | Suitability Finding | Suitability Level[a] |
|---|---|---|
| DISQUALIFYING CONDITIONS | | |
| Condition is present or likely to be present | Unsuitability | 1(b) or 2(b) |
| Condition is not present but additional information could change conclusion | Lower-level suitability | 1(a) |
| Condition is not present and it is unlikely that the conclusion will change with additional information | Higher-level suitability | 2(a) |
| QUALIFYING CONDITIONS | | |
| Site cannot meet the condition or is not likely to meet the condition | Unsuitability | 3(b) or 4(b) |
| Site is likely to meet the condition but additional information could change the conclusion | Lower-level suitability | 3(a) |
| Site meets the condition and it is unlikely that the conclusion will change with additional information | Higher-level suitability | 4(a) |

[a]As defined in Appendix III, 10 CFR Part 960

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 4 of 31

2. Page 2 of 2

3. Name Walter J. Arabasz
(Print Name)

4. Date November 12, 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

9 Comment ( continued )

Appendix III requires effort.

Ideally, I would prefer to see Table 1-3 list each original proposition, together with its index--1(a), 1(b),...4(b)--and a descriptor in the language of the ESSE Report (e.g., 1(a) would be "lower-level suitability"; 1(b), "unsuitability" or "lower-level finding of unsuitability"; etc.). This would allow the easiest tracking and a convenient basis for discussing conclusions about findings throughout the report.

Alternatively, I suggest incorporating into Table 1-3 cross-reference to the original eight propositions of Appendix III. For example, the first entry in Table 1-3 reads: "(Disqualifying) Condition is present or likely to be present." This conclusion relates either to proposition 1(b) or 2(b) of Appendix III. Such index numbers could also be incorporated into Figure 1-2 to link the logic to Appendix III. Each arrow in the flow chart of the enlarged box could be labeled with one or two indexes. For example, in the case of the decision-node "Qualifying condition met?" the "Unlikely" branch is linked either to proposition 3(b) or 4(b) and leads to "Unsuitability."

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes Items 1 - 9.)

1. Comment 5 of 31
2. Date November 12, 1991
3. Reviewer Walter J. Arabasz
4. Organization University of Utah
5. Revision Draft/Date August 1991
6. Section 1.2.2
7. Page 1-9
8. Paragraph 5

9. Comment

(minor)

The text states that "A lower-level suitability finding is the converse of the unsuitability finding...." I believe a more precise statement would be, "A lower-level suitability finding results from the negation of an unsuitability finding..." In logic, the "converse" results from interchanging the subject and the predicate of a proposition. I purposely use the article "an" rather than "the" before "suitability finding," because, in fact, a lower-level suitability finding results from negating either proposition 1(b) or 3(b) or 4(b) in Appendix III of 10 CFR Part 960.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The intent of this suggested improvement will be incorporated in the revised executive summary. The executive summary will be revised to make it more readable to a general audience. The revised text in the section describing the findings will read as follows:

"In accordance with the Siting Guidelines, conclusions about the site can be either that current information supports an unsuitability finding or a suitability finding. An unsuitability finding means that (1) a disqualifying condition is present, or (2) a qualifying condition is not present. A suitability finding means that (1) a disqualifying condition is not present, or (2) a qualifying condition is present."

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 6 of 31
2. Date November 12,1991
3. Reviewer Walter J. Arabasz
4. Organization University of Utah
5. Revision Draft/Date August 1991
6. Section 1.2.6
7. Page 1-18
8. Paragraph 2

9. Comment

(editorial)

Consistent with tense usage elsewhere, change "Peer reviewers will be asked" to "Peer reviewers were asked" and "Individual peer reviewers will be asked" to "Individual peer reviewers were asked..."

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The tense usage will be revised as suggested.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 7 of 31
2. Date November 12, 1991
3. Reviewer Walter J. Arabasz
4. Organization University of Utah
5. Revision Draft/Date August 1991
6. Section 1.3.1
7. Page 1-21
8. Paragraph 4

9. Comment

(minor)

The tectonic history summarized at the beginning of this paragraph is incomplete and confusing, and I'm uncertain whether the individual descriptions were intended indeed to refer to the "region" or to Yucca Mountain. Mesozoic deformation isn't mentioned among the major phases of tectonism. The text refers to "extensional faulting associated with silicic volcanism that occurred from about eleven to about seven million years ago...." The syntax is ambiguous. If the dates refer to silicic volcanism, silicic and volcaniclastic rocks at and near Yucca Mountain, derived from the Timber Mountain-Oasis Valley caldera complex, are described as 9.5 to 16 million years old in the SCP (DOE, 1988a, p.1-89), and the ages of the four major ash-flow tuffs at Yucca Mountain are described by Scott (1990, p. 253) as ranging from about 15 to 11.5 million years old. The SCP (DOE, 1988a, p. 1-110) describes extensional faulting around Yucca Mountain "contemporaneous with early volcanic activity, around 14 to 16 million years ago" and implies continued contemporaneity of extensional

10. Proposed Resolution *(To be completed by ESSE Core Team)*

In response to this comment and to Dr. Hodges's Comment #6, we will replace the third and fourth paragraphs of page 1-21 with the following new text:

"The Timber Mountain-Oasis Valley caldera complex, to the north of the potential repository site, erupted these ash-flow tuffs, between 16 and 9.5 million years ago (mya), with deposition of the Paintbrush tuff occurring about 13 mya. Several episodes of basaltic volcanism occurred since the late Miocene, and some activity may be younger than 140,000 years. While silicic volcanism has ceased in the area, there is evidence of more recent basaltic volcanism and cinder cones less than 2 million years old in the area. North-trending extensional faulting in the area started at about the same time as the silicic volcanism, between 16 to 14 mya, with most of the offset in the vicinity of the site occurring between 12.9 and 11.6 mya (DOE, 1988a), after deposition of the Paintbrush tuff. Continued extensional faulting, associated with development

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 7 of 31

2. Page 2 of 2

3. Name Walter J. Arabasz
(Print Name)

4. Date November 12, 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

9 Comment ( continued )

faulting and silicic volcanism at about 11 million years ago and later. The text further refers to "basin-and-range style faulting that occurred in the past seven million years...." The SCP (DOE, 1988a, p. 1-110) does indicate that "Faulting has been nearly continuous since about 7 million years ago..." but it also describes other aspects of basin-range faulting in the region dating from about 15 million years ago.

END OF TEXT

10 Proposed Resolution ( continued )

of the Basin-and-Range province during the last 7 million years dominates the modern topography at the site. Yucca Mountain is composed of a series of north-trending structural blocks that have been tilted eastward along west-dipping, high-angle normal faults. The underground facility for the potential repository would be located in one of these structural blocks. This block is bounded on the west by the Solitario Canyon fault, on the northeast by an inferred fault in the Drill Hole Wash, and on the east and southeast by a hypothesized series of imbricate normal faults. One of the north-trending faults, the Ghost Dance fault, transects the potential repository layout within this block."

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 8 of 31
2. Date November 12, 1991
3. Reviewer Walter J. Arabasz
4. Organization University of Utah
5. Revision Draft/Date August 1991
6. Section 1.3.1
7. Page 1-21
8. Paragraph 5

9. Comment

(minor)

In describing the setting of the Yucca Mountain site with respect to regional seismicity, the text states, "The Yucca Mountain site is about 100 miles to the east of the Nevada-California seismic belt and about 150 miles to the northwest of the Intermountain seismic belt." This description fails to note that the site lies "on the southern margin of the southern Nevada East-West Seismic Belt" (DOE, 1986, p. 3-20; see also DOE, 1988a, p. 1-151 and Fig. 1-51). Also, the description should correctly read: "...150 miles to the southwest of the Intermountain seismic belt."

The text in this place also states, "However, the area immediately surrounding Yucca Mountain (including the eastern Mojave Desert and the southwest quadrant of the Nevada Test Site) has been relatively quiet seismically during the past 150 years." In order to be more informative for those unfamiliar with historical seismicity, and to preclude the inference that

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The text will be revised as suggested in the comment.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 8 of 31

2. Page 2 of 2

3. Name Walter J. Arabasz
(Print Name)

4. Date November 12, 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

9 Comment ( continued )

seismicity prior to the mid-1800's may have been different, I suggest the wording: "...has been relatively quiet seismically since the 1850's, when the historical earthquake record for the region began."

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 9 of 31
2. Date November 12, 1991
3. Reviewer Walter J. Arabasz
4. Organization University of Utah
5. Revision Draft/Date August 1991
6. Section 1.3.2 (general comment)
7. Page 1-24 ff.
8. Paragraph NA

9. Comment

(editorial)

The technical and regulatory concepts of containment, isolation, and engineered barrier system are fundamentally important in the ESSE Report. I believe an explanation of these concepts should be given at least by the end of the Introduction, and this section seems an appropriate place to do so.

Another reason for this suggestion is that I was given to understand that the terms "containment" and "isolation" are used slightly differently by the EPA and in 10 CFR Part 960. (In 10 CFR 960.2, only a very general definition is given for "containment.") Finding explanations of these terms in a readily-identifiable place would be greatly helpful.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The following text will be added to the end of Section 1.3.2 to describe the meaning of the terms "containment," "isolation," and "engineered barrier system," as requested in this comment:

"Containment is the term used by the NRC to describe confinement of the radioactive waste within the waste package for a period of 300-1,000 years. According to the NRC, the containment period is the first several hundred years following permanent closure of a geologic repository, when radiation and thermal levels are high and the uncertainties in assessing repository performance are large. During this time, "special emphasis is placed upon the ability to contain the wastes by waste packages within an engineered barrier system." In 10 CFR Part 960, DOE more generally describes containment as "...confinement of radioactive waste within a designated boundary." In 40 CFR Part 191, the EPA used the term containment to describe their 10,000-year cumulative release requirements.

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 9 of 31

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3. Name Walter J. Arabasz
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5. Comment or Proposed Resolution or Resolution *(Circle one)*

10 Proposed Resolution ( continued )

Isolation is defined in 10 CFR Part 960 as "inhibiting the transport of radioactive material so that the amounts and concentrations of this material entering the accessible environment will be kept within prescribed limits." The NRC uses the phrase "Isolation of Waste" (10 CFR 60.102 (e) to include both containment by the engineered barrier system and "isolation of wastes by virtue of the characteristics of the geologic repository." The EPA only uses the term isolation to describe "Disposal" as "permanent isolation of spent nuclear fuel or radioactive waste from the accessible environment with no intent of recovery.

The EPA describes a "barrier" as any material or structure that prevents or substantially delays movement of water or radionuclides toward the accessible environment." The engineered barrier system is defined in 10 CFR Part 960 as "the manmade components of a disposal system designed to prevent the release of radionuclides from the underground facility or into the geohydrologic setting....." The NRC defines the engineered barrier system as "the waste packages and the underground facility."

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes Items 1 - 9.)

1. Comment 10 of 31
2. Date November 12, 1991
3. Reviewer Walter J. Arabasz
4. Organization University of Utah
5. Revision Draft/Date August 1991
6. Section 1.3.2
7. Page 1-26
8. Paragraph (Fig. 1-7)

9. Comment

(major)

Figure 1-7 shows the siting of the "Finished Tuff Pile" upslope from the "Central Surface Facilities Area." The vulnerability of the tuff pile to seismically-induced instability and rapid downslope movement during the preclosure period is an important issue for consideration. But I can't find the issue explicitly addressed anywhere in the ESSE Report. My reading of section 3.3.3.4.4 under "Issue #3: Seismic-induced Surface Failure" (p. 3.3.3-48) suggests to me that the stability of the tuff pile wasn't included among the considerations.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The locations of the surface facilities, ramps, and tuff pile(s) have not been finalized. Fig. 1-7 represents an early design for the waste and tuff portals, surface facilities, and the tuff pile(s) that result from excavation of the underground facility. Current design concepts being examined involve two ramps: one located at the waste portal on Fig. 1-7 and the other to the south of the area included in this figure. Both of the ramps would be used to remove mine tailings. Discussions with engineers working to define the final design indicate that they are aware of the potential for seismically induced slope failures on the tuff piles and that they are mitigating this possible hazard by locating the tuff pile(s) sufficiently far from the surface facilities. These designs are not yet mature enough to modify Fig. 1-7. Note that the new design plans have an additional benefit. The use of multiple tuff piles would reduce the height of each pile and reduce the slope-failure hazard to the surface facilities from the tuff pile(s).

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 10 of 31

2. Page 2 of 2

3. Name Walter J. Arabasz
(Print Name)

4. Date November 12, 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

10 Proposed Resolution ( continued )

Text will be added to Section 3.3.3.4.4, page 3.3.3-48, at the end of the first paragraph under Issue #3 as follows: "Proper location and design is also expected to mitigate the hazard from seismically induced slope failure on the tuff piles that result from excavation of the underground facility."

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes Items 1 - 9.)

1. Comment 11 of 31
2. Date November 12, 1991
3. Reviewer Walter J. Arabasz
4. Organization University of Utah
5. Revision Draft/Date August 1991
6. Section 2.3.1.3.1
7. Page 2-14
8. Paragraph first full paragraph

9. Comment

(editorial)

The text states: "The EA acknowledges that stratigraphic and structural relationships appear complex, with rocks ranging in age from Precambrian through Holocene that have undergone many periods of structural deformation." Syntax incorrectly implies that rocks of Holocene age have undergone many periods of structural deformation. Suggested wording: "The EA acknowledges that stratigraphic and structural relationships appear complex. Rocks range in age from Precambrian through Holocene, and many periods of structural deformation have affected the older rocks."

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The text will be revised as suggested by the reviewer.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 12 of 31
2. Date November 12, 1991
3. Reviewer Walter J. Arabasz
4. Organization University of Utah
5. Revision Draft/Date August 1991
6. Section 2.3.1.3.1
7. Page 2-14
8. Paragraph first full paragraph

9. Comment

(minor)

The use of the term "major" to specify faults here and elsewhere in the report (e.g., section 2.3.7.3.3, p. 2-103, paragraph 6) raises confusion because a definition isn't provided. The sentence structure associates the descriptor, "with vertical displacements exceeding 70 meters," to "faults that occur elsewhere in the Great Basin." If this is to be the definition of "major" faults for the Yucca Mountain area, the wording needs to be revised.

Careful thought should be given here. Labeling some of the faults in the Yucca Mountain area as "major" and inviting comparison to "major" basin-range faults elsewhere in the Great Basin introduces many implications about subsurface structure, seismic potential, and so on.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The ESSE Core Team agrees with the reviewer's point. The adjective "major" comes directly from Bath and Jahren (1984), whose usage merely described faults that produced clearly defined magnetic anomalies as measured from aircraft 120 meters above the land surface. For the magnetic stratigraphy and structural setting of Yucca Mountain, a 70-meter fault displacement was the approximate lower limit of detectability. We propose replacing the last sentence of the referenced paragraph with the following:

"North-striking, high-angle extensional faults displace the eastward-dipping Tertiary volcanic rocks both east and west of the potential site, and smaller faults intersect the site itself (Bath and Jahren, 1984; Scott and Bonk, 1984)."

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

***(Instructions on back of form)***

(Reviewer completes Items 1 - 9.)

1. Comment 13 of 31
2. Date November 12, 1991
3. Reviewer Walter J. Arabasz
4. Organization University of Utah
5. Revision Draft/Date August 1991
6. Section 2.3.7.1.1
7. Page 2-78, -79
8. Paragraph last para. on p. 2-78

9. Comment

(editorial)

The text first states: "The disqualifying condition is somewhat narrower than the qualifying condition in its considerations." The paragraph then proceeds in an incisive way to analyze key wording in the disqualifying condition [10 CFR 960.4-2-7 (d)]. For cogency, I urge the authors to end this important paragraph after the words: "...would be unlikely to result in a loss of isolation."

The ensuing text, beginning with the statement, "A resolution that the site is not disqualified under this condition can, therefore, be reached by a negative answer to either of the following two questions...," can be better worded, I believe, to alert the reader that a crucial stage of argument is about to follow, rather than specious logic. The authors are about to address the first part of proposition 2(a) of 10 CFR 960, Appendix III--namely, "The evidence supports a finding that the site is <u>not</u> disqualified on the basis of

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The ESSE Core Team believes this comment is helpful in proposing a more easily understood pathway through the logic of resolving the disqualifying condition. Note, however, that the second question is predicated on the basis of an affirmative answer to the first--a point which, upon rereading, is not sufficiently clear in the report. We propose ending the paragraph as recommended and adding the following paragraph:

"Critical judgment about whether or not the site is disqualified can be guided by sequential consideration of the following two questions: (1) Based on the Quaternary record, is it expected that fault movement will occur within the repository or that ground motion within the repository from outside seismogenic sources will be so severe as to cause a loss of containment with the engineered barrier system (EBS)? (2) If fault movement or ground motion causes a loss of containment, is it likely to result in a loss of waste isolation,

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 13 of 31

2. Page 2 of 2

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4. Date November 12, 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

9 Comment ( continued )

that evidence and is not likely to be disqualified." Affirmation will lead to a higher-level suitability finding.

Suggestion: Begin a new paragraph with wording such as, "Critical judgment about whether or not the site is disqualified can be guided by the following two questions: [insert questions (1) and (2) from paragraph 1 on p. 2-79]." Then end the paragraph with wording such as, "A negative answer to either (but preferably both) of the two preceding questions would provide a solid basis for resolving that the site is not disqualified under the technical guideline."

END OF TEXT

10 Proposed Resolution ( continued )

i.e., releases of radionuclides to the accessible environment exceeding those allowed by the regulations? A negative answer to the first question would provide the basis for a determination that the site is not disqualified under this condition. However, an affirmative answer to the first question would cause deferral of the determination until the effect on waste isolation, which is addressed in the second question, can be evaluated by system performance calculations."

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes Items 1 - 9.)

1. Comment 14 of 31
2. Date November 12, 1991
3. Reviewer Walter J. Arabasz
4. Organization University of Utah
5. Revision Draft/Date August 1991
6. Section 2.3.7.2.2
7. Page 2-83
8. Paragraph (ground-motion model)

9. Comment

(major) (See also Comment XX.)

I understand and strongly endorse the stated need for "a probabilistic assessment of ground motion at the repository depth"--particularly to address the regulatory concept of "likely," specified in the qualifying condition for postclosure tectonics [10 CFR 960.4-2-7(a)]. Within the context of "information required to resolve issues," I believe a well-founded deterministic assessment of ground motion is also required, as a practical matter, and should be specifically mentioned here. Admittedly, regulatory policy has not yet been fully developed regarding the site characterization of seismic ground motion and fault displacement at a geologic repository. Nevertheless, experience, together with preliminary indications of the thinking of NRC staff (Blackford and McConnell, 1991), suggest that the need for companion guidance from a deterministic analysis is inescapable.

Let me be clear. I do not suggest that a deterministic

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The reviewer makes a compelling case, including recent and authoritative references, for explicitly considering deterministic assessment of ground motion as a companion guide to a probabilistic assessment. Relevant perspectives on ground-motion assessment are also given in the responses to this reviewer's Comments #23, #25, #26 and #27, all of which relate to the preclosure time frame. We propose the following revisions to this section:

a. The paragraph labeled "(2) Probabilistic ground-motion model" will be labeled "(2) ground-motion model" and the first paragraph will be replaced by the following text:

"To estimate the postclosure effects of earthquakes, the hazard from ground shaking at the proposed repository depth must be assessed. Models for expected ground motion during the postclosure period are available, but additional calculations will be needed as data, viable

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 14 of 31

2. Page 2 of 3

3. Name Walter J. Arabasz
(Print Name)

4. Date November 12, 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

9 Comment ( continued )

analysis of seismic ground motion should govern the issue of site suitability--under technical guidelines for either postclosure or preclosure tectonics. What I'm suggesting is the following: (1) Regulators will likely require, for their own understanding and confidence, at least the availability of a rigorous, well-founded deterministic analysis before acceding to the conclusions of a probabilistic analysis. (2) A deterministic seismic hazard analysis has great practical value, either as a companion guide to, or integrated with, a probabilistic analysis; the joint information facilitates critical decision-making among scientists and engineers and provides important information for public scrutiny (see, for example, Reiter, 1990, p. 227-230).

END OF TEXT

10 Proposed Resolution ( continued )

tectonic models, and/or analysis techniques change (see Section 3.3.3.4.4, Issue #1: Maximum Ground Motion). Instrumental measurements of subsurface ground motion at Yucca Mountain are sparse, as are reported observations of the effects of ground motion on underground openings. Thus additional data will be needed to improve the reliability of characterizing ground motion at the repository depth compared to predicted ground motion at the surface. Because of various uncertainties relating to future tectonic activity, probabilistic estimates of ground motion (see Section 3.3.3.4.4, for example) are inherently difficult to validate for the long postclosure period of concern. Deterministic analyses will be required to provide companion guidance in evaluating the exposure of the repository to future ground motions associated with the earthquake-generating framework of the Yucca Mountain region."

b. The second sentence of the second paragraph will be revised to read:

"The instrumental record is limited, however, and must be extended by estimates of paleoseismicity from field studies of faults in the vicinity of Yucca Mountain and at sites that are possible analogs for future tectonism at Yucca Mountain region."

c. We propose no changes to third paragraph of this section.

d. A fourth paragraph will be added as follows:

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 14 of 31

2. Page 3 of 3

3. Name Walter J. Arabasz
(Print Name)

4. Date November 12, 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

10 Proposed Resolution ( continued )

"Deterministic calculations, probabilistically predicted ground motion guided in part by information from tectonically analogous settings, and observations of subsurface effects must be considered together to reach defensible judgments of the hazard to waste containment and isolation. If the hazard is shown to be of credible consequence, system performance assessments can appropriately be expressed probabilistically, accounting for associated uncertainties."

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

***(Instructions on back of form)***

(Reviewer completes items 1 - 9.)

1. Comment 15 of 31
2. Date November 12, 1991
3. Reviewer Walter J. Arabasz
4. Organization University of Utah
5. Revision Draft/Date August 1991
6. Section 2.3.7.3.2 (general comment)
7. Page 2-90 ff.
8. Paragraph

9. Comment

(minor)

The scope and objectivity of this "Review of Information Obtained since the EA," relevant to postclosure tectonics, warrant comment. One of the principal charges for this Peer Review is to confirm the adequacy of information presented in the ESSE. I have carefully read: the EA (DOE, 1986); those parts of the SCP (DOE, 1988a) relevant to the site geology, tectonics, and seismic hazards; and dozens of supporting references cited in the ESSE Report that bear on critical issues of tectonic models, potential fault displacement, and seismic ground motion. The text of this section provides an excellent summary, and it reflects well the extraordinary degree of expert examination and devil's advocacy that I find being applied to evaluating geoscience aspects of the suitability of the Yucca Mountain site as a potential repository.

Obviously, site-characterization is still at an early stage. Nevertheless, the approaches taken to date to evaluate geoscience aspects of site suitability

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The authors of the ESSE report appreciate comments by Dr. Arabasz regarding the quality and adequacy of the information presented in the Postclosure Tectonics section. We are encouraged that he found the report to represent a balanced view of the uncertainties related to his area of expertise.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 15 of 31

2. Page 2 of 2

3. Name Walter J. Arabasz
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4. Date November 12, 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

9 Comment ( continued )

have been on the right track, in my opinion, and I come away with great confidence in the objectivity of the ongoing process. Put another way, a number of tough questions occurred to me as I read the EA and the SCP, but when I came to the ESSE Report, I was pleasantly surprised to find the authors had explored the same tough questions--and the report candidly discusses problems, alternative interpretations, and basic uncertainties.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 16 of 31
2. Date November 12, 1991
3. Reviewer Walter J. Arabasz
4. Organization University of Utah
5. Revision Draft/Date August 1991
6. Section 2.3.7.3.2.1
7. Page 2-93
8. Paragraph last paragraph

9. Comment

(minor)

The text refers to a suggestion of dePolo and others (1990) "that the MBE [maximum background earthquake] for the Basin and Range Province is at least magnitude 6.3 and may be as high as magnitude 6.8...." The upper-bound size of 6.8, suggested by dePolo and others (1990), comes from the 1925 Clarkston Valley, Montana, earthquake, for which no surface rupture was observed. For the record, Doser (1989) has determined an instrumental moment magnitude ($M_w$) of 6.6 for the 1925 Clarkston Valley earthquake; Gutenberg and Richter (1954) assigned a magnitude [inferred to be a surface-wave magnitude] of 6 3/4.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

In response to this comment, the following changes will be made to the last paragraph on page 2-93. The latter part of the second sentence will be replaced: add a third sentence, and remove ", however," from the former third sentence, so as to read: "...basing their conclusion on analysis of 38 historical earthquakes in the Basin and Range Province." A sentence will be added reading "The upper bound for the MBE, a local ($M_l$) or surface-wave ($M_s$) magnitude 6.8, is based on the 1925 Clarkston, Montana earthquake; Doser (1989) has determined an instrumental moment magnitude ($M_w$) of 6.6 for that earthquake." The word "however" will be removed from the former third sentence.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
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(Reviewer completes items 1 - 9.)

1. Comment 17 of 31
2. Date November 12, 1991
3. Reviewer Walter J. Arabasz
4. Organization University of Utah
5. Revision Draft/Date August 1991
6. Section 2.3.7.3.2.1
7. Page 2-94
8. Paragraph 1

9. Comment

(minor)

The text incorrectly gives a surface-wave magnitude ($M_s$) of 7.6 to the 1932 Cedar Mountain, Nevada, earthquake. An authoritative study and catalog made by Abe (1981) assigns that earthquake a surface-wave magnitude of 7.2; dePolo and others (1990, Table 3) also list $M_s$=7.2 for the earthquake.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The comment is correct and probably identifies a typographical error. The text will be changed to specify $M_s$=7.2 for the Cedar Mountain earthquake.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 18 of 31
2. Date November 12, 1991
3. Reviewer Walter J. Arabasz
4. Organization University of Utah
5. Revision Draft/Date August 1991
6. Section 2.3.7.3.3
7. Page 2-103
8. Paragraph 4

9. Comment

(major)

I agree with the conclusion that a lower-level suitability finding is supported for the qualifying condition under the postclosure guidelines for tectonics [10 CFR 960.4-2-7(a)]. In my judgment, the logic of proposition 3(a) of 10 CFR Part 960, Appendix A applies: "The evidence does not support a finding that the site is not likely to meet the qualifying condition."

In my opinion, the authors of the ESSE Report follow well-reasoned logic in applying the relevant technical guidelines for postclosure tectonics. Their presentation and analysis of available geoscience information is thorough and notably objective. Appropriately, given the preliminary nature of available site-characterization information, the authors are conservative in their evaluation, use carefully-measured arguments, and stay within defensible bounds. The following statement (p. 2-102, para. 4) typifies their careful approach: "Although damaging fault movement or ground motion are not expected,

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The authors of the ESSE Report appreciate explicit statements by Dr. Arabasz in this comment regarding his support for the lower-level finding for the qualifying condition for the Postclosure Tectonics Guideline. We also are pleased that he found the evaluation of this guideline to be objective and appropriately conservative.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
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*(Instructions on back of form)*

1. Comment 18 of 31

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5. Comment or Proposed Resolution or Resolution *(Circle one)*

9 Comment ( continued )

as discussed in Section 2.3.7.3.3.1, neither have they been demonstrated to be so unlikely as to be considered inconsequential."

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

***(Instructions on back of form)***

(Reviewer completes items 1 - 9.)

1. Comment 19 of 31
2. Date November 12, 1991
3. Reviewer Walter J. Arabasz
4. Organization University of Utah
5. Revision Draft/Date August 1991
6. Section 2.3.7.3.3
7. Page 2-103
8. Paragraph (disqualifying condition)

9. Comment

(major)

Regarding the disqualifying condition for postclosure tectonics, the authors state: "It is the consensus of the team conducting this evaluation that the evidence supports a conclusion that (1) the site is not disqualified and (2) information to be collected in the future is unlikely to result in disqualification under this condition (Level 2)." Hence, the authors assert support for a higher-level suitability finding under this technical guideline. I have come to agree with this position--but only after a great deal of wrestling with the logic and issues involved.

When I first encountered this position in the Executive Summary, I was highly skeptical about being able to agree. There seemed to be evident dilemmas in advocating a higher-level suitability finding for this disqualifying condition while at the same time advocating (1) a lower-level suitability finding for the disqualifying condition for postclosure

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The ESSE Core Team believes that the necessity for the reviewer's reconstruction of the logic for the recommended finding on this disqualifying condition indicates that clarification is appropriate. We propose the following revision of the disqualifying condition discussion on pages 2-103 and 2-104:

"The consensus of the Core Team is that the evidence supports a conclusion that (1) the site is not disqualified and (2) information to be collected in the future is unlikely to result in disqualification under this condition (Level 2). The conclusion results from the lack of expectation that fault movement or ground motion will cause a loss of containment within the EBS, i.e., a negative answer to the first of the two questions posed in Section 2.3.7.1.1.

Yucca Mountain and the surrounding vicinity have been intensely

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
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1. Comment 19 of 31

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5. Comment or Proposed Resolution or Resolution *(Circle one)*

9 Comment ( continued )

geohydrology and (2) a lower-level suitability finding for the qualifying condition for postclosure tectonics.

My quandry about linkage to hydrology raised the following questions: What's the scope of site suitability being considered under this guideline for tectonics? Was this guideline intended to isolate direct effects of faulting and vibratory ground motion on the EBS from indirect effects that might be linked to changes in the hydrologic system? Does it deal only with possible damage to the EBS by faulting or ground motion--or does the phrase "such that" require concern too for indirect effects like changes to the hydrologic system that might threaten waste isolation? I finally reasoned, after interactions with members of the core team, that the primary intent of the guideline was to address tectonic events--separate from tectonic-hydrologic-coupled events. And if the latter indeed had to be considered as entangled, such events were possible only as short-duration events and not as a serious disqualifying factor.

The apparent inconsistency of different level findings for the disqualifying and qualifying conditions for postclosure tectonics was easier to reconcile, thanks to the careful analysis presented in section 2.3.7.1.1. The text points out convincingly, I believe, that there are different considerations involved in the qualifying and disqualifying conditions. Importantly, the disqualifying condition focuses on the geologic record rather than on the geologic setting, it restricts consideration to "fault movement or other ground motion," and it uses the key word "expected."

In sum, I'm persuaded by the evidence and arguments for a higher-level suitability finding under guidelines for the disqualifying condition for postclosure tectonics. A screening process can't be inherently open-ended. There's a strong case for resolving the disqualifying condition for postclosure tectonics--but my own experience suggests that others may similarly face some initial mental roadblocks before agreeing.

END OF TEXT

10 Proposed Resolution ( continued )

studied by means of geologic mapping, geophysical surveys, remote sensing, and geomorphic analysis. Evaluations of the resulting geologic record, though preliminary, provide a reasonable expectation that Quaternary fault movement has occurred only on the principal north-striking faults, which formed in Miocene time and which have had continued or renewed activity in the Quaternary, but with small slip

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
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5. Comment or Proposed Resolution or Resolution *(Circle one)*

10 Proposed Resolution ( continued )

rates. The current state of stress in the shallow crust at Yucca Mountain is consistent with continued movement on these faults rather than initiation of new faults. Although distributive or secondary faulting is probably responsible for the closely spaced small-displacement faults west of the principal faults, such subsidiary faults have not been identified within the boundaries of the potential repository. Furthermore, there is no evidence to suggest that the small Tertiary faults, such as the Ghost Dance fault, within the repository boundaries have Quaternary displacement. The combined evidence argues against an expectation that fault movement will disrupt the EBS directly or cause new infiltration pathways that might lead to accelerated degradation of the EBS.

The geologic record, in terms of observed displacements on presently identified faults, provides a basis for inferring potential ground motion. The Paintbrush Canyon fault is expected to govern both the maximum earthquake and ground motion near Yucca Mountain. Large individual fault displacements during the Quaternary have not been identified in the trenches that have been excavated and examined on the Paintbrush Canyon and other faults, providing paleoseismic evidence against large-magnitude ($M \geq 7$) earthquakes. However, the exposures in these trenches do indicate surface rupture, implying associated earthquakes in the magnitude 6 range, perhaps arguably exceeding the maximum background earthquake of local or surface-wave magnitude 6.8 proposed by dePolo et al. (1990). The stability of steep slopes at Yucca Mountain and the unrotated orientations of heavily varnished colluvial boulders on these slopes provide empirical, though nonquantitative, evidence against severe ground motion from nearby, large-magnitude earthquakes. Peak horizontal acceleration in the repository area is expected to be less than 1g, probably less at the repository depth, and of long wavelength relative to the dimensions of the EBS. Consequently, it is not expected that subsurface ground motion will damage the EBS sufficiently to precipitate a loss of containment.

In summary, based on the available geologic record of the Quaternary Period, the consensus of the Core Team is that the nature and rates of fault movement or other ground motion are not expected to be such that a loss of waste containment is likely to occur. The team therefore conclude that a higher-level suitability finding can be supported for this disqualifying condition. Site characterization

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# COMMENT RESPONSE FORM
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10 Proposed Resolution ( continued )

activities should focus on reducing the existing uncertainties to the levels required for resolving the broader and more stringent requirements of the qualifying condition."

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 20 of 31
2. Date November 12, 1991
3. Reviewer Walter J. Arabasz
4. Organization University of Utah
5. Revision Draft/Date August 1991
6. Section 2.3.7.3.3
7. Page 2-104
8. Paragraph 2

9. Comment

(minor)

In characterizing aspects of the Quaternary geologic record, the text states: "...and the stability of steep slopes at Yucca Mountain, including the mantles of heavily varnished colluvial boulders, argue strongly against the occurrence of strong ground motion within at least the last million years."

I do not agree that "the stability of steep slopes at Yucca Mountain, including the mantles of heavily varnished colluvial boulders, argue [sic] strongly against the occurrence of strong ground motion within at least the last million years." Evidence for the long-term stability of hillslopes in the Yucca Mountain area is described in the SCP (DOE, 1988a, p. 1-31) and is acknowledged. Apart from the fact that the dating of desert varnish is controversial (e.g., Gibson and others, 1991, p. 34-36), no information is presented in the ESSE Report to suggest that heavily varnished clasts have been objectively studied to investigate exposure (or non-exposure) to seismic

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The ESSE Core Team concurs that the importance placed on the suitability of slopes and varnished colluvial boulders was probably stronger than is justified, and that the argument, if presented here, should be supported in the earlier text. We propose the following changes:

(1) p. 2-97, Section 2.3.7.3.2.2, insert paragraph between existing first and second paragraphs (following "...concern for the postclosure period."):

"Yucca Mountain is characterized by very steep slopes, mantled in places by colluvial boulders that are coated by well developed desert varnish. These features and methods for estimating their antiquity are discussed in Section 2.3.5.3.2.1 relative to their use in demonstrating low rates of erosion (Whitney and Harrington, 1988 and in preparation). Although slope failures and rockfalls occur commonly near epicentral zones of major earthquakes, the inverse problem--that

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
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9 Comment ( continued )

shaking. I suggest deleting the subjective arguments. Introducing them in a concluding statement, without prior discussion and substantiation, weakens the conclusions.

END OF TEXT

10 Proposed Resolution ( continued )

of estimating peak ground motion experienced by still-stable slopes--has apparently not been addressed. Varnished colluvial boulders, including many in apparently precarious positions, have remained unrotated for apparently hundreds of thousands of years suggests that severe ground acceleration approaching 1g has not occurred during this period. However, this observation has not been calibrated by systematic correlations of rockfalls or boulder rotation with measured ground motion."

(2) p. 2-103 and 2-104: See the revised text under the "Disqualifying Condition" paragraph added in response to Dr. Arabasz's Comment #19.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
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(Reviewer completes items 1 - 9.)

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2. Date November 12, 1991
3. Reviewer Walter J. Arabasz
4. Organization University of Utah
5. Revision Draft/Date August 1991
6. Section 3.0 (general comment)
7. Page 3-1 ff.
8. Paragraph NA

9. Comment

(minor)

Within the realm of seismic-hazard considerations (ground motion and fault displacement), there is fundamental overlap between analyses for postclosure and preclosure tectonics, despite different issues applying. Accordingly, comments about site vulnerability to fault displacement and seismic ground motion are generally relevant to both time frames. Postclosure concerns relate chiefly to whether faulting or ground motion will damage the EBS, and perhaps induce tectonic-hydrologic-coupled changes that could jeopardize waste isolation. The major issues for the preclosure time frame are the potential effects of fault displacement and strong ground motion relating to the location and seismic design of the surface facilities.

Under 10 CFR Part 960, preclosure guidelines are given secondary significance to the postclosure guidelines, and "Ease and Cost" guidelines are ranked lower in importance than guidelines for preclosure radiology safety.

10. Proposed Resolution *(To be completed by ESSE Core Team)*

This comment correctly points out that 10 CFR Part 960 places primary significance on the Postclosure Guidelines. However, as indicated, site data collected to resolve technical issues in tectonics must be used to address both preclosure seismic hazards and postclosure tectonic effects. The need for a unified approach to the general topics of ground motion and fault displacement is recognized by the ESSE Core Team, and close coordination has occurred between the authors of the pre- and postclosure tectonics sections. If the Yucca Mountain Site is found suitable and enters the licensing process with the U.S. Nuclear Regulatory Commission (NRC), the NRC's responsibility for protection of public health and safety ensures that seismic hazard issues will receive further attention. If the NRC technical staff and consultants are not convinced that seismic-hazard issues are properly addressed, it is unlikely they would recommend that licensing proceed.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
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5. Comment or Proposed Resolution or Resolution *(Circle one)*

9 Comment ( continued )

This hierarchy shouldn't lead to confusion about the relative importance of information on fault displacement or ground motion. Reliable, unified modeling is needed to address all the seismic-hazard issues, in whatever time frame.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
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*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 22 of 31
2. Date November 12, 1991
3. Reviewer Walter J. Arabasz
4. Organization University of Utah
5. Revision Draft/Date August 1991
6. Section 3.3.1.4.4.1(new 3.3.1.4.5.1)
7. Page 3.3.1-17
8. Paragraph 2

9. Comment

(minor)

The text states: "Test areas for UNEs [underground nuclear explosions] are 24 to 33 miles north and east of the Yucca Mountain site. If a repository were to be constructed at the site, it would be built to withstand ground motion from both UNE and natural sources. The maximum ground motion (99 percent confidence) from UNEs was predicted to be 0.32g." The distance range given for the UNEs is confusing.

The report by URS/Blume (1986, p. 73) indicates that the location of the UNE event that has the maximum potential of inducing ground motion at the Yucca Mountain site is "a 700-kt event located in the Buckboard Mesa area at its closest approach, a distance of 21.3 km, to the reference conceptual site for repository surface facilities." Walck and Phillips (1990) similarly refer to "the Design Basis underground nuclear explosion for the Yucca Mountain Project, which is a 700 kt blast in the Buckboard Mesa area, about 23 km from Yucca

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The reviewer points out inconsistencies in the text and supporting references regarding the locations and sizes of underground nuclear explosions (UNE) at the Nevada Test Site (NTS). The text being reviewed in this section is from the Environmental Assessment (DOE, 1986) and thus, is somewhat dated, although it correctly describes the locations of the ongoing UNE program at the NTS. The newer URS/Blume (1986) and Walck and Phillips (1990) references explain that a 700-kt event at Buckboard Mesa is used as the "design basis UNE" for the repository, rather than smaller events that are currently conducted at locations 24 to 33 miles north and east of Yucca Mountain. This is because Buckboard Mesa could become a future UNE testing area under certain scenarios, and the 700-kt event is a size that could not be exceeded due to offsite damage restrictions. Note that the UNE that generates the 0.32g (99 percent confidence) is predicted only if the current limits (The Threshold Test Ban Treaty--TTBT--limits the size of UNEs to 150 kt) on the size of UNEs were no longer in effect. The current U.S. testing program complies with

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

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# COMMENT RESPONSE FORM
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1. Comment 22 of 31

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5. Comment or Proposed Resolution or Resolution *(Circle one)*

9 Comment ( continued )

Mountain."

END OF TEXT

10 Proposed Resolution ( continued )

the TTBT and is conducted in geographic locations that are further removed from the Yucca Mountain Site than the Buckboard Mesa area.

END OF TEXT

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# COMMENT RESPONSE FORM

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(Reviewer completes items 1 - 9.)

1. Comment 23 of 31
2. Date November 12, 1991
3. Reviewer Walter J. Arabasz
4. Organization University of Utah
5. Revision Draft/Date August 1991
6. Section 3.3.3.4.2.1
7. Page 3.3.3-25 f.
8. Paragraph 2 of 3.3.3.4.2.1

9. Comment

(minor)

In describing the four issues for Preclosure Tectonics, the authors propose to analyze "the expected maximum ground motion" in Issue 1 and "the expected surface displacement" in Issue 2. The choice to specify maximum for ground motion but not surface displacement raises confusion about whether the authors are intentionally distinguishing deterministic versus probabilistic considerations for the two issues.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

Both Issues #1 and #2 should be cast in a probabilistic framework. The ESSE Core Team agrees, however, with the reviewer's Comment #14 that both probabilistic and deterministic analyses will be expected by the NRC prior to licensing. For site-suitability evaluations under the Preclosure Tectonics Guideline in 10 CFR Part 960, however, we consider the probabilistic approach described here to be adequate to determine if the site should be further characterized and evaluated as a potential repository site. For this evaluation and with a limited data base, a comprehensive probabilistic-deterministic analysis is not warranted at this time; however, we believe that a comprehensive analysis should be performed as data become available.

Wording throughout the text under Issue #1 will be changed from "expected maximum ground motion" to "expected ground motion" to be consistent with the wording for Issue #2 and with the probabilistic approach.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

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(Reviewer completes Items 1 - 9.)

1. Comment 24 of 31
2. Date November 12, 1991
3. Reviewer Walter J. Arabasz
4. Organization University of Utah
5. Revision Draft/Date August 1991
6. Section 3.3.3.4.3.1
7. Page 3.3.3-29
8. Paragraph (Table 3.3.3-4)

9. Comment

(editorial)

In the description of DOE findings for Potentially Adverse Condition (2) the text states: "...historical earthquakes and past man-induced seismicity are not expected to cause ground motion at the site that would exceed reasonable design limits." Suggested revision: "...a repeat of historical earthquakes or past man-induced seismicity is not expected to cause ground motion..."

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The text of the conclusions for the potentially adverse conditions cannot be changed since these were quoted from the Environmental Assessment (DOE, 1986) and therefore are not open to revision. However, the phrase will be corrected as suggested by Dr. Arabasz if it is used again.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 25 of 31
2. Date November 12, 1991
3. Reviewer Walter J. Arabasz
4. Organization University of Utah
5. Revision Draft/Date August 1991
6. Section 3.3.3.4.3.2
7. Page 3.3.3-34
8. Paragraph 3

9. Comment

(major)

The text states: "In general, most north-trending faults at Yucca Mountain are active and have experienced multiple displacements during the Quaternary period. The timing and rate of this seismic activity is important to understanding the seismic threat to the surface facilities and the degree to which RAT can accommodate this activity. Additional paleoseismic studies are needed to reduce current uncertainties with respect to likely seismic activity near and at the site."

The above assessment is part of an excellent summary of information obtained since the EA (DOE, 1986) relevant to Quaternary geology in the Yucca Mountain area. However, both the assessment and the summary are incomplete, in my opinion, in neglecting to point out some fundamental uncertainties.

Alternative tectonic models allow the possibility that Quaternary faulting

10. Proposed Resolution *(To be completed by ESSE Core Team)*

New text will be added to the document discussing the uncertainty in tectonic models and the impact of this uncertainty on expected ground motion. Also, discussion will be added on uncertainties inherent in paleoseismic measurements.

The following text will be added at the end of the discussion on Quaternary Geology within Section 3.3.3.4.3.2, page 3.3.3-34: "It should be noted that multiple tectonic models exist for Yucca Mountain. Some of these models involve strain partitioning or decoupling of the upper and lower crust. Strain rates in the lower crust may be different than those in the upper crust; seismogenic sources at depths not yet accounted for could conceivably result in a higher seismic hazard from ground motion than would be obtained from paleoseismic and historical seismicity studies [see Section 2.3.7.3.2]. These uncertainties should be accounted for in future seismic hazard analyses. In addition, other crustal models have been postulated that suggest regional

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION COMMENT RESPONSE FORM (CONTINUATION SHEET)

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1. Comment 25 of 31

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5. Comment or Proposed Resolution or Resolution *(Circle one)*

9 Comment ( continued )

in the vicinity of the Yucca Mountain site may represent accommodation of deformation above deeper (and perhaps different) seismogenic structures, due to some type of strain partitioning (e.g., Lettis and Hanson, 1991) or decoupling of deformation between upper crustal and underlying levels. The latter issue is raised explicitly in section 2.3.7.3.2 (p. 2-91) in connection with Postclosure Tectonics, where the statement is made: "If at least partial decoupling of an upper plate from the underlying seismogenic zone is demonstrated, paleoseismic investigations in the immediate vicinity of the Yucca Mountain site may have limited application in forecasting ground-motion characteristics; however, local paleoseismic data would still be needed in predicting the probability of primary and secondary faulting within the repository." The idea that upper-crustal faults might represent "accommodation structures" above deeper seismogenic structures does not require validation of a detachment model. For example, extensional faulting in the upper crust can be easily related conceptually to en echelon strike-slip faulting at depth (e.g., Sylvester, 1988).

Another area of uncertainty regarding observed slip rates described in the subject paragraph relates to unknown amounts of strike slip. The SCP (DOE, 1988a, p. 1-208) raises the appropriate caveat, "Considering that Yucca Mountain is in the Walker Lane, a belt of right-lateral shear, vertical displacement rates may be deceiving, because strike slip may well have exceeded dip slip on many of the faults near Yucca Mountain."

END OF TEXT

10 Proposed Resolution ( continued )

stresses may be oriented such that strike-slip movement on faults may be the dominant slip component. Paleoseismic data and historical earthquake studies will be needed to evaluate the likelihood of strike-slip faulting as the dominant slip component and to evaluate the probability of distributed faulting within the repository and at the surface facilities."

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
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2. Date November 12, 1991
3. Reviewer Walter J. Arabasz
4. Organization University of Utah
5. Revision Draft/Date August 1991
6. Section 3.3.3.4.3.2(3) (general comm.)
7. Page 3.3.3-36 ff.
8. Paragraph

9. Comment

(minor)

The subsection dealing with the "Seismic Design of the Repository" summarizes results of a remarkable engineering analysis by Subramanian et al. (1989). I emphasize "remarkable" because seldom does an engineering analysis strike such a hammer-blow for decisive closure to earth-science deliberations.

Unless more site-specific seismic-hazard data change the assumptions of the analysis, a good blueprint has been set for choosing a design level--and accommodation by "reasonably available technology" isn't a serious concern, in my opinion.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The ESSE Core Team recognizes the need to review the Subramanian et al. (1989) study as new site-specific seismic hazard data become available and appreciates your positive statements about the importance of this study.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

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1. Comment 27 of 31
2. Date November 12, 1991
3. Reviewer Walter J. Arabasz
4. Organization University of Utah
5. Revision Draft/Date August 1991
6. Section 3.3.3.4.4
7. Page 3.3.3-37 ff.
8. Paragraph (Issue #1: Ground Motion)

9. Comment

(major)

I offer some general comments regarding Issue #1: Maximum Ground Motion. As in Comment 14, I reiterate my strong belief that the need for both probabilistic and deterministic seismic hazard analyses is inescapable. Work done to date on both types of analyses (briefly summarized on p. 3.3.3-35) is acknowledged. The rigor of the methodology applied by URS/Blume (1987) gives me substantial confidence in the quantitative, probabilistic assessments of both ground motion and surface-rupture hazards--based on existing information. Gibson (1991) forthrightly comments on the numerous deterministic and probabilistic seismic hazard studies performed to date for the Yucca Mountain site and cautions that, "All of these hazard analyses contain large uncertainties, owing to the limited site-specific data." Similarly, the authors of the ESSE Report (p. 3.3.3-52) acknowledge that "additional site-specific data is needed to confirm that estimates of the seismic hazard potential are valid."

10. Proposed Resolution *(To be completed by ESSE Core Team)*

Additional text will be added in response to Dr. Arabasz's Comment #25 describing the uncertainty in tectonic models and the implications of this uncertainty to seismic hazard analysis. Wording at the top of page 3.3.3-40 will be changed to read: "Additional calculations of expected ground motion are likely to be needed as data, viable tectonic models, and/or analysis techniques change."

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
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9 Comment ( continued )

My chief concern regarding seismic hazard (ground-motion) analyses done to date lies with the seismic-source scenarios and maximum magnitudes so far considered. In particular, if the Quaternary faulting in the immediate vicinity of Yucca Mountain reflects deformation that is an accommodation of strain above deeper and different seismogenic structures (see Comment 25), then the hazard hasn't yet been reliably modeled. The "wild card," in my view, would be the nucleation of infrequent sizable earthquakes on buried strike-slip faults beneath or near the site, rather than seismogenesis on a subsurface detachment. The common and not-understood occurrence of background earthquakes with strike-slip focal mechanisms in the general region of Yucca Mountain (DOE, 1988a, p. 1-171 ff.) signals a lack of a fundamental understanding of the earthquake-generating framework in the southern Great Basin.

That said, my familiarity with seismic hazard analysis suggests to me that revised probabilistic seismic hazard analyses--for the exposure period of the surface facilities--will probably not lead to results that invalidate the levels of ground motion already being considered for the repository design. The frequency of sizable earthquakes on buried faults somehow would have to be reflected in the (already known) surface displacement field, and distance to deeper nucleation points would probably result in peak ground-motion parameters comparable to those already being considered. Rigorous analysis should still be pursued though.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
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(Reviewer completes items 1 - 9.)

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2. Date November 12, 1991
3. Reviewer Walter J. Arabasz
4. Organization University of Utah
5. Revision Draft/Date August 1991
6. Section 3.3.3.4.4
7. Page 3.3.3-40
8. Paragraph 2

9. Comment

(minor)

The text states: "In summary, during the next 10,000 years, we should expect a maximum PGA of approximately 0.5g, based on the assumptions presented in URS/Blume." Reference is made in the following sentence to "Lee et al., in press" [Lee et al., 1991], who give a design-basis ground motion, for waste canister design, as 0.6g--the peak horizontal ground acceleration with an exceedance probability of less than 10% in 1,000 years. This ground-motion level is also described for the reader in section 2.3.7.3.2.2 (p. 2-97). For consistency, I suggest the results of Lee et al. (1991) should be explicitly mentioned in this paragraph.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The text in Section 3.3.3.4.4, page 3.3.3-40, paragraph 2, beginning in the third sentence, will be modified to state: "For a recurrence expectancy of 10,000 years in Fig. 3-6 (previously Fig. 3.3.3-5), the largest expected PGA is about 0.6g, a value where a "light damage" level has a very small probability. Virtually no damage, "light damage," in the worst case, is expected during the next 100 years for a WHB facility (see also Lee et al., 1991), because of its inherent robustness."

The following text will be added to page 3.3.3-40, after the second complete paragraph: "URS/Blume (1987) focuses on the sensitivity of seismic hazard to various earthquake magnitude recurrence and fault behavior parameters. The authors differentiate the contribution by certain faults and families of faults to the total seismic hazard. The calculated ground motion is dominated by the behavior of the Paintbrush Canyon fault and associated nearby faults and by background seismicity. Of the various input parameters

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
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10 Proposed Resolution ( continued )

considered in the study, the seismic hazard is most sensitive to an assumed slip-rate; however, few Quaternary slip-rates were available at the time of these calculations.

Alternative seismotectonic interpretations were parameterized by considering only normal faulting in one case and oblique-slip in the other. Recent work, including that by Whitney and Muhs (1991), supports oblique-slip on at least the Paintbrush Canyon-Stagecoach fault system. Preliminary evaluation of three alternative tectonic models--oblique-slip, detachment, and shear--was also made by URS/Blume (1987). Of these simple tectonic models, the shear model produced the greatest hazard while the detachment presented the least hazard. These models will presumably be refined as study continues."

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes Items 1 - 9.)

1. Comment 29 of 31
2. Date November 12, 1991
3. Reviewer Walter J. Arabasz
4. Organization University of Utah
5. Revision Draft/Date August 1991
6. Section 3.3.3.4.4 (general comment)
7. Page 3.3.3-40 ff.
8. Paragraph (Issue #2)

9. Comment

(minor)

The discussion relating to "Issue #2: Expected Surface Displacement" focuses, appropriately, on the results of rigorous analyses made by Subramanian et al. (1989) and URS/Blume (1987). These results, together with the consistency of the order of magnitude of slip-rate observations for Quaternary faulting in the Yucca Mountain area, allowance for secondary rupture resulting from coseismic slip on nearby faults (Coppersmith and Youngs, 1990), and results of preliminary trenching and geophysical studies in the site area (Gibson et al., 1991), all give me confidence that a good provisional assessment of surface-displacement hazard is in hand.

A tangential issue relating to surface displacement is that of the expected length and pattern of surface faulting which might be inferred from paleoseismic and empirical data. My remarks in Comment 25 about the possibility that upper-crustal faults may reflect accommodation structures above

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The ESSE Core Team recognizes that the current assessment of surface-displacement hazard is provisional and that further field data on Quaternary fault activity, as well as further investigation of the model that surface faults represent distributed faulting above deeper seismogenic structures, could lead to revisions in the hazard estimates. New text is proposed to explicitly address these uncertainties in the response to Dr. Arabasz's Comment #25.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 29 of 31

2. Page 2 of 2

3. Name Walter J. Arabasz
(Print Name)

4. Date November 12, 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

9 Comment ( continued )

deeper seismogenic structures lead me to be sympathetic to arguments about the possibility of distributed faulting, analogous to the case of the 1932 Cedar Mountain earthquake (see SCP, DOE, 1988a, p. 111 f.).

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes Items 1 - 9.)

1. Comment 30 of 31
2. Date November 12, 1991
3. Reviewer Walter J. Arabasz
4. Organization University of Utah
5. Revision Draft/Date August 1991
6. Section 3.3.3.4.4
7. Page 3.3.3-48
8. Paragraph para. 1 of Issue #3

9. Comment

(major)

Regarding the discussion of "Issue #3: Seismic-induced Surface Failure," cross-reference is made to Comment 10. It appears to me that the vulnerability of the "Finished Tuff Pile" to seismically-induced instability and rapid downslope movement during the preclosure period was not included among considerations here.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

Text will be added to page 3.3.3-48 in response to Dr. Arabasz's Comment #10 regarding the potential for seismically induced slope failures of the tuff pile(s).

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 31 of 31
2. Date November 12, 1991
3. Reviewer Walter J. Arabasz
4. Organization University of Utah
5. Revision Draft/Date August 1991
6. Section 3.3.3.4.5
7. Page 3.3.3-50
8. Paragraph para. 2 & 3 of 3.3.3.4.5

9. Comment

(major)

Under the guidelines of 10 CFR Part 960 for preclosure tectonics, I agree with the ESSE Report's conclusion that evidence continues to support a lower-level suitability finding for the qualifying condition. I also agree that a higher-level suitability finding is supported for the disqualifying condition. The logic is succinctly stated on p. 3.3.3-52: "Although current evidence indicates that seismic and volcanic hazards at the Yucca Mountain site can be accommodated by RAT, additional site-specific data are needed to confirm that estimates of the seismic hazard potential are valid."

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The ESSE Core Team appreciates Dr. Arabasz's agreement with its conclusions.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

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# *Dr. John H. Bell*

## HEALTH PHYSICS & RADIOLOGICAL SAFETY

University of Nevada
Las Vegas, NV

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESOLUTION RECORD

Peer Reviewer's Statement:

I have reviewed the ESSE Integrated Evaluation Package in accordance with ESSE Peer Review Plan. My conclusions with respect to the review criteria of the ESSE Peer Review Plan are:

| Review Criteria | Yes: See Comment(s) Nos.* | Adequate No: See Comment(s) Nos. |
|---|---|---|
| In my areas of expertise: | | |
| A. The content of the ESSE Integrated Evaluation Package provides an unbiased and objective presentation of information relevant to the suitability issues covered by each guideline. | ✓ | |
| B. The conclusions about the status of lower and higher-level findings on the siting guidelines are balanced and defensible. | ✓ | |

Comments 1 through 29 are attached.

Peer Reviewer John H. Bell Date Dec. 11, 1991

Comment Resolution Record

Yes ✓ The revised ESSE Integrated Evaluation Package adequately addresses my comments.

No _____ The following comments have not been adequately addressed:

Peer Reviewer John H. Bell Date Dec. 11, 1991

Comments not resolved between the Peer Reviewer and the ESSE Core Team have been noted by the T&MSS Task Manager.

T&MSS Task Manager Jean L Younker Date 12-11-91

* Note: May explain adequacy of comment(s) if needed.

ESSEFIG4.MISC/5-21-91

Figure B-3. Early Site Suitability Evaluation (ESSE) Comment Response Record.

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

***(Instructions on back of form)***

(Reviewer completes items 1 - 9.)

1. Comment 1 of 29
2. Date November 1991
3. Reviewer John H. Bell
4. Organization UNLV
5. Revision Draft/Date August 1991
6. Section 3.3.1.1.1
7. Page 3.3.1-2
8. Paragraph para. 1 of 3.3.1.1.1

9. Comment

Geographically, what is the closest population for exposure to "any incorporated place" (e.g., unincorporated NTS, Beatty, Amargosa)? Applicable census data re 1990? Is the target population in Las Vegas? If so, how calculate/determine to meet 960.5-1 (a) (1)?

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

To better explain population density and distribution in the Yucca mountain area and to resolve concerns regarding the availability of 1990 census data, the following paragraph will be inserted into Section 3.3.1.1.3 in the review of information obtained since the Environmental Assessment (page 3.3.1-4):

"While the complete 1990 census data are not yet available and analyzed, the initial information indicates that the closest 'highly populated area' will be the unincorporated town of Pahrump, approximately 40 miles from the Yucca Mountain site, and the closest 1 mile by 1 mile area with a population of 1,000 or more persons will be in the unincorporated town of Beatty, approximately 20 miles from the site, or in the unincorporated town of Pahrump. The 1980 and 1990 census data do not provide exact information concerning the closest residents to the site. However, information from the radiological monitoring program indicates that the closest resident population is

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 1 of 29
2. Page 2 of 2
3. Name John H. Bell (Print Name)
4. Date November 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

10 Proposed Resolution ( continued )

in the Lathrop Wells/Amargosa Valley area, approximately 10 to 14 miles from the Yucca Mountain site, but this population does not meet the population density definitions in the guidelines."

To address the question regarding Las Vegas, the first paragraph of Section 3.3.1.1.3 (page 3.3.1-3) will be modified to indicate that, based on the 1980 census, the Las Vegas urban area is both the closest highly populated area and the closest 1 mile by 1 mile area with a population of 1,000 or more individuals.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 2 of 29
2. Date November 1991
3. Reviewer John H. Bell
4. Organization UNLV
5. Revision Draft/Date August 1991
6. Section 3.3.1.1.1
7. Page 3.3.1-2
8. Paragraph para. 2 of 3.3.1.1.1

9. Comment

What is the population density in the 1 mile x 1 mile areas adjacent to the "surface facility of the repository? How determined? Daytime population of NTS? (How can third disqualifying condition exist if don't have 1 square mile population data?)

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

Information from the radiological monitoring program indicates that the population density in the 1 mile by 1 mile areas adjacent to the "surface facility of a repository" (or the Yucca Mountain site) is zero if the term "adjacent to" is interpreted to mean adjoining or contiguous. In response to Dr. Bell's Comment #1, an additional paragraph will be inserted in Section 3.3.1.1.3 to explain population density and distribution in the Yucca Mountain area. That paragraph also addresses this comment.

A discussion of the daytime population of the Nevada Test Site has not been included in this section because the test site workers are not enumerated by the census as residents of the area.

The third disqualifying condition involves development of an emergency preparedness program, which would be required whether or not a highly populated area is adjacent to the site. The emergency preparedness program is a separate

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 2 of 29

2. Page 2 of 2

3. Name John H. Bell
(Print Name)

4. Date November 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

10 Proposed Resolution ( continued )
consideration from the population density and distribution factors.
END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 3 of 29
2. Date November 1991
3. Reviewer John H. Bell
4. Organization UNLV
5. Revision Draft/Date August 1991
6. Section 3.3.1.1.3
7. Page 3.3.1-3
8. Paragraph para. 1 of 3.3.1.1.3

9. Comment

If the Qualifying Condition #2 can "take into account the possibility of releases" such that a LLS-3 is subjectively (?) determined, why couldn't it just as well be an unsuitable?

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The Level 3 finding for the second qualifying condition that was documented in the Environmental Assessment was based on a conservative interpretation of the information available at that time. The information that was assessed did not indicate that the site would be unsuitable, but was not judged to be sufficient to reach the Level 4 finding at that time. To address the concern regarding subjective determination of suitability, the last two sentences of the first paragraph of Section 3.3.1.1.3 will be modified to reiterate the findings of the Environmental Assessment:

"The information regarding the qualifying condition presented in the EA (p. 6-20 and 6-21) resulted in a finding that 'Preliminary calculations indicate that even the expected worst-case radiological dose will not exceed the limits of 10 CFR 960.5-1(a)(1) (1984) and will be negligible when compared to the background radiation dose.' Based on that evaluation, the EA stated that 'the evidence does not

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

***(Instructions on back of form)***

1. Comment 3 of 29

2. Page 2 of 2

3. Name John H. Bell
(Print Name)

4. Date November 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

10 Proposed Resolution ( continued )

support a finding that the site is not likely to meet the qualifying condition for population density and distribution,' which resulted in a Level 3 finding."

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 4 of 29
2. Date November 1991
3. Reviewer John H. Bell
4. Organization UNLV
5. Revision Draft/Date August 1991
6. Section 3.3.1.1.3
7. Page 3.3.1-3
8. Paragraph 4

9. Comment

Is there, anywhere, an emergency plan that is site-specific as evidence that DOE can satisfy requirements of DOE Order 5500.3 and 10 CFR 60?

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The Nevada Operations Office currently maintains a site-specific emergency response plan under DOE Order 5500.3 A (DOE, 1991a). This can be activated either at their own action or at the request of the State of Nevada. An example of this response process is covered in "DOE/NV Radiological Assistance Team Notification Procedure Revision 17 (DOE, 1991b)."

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 5 of 29
2. Date November 1991
3. Reviewer John H. Bell
4. Organization UNLV
5. Revision Draft/Date August 1991
6. Section 3.3.1.1.3
7. Page 3.3.1-4
8. Paragraph 2

9. Comment

With the change of administration of YMP is or is not the MOU with DOE/NV applicable, and how does the answer affect the "condition" of the requirement of an emergency preparedness plan per DOE Order 5500.3 or 10 CFR 60?

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The Memorandum of Understanding (State of Nevada, 1984) remains applicable as DOE/NV is the "landlord" of Area 25, where the support facilities for the proposed repository would be located. To clarify this, a sentence will be added at the end of the second paragraph on page 3.3.1-4 stating, "Plans and procedures to be developed would be integrated with overall NTS emergency response plans that are in force at that time."

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 6 of 29
2. Date November 1991
3. Reviewer John H. Bell
4. Organization UNLV
5. Revision Draft/Date August 1991
6. Section 3.3.1.1.3
7. Page 3.3.1-4
8. Paragraph 2

9. Comment

Apparent conflict. Who "directly" administers the YMP? DOE/NV?

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

As indicated by the response to Dr. Bell's Comment #5, DOE/NV has "landlord" responsibilities for Area 25, where support facilities for the proposed repository would be located. The DOE Project Office reports to the Associate Director of the Office of Geologic Disposal, who reports to the Manager of the Office of Civilian Radioactive Waste Management for programmatic issues.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes Items 1 - 9.)

1. Comment 7 of 29
2. Date November 1991
3. Reviewer John H. Bell
4. Organization UNLV
5. Revision Draft/Date August 1991
6. Section 3.3.1.1.4
7. Page 3.3.1-4
8. Paragraph 3

9. Comment

What are the "factors" that demonstrate that there would be no dose to an individual that would exceed the regulatory limits? What is the "maximum individual?" (maximum dose to an individual?) Individuals on NTS or Beatty or Amargosa? (LLS-3?)

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

To address the question regarding population distribution factors, the second sentence in the first paragraph of Section 3.3.1.1.4 will be modified to state the following: "First, because the Yucca Mountain site is not located in or adjacent to a highly populated area, there is nothing to suggest that the site will not meet the requirements of the qualifying condition."

The references to the "maximum individual" in Sections 3.3.1.1.3 and 3.3.1.1.4 referred to the "maximally exposed individual." Conceptually, the maximally exposed individual is any member of public standing at the boundary of the restricted area.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 8 of 29
2. Date November 1991
3. Reviewer John H. Bell
4. Organization UNLV
5. Revision Draft/Date August 1991
6. Section 3.3.1.1.4
7. Page 3.3.1-4
8. Paragraph para. 2 of 3.3.1.1.4

9. Comment

If the 1990 census has yet to be analyzed to determine "highly populated area" and one (1) square mile area, why the HLF-2?

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The higher-level findings for the first two disqualifying conditions were established in the Environmental Assessment using data from the 1980 census. In response to Dr. Bell's Comment #1 an additional paragraph will be added in Section 3.3.1.1.3 to better explain population density and distribution in the Yucca Mountain area and to resolve concerns regarding the availability of 1990 census data. That paragraph also addresses this comment.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 9 of 29
2. Date November 1991
3. Reviewer John H. Bell
4. Organization UNLV
5. Revision Draft/Date August 1991
6. Section 3.3.1.1.4
7. Page 3.3.1-5
8. Paragraph 1

9. Comment

Won't the site specific emergency preparedness plan written under the DOE Order 5500.3 actually be "approved" when accepted by the NRC when DOE submits license application to NRC?

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

Under DOE Order 5500.3A (DOE, 1991a), DOE can self-approve site-specific emergency response plans. The reviewer is correct that the NRC will review this plan against standards that exist at that time. This would be in addition to any DOE approvals and would occur after site selection. For this reason, no text changes are proposed.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 10 of 29
2. Date November 1991
3. Reviewer John H. Bell
4. Organization UNLV
5. Revision Draft/Date August 1991
6. Section 3.3.1.3.2
7. Page 3.3.1-9
8. Paragraph all of 3.3.1.3.2

9. Comment

a. What is the definition of "significant amount"? Quantify. Is it related to "source" term? How?

b. How are the potential release of radionuclides, design factors, release of radionuclides to unrestricted areas, weather, and that amount less than allowable related? What method of analysis to determine "significant amount"?

c. What <u>is</u> the existing information that allows for "reasonable judgments"?

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

a. The phrase "significant amounts" is a poor choice of words for the sentence. The amount of radioactive release that should be discussed in this context is that amount that is addressed by the allowable releases in the regulations. The first paragraph in Section 3.3.1.3.2 will be revised to read:

"It is not likely that radioactive material in excess of the amount allowable under the requirements specified in 10 CFR 960.5-1(a)(1) will ever become airborne so that atmospheric dispersion or preferential transport would become an issue. However, the qualifying condition requires that consideration be given to design features that limit routine releases, such as ventilation systems, and to the potential for weather conditions to cause an accident."

b. The potential release of radionuclides, design factors, release of radionuclides to unrestricted areas, weather, that amount less than allowable

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 10 of 29

2. Page 2 of 2

3. Name John H. Bell
(Print Name)

4. Date November 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

10 Proposed Resolution ( continued )

under the regulations, and many more parameters are all related through a comprehensive dose assessment model and calculations for the site, yet to be completed. Such an effort will be accomplished and discussed as part of the system guideline for radiological safety. All input will contribute to a systems analysis of normal operations and accident scenarios to include parameters of characteristics of populations in the area, weather, land controls, and association with offsite installations and operations. This technical guideline for meteorology addresses primarily site characteristics with regard to natural weather conditions.

c. The phrase "reasonable judgments" was a poor choice of words in that definitions of "reasonable" could be an issue in many different forums. The phrase in the last sentence of the second paragraph of Section 3.3.1.3.2 has been replaced with "good scientific judgments and some assumptions." Nevertheless, the existing information that allows these judgments to be made is five years of site-specific meteorological data. The references to these data reports are on the following page of the report in Section 3.3.1.3.3, Review of Information Obtained since the Environmental Assessment.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 11 of 29
2. Date November 1991
3. Reviewer John H. Bell
4. Organization UNLV
5. Revision Draft/Date August 1991
6. Section 3.3.1.3.3
7. Page 3.3.1-9
8. Paragraph para. 1 of 3.3.1.3.3

9. Comment

a. Didn't the EA evaluation reveal more than an "indication" of infrequent severe weather?

b. What quantity of radionuclides is expected to be released? Has a dispersion model for the site been developed? What does it show quantitatively?

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

a. The EA did not actually reveal a mere "indication" of infrequent severe weather, it directly stated, using area meteorological information, that severe weather was infrequent in the area. The second sentence of the first paragraph of Section 3.3.1.3.3 will be revised to read as follows: "The EA evaluation concluded that occurrences of severe weather....."

b. Radionuclide releases from the proposed facility are expected to be minimal and within allowable regulatory limits. A site dispersion model has not been developed; however, site-specific data indicate good dispersion characteristics and future information (including dispersion modeling) is unlikely to change the conclusion, hence, one reason for recommending the higher-level finding. Site dispersion modeling, however, will be done to better characterize the dispersion characteristics and provide input for the comprehensive dose assessment calculations planned to address the system

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 11 of 29

2. Page 2 of 2

3. Name John H. Bell
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5. Comment or Proposed Resolution or Resolution *(Circle one)*

10 Proposed Resolution ( continued )

guideline for preclosure radiological safety.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 12 of 29
2. Date November 1991
3. Reviewer John H. Bell
4. Organization UNLV
5. Revision Draft/Date August 1991
6. Section 3.3.1.3.3
7. Page 3.3.1-10
8. Paragraph 2

9. Comment

a. Isn't Amargosa at the "end" of drainage winds down Amargosa Valley?

b. What are the "assumed" proper design considerations?

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

a. The townsite of Amargosa Valley is in a southerly direction from Yucca Mountain and also "downslope" from the Yucca Mountain area. Given the relatively long distance (approximately 14 miles) from the Yucca Mountain site and the complex terrain in the vicinity, effective dispersion characteristics are apparent. However, continued monitoring of the phenomenon will ensure site conditions have been documented adequately for radiological safety and dose assessment calculations as part of the system guideline analysis.

b. The ESSE Core Team agrees the term "proper" should be replaced with some more definitive terms. The second sentence of the second paragraph under the heading labeled "Review of Information Obtained since the Environmental Assessment" in Section 3.3.1.3.3 has been revised to read:

"While these results require further review, they do not represent

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 12 of 29

2. Page 2 of 2

3. Name John H. Bell
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4. Date November 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

10 Proposed Resolution ( continued )

unsuitability concerns given that the technology exists to design facilities such that releases of radioactive material greater than that allowable under the regulations will be controlled. In addition, prevailing winds at the site are such that overall effective dispersion is apparent."

In addition, a sentence will be added to the paragraph in Section 3.3.1.3.3. labeled "Atmospheric dispersion." The sentence will read as follows:

"The above information supports the conclusion that dispersion characteristics are not expected to contribute to a potential dose of radioactive material to any population in the Amargosa Valley area in excess of the amount allowable under the regulations, should a release occur."

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 13 of 29
2. Date November 1991
3. Reviewer John H. Bell
4. Organization UNLV
5. Revision Draft/Date August 1991
6. Section 3.3.1.4.3. (new 3.3.1.5.3)
7. Page 3.3.1-18
8. Paragraph 3,5

9. Comment

a. Why are statements relative to "radioactive releases" only two sentences? What were the estimates of the EA vs MacDougall (SNL, 1987) study? State release amounts and effect/significance. Define "source term."

b. What does "Accident consequences were found to be generally lower than in the EA" mean? Are overflights allowed or prohibited? If overflights are allowed, what are the consequences of an aircraft accident to the WHBs?

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

a. The EA evaluation of radiological safety for accidental conditions was based on a preliminary safety assessment performed by Jackson et al. (1984). These release calculations were updated in the Site Characterization Plan - Conceptual Design Report (SNL, 1987). This evolution of information will be explained in the text of the ESSE report.

Section 3.3.1.4.5.3, "Repository Conceptual Design Studies" will be revised to read as follows: "In the Repository Conceptual Design Report, prepared to support the Site Characterization Plan (DOE, 1988a), Sandia National Laboratory (SNL) (1987) revised estimates of radiological releases from accidents that could occur at the repository. Estimates in this study were made taking less credit for release mitigation systems (for example, filters) than the EA. For this reason, higher doses to the maximally exposed individual (up to 1.1 rem) are estimated. At the same time, updated accident frequencies are lower than those presented in the EA. When frequency and consequences are combined to

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 13 of 29

2. Page 2 of 2

3. Name John H. Bell
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5. Comment or Proposed Resolution or Resolution *(Circle one)*

10 Proposed Resolution ( continued )

predict risk levels (frequency time consequences), both reports predict risks due to accidents are low for the waste handling building."

b. Predicted doses to the maximally exposed individual are higher in the SCP-CDR than in the EA. However, frequencies are lower. Risks predicted by both studies are comparable and low. The text will be added at the end of the second paragraph in Section 3.3.1.4.4.1 (new 3.3.1.4.5.3).

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 14 of 29
2. Date November 1991
3. Reviewer John H. Bell
4. Organization UNLV
5. Revision Draft/Date August 1991
6. Section 3.3.1.4.4.4(new 3.3.1.4.5.4)
7. Page 3.3.1-19
8. Paragraph (Ionizing radiation)

9. Comment

If "estimates of expected releases" from NTS can be 'predicted,'" why is there "no specific estimate of planned releases from the repository"? What about "unplanned"? Why any release from the repository if "Technology exists for the control of repository releases to negligible levels"? For example, K-85, T-3, C-14, and I-129?

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

No specific evaluation has been done for a repository at Yucca Mountain for expected releases, since design details are not yet available. However, given experience in similar facilities, filtration technology is adequate to avoid unusual dispersion hazards. No site condition precludes mitigation of impacts from small planned releases to levels in compliance with applicable dose standards. These releases would be primarily particulates from activated corrosion products present on the outside of the fuel rods (crud). Unplanned releases could occur if accidents or fuel rod failures occur. These could involve quantities of the isotopes mentioned in the comment as well as spent fuel particulates. Gaseous products are assumed to be released, and particulates are assumed to be reduced with filters.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 15 of 29
2. Date November 1991
3. Reviewer John H. Bell
4. Organization UNLV
5. Revision Draft/Date August 1991
6. Section 3.3.1.4.4.4. (new 3.3.1.4.5.4)
7. Page 3.3.1-21
8. Paragraph (Aircraft mishaps)

9. Comment

Will agreements be established to preclude aircraft overflights of aircraft? If not, why not?

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The need to preclude overflights will be decided after a review of the overflight analyses. If needed, this could be accomplished through a Memorandum of Understanding with the U.S. Air Force. The current predicted frequencies of potential crashes are on the order of 1 in 1,000,000 per year.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 16 of 29
2. Date November 1991
3. Reviewer John H. Bell
4. Organization UNLV
5. Revision Draft/Date August 1991
6. Section 3.3.1.4.4.5 (new 3.3.1.4.5.5)
7. Page 3.3.1-22
8. Paragraph Ionizing radiation

9. Comment

If releases of radioactive material and radiation from the repository are expected ("to be minor"), why not state that technology will be used to control releases to "negligible levels" rather than that the technology just "exists"?

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The details of air treatment to be used have not been decided. It will be based on needs identified in a detailed facility analysis. At a minimum, (high efficiency particulate air (HEPA) filters will be used on all hot cells. Filtration of mine air will be available on a diversion basis. This will be added to the discussion. Air treatment for iodine is available, but may not be necessary due to the long cooling time of the fuel. The last sentence of the paragraph will be revised to reflect the lack of specific estimates of releases at this time and will read as follows:

"Releases of radioactive material and radiation from the potential repository are expected to be minor, and will be less than applicable regulations and standards. However, specific estimates for these releases have not been completed. During future design activities, these releases will be evaluated and mitigation technology applied such that ionizing radiation is not expected to lead to an irreconcilable conflict with atomic energy defense

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 16 of 29

2. Page 2 of 2

3. Name John H. Bell
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4. Date November 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

10 Proposed Resolution ( continued )
activities."

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

***(Instructions on back of form)***

(Reviewer completes items 1 - 9.)

1. Comment 17 of 29
2. Date November 1991
3. Reviewer John H. Bell
4. Organization UNLV
5. Revision Draft/Date August 1991
6. Section 3.3.1.4.4.5 (new 3.3.1.4.5.5)
7. Page 3.3.1.1-23
8. Paragraph (Facility Accidents)

9. Comment

What is the meaning of "repository" - the total facility or the storage site? Where are explosives and propellants to be stored? What is the distance from "onsite" activities? It would seem that the greatest potential hazard is from an explosion on the repository or WHFS.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

"Repository" refers to both surface and subsurface preclosure activities at the Yucca Mountain site. To clarify this in the text, the word "site" will be inserted after "repository" in the first sentence. Explosive storage will be remote from the waste handling buildings on the surface and waste emplacement underground. The structures used for shielding of high-level waste preclude significant damage from explosions. See Section 3.3.1.4.5.4 on facility accidents leading to radioactive material releases.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 18 of 29
2. Date November 1991
3. Reviewer John H. Bell
4. Organization UNLV
5. Revision Draft/Date August 1991
6. Section 3.3.1.4.4.5.(new 3.3.1.4.5.5)
7. Page 3.3.1.1-23
8. Paragraph (...radioactive material)

9. Comment

Though accidents of this type (releases of large quantities of radioactive material) are expected to be "rare" only one (1) needs to occur. Does this statement mean that releases of "large" quantities of radioactive material are to be expected - inevitable? This is the primary concern of the public.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

This paragraph heading will be revised to read "Releases of significant quantities of radioactive material." A release with a fenceline 50-year dose commitment of 500 millirem is not "large." The 500 millirem level is a proposed design basis for the repository facilities. The design would limit releases below this level and seek to minimize the potential for all accidents. The first sentence will be revised to state "Repository design standards require that releases under accident conditions will not allow offsite doses to exceed 500 millirem."

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

***(Instructions on back of form)***

(Reviewer completes items 1 - 9.)

1. Comment 19 of 29
2. Date November 1991
3. Reviewer John H. Bell
4. Organization UNLV
5. Revision Draft/Date August 1991
6. Section 3.3.1.4.4.5 (new 3.3.1.4.5.5)
7. Page 3.3.1-24
8. Paragraph (Security)

9. Comment

Will there be outside (non DOE) oversight (NV?) of the YMP operation? Or will "security" preclude "outside" oversight?

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

Security will not preclude oversight. It is our understanding that the State of Nevada, NRC, and DOE safety organizations will have reasonable access to the facility.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes Items 1 - 9.)

1. Comment 20 of 29
2. Date November 1991
3. Reviewer John H. Bell
4. Organization UNLV
5. Revision Draft/Date August 1991
6. Section 3.3.1.4.4.6 (new 3.3.1.4.5.6)
7. Page 3.3.1-24
8. Paragraph (Discussion)

9. Comment

Question HLS-4 for part (2) of the Qualifying Condition relative to radionuclide releases to an unrestricted area. Wording of "...no significant (?) releases....are expected.", "planned releases" (versus unplanned), "releases of large quantities...", accidents of this type are expected to be rare..." lead one to question confidence of HLS-4. Perhaps the suitability level should be changed (to LLS-3) or the wording changed given the analysis of the data to support the HLS finding.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

This finding is based on a review of current technology, conceptual designs, and needed features of the site for radiological safety. Nothing currently at the site or expected to be discovered during characterization would preclude a radiologically safe facility given a comprehensive approach to design. However, the conclusions and recommendations section will be revised and expanded to reflect that the site is suitable for characterization under this guideline and that additional design evaluations are needed to support the higher-level finding.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

***(Instructions on back of form)***

(Reviewer completes items 1 - 9.)

1. Comment 21 of 29
2. Date November 1991
3. Reviewer John H. Bell
4. Organization UNLV
5. Revision Draft/Date August 1991
6. Section 3.3.1.5.1, 3.3.1.5.3
7. Page 3.3.1.1-25, -27
8. Paragraph

9. Comment

The system guideline addresses projected releases during repository operations. The accidental releases are addressed as a result of "normal operations." What accidental releases were considered in the "newer studies" that provide "better descriptions of accident scenarios and releases from abnormal operations" or "nonnormal accidents"? What abnormal accidents did the newer accident scenarios consider?

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The reference to radiological dose limits in Section 3.3.1.5.1 is not explicitly used in Section 3.3.1.5.3. The reference documents identify a number of accident scenarios with various dose consequences that could be compared with the limits. However, that discussion would be lengthy and would not add much to the ideas in Section 3.3.1.5.3. In general, the newer evaluations reexamined the major and minor accident scenarios considered in the earlier studies. These studies were designed to assist in the implementation of quality assurance in the design process, not for the resolution of 10 CFR Part 960 issues. The text of Section 3.3.1.5.3 will be modified to discuss intended usage of the studies and to remove the ambiguity of why these things are in the report.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes Items 1 - 9.)

1. Comment 22 of 29
2. Date November 1991
3. Reviewer John H. Bell
4. Organization UNLV
5. Revision Draft/Date August 1991
6. Section 3.3.1.5.4
7. Page 3.3.1-28
8. Paragraph 2

9. Comment

Until detailed abnormal accident/release scenarios are considered relative to the system guideline, an LLS-3 rather than a level-4 finding is applicable.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The ESSE Core Team agrees that additional design information is necessary to first describe the facility and its operations and then to justify the higher-level finding for the system guideline. Commentary will be added to Section 3.3.1.5.3 to discuss the data obtained since the EA (e.g., SNL (1987) supporting development of the Site Characterization Plan), reverting to the EA (lower-level) finding, and stating that additional facility design information is necessary before a higher-level finding can be supported.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

***(Instructions on back of form)***

(Reviewer completes items 1 - 9.)

1. Comment 23 of 29
2. Date November 1991
3. Reviewer John H. Bell
4. Organization UNLV
5. Revision Draft/Date August 1991
6. Section 3.3.2.3.3.1
7. Page 3.3.2-16
8. Paragraph para. 2 of 3.3.2.3.3.1

9. Comment

If the design of the transportation cask precludes rupture and radiation levels external to unruptured casks is negligible (within DOT levels), why is the route unfeasible due to land use conflicts with wilderness study areas and residential development? Won't any other route(s) impact in a similar fashion on other wilderness or populated areas?

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The land-use conflict is not radiological in nature. Land-use restrictions preclude the development of any right of way in these areas until their wilderness attributes can be evaluated. No changes to the text are proposed.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 24 of 29
2. Date November 1991
3. Reviewer John H. Bell
4. Organization UNLV
5. Revision Draft/Date August 1991
6. Section 3.3.2.3.3.1
7. Page 3.3.2-16
8. Paragraph (in-text table)

9. Comment

What does 0.37 Regional and 11.3 National Radiological Fatalities mean? How are they caused? Isn't this an "unacceptable risk" to the public or an "unacceptable public health impact"?

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

These estimates are based on a linear dose effects model for miniscule radiation doses that would be received by population along the route. Accidental releases of material, weighted by their low expected frequency, are included and are less than 10 percent of the total predicted potential impacts. The indicated potential impacts are insignificant when compared with health effects from natural background radium doses using the same model. No changes to the text are proposed.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 25 of 29
2. Date November 1991
3. Reviewer John H. Bell
4. Organization UNLV
5. Revision Draft/Date August 1991
6. Section 3.3.2.3.3.2
7. Page 3.3.2-17
8. Paragraph 3

9. Comment

What are the different states' "designated routes" For Nevada?

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

Currently the State of Nevada has not designated alternative routes to I-15 and U.S. 95 to Yucca Mountain. The State is currently evaluating alternatives that include U.S. 93A from Wendover, U.S. 6, and U.S. 95. Past shipments have traveled this general route to the north. Shipments to the south could travel state highways to Baker, California, where they would access I-15.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 26 of 29
2. Date November 1991
3. Reviewer John H. Bell
4. Organization UNLV
5. Revision Draft/Date August 1991
6. Section 3.3.2.3.3.3
7. Page 3.3.2-18
8. Paragraph (Transportation planning)

9. Comment

What specifically is the "planning issue" that remains open at this time relative to cask design?

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The Office of Civilian Radioactive Waste Management plans to design, license, and build new cask designs that will carry more fuel than current models. This is possibly due to the long cooling time of fuel available for transport to a repository. Final designs are not available at this time. Thus, final estimates of the numbers of shipments and specific cask design features are not currently available. There is, however, no specific site feature that would need to be considered in the cask design. This makes the cask design activity independent of site suitability evaluations. Thus, no changes to the text are proposed.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 27 of 29
2. Date November 1991
3. Reviewer John H. Bell
4. Organization UNLV
5. Revision Draft/Date August 1991
6. Section 3.3.3
7. Page 3.3.3-2
8. Paragraph 2

9. Comment

How can it be concluded that the site would not require "particularly expensive" mitigation techniques (e.g., for negligible release) if the design requirements and plans for activities are not completely developed?

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The intent of the sentence was to convey the fact that no site conditions have been identified to date that would cause difficulties. The last sentence of the second paragraph on p. 3.3.3-2 will be changed as follows: "The Core Team did not identify any characteristics of this particular site that would lead to use of mitigation techniques that are unusually expensive. However, detailed considerations of costs were not made in this evaluation."

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 28 of 29
2. Date November 1991
3. Reviewer John H. Bell
4. Organization UNLV
5. Revision Draft/Date August 1991
6. Section 3.3.3.2.3.1
7. Page 3.3.3-10
8. Paragraph Table 3.3.3-2, 3.3.3.2.3

9. Comment

How can DOE state "no rock characteristics that could cause undue hazards to personnel have been identified..." when compared to the statement "Unacceptable uncertainty remains concerning occupational health risk and environmental impact represented by mordenite"?

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The statement "...no rock characteristics that could cause undue hazards to personnel have been identified..." in Section 3.3.3.2.3.1, Summary of Environmental Assessment Findings, was the status at the time of the EA. "Unacceptable uncertainty remains concerning the occupational health risk and environmental impact represented by mordenite" in Section 3.3.3.2.3.2, Information Acquired since the Environmental Assessment, is the current status as a result of the early site suitability evaluation. The subject issue is a post-EA development. The two statements are not inconsistent in that they appear in the proper context for the period of time being discussed, thus no text changes are proposed.

A separate concern with the second phrase discussed above is with the word "unacceptable." Since the lower-level finding has been maintained for this guideline, the uncertainty associated with the subject risk requires additional information through the site characterization program to address the

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 28 of 29

2. Page 2 of 2

3. Name John H. Bell
(Print Name)

4. Date November 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

10 Proposed Resolution ( continued )

high-level finding. The term "unacceptable" has been deleted from the sentence (penultimate sentence in last paragraph of Section 3.3.3.2.3, p. 3.3.3-12).

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 29 of 29
2. Date November 1991
3. Reviewer John H. Bell
4. Organization UNLV
5. Revision Draft/Date August 1991
6. Section
7. Page 4-7
8. Paragraph 4.3

9. Comment

If "there is some probability that this release limit (EPA limit for gaseous C-14) to the environment" could be exceeded, how can a HLS-4 (Table 4-2) be stated for System Guideline and Offsite Installations and Operations (QC #2)?

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The ESSE Core Team agrees that there are areas within the System Guideline and the Offsite Installations and Operations technical guideline, especially regarding surface facility design, that require additional study efforts before higher-level findings can be recommended. For this reason, maintaining lower-level findings for these subject areas is a prudent approach at this time. The conclusion and recommendation sections of the guidelines have been revised to reflect the above approach.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

## REFERENCES FOR DR. JOHN H. BELL

DOE (U.S. Department of Energy), 1986. Final Environmental Assessment: Yucca Mountain Site, Nevada Research and Development Area, Nevada, 3 volumes, DOE/RW-0073, Office of Radioactive Waste Management, Washington, DC.

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Younker, J. L., W. B. Andrews, G. A. Fasano, C. C. Herrington, S. R. Mattson, R. C. Murray, L. B. Ballou, M. A. Revelli, A. R. Ducharme, L. E. Shepard, W. W. Dudley, D. T. Hoxie, R. J. Herbst, E. A. Patera, B. R. Judd, J. A. Docka, and L. D. Rickertsen, 1992. Report of Early Site Suitability Evaluation of the Potential Repository Site at Yucca Mountain, Nevada, SAIC-91/8000, Las Vegas, NV.

10 CFR Part 60 (Code of Federal Regulation), 1990. Title 10, Energy, Part 60, Disposal of High-Level Radioactive Wastes in Geologic Repositories, U.S. Government Printing Office, Washington, DC.

10 CFR Part 960 (Code of Federal Regulation). Title 10, Energy, Part 960, General Guidelines for the Recommendation of Site for Nuclear Waste Repositories, U.S. Government Printing Office, Washington, DC., pp 518-551.

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# *Dr. F. William Cambray*

STRUCTURAL GEOLOGY,
TECTONICS

Michigan State University
East Lansing, MI

## EARLY SITE SUITABILITY EVALUATION
## COMMENT RESOLUTION RECORD

Peer Reviewer's Statement:

I have reviewed the ESSE Integrated Evaluation Package in accordance with ESSE Peer Review Plan. My conclusions with respect to the review criteria of the ESSE Peer Review Plan are:

| Review Criteria | Adequate Yes: See Comment(s) Nos.* | No: See Comment(s) Nos. |
|---|---|---|
| In my areas of expertise: | | |
| A. The content of the ESSE Integrated Evaluation Package provides an unbiased and objective presentation of information relevant to the suitability issues covered by each guideline. | 1-4 | |
| B. The conclusions about the status of lower and higher-level findings on the siting guidelines are balanced and defensible. | 1-4 | |

Comments 1 through 4 are attached.

Peer Reviewer F. W. Cambray Date 12/16/91
F. W. CAMBRAY

Comment Resolution Record

Yes X The revised ESSE Integrated Evaluation Package adequately addresses my comments.

No _____ The following comments have not been adequately addressed:

Peer Reviewer F. W. Cambray Date 12/16/91
F. W. CAMBRAY

Comments not resolved between the Peer Reviewer and the ESSE Core Team have been noted by the T&MSS Task Manager.

T&MSS Task Manager Jean L Younker Date 12-16-91

* Note: May explain adequacy of comment(s) if needed.

ESSEFIG4.MISC/5-21-91

Figure B-3. Early Site Suitability Evaluation (ESSE) Comment Response Record.

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

***(Instructions on back of form)***

(Reviewer completes items 1 - 9.)

1. Comment 1 of 4
2. Date November 11, 1991
3. Reviewer F. William Cambray
4. Organization Michigan State University
5. Revision Draft/Date August 1991
6. Section 2.3.7.3.3
7. Page 2-104
8. Paragraph 5

9. Comment

Under Recommendations for Future Activities. The need for credible tectonic models is referred to. There seems to be an emphasis on a detachment model for the region but much of the evidence points towards strike-slip being the most important factor in this area in recent times. The observations of Gianella and Callaghan (Bull. Seism. Soc.Am 1934) indicate that there is a marked difference between the strike slip movement associated with the earthquake on the Walker Lane Belt and the proposed low angle normal faulting associated with detachment faults. Wright (ref.#3515) has suggested that detachment faulting was important until 16-14 Ma ago and then strike slip faulting became the dominant tectonic activity in region. This proposed change coincides with the change in igneous activity from predominantly large scale felsic volcanic centers to small basaltic cones and minor intrusions.

The Yucca Mt. Crater Flats region could be modeled as a releasing bend in a strike slip setting on the Walker-Lane Belt. The Yucca Wash Fault extending

10. Proposed Resolution *(To be completed by ESSE Core Team)*

This comment appropriately points out that earlier revisions, meant to provide a more balanced discussion of alternatives to regional detachment faulting as the basic tectonic model in Section 2.3.7.3.2.1, were not carried over into the discussion on page 2-104. In addition, the comment and subsequent discussions with Dr. Cambray provide a compelling reason to reorganize and supplement Section 2.3.7.3.2.1.

We will revise Section 2.3.7.3.2.1 to read as follows:

"2.3.7.3.2.1 Tectonic models.

The EA considered two basic tectonic models for the Yucca Mountain area. The first was a caldera model, in which the faults near the potential repository block were portrayed as subsidiary features resulting from inferred caldron subsidence in Crater Flat. The second was a Basin-and-Range model, in

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

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9 Comment ( continued )

NW from the north side of the region could be one branch of the strike slip fault and the proposed buried strike slip fault extending along the south side of Crater Flat and under the Amargosa Valley (Schweickert ref.#3843) the other. The termination of the NS faults against the Yucca Wash Fault and the lack of continuation of this fault to the south east (Scott ref.#3173) makes this a reasonable interpretation. As a first approximation the Paintbrush Fault might represent the eastern termination of the pull-apart basin formed in this releasing bend and the Bare Mountain Fault on the west side of Crater Flats could be the western termination. This would explain why the Bare Mountain normal fault cuts the detachment proposed by Scott (ref.#3173 fig.15). It would place the mafic volcanic rocks in a releasing bend which could help to explain their rise from the mantle without differentiation or contamination (several authors P.2-94 ESSE report) and the clustered arrangement. The thick sequence of volcanic rocks underlying Crater Flats would be the pull-apart basin fill in this model. The detachment referred to by Scott may be a dissected older detachment as he suggests. If so it is now cut by faults associated with the releasing bend. It may however be an accommodation zone that developed in response to the transfer of motion from the underlying strike slip fault in the basement to the package volcanic rocks above (see Manspeizer, W. The Dead Sea Rift, Impact of Climate and Tectonism on Pleistocene and Holocene Sedimentation in Strike-Slip Deformation, Basin Formation and Sedimentation. Soc. Econ. Pal.and Min., Spec.Pub.37, 1985, fig.13). This has important implications for the use of tectonic models in predicting groundwater movement.

In such a setting the NS faults on Yucca Mountain would also be accommodating movements to the underlying strike slip movement and give rise to the decoupling referred to in the report. The clockwise rotation at the southern end of the mountain is consistent with this hypothesis. On page 2-94 the Cedar Mountain earthquake is referred to as 'exceptional' but the author goes on to say that 'the occurrence of the distributed faulting at the smaller Excelsior Mountain earthquake indicates that this model should be considered in the faulting potential at Yucca Mountain'. I endorse this comment and suggest that strike slip faulting be elevated to the most likely source of potentially damaging seismic activity in the area.

END OF TEXT

10 Proposed Resolution ( continued )

which crustal extension is accommodated by a combination of N-striking normal faults and NE- and NW-striking strike-slip faults that penetrate to the brittle-ductile transition. More recently, in the Site Characterization Plan

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10 Proposed Resolution ( continued )

for Yucca Mountain (DOE, 1988a), detachment faulting (low-angle extensional faulting) of various styles and planar-rotational faults (producing a "tilted-domino" block structure), whether deep-seated or terminating on an underlying detachment, have been recognized as possible alternatives to the interpretations in the EA.

Use of Terms

As used in this report without qualifying terms, a detachment fault (or simply detachment) is a low-angle extensional fault within the brittle crust, whether regional or local in areal extent. No implication as to the amount of displacement is intended. The degree of mechanical coupling between the rocks below and above a detachment may vary spatially and temporally, and styles of subsidiary faulting above the detachment are not specified. The subsidiary faults may include additional shallower detachments, planar normal faults that abut downward into an intensely sheared detachment, or listric normal faults, which decrease in dip downward to merge into the detachment surface. Local variations of stress and preexisting geology, particularly near the edges of the upper plate(s), may result in subsidiary strike-slip faults, reverse faults, dip-slip faults that increase in dip with depth, oblique-slip faults, or bending of the upper plate about a steeply plunging axis. Where the special case of essentially lateral dislocation between the brittle crust and underlying ductile deformation is intended, it is specified in the context. The boundaries of such a deep-seated detached plate ideally would be high-angle strike-slip faults and listric faults of such large radius of curvature that, near the land surface, they would be indistinguishable from normal faults that intersect the brittle-ductile transition at high angles. At this scale, there may be a loss of distinction between detachment and deep-seated "Basin-and-Range" styles of faulting in terms of their seismic and hydrologic significance.

Depending on its age, the proposed detachment faulting in the vicinity of Yucca Mountain (see, for example, Scott, 1990) has differing implications for site characterization and performance evaluation. If the detachment structures are very old and overprinted by young tectonic features, they may have little significance for earthquake-hazard or hydrologic studies, but they may laterally displace still older structural and volcanic features. If the detachments are active, paths of upward magma migration might still be offset somewhat along the detachment surface, and the fracturing that may accompany upper-plate movement may dominate the hydrogeologic character of the area. Subsidiary faults in the upper plate, depending on plate thickness, might have

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10 Proposed Resolution ( continued )

limited potential for seismic energy release, whereas the greater seismogenic potential may actually be associated with deeper faults that may not be readily identified beneath the detachment. Because of the ranges of the possible significance of different tectonic styles or models, the principal evidence for these models and their significance to this evaluation of postclosure tectonics are discussed in greater detail below.

Regional and Local Evidence for Detachment Faults

The basis for the detachment-fault model in the southern Great Basin has been summarized recently by Scott (1989a, 1990), who cites evidence throughout the region for westward to southwestward migration of gentle doming and multiple levels of west-dipping detachment surfaces. He interprets three levels of low-angle normal faults mapped by Burchfiel (1965) in lowermost Paleozoic and upper Precambrian rocks in the Spring Mountains, 45 km southeast of the Yucca Mountain site, possibly to be part of a relatively deep regional detachment that may now surface at the edge of the Precambrian core complex in the Bullfrog Hills (Maldonado, 1985; 1990b) and in the northern part of Bare Mountain (Monsen et al., 1990), respectively about 40 km and 15 km west of Yucca Mountain. However, Scott (1989a, 1990) also discusses probable shallower, more local detachments identified by seismic investigations in Mid Valley (McArthur and Burkhard, 1986) (25 km east of Yucca Mountain), by mapping of exposures of the Tertiary-Paleozoic contact north of Mercury (Myers, 1987) (40 km east of Yucca Mountain), and by mapping of low-angle faults within the Tertiary and Paleozoic sections of the Calico Hills (Simonds and Scott, 1987) (about 19 km northeast of Yucca Mountain). Common features of the exposed faults are structural discordance with termination of dipping stratigraphic contacts and faults within the upper plate at its base, and structural and textural evidence of shear displacement parallel to the contact of the upper and lower plates.

In addition to the several references cited in the SCP (DOE, 1988a), the following papers discuss the evidence for one or more detachment plates at Yucca Mountain itself: Scott and Rosenbaum (1986); Scott and Whitney (1987); Hamilton (1988); Scott (1989a, 1990); Fox and Carr (1989); and Spengler and Fox (1989). In the composite detachment model of these authors, as recently summarized by Scott (1990), the high-angle north-striking faults that intersect the surface at and near Yucca Mountain decrease in dip listrically with depth, merging with an underlying low-angle extensional fault within the brittle crust. Scott (1989a, 1990) also discusses evidence that the rate of displacement along the detachments decreased markedly before deposition of the

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10 Proposed Resolution ( continued )

11-million-years-old Timber Mountain Tuff, but that much less extension continued into the Quaternary along a shallower, secondary fault system. Movement on faults in the upper plate (or uppermost of two or more stacked plates) would be limited in depth of penetration, possibly placing constraints on the depth to which hydraulic pathways would be developed or refreshed. The depth limitation might be expected to limit also the seismic energy released by fault movement in the upper plate, but this may be a moot point if faulting above the detachment is coupled to deep faulting beneath. In fact, detachment of near-surface rocks may be a passive means of accommodating deep strike-slip fault displacement where the shallow section is imperfectly coupled to deeper rocks; this has been proposed by Scott and Rosenbaum (1986) to be the origin of the rotation of the tuffs about a vertical or nearly vertical axis at central and southern Yucca Mountain.

The east-bounding breakaway zone for the detachment with Quaternary movement beneath Yucca Mountain is proposed to occur about 2 km east of the potential repository site, along the Paintbrush Canyon fault. Fox and Carr (1989) suggest that this detachment occurs at the Tertiary-Paleozoic contact beneath Yucca Mountain, though they do not exclude the possibility that it is deeper. A generalized cross section in Scott (1989a, Figure 2) indicates a westward thickening of the upper plate beneath Yucca Mountain, in part because of topographic rise, from about 2.5 km to about 4 km. Young et al. (1991) applied computer techniques in a geometric-kinematic analysis of the geologic observations of Scott and Bonk (1984) and data from a drill hole that penetrates Paleozoic rocks at a depth of about 1.2 km (Carr et al., 1986). They suggest that the cross section cannot be balanced with the representation that the Paintbrush Canyon Fault merges listrically into a detachment at the base of the Tertiary section; rather, they propose that the detachment must occur at a greater depth, in the range of 3.5 to 6 km. The differences between these interpretations probably cannot be resolved, nor can other alternatives be identified, until the structural architecture is explored in greater detail by intensive geologic studies, including mapping, and to greater depths by geophysical techniques and possibly deep drilling.

Alternative Interpretations of the Evidence

Low-angle, even near-horizontal normal faults have been explained in the literature by mechanisms other than detachment faulting, as defined above to occur within the brittle crust. For example, Proffett (1977) proposed that the basic style of faulting in the Yerington district of western Nevada is deep-seated listric faulting, steeply dipping near the surface but decreasing

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10 Proposed Resolution ( continued )

in dip with depth until the extension is accommodated by ductile flow. Where segments of faults that were originally deep are now exposed, they dip at very shallow angles, even forming apparent low-angle reverse faults. Proffett (1977) suggests that original dips have further decreased by two mechanisms. First, there is evidence of substantial westward tilting in the Yerington region, such that the east-dipping faults that dominate in the area were rotated to shallower dips. Second, in the Yerington district, the positions of new faults tended to migrate westward or into the footwall blocks of previous faults. The tendency for extensional openings at the shallow, steeply dipping fault segments was accommodated principally by west-dipping sagging of the hanging wall, rather than by antithetic faults, further decreasing the dip of older faults close to their successors (Proffett, 1977).

Wright (1989) accepts the existence of detachment faults in the region within and east of Death Valley, but he argues that, beginning 16 to 14 Mya, this region was divided into structural blocks by major strike-slip and normal faults. He proposes that the detachments, rather than being regional features, are unconnected local features within the individual blocks. The emphasis of Wright's (1989) synthesis of mapped faults and gravity data is the accommodation, beginning in the mid-Miocene, of right-stepping strike-slip fault zones by en echelon, obliquely oriented normal faults, "pull-apart" basins, and associated igneous activity. In his interpretation, the Amargosa Desert and Crater Flat, respectively south and west of Yucca Mountain, are within a zone of pull-apart basins termed the Amargosa Desert Rift Zone (ADRZ). He relates the ADRZ genetically to the Pahrump Valley and Stewart Valley right-lateral strike-slip faults which, if projected to the northwest, coincide approximately with the Walker Lane structural zone. Although Wright (1989) notes that Quaternary faults in Pahrump Valley and western Crater Flat follow those established in mid-Miocene time, he does not address the possible relation of these structures to Pliocene-Quaternary basaltic volcanism in the region. Schweikert (1989), however, suggests that the northwest alignment of basaltic cones in and northwest of Crater Flat may indicate the presence of a major right-lateral strike-slip fault that is not evident at the alluvial surface of Crater Flat.

Controls on Patterns and Characteristics of Volcanics

A series of papers by Crowe and his colleagues (Vaniman and Crowe, 1981; Vaniman et al., 1982; Crowe et al., 1983a; Crowe, 1986) discusses the petrology and geochemistry of the Pliocene-Quaternary basalts of the southern Great Basin, inferring that the magma chambers must be at or below the

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10 Proposed Resolution ( continued )

crust-mantle boundary. Crowe et al. (1983b) defined a volcanic zone the Death Valley-Pancake Range Volcanic Zone (DVPRVZ), extending from Death Valley northward to the Pancake Range in Central Nevada, suggesting regional structural control of basalt centers. Carr (1984) suggested that some of the Pliocene-Pleistocene basalt centers occur along northeast-trending rifts within the DVPRVZ. North-northeast-trending structural controls also are components of later models proposed by Fox and Carr (1989), Smith et al. (1990), and Naumann et al. (1991).

In recent reassessments of volcanism patterns and characteristics in the Yucca Mountain area, Crowe and Perry (1989) and Crowe (1990) define the Crater Flat volcanic zone (CFVZ), favoring a northwest alignment of Pliocene-Pleistocene basaltic centers from the Lathrop Wells cone (20 km south of the Yucca Mountain site) to the basalts of Sleeping Butte. This trend is compatible with that of the Walker Lane structural system, suggesting control of paths for ascending magma along northwest-trending, right-lateral strike-slip faults, as was suggested also by Schweikert (1989). Crowe and Perry (1990) consider a secondary northeast alignment of vents in clustered centers to reflect near-surface feeder dikes perpendicular to the direction of regional extension and least principal stress.

Smith et al. (1990) chose to define their area of most recent volcanism (AMRV) based only upon the factor of age, and they did not include magma composition and tectonic setting as criteria. The inclusion of the 2.8 Ma basaltic andesite of Buckboard Mesa allows Smith et al. (1990) to define an elliptical AMRV that encompasses Yucca Mountain. However, it should be noted that all Quaternary (<1.6 Ma) basaltic eruptive centers near Yucca Mountain occur inside the northwest trend of the CFVZ. In the CFVZ model, the geochemically similar basalts erupted since 3.7 Mya within the northwest alignment of the CFVZ are distinct from the basaltic andesite of Buckboard Mesa. The Crowe and Perry (1989) analysis is considered to be more rigorous, but further investigations are planned to examine the structural controls on basaltic volcanism. The structural controls on volcanism are important components of an overall understanding of Quaternary tectonism. A direct linkage of faulting and volcanic activity was proposed by Fox and Carr (1989), who deduced from the common occurrence of volcanic ash within the north-striking fault zones near Yucca Mountain that the Quaternary faulting and nearby basaltic volcanism have been coeval.

Crowe (1991b) has suggested that basaltic volcanism in this extensional setting tend to occur within alluvial basins or along range-front faults, but

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that it is rare in the range interiors. However, there are examples of volcanic centers in uplifted range blocks, such as the Fortification Hill volcanic field south of Lake Mead and basalts in Reveille Range in south-central Nevada (Smith et al., 1990), as well as the intracaldron basalts of the Lunar Crater Field (Crowe et al., 1986). This suggests that gross topography may be related to the occurrence of basaltic centers only where it accurately reflects deep crustal structure, a relationship that is probable but not fully demonstrated near Yucca Mountain.

Evidence from Patterns of Fault Movement

The geochemically indicated ascent of the basalts along northwest-striking, deeply penetrating faults and the temporal coincidence of volcanism with movement on the north-striking faults near Yucca Mountain provide strong grounds for inferring a ginetic linkage between the two directions of faulting. If the north-striking faults represent only shallow, brittle failure within a d tachment plate, the plate must be sufficiently coupled to rocks beneath the detachment to deform in direct response to deeper fault movement. Alternatively, the north-striking faults may be deep-seated structures that accommodate releasing bends resulting from offsets or changes of direction of the strike-slip fault segments (as stated by Cambray in Younker et al., 1992).

The deep-seated accommodation of right-stepping offsets is consistent with Wright's (1989) hypothesis for pull-apart basins, filled by thick volcanic rocks and sediments, beneath the Amargosa Desert and Crater Flat. Irregular boundaries, formed in part by secondary reentrants into the footwalls, probably are part of an evolutionary reestablishment of strike-slip motion through inherently unstable releasing bends (Ellis and Trexler, 1991).

The Las Vegas shear zone, a major right-lateral structure that strikes about N 65 degrees W on average, loses clear expression at its northwest end, about 50 km southeast of Yucca Mountain. If projected to the northwest, it would intersect the projected Walker Lane trend (N 35 - 40 degrees W) in the vicinity of several faults that strike west-northwest in northern Yucca Mountain. The Las Vegas shear zone is aligned in the direction of the current extensional axis and is interpreted to have been inactive since about 11 Ma (Fleck, 1970; Bohannon, 1983). Therefore, it seems unlikely to be temporally related to the Pliocene-Quaternary volcanism or fault displacement, but it may have contributed to the development of the prominent Miocene structural depression beneath Crater Flat.

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O'Neill et al. (1991) describe NW-trending pull-apart structures at Yucca Mountain that are structurally linked to the N-striking faults, which display dominant normal dip slip and auxiliary left-lateral slip. Scott and Rosenbaum (1986) and Scott (1989a, 1990) considered the southward-increasing clockwise rotation of Yucca Mountain about a vertical axis, which is indicated by paleomagnetic data, probably to indicate interaction of an upper detachment plate with right-lateral oroclinal bending and shearing associated with the Walker Lane structural belt beneath the detachment surface. O'Neill et al. (1991) consider this clockwise rotation, the left-lateral oblique slip on the North-striking faults, and the Northwest-trending pull-apart zones to be consistent with "domino style" rotation of rigid fault blocks. These features also are consistent with deformation within a pull-apart structure.

Although considerable progress has been made in understanding the near-surface structural features, extending this understanding to depths of several kilometers in order to infer their seismogenic, volcanic, and hydrologic significance remains elusive. However, modern data on seismicity and ground-water temperatures indicate the importance of gaining an understanding of the deep structures.

Evidence from Seismicity and Heat Flow

Current seismicity in the immediate vicinity of Yucca Mountain is very low, but earthquakes have been recorded in the area at depths as great as 15 kilometers (Rogers et al., 1987b). The deeper historical earthquakes are dominated by strike-slip focal mechanisms. Although the seismicity supports the presence of deeply penetrating faults, it does not preclude interpretations of shallower detachment faulting. The focal mechanisms for the deeper earthquakes may suggest mechanical decoupling from an upper plate in which a normal-faulting stress regime has been interpreted from borehole hydrofracture testing results (Stock et al., 1985) and paleoseismic studies. Historical earthquake locations in the southern Great Basin do not correlate well with major faults at the surface (Rogers et al., 1987b), whereas Coppersmith (1990) notes that inversions of teleseismic data for several Basin-and-Range earthquakes show them to be associated with moderately to steeply dipping faults rather than subhorizontal reflectors seen on seismic-reflection data. dePolo et al. (1990) suggest that partial decoupling within the upper crust may explain the complex surface-rupture patterns (distributed faulting) of several historical Basin-and-Range earthquakes. Partial decoupling is consistent also with the coincident west-northwest direction of the least principal stress for both shallow (hydrofracture) and deep (focal-plane)

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determinations (Rogers et al., 1987b) and with the oblique sense of movement on some of the faults in the vicinity of Yucca Mountain. If at least partial decoupling of an upper plate from the underlying seismogenic zone is demonstrated, paleoseismic investigations in the immediate vicinity of the Yucca Mountain site may have limited application in forecasting ground-motion characteristics; however, local paleoseismic data would still be needed in predicting the probability of primary and secondary faulting within the repository.

Using the data of Sass et al. (1988), Szymanski (1989) constructed a generalized map showing subsurface temperatures at Yucca Mountain at a depth of 350 meters. Fridrich et al. (1991) constructed a similar map but based it on temperatures at the water table. The maps give similar results, showing positive anomalies of several degrees Celsius along the Solitario Canyon Fault and of a few degrees between Yucca Mountain and the Paintbrush Canyon Fault. Szymanski (1989) suggested that the anomalies overlie hydrothermal convection in the fault zones, whereas Fridrich et al. (1991) attribute the anomalies to upward leakage along the faults of water flowing generally southward in the deep (>2 km) Paleozoic rocks, which is within the normal regional flow system and without significant thermal influence on this system. Although the interpretations differ, they both require that the north-striking normal faults both east and west of Yucca Mountain penetrate and provide hydraulic pathways in the Paleozoic rocks.

Most descriptions of the more recent tectonic models have not addressed possible changes in the probability of fault displacement within the potential repository. However, Coppersmith and Youngs (1990) consider secondary faulting potentially to increase the frequency of waste-canister failure by as much as an order of magnitude, relative to the frequency estimated to result from only primary fault movement. Extensive field mapping, remote sensing, and geomorphic studies of the area have not revealed any faults of significance other than those that have been recognized since the mid-1980s (DOE, 1988a). All the faults for which evidence of Quaternary movement is currently available are outside the design repository boundaries, and they all achieved most of their displacement prior to 11 Mya, the age of the Timber Mountain Tuff (Fox and Carr, 1989). The Ghost Dance Fault, which strikes northward through the proposed repository area, is covered by a thin veneer of young alluvium in only a few washes. Although Quaternary movement is unlikely, it has not yet been ruled out because of the very limited evidence. Lee et al. (1991) note that the current waste-emplacement strategy is to avoid known faults and faults or fracture zones identified during excavation of the repository. They

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also present results of probabilistic modeling of exceedance rates for fault ruptures of 5 and 50 cm on the Ghost Dance Fault. Using the most conservative ("high seismicity") of their three models, they conclude that direct or indirect rupture effects that would compromise waste-canister performance are highly unlikely.

dePolo et al. (1990) define the "maximum background earthquake" (MBE) as the largest earthquake that can occur without primary surface rupture. They suggest "that the MBE for the Basin and Range Province is at least magnitude 6.3 and may be as high as magnitude 6.8," basing their conclusion on analysis of 38 historical earthquakes in the Basin and Range Province. The upper bound for the MBE, a local ($M_l$) or surface-wave ($M_s$) magnitude 6.8, is based on the 1925 Clarkston, Montana, earthquake. Doser (1989) has determined an instrumental moment magnitude ($M_w$) of 6.6 for that earthquake. Eight earthquakes of magnitude 6 to 6.6 produced secondary or distributed surface ruptures but no significant primary rupture. One of these, the 1934 Excelsior Mountain, Nevada, earthquake ($M_l$=6.3) was about 200 kilometers northwest of Yucca Mountain in the Walker Lane, the zone of right-lateral shearing that has been postulated to continue southeastward through the vicinity of Yucca Mountain (Stewart, 1985). The Excelsior Mountain earthquake was preceded by the 1932 Cedar Mountain earthquake, also about 200 kilometers northwest of Yucca Mountain and in the Walker Lane. The Cedar Mountain earthquake, $M_s$=7.2, produced a 60-kilometer discontinuous surface rupture with a maximum surface displacement of 2 meters and also a zone of secondary faulting 6-15 kilometers wide. Molinari (1984) proposed that right-lateral strike-slip movement on an underlying fault was distributed upward through an upper detachment plate to produce the wide zone of deformation. Hardyman et al. (1975) and Hardyman (1978, 1984) proposed a similar model to explain many of the relationships associated with Tertiary detachments throughout the central Walker Lane. Although the Cedar Mountain earthquake was exceptional, the occurrence of distributed faulting at the smaller Excelsior Mountain earthquake indicates that this model should be considered in the evaluation of faulting potential at Yucca Mountain.

However, the topographic and surficial structural features in the vicinity of Yucca Mountain are not analogous to those of active segments of the Walker Lane, indicating a lack of continuity of this structural zone southeastward across the area into Pahrump Valley. Similarly, there is a lack of observational evidence for extending the Las Vegas shear zone west-northwestward to an intersection with the Walker Lane trend near Yucca Mountain. This may not be merely fortuitous and temporary. Rather, it could

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10 Proposed Resolution ( continued )

indicate a fundamental accommodation of deep-seated offsets of the potentially active strike-slip fault zones, which upon further kinematic analysis may be found consistent with the conceptual models of Wright (1989) or Cambray (Younker et al., 1992). The accommodation faults, i.e., the left-lateral oblique-slip north-striking faults at and near Yucca Mountain (O'Neill et al., 1991; Whitney and Muhs, 1991) and the left-lateral northeast-striking faults of the Spotted Range-Mine Mountain zone (Carr, 1984) to the southeast and east of Yucca Mountain, may also be deep-seated structures. In this model, regional displacements might be accommodated locally by coeval smaller displacements on several faults within a moderately large area, consistent with the occurrence of indistinguishable tephra in fault zones both east and west of Yucca Mountain (Fox and Carr, 1989). Implications of this model are (1) the currently mapped faults are probably deep-seated and are the most likely local seismogenic sources, indicating that continued paleoseismic studies are pertinent, and (2) local energy release may be dispersed spatially and perhaps chronologically throughout the set of accommodation structures.

Evidence from Rates of Displacement

Although the paleoseismic data base is far from complete, interpretations of the existing information (Scott, 1990; Gibson et al., 1990) indicate that strain rates have decreased substantially from the Miocene maximum (13 to 11.5 Ma) to the Quaternary. On the basis of the work of Whitney et al., (1986) and Scott and Whitney (1987), Scott (1990) reports estimated slip rates for the period 11.5 Mya to present to be 0.026 mm per year on the Windy Wash fault, 0.010 mm per year on Solitario Canyon and Paintbrush Canyon faults, and 0.029 mm per year on the Stagecoach Road fault. Two of these rates are at least an order of magnitude less than the geologic record indicates for the 13 to 11.5 million year period, and that for the Windy Wash fault is reduced by a factor of 3. The late Quaternary slip rate on the Windy Wash fault, 0.0015 mm per year during the last 270,000, is about half the slip rate during the last 3.4 million years (0.003 mm per year) (J. W. Whitney, oral communication, August 20, 1991) and is more than an order of magnitude less than the slip rate averaged over the last 11.5 million years. In Scott (1990), only maximum ages could be established for Quaternary units that are displaced by the Paintbrush Canyon and Stagecoach Road faults, resulting in calculated minimum slip rates, and dip-slip displacement was assumed. Respectively, these are 740,000 years ago and 0.006 mm per year for the Paintbrush Canyon fault (at Busted Butte) and 1.7 Mya and 0.003 mm per year for the Stagecoach Road fault. More recently, Whitney and Muhs (1991) provide evidence that the Paintbrush Canyon fault at Busted Butte has oblique-slip displacement with a rake of about 45 degrees.

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10 Proposed Resolution ( continued )

The deepest soil exposed in a deep arroyo (about 20 m) has a dip-slip displacement of 4.1 m., or about 5.8 m of oblique-slip displacement. The soil is estimated to be 700 years old because it overlies an aeolian unit containing the 738 years old Bishop Ash and underlies a substantial thickness of deposits containing younger soils. The calculated oblique slip rate of 0.008 mm per year is probably close to the actual average rate over the 700,000 year period. The composite results indicate that, relative to the 11.5 million year slip rate, Quaternary slip rates were substantially less on the Windy Wash and Stagecoach Road faults, and somewhat less on the Paintbrush Canyon fault at Busted Butte.

Note, however, that rates of tectonic activity are typically variable, particularly within a small locality. Therefore, average slip rates over long time periods may differ greatly from those during episodes of greater or less activity, requiring that paleoseismic investigations be applied within a broad context of the tectonic history of the specific locale and its geologic setting.

Evidence from Other Tectonic-related Processes

As was stated in Section 2.3.7.2.2.(1), issue resolution requires that considerations of tectonic models address the potential for uplift, subsidence, folding, and natural changes of the hydrothermal regime. Other than the possible minor continuation of detachment rotation, no significant folding, tilting, or vertical movement has been proposed for the Quaternary tectonic environment of Yucca Mountain. However, Fox and Carr (1989) cite geomorphic evidence for late Quaternary uplift of the Skeleton Hills-Mount Sterling area south of the Rock Valley Fault, which is about 25 km southeast of Yucca Mountain.

The possibility of more regional gentle tilting, inferred from a southward decrease in elevation of apparent lake-shore deposits, was discussed by Carr (1984) and in the EA (DOE, 1986). Hay et al. (1986), Huber (1988), and Hoover (1989) conclude that the deposits in question mark isolated marsh and pond locations, for which southward decrease of elevation reflects down-gradient lowering of the discharges from the Pliocene-Pleistocene regional ground-water system. Additionally, Huber's (1988) geomorphic analysis of the Yucca Mountain area suggests relative tectonic stability since about 11 million years ago.

Fox and Carr (1989) and Spengler and Fox (1989) relate their interpretations of tectonic processes to hydrologic effects. The former paper

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10 Proposed Resolution ( continued )

proposes that episodic faulting has provided open pathways for the circulation of meteoric water or ground water, as indicated by precipitates of calcium carbonate and silica in the fault zones. The latter paper cites a southward increase of fault displacement and width of broken zones in proposing a corresponding southward increase of transmissivity; it further proposes that the cyclic faulting periodically refreshes the transmissivity of fault zones that might otherwise heal with chemical precipitates.

Szymanski (1989) has proposed the tectonic dominance of deep-seated faulting, driven by viscous flow in the upper mantle, on the geothermal regime and hydrology of the Yucca Mountain region. He relates the tectonic setting of the area to an incipient intracontinental rift zone, which is consistent neither with the geothermal regime (Sass et al., 1988; Dudley et al., 1989) nor with the regional structure. Szymanski (1989) attempts to establish cyclicity of the local tectonism, which is important to transient hydrologic control, from the chronology of secondary calcium carbonate in the region, which he concludes has been deposited by tectonically and hydrothermally driven ascending ground water. A large number of papers, which present incremental results of current investigations, have addressed the origin of the calcite-silica veins in faults near Yucca Mountain with the consistent conclusion that they formed beneath the soil zone as precipitates from infiltrating meteoric water. Among these are Taylor and Huckins (1986), Vaniman et al. (1988), Whelan and Stuckless (1990), Marshall et al. (1990), Quade and Cerling (1990), Cerling and Quade (1991), Kroitoru et al. (1991), Marshall et al. (1991), and Stuckless (1991). Although there is considerable evidence that Szymanski's basis for demonstrating tectonic cyclicity is incorrect, Whitney et al. (1986) and Fox and Carr (1989) propose that extensional episodes (not necessarily cyclic) may have an average period of not greater than 75,000 years, based on the composite slip of the Windy Wash fault during the last 300,000 years.

Summary of tectonic models. The foregoing discussion does not support uniquely any single tectonic model for the Yucca Mountain area. The evidence is at least permissive of the alternatives listed below, and combinations of some features are likely.

(1) Regional detachment model. In this model, regional extension is accommodated above the brittle-ductile transition by detachments along shallower surfaces within the brittle crust. Strike-slip, normal, and even reverse faults may develop to accommodate differential rates or directions of movement within a detachment

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10 Proposed Resolution ( continued )

sheet, but these faults are unlikely to cut across detachment surfaces. Structures visible at the surface are limited to the uppermost sheet and provide little if any information about deeper structure. Persistence of cross-cutting pathways for basaltic volcanism would indicate that extension by quasi-horizontal detachments has ended, being replaced by a different mode of extension.

(2) Shallow-detachment model. This model entails at least partial decoupling of the near-surface crust (not more than several kilometers in thickness) from deeper parts of the brittle crust, which is extending by failure along high-angle faults (predominantly strike-slip) that penetrate to ductile crust. The upper sheet (which may be subdivided into more than one sheet) fails complexly in response to both lateral and vertical movements of deeper blocks, and surface structures may bear little apparent relationship to seismogenic structures or deeply penetrating faults that serve as magma pathways. Underlying fault displacement may cause a variety of surface expressions, such as distributed fault zones, sag or collapse structures, vertical-axis bending, or lateral sliding of detachment-sheet segments. In terms of seismogenic capability, this model provides the possibility of undetected and historically inactive faults beneath the detachment surface (possibly as shallow as 2 to 3 km beneath the proposed repository), limiting our capability to place constraints on potential earthquake magnitudes, ground motion, and distributed faulting at the repository site.

(3) Caldera model. Although different in origin, the caldera model presented in the EA (DOE, 1986) is similar in some aspects to the shallow detachment model. The near-surface structures at Yucca Mountain are local and relatively shallow (< 5 km), associated with detachment(s) of (or within) the Tertiary volcanic rocks and slumping or lateral sliding toward the presumed volcanic depression beneath Crater Flat. Structural control of volcanism may be related to the caldera structure or to a later change of tectonic style, such as reestablishment of Walker Lane deformation.

(4) Segmented strike-slip model. Strike-slip faults comprising laterally offset or intersecting segments are the basic mode of extension but are replaced locally by accommodating pull-apart or sag basins, which are bounded by normal or oblique-slip faults. At least

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10 Proposed Resolution ( continued )

the principal accommodation faults penetrate to ductile crust. The upper crust may be detached locally in response to vertical dislocations. Displacement on the strike-slip fault is dispersed locally throughout the accommodation structure. Deterministic analyses of paleoseismic data from a single fault may underestimate the energy release and, thus, ground motion in the vicinity of the accommodation structure. As noted above, segment offsets are inherently unstable and over geologic time through-going strike-slip faulting may be reestablished.

(5) Normal-fault model. This model comprises subsets sharing the basic dominance of normal faults that penetrate the brittle crust to a depth (about 15 km) at which extension is accommodated by ductile deformation. Regionally the styles of faulting can include steeply dipping planar faults (horst and graben structure), tilted planar faults and interfault blocks (tilted domino structure), or listric (curving to progressively shallower dip with depth) faults on which the hanging-wall block rotates. On a regional scale, individual domains of normal-fault style may be separated by zones of strike-slip faulting, with associated edge effects such as vertical-axis drag rotation. If this model is appropriate for Yucca Mountain, the tilted fault blocks require either the listric or tilted-domino style. Furthermore, the influence of edge effects would be indicated by the southward increase of displacement and width of north-striking fault zones and by the vertical-axis rotation of the volcanic rocks. Locally, this model may be indistinguishable from the segmented strike-slip model, and the seismogenic implications of the two models are similar.

At this time there is no unambiguous evidence for distinguishing between the shallow-detachment, segmented strike-slip, and normal-fault models. The caldera model represents structures that are inherited from processes that ended locally by mid-Miocene time and, therefore, is an unlikely and nonconservative alternative for understanding Quaternary and future tectonism. Similarly, the regional detachment model does not readily explain the basaltic volcanism in Crater Flat unless the detachment complex reflects an extinct, superseded process. A complicating factor is that shallow or thin-skinned detachments could develop locally within the area as secondary features were superimposed on deep-seated strike-slip and normal-fault styles as proposed by Wright (1989). In view of the rather compelling evidence for both deep-seated faulting and detachment structures in the vicinity of Yucca

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10 Proposed Resolution ( continued )

Mountain, the coexistence of these styles currently seems to be likely. Nonetheless, in evaluating the site with respect to the qualifying condition of this guideline, it is prudent to consider the above models, or combinations, to be plausible, but not to the exclusion of considering other alternatives.

In terms of faulting and ground-motion characteristics that are expected based on the currently known Quaternary record, i.e., the basis for evaluating the disqualifying condition, the persistence of tectonic activity on the principal north-striking faults is a significant characteristic. Most of the displacement on these faults occurred before about 11 Mya, the age of the Timber Mountain tuff. Despite intensive study, Quaternary fault displacements have not been found at locations that do not exhibit Tertiary displacement. The persistence of activity on long-established structures suggests the involvement of a substantial thickness of the brittle crust. In turn, this suggests that the segmented strike-slip model, the normal-fault model (with edge effects), or the shallow-detachment model with an upper-plate thickness of at least several kilometers represent the causative processes. Hidden underlying faults, if present, are therefore likely to be quite deep, and the north-striking faults probably penetrate deeply. Predictions made with the assumption that the presently known north-striking faults are the controlling seismogenic structures are unlikely to result in significant underestimates of ground-motion intensity."

In Section 2.3.7.3.3, p. 2-104, para. 5, the following text will be inserted after the first sentence ("... data and observations."):

"Presently, at least three basic models appear to be about equally consistent with the evidence -- (1) a shallow or thin-skinned detachment model, in which surficial structures may not directly reveal the nature of deep extensional faults, probably both strike-slip and normal; (2) a segmented strike-slip model, in which accommodating normal faults may dominate the local deformation and seismicity within a releasing bend; and (3) a normal-fault model, in which a regional domain of deeply penetrating normal faults is interacting with an edge defined by strike-slip faults. Models yet to be identified and those that are currently judged to be less plausible in terms of contemporary tectonics of the area--the caldera and regional-detachment models--should still be considered. The implications of these models as to the potentials for faulting, ground motion, volcanism, and deep ground-water flow differ substantially."

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10 Proposed Resolution ( continued )

The second sentence of para. 5 will be deleted (e.g., "Further investigation ... paleoseismic studies."), and a new paragraph will start with the former third sentence ("Continued exploration..."). The former fourth and fifth sentences ("The need to ... and volcanism.") will be deleted and the following text will be inserted:

"Equally important is the deep geometry of principal structures, including possible detachments. The design of subsurface studies should incorporate the need to evaluate the potential importance of secondary or distributed faulting."

END OF TEXT

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(Reviewer completes items 1 - 9.)

1. Comment 2 of 4
2. Date November 11, 1991
3. Reviewer F. William Cambray
4. Organization Michigan State University
5. Revision Draft/Date August 1991
6. Section 2.3.7.3.3
7. Page 2-105
8. Paragraph 2

9. Comment

The groundwater gradient north and northwest of the site is of great concern and needs to be understood in more detail. The pattern of the potentiometric surface must be related in detail to the underlying geology in order to construct realistic models for groundwater flow. This involves a better knowledge of the tectonic setting, especially in relation to fracture patterns associated with faulting and the possibility of fast pathways in the system.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The ESSE Core Team agrees fully with this comment. We propose that the spirit of the comment (and several other comments) can be met by the addition of the following sentence to page 2-105, paragraph 2:

"The results of this exploration should be incorporated into three-dimensional models, simulating both the existing geologic framework and credible modifications of this framework by tectonic processes, in order to predict possible changes to the local flow system and the position of the water table."

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

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(Reviewer completes Items 1 - 9.)

1. Comment 3 of 4
2. Date November 11, 1991
3. Reviewer F. William Cambray
4. Organization Michigan State University
5. Revision Draft/Date August 1991
6. Section 2.3.7.3.1
7. Page 2-94
8. Paragraph 1

9. Comment

Considering the remarks made in Comment #1 I think that more attention should be given to the probability of a Cedar Mountain type earthquake affecting the site. All indications are that there has been a change in tectonic style over the past 12 Ma.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The ESSE Core Team agrees as to the possible likelihood of a tectonic style similar to that of the releasing-bend model proposed in the reviewer's Comment #1, but also expect that earthquakes within the releasing bend would likely be spatially and perhaps temporally dispersed. However, Dr. Cambray also noted in his Comment #4 that releasing bends are inherently unstable, ultimately allowing the reestablishment of an unsegmented strike-slip fault. We propose to resolve this comment by the wording suggested at the following locations in our response to Dr. Cambray's Comment #1: p. 157, para. 3 under "Evidence from Patterns of Fault Movement"; p. 161, para. 1 under "Evidence from Rates of Displacement"; p. 164, para. (2) - "Shallow detachment model"; and p. 165, para. (5) - "Normal fault model."

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
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(Reviewer completes items 1 - 9.)

1. Comment 4 of 4
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3. Reviewer F. William Cambray
4. Organization Michigan State University
5. Revision Draft/Date August 1991
6. Section 2.3.7.3.2.1
7. Page 2-95
8. Paragraph 1

9. Comment

If it can be demonstrated that the mafic volcanic rocks are emplaced in a releasing bend on a strike-slip fault would it be useful to investigate the history of other examples of this setting with respect to the frequency and duration of the activity? It appears that releasing bends are an unstable configuration and have a limited lifespan. This has been investigated recently in Death Valley (Ellis, M.A. and Trexler, J.H. Jr., G.S.A. Abstracts with Programs, 1991, p. A82).

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The ESSE Core Team proposes to resolve this comment partly by the wording suggested in the paragraphs cited in response to Dr. Cambray's Comment #3. We also propose that future studies of volcanism, as recommended on page 2-105, paragraph 4 of the report, are consistent with this recommendation.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

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# *Dr. Steven Carothers*

## ENVIRONMENTAL QUALITY

SWCA, Inc. Environmental Consultants
Flagstaff, AZ

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESOLUTION RECORD

Peer Reviewer's Statement:

I have reviewed the ESSE Integrated Evaluation Package in accordance with ESSE Peer Review Plan. My conclusions with respect to the review criteria of the ESSE Peer Review Plan are:

| Review Criteria | Adequate Yes: See Comment(s) Nos.* | Adequate No: See Comment(s) Nos. |
|---|---|---|
| In my areas of expertise: | | |
| A. The content of the ESSE Integrated Evaluation Package provides an unbiased and objective presentation of information relevant to the suitability issues covered by each guideline. | ✓ | |
| B. The conclusions about the status of lower and higher-level findings on the siting guidelines are balanced and defensible. | ✓ | |

Comments 1 through 14 are attached.

Peer Reviewer Steven W. Carothers Date 23 Dec 1991

Comment Resolution Record

Yes ✓ The revised ESSE Integrated Evaluation Package adequately addresses my comments.

No _____ The following comments have not been adequately addressed:

Peer Reviewer Steven W. Carothers Date 23 Dec 1991

Comments not resolved between the Peer Reviewer and the ESSE Core Team have been noted by the T&MSS Task Manager.

T&MSS Task Manager Jean L Younker Date 12/23/91

* Note: May explain adequacy of comment(s) if needed.

ESSEFIG4.MISC/5-21-91

Figure B-3. Early Site Suitability Evaluation (ESSE) Comment Response Record.

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 1 of 14
2. Date November 6, 1991
3. Reviewer Steven W. Carothers
4. Organization SWCA, Inc.
5. Revision Draft/Date August 1991
6. Section Executive Summary
7. Page E-7
8. Paragraph 4

9. Comment

After reviewing the 1986 EA materials and 1991 ESSE document and other supporting materials, I agree that the current information supports a finding that NO disqualifying conditions prescribed in the Postclosure Guidelines are present or likely to be present at the Yucca Mountain Site. I also agree that additional information is not likely to change the suitability conclusions for any of the postclosure disqualifying conditions. The comments which follow for Section 2, however, reflect certain areas (primarily geohydrology) where I feel additional information is needed to increase the level of certainty that the accessible environment will be protected from "waste" contamination. Certain comments also call for clarification of issues and intent.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The ESSE Core Team agrees that additional information is necessary to increase confidence in the suitability of the Yucca Mountain site. In the geotechnical areas, the Site Characterization Plan (DOE, 1988a) provides a comprehensive means to improve our overall understanding of site conditions and processes.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 2 of 14
2. Date November 6, 1991
3. Reviewer Steven W. Carothers
4. Organization SWCA, Inc.
5. Revision Draft/Date August 1991
6. Section 2.3.1.1
7. Page 2-7
8. Paragraph 1

9. Comment

Because of present uncertainties in the Yucca Mountain Geohydrologic setting, I believe a determination of whether or not the site satisfies the Qualifying Condition, that the "Geohydrologic setting (is) compatible with waste containment and isolation," must remain at a low level finding, until data are gathered to demonstrate otherwise. My greatest concern is the apparent lack of an adequately presented research design which has the possibility of eventually producing the data necessary to definitively qualify or disqualify the Yucca Mountain Site. The response I am looking for is a presentation from both the pro and con Yucca Mountain Geohydrologists as to whether or not it is realistic to assume the definitive data can ever be gathered. It seems to me that a "fatal flaw" in the entire site suitability selection process would occur if uncertainties in existing science and technology demand a low level finding on this critical issue.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

It is not the purpose of this report to present details of the research design that is contained in the Site Characterization Plan (DOE, 1988a) and the more specific study plans. However, Dr. Carothers echoes the comments of numerous others in reviews of the project's results and plans, including those of project scientists, who recently ranked the current and possible residual uncertainty regarding aqueous transport as a principal concern (Mattson et al., 1991). Ultimately, the judgment as to the suitability of the geohydrologic setting must be determined by the contribution of aqueous releases to the probabilistic representation of the postclosure system performance calculations, as described in Section 2.4 of this report.

No changes to the text are proposed.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 3 of 14
2. Date November 6, 1991
3. Reviewer Steven W. Carothers
4. Organization SWCA, Inc.
5. Revision Draft/Date August 1991
6. Section 2.3.1.3.2, 3.3.2.1.3.3
7. Page 2-16, 3.3.2-9
8. Paragraph

9. Comment

Section 3.3.2.1.3.1 Terrestrial Ecosystems, page 3.3.2-5,6
(this comment applies to designated pages in both sections)

The Primary emphasis on groundwater contamination has been, necessarily, on the probability of radionuclide release to the accessible environment. I am concerned with the lack of discussion in the EA and in the ESSE with postclosure groundwater thermal loading. In the EA (Section 5.2.2, Hydrologic Impacts, p 5-36) Potential Impacts to the hydrologic system do not include any discussion of thermal changes, I find this oversight curious. It appears that extensive concern has been given to thermal loading in the surface terrestrial environment (per Ostler, W.K., Biological Resource Concerns, Presentation to the Nuclear Waste Technical Review Board, 8-10 October 1991), however, the importance of understanding potential thermal changes in the saturated zone appears to have been given little consideration.

10. Proposed Resolution *(To be completed by ESSE Core Team)*

Dr. Carothers has identified a very important inconsistency within the report regarding the source of water in Devils Hole and discharging in Ash Meadows. The cited statement on page 3.3.2-9 is correct. However, the cited statement on page 2-16 requires modification. First, the statement refers to the Ash Meadows ground-water system which, as is explained below, encompasses the eastern half of the Nevada Test Site (NTS), whereas Yucca Mountain is within the Alkali Flat-Furnace Creek Wash ground-water system (referred to in some of the older literature as the Pahute Mesa system). Second, the source cited in the statement suggests that the ground-water travel time from the NTS (presumably from the southern tip south of Mercury and far from the areas of underground nuclear-weapons testing) to Ash Meadows "...is approximately 300 years." This statement is not supported by reference nor by calculations within the document (SAIC/DRI, 1991), although back-calculating results in a represented velocity of 200 to 220 feet per year. This is within the range estimated with considerable uncertainty by various authors over the past three

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 3 of 14

2. Page 2 of 5

3. Name Steven W. Carothers
(Print Name)

4. Date November 6, 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

9 Comment ( continued )

The Ash Meadows and Devil's Hole aquatic ecosystems could be dramatically influenced by relatively small changes in groundwater temperature if their discharge points are connected to the aquifer underlying Yucca Mountain. Statements in the EA and the ESSE, however, have left me somewhat confused on this issue. On page 2-16 (ESSE) it is stated that the ground-water travel time from the Nevada Test Site to the Ash Meadow discharge area is approximately 300 years. On page 3.3.2-9, however, it is stated that "outflows of springs in the Ash Meadows area would not be affected by water withdrawals for a repository program because the springs in Ash Meadows emerge from a different aquifer than the aquifer underlying Yucca Mountain." For both of the above statements to be true the Yucca Mountain aquifer and the Nevada Test Site aquifers are not within a continuous system. Yet, Figure 2-5 of the EA shows both the Yucca Mountain Area and the Nevada Test Site to be within the "Alkali Flat Furnace Creek Ranch Ground-Water Basin." How could it take 300 years for the water to get from NTS to Ash Meadows if they are in separate ground-water basins? I have not been able to reconcile this in reading the EA. It is clear, however, that the Yucca Mountain aquifer is connected to the Death Valley aquifer, and I assume this to mean there may be some relationship with the Devil's Hole spring. Given that surface temperatures could rise by as much as 5 degrees C, with a terrestrial temperature maximum obtained 2,000-3,000 yrs. after initial emplacement, could there be a waste related change in the Devil's Hole or Ash Meadows discharge temperatures? My personal opinion is that the potential for groundwater temperature change is relatively small, especially over the distances required to negatively influence the endangered species present in the aforementioned aquatic ecosystems, however, this issue demands attention in the overall analysis of site suitability.

END OF TEXT

10 Proposed Resolution ( continued )

decades, but toward the higher end of that range. Because the referenced source is an administrative document rather than a properly qualified scientific report, and because it refers to an adjacent ground-water basin with significant geologic differences from the Yucca Mountain area, the proposed resolution for this aspect of the reviewer's comment involves eliminating the citation.

Figure 2-5 of the EA is approximately consistent with current understanding of flow-system boundaries. The eastern boundary of the Alkali Flat-Furnace Creek Wash system should be shifted westward to be consistent with current understanding but would still pass through central Jackass Flats in the southwestern quarter of the NTS, 8 to 10 miles east of the Yucca Mountain site.

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 3 of 14

2. Page 3 of 5

3. Name Steven W. Carothers
(Print Name)

4. Date November 6, 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

10 Proposed Resolution ( continued )

The paths of ground-water flow from Yucca Mountain are southward through the volcanic rocks and the basin fill of the Amargosa Desert to Alkali Flat, near Eagle Mountain. Approximately the eastern half of the NTS, along with a large area to the east, is tributary to the Ash Meadows ground-water system, in which most flow occurs in the thick sequence of Paleozoic carbonate rocks termed the lower carbonate aquifer. The same carbonate rocks do occur beneath the volcanic rocks at Yucca Mountain, in a narrow segment (along Furnace Creek Wash) of the Funeral Mountains between the Amargosa Desert and Death Valley, and, in fact, throughout much of Utah, most of the eastern half of Nevada, and adjacent parts of Arizona and California. Within this vast area, flowpaths divide as necessary to deliver water most efficiently from areas of recharge to available discharge areas; thus, the regionally extensive aquifer is partitioned hydraulically, though not necessarily geologically, into several flow systems. Locally, the partitioning is in fact assisted by geologic conditions that disrupt the continuity of the aquifer. Additionally, many of the dominant flow paths are controlled by regional structures such as fault zones.

The interaction of hydraulic potential for flow with the availability of flowpaths (provided by aquifers and structural conditions) and discharge areas exists in the third dimension also. Beneath Yucca Mountain, the hydraulic potential (head) in the lower carbonate aquifer is greater than that in the overlying volcanic rocks, providing the potential for upward flow where permeability is sufficient, again due principally to faults or fracture zones because of the low primary permeability of the lower (mainly nonwelded) tuffs. Most of the flow in the deep aquifer, however, is thought to be lateral to the south, beneath but essentially parallel to that in the upper units, gradually leaking upward until most of the head difference is dissipated. The continuity of the lower carbonate aquifer is disrupted by structurally elevated older rocks (the lower clastic aquitard) between Yucca Mountain and Ash Meadows, making it unlikely that deep flow follows a southeasterly path between the two. It should also be noted that, because of the upward hydraulic-potential gradient and the great depth to the carbonate aquifer (>6,000 ft) at Yucca Mountain, there is no credible chance of transporting waste products within that aquifer, regardless of its discharge area.

Although the Ash Meadows area would seem not to be thermally impacted, the question as to whether other areas might be is a legitimate inquiry. The reviewer's intuition that the thermal effect would be small in down-gradient areas is consistent with ours, but calculations to evaluate this postulated effect have not been done. If the entire repository were to be simultaneously

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 3 of 14

2. Page 4 of 5

3. Name Steven W. Carothers
(Print Name)

4. Date November 6, 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

10 Proposed Resolution ( continued )

subjected to the nominal thermal load of 57 kilowatts per acre, the total power output would be about 100 million watts, which is significant in the context of the natural geothermal heat flow. During the thermal-pulse period, some of the heat output would be consumed by vaporization of water, but most would be stored temporarily (1000s of years?) in the huge thermal capacitance of the unsaturated rock mass. Ultimately, in a time frame of at least 1000s of years, most of the heat discharge would seek the land surface, which is about 15 degrees C cooler than the present water table.

The question of the magnitude and duration of the average transient temperature rise within the zone of active saturated flow beneath the water table is complex and currently unanswered. Among other requirements, definition of that zone of active flow and its relative contribution to the total ground-water flux at down-gradient locations are lacking. However, some preliminary estimates of the peak temperature beneath the potential repository have been made (Eric Ryder, oral communication), maximizing the thermal effect by neglecting the convective heat sink associated with the flowing ground water. The results indicate the possibility of a temperature increase of about 8 degrees C in the rocks at the water table immediately beneath the repository and declining rapidly with distance from the repository. Because of the much larger volume and thermal mass of water derived from elsewhere but discharging in the same area, and because of the thermal capacitance of the rock itself below the water table, the likelihood of significant effects--even approaching 1 degree C--beyond a very few kilometers from the site appears to be remote. We recommend additional scoping calculations before a fully coupled, transient thermal-hydrologic model is given serious consideration.

A. To address this concern, replace the last sentence ["Ground-water flow velocities...(SAIC/DRI, 1991)."] of paragraph 3, page 2-16 with the following:

"Yucca Mountain and the controlled area for the potential repository are within the Alkali Flat-Furnace Creek Wash ground-water system. Flow within the volcanic rocks underlying the site is southward to the Amargosa Desert, continuing southward and mixing with inflow from other areas in basin-fill deposits to discharge principally at Alkali Flat, about 45 miles south of the site. Some of the discharge in the Furnace Creek Wash area of Death Valley may be derived from water in the Amargosa basin-fill deposits, but other sources probably provide much of the discharge by way of regional flow in the thick Paleozoic carbonate rocks that underlie the region. These carbonate rocks are believed to be present beneath the Yucca Mountain site also, but the hydraulic potential within them is greater than that in

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

***(Instructions on back of form)***

1. Comment 3 of 14

2. Page 5 of 5

3. Name Steven W. Carothers
(Print Name)

4. Date November 6, 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

10 Proposed Resolution ( continued )

the volcanic rocks (Craig and Robison, 1984). Therefore, if flow occurs vertically, it is from the deep carbonates upward into the volcanics."

B. Dr. Carothers' concerns regarding the long-term (postclosure) thermal impact of the repository do not have an apparent home within the context of 10 CFR 960, which this report addresses. We propose, rather, to submit the comment and the discussion above to the U.S. Department of Energy for further, more thorough consideration.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes Items 1 - 9.)

1. Comment 4 of 14
2. Date November 6, 1991
3. Reviewer Steven W. Carothers
4. Organization SWCA, Inc.
5. Revision Draft/Date August 1991
6. Section 2.3.1.3.1
7. Page 2-11
8. Paragraph (Favorable condition 2)

9. Comment

I have one final comment on groundwater thermal loading and its potential impact on site suitability. One of the favorable conditions in the Postclosure Geohydrology Guidelines (DOE, 1986), Favorable condition No. 2, assumes if the hydrologic processes operating in the Quaternary continued to the present, there would still be no significant change in the ability of the repository to isolate the waste. My contention is that any heat generated above ambient rock temperatures is also "waste." Would the favorable condition still be met if transfer of waste heat from the rock to the saturated zone were taken into consideration?

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

As noted in Part B of the proposed response to Dr. Carothers' Comment #3, the 10 CFR Part 960 guidelines do not address postclosure, regional thermal impacts. Rather, they specifically address only containment and isolation of the "radioactive materials, including spent fuel, that are received for emplacement in a geologic repository." We propose to submit this comment to the U.S. Department of Energy along with Dr. Carothers' Comment #3 for further consideration.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

***(Instructions on back of form)***

(Reviewer completes items 1 - 9.)

1. Comment 5 of 14
2. Date November 6, 1991
3. Reviewer Steven W. Carothers
4. Organization SWCA, Inc.
5. Revision Draft/Date August 1991
6. Section
7. Page 2-16
8. Paragraph last paragraph

9. Comment

The following statement reflects a problem I have with the original siting guidelines and DOE's apparent willingness to accept a substantial level of uncertainty in site characteristics and still perhaps find the site suitable. "This work continues to support the lower-level suitability findings presented in the EA that the geohydrologic setting of the site is not incompatible with waste isolation and containment." My problem with the statement is, simply, given the existing constraints on the state-of-the-science in geohydrology and the difficulty in predicting the future, will there ever be a higher-level finding, indeed a lower-level finding that the site <u>is compatible with waste isolation and containment</u>?

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The ESSE Core Team agrees that the "state-of-the-science" in the field of unsaturated flow in fractured media is in its infancy and contains large uncertainties that arise from several factors including a limited understanding of the dominant processes and mechanisms influencing flow within unsaturated media. Similarly, predicting the future over any period, much less intervals of thousands of years, is extremely difficult, technically challenging, and also characterized by large uncertainty. We believe that the uncertainty associated with both of these areas can be bounded with reasonable confidence and perhaps reduced, through the implementation of specific activities planned as part of the site characterization program. Sensitivity analyses are planned to evaluate the effects of these uncertainties on the qualifying condition as it relates to waste isolation and containment and on the disqualifying condition related to ground-water travel time. We also recognize (and tried to make clear in Section 2.3.1.1) that our present level of understanding is not adequate to state explicitly that the site is

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 5 of 14

2. Page 2 of 2

3. Name Steven W. Carothers
(Print Name)

4. Date November 6, 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

10 Proposed Resolution ( continued )

compatible with "waste isolation and containment" on the basis of an evaluation of the existing information pertaining to the Postclosure Geohydrology Guideline. There is a considerable amount of work to be performed before such an assessment can be made (see proposed resolution to Dr. Vogel's Comment #1) and the "burden of proof" clearly rests with the DOE.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

***(Instructions on back of form)***

(Reviewer completes items 1 - 9.)

1. Comment 6 of 14
2. Date November 6, 1991
3. Reviewer Steven W. Carothers
4. Organization SWCA, Inc.
5. Revision Draft/Date August 1991
6. Section 2.3.1.5
7. Page 2-24
8. Paragraph para. 1 of 2.3.1.5

9. Comment

The last two lines of the paragraph read..."substantial testing and analysis are likely to be needed to support a higher-level suitability finding." A more direct and factual sentence would change "are likely to be needed..." to "are necessary."

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The wording in the ESSE report that is referred to in this comment reflects a general theme underlying the suitability evaluations. There are very few purely quantitative solutions to questions of suitability, and the level of confidence needed to support a higher-level finding cannot be absolutely specified. Therefore, the ESSE Core Team generally avoided making statements that actions are "necessary" or "required" because we recognize that different overall strategies could dramatically change what is "necessary or required." For example, in this case, if a strategy of placing much greater reliance on the engineered barriers for protecting public health and safety were adopted, then the need for extensive characterization of the natural site features and processes could be reevaluated.

In response to this comment, the "likely to be" will be deleted from the referenced sentence.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 7 of 14
2. Date November 6, 1991
3. Reviewer Steven W. Carothers
4. Organization SWCA, Inc.
5. Revision Draft/Date August 1991
6. Section 1.2.6
7. Page 1-19
8. Paragraph Table 1-6

9. Comment

Change the organization after Steven W. Carothers from "Southwest Environmental Consultants, Inc" to "SWCA, Inc. Environmental Consultants."

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The name of the organization that Dr. Carothers represents will be corrected in the text as requested.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

***(Instructions on back of form)***

(Reviewer completes items 1 - 9.)

1. Comment 8 of 14
2. Date November 6, 1991
3. Reviewer Steven W. Carothers
4. Organization SWCA, Inc.
5. Revision Draft/Date August 1991
6. Section 2.3.4.3.2.1
7. Page 2-57 to 2-59
8. Paragraph all of section

9. Comment

Hopefully, the authors of this section can forgive some editorial criticisms, but the information on former lake levels seems excessively long and not clearly to the point. The reader and reviewer could be led to the similar conclusions in lots less space. Also, in a number of places the reader is given a definition of ka (thousands of years before present), and some places not, why the inconsistencies? This entire Climatic Change Section with its excessively long paragraphs seems out of synch with the crisp efficiency of earlier and later sections.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The editorial comments are appreciated. The discussion of lake-level data will be revised and, hopefully, condensed. The symbol "ka" needs to be defined and will be defined only when it is first used in the text. The author will revisit the chapter in order to achieve improved "crispness" and "efficiency.

Text in Section 2.3.4.3.2.1 will be revised as follows:

"Past regional and global climatic conditions and variability are inferred primarily from the analysis and interpretation of paleoenvironmental data. Sources of paleoenvironmental data in the western United States include lake-level records from present and former lakes, lake-bottom sediment cores, macrofossil assemblages from pack-rat middens, and stratigraphic pollen sequences. Data and analyses that have become available since the EA indicate that a complex regional pattern of climatic conditions and change developed over the western United States following the last Wisconsin glacial maximum

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 8 of 14

2. Page 2 of 2

3. Name Steven W. Carothers
(Print Name)

4. Date November 6, 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

10 Proposed Resolution ( continued )

18 to 20 ka. The results of global-scale climate modeling (COHMAP, 1988) support the hypothesis that these climatic conditions and changes occurred in response to the combined effects of increasing summer insolation in the Northern Hemisphere and the initial presence and subsequent retreat of the continental ice sheets in North America. A general trend toward warmer and drier conditions in the Yucca Mountain region during the late Quaternary continues to be supported. Presently available data, however, are not sufficiently well distributed spatially to permit detailed inferences regarding past climatic conditions at the Yucca Mountain site; however, in the discussion that follows, it is assumed the past climatic conditions at the Yucca Mountain were similar to those that prevailed elsewhere in the Great Basin.

Lake-level chronologies for closed-basin late-Pleistocene lakes in the Great Basin have been developed by Benson and Thompson (1987), Benson et al. (1990), Dorn et al. (1990), and Stine (1990). These studies indicate that the period from about 30 to 18 ka prior to and during the last Wisconsin glacial maximum was a time of persistent moderate-to-low lake levels suggesting cool, dry climatic conditions then prevailed in the Great Basin. Lake-level highstands were attained between about 16 and 12 ka, which Dorn et al (1990) attribute to the occurrence of warmer and wetter conditions that developed at the time of and continued following alpine glacial retreat in the region. Evidence indicates that several lakes underwent lake-level oscillations between about 15 and 14 ka, which may have been responses to localized climatic variability during this time. Most of the lakes experienced nearly synchronous recession between about 14 and 13.5 ka, apparently in response to the widespread occurrence of effectively drier conditions. This was followed by a period of lake-level stability until about 11.5 to 10 ka when minor enlargement occurred, apparently in association with a terminal Pleistocene glacial advance in the Great Basin (Dorn et al., 1990). Except for minor oscillations, the lakes have remained at low levels throughout the Holocene. Based on a study of Mono Lake, California, Stine (1990) suggests that the Holocene lake-level oscillations probably occurred in response to hydroclimatic-induced differences in lake inflow and evaporation."

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

***(Instructions on back of form)***

(Reviewer completes items 1 - 9.)

1. Comment 9 of 14
2. Date November 6, 1991
3. Reviewer Steven W. Carothers
4. Organization SWCA, Inc.
5. Revision Draft/Date August 1991
6. Section 2.3.4.3.2.2
7. Page 2-59
8. Paragraph 2, line 17

9. Comment

The sentence beginning..."A trend toward etc..." seems to be leaving out the possibility that spring discharge reduction and abandonment in the upper Las Vegas Valley could be the result of human related over-utilization rather than significant climatic changes in the region.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The text will be revised as follows: "A trend toward increasing aridity in the region also is supported by evidence cited by Quade (1986) and Quade and Pratt (1989) who interpret widespread fine-grained deposits in the upper Las Vegas Valley, Southern Nevada, to be the sites of former spring-supported marsh environments. Radiocarbon dating of organic materials within these deposits indicate that the springs were active as early as 30 ka and had undergone progressive down-valley dessication and abandonment by about 9 ka." There is no evidence for extensive human habitation, let alone "human-related over-utilization" of water, during this time in the Las Vegas Valley.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 10 of 14
2. Date November 6, 1991
3. Reviewer Steven W. Carothers
4. Organization SWCA, Inc.
5. Revision Draft/Date August 1991
6. Section 2.3.6.3.1
7. Page 2-76
8. Paragraph 2, sent. 2 & 3

9. Comment

(Summary of Environmental Assessment Findings)

In sentence 2 "data" is used as singular, in sentence 3 as plural. Throughout the entire ESSE document there is inconsistent use of the tense of the word "data."

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The text will be corrected to read "The data that support these evaluations..." and the editors will address this problem throughout the text.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

***(Instructions on back of form)***

(Reviewer completes items 1 - 9.)

1. Comment 11 of 14
2. Date November 6, 1991
3. Reviewer Steven W. Carothers
4. Organization SWCA, Inc.
5. Revision Draft/Date August 1991
6. Section 3.3.2.1.2
7. Page 3.3.2-3
8. Paragraph 1 and 2 of 3.3.2.1.2

9. Comment

(Approach for Evaluation)

These paragraphs are exact duplicates of paragraphs 3 and 4 Section 3.3.2, page 3.3.2-1.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The text referred to in this comment (Section 3.3.2) is a general statement of the approach that was taken in evaluating the Environmental Quality, Socioeconomics, and Transportation Guidelines, as well as for the System Guideline for this group of guidelines. There are minor differences in the text in Section 3.3.2.1.2, which applies only to the Environmental Quality Guideline evaluation. In general, the approach taken was for each guideline evaluation section to be as self-contained as possible because most reviewers read only the material of direct interest to them. We will revise the second paragraph to lessen the duplication.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes Items 1 - 9.)

1. Comment 12 of 14
2. Date November 6, 1991
3. Reviewer Steven W. Carothers
4. Organization SWCA, Inc.
5. Revision Draft/Date August 1991
6. Section 3.3.2.1.3
7. Page 3.3.2-3 & 3.3.2-4
8. Paragraph all

9. Comment

(Status of Current Information)

also: Conclusions and Recommendations, Section 3.3.2.4.4. Page 3.3.2-21

After reviewing Section 3, the EA and additional supporting documents I agree that the evidence does not support a finding that the site is not likely to meet the qualifying condition (level 3) and the evidence does not support a finding that the site is disqualified (level 1) for the disqualifying condition.

I also agree with the team evaluation that there is no reason to believe the Yucca Mountain Site is not suitable with respect to the Environmental Quality, Socioeconomic Impacts, and Transportation Guidelines.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The ESSE Core Team appreciates Dr. Carothers' support of the evaluation.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 13 of 14
2. Date November 6, 1991
3. Reviewer Steven W. Carothers
4. Organization SWCA, Inc.
5. Revision Draft/Date August 1991
6. Section 3.3.2.1.3.1
7. Page 3.3.2-4
8. Paragraph (air quality)

9. Comment

"...air quality impacts remain within acceptable levels (my italics)..."
Please reference the air quality standards indicated.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The ESSE Core Team agrees the indicated air quality regulations should have been cited. The text in question will be modified by adding the following to the last sentence under Air Quality, Section 3.3.2.1.3.1:

"...as required by the standards enumerated in the federal Clean Air Act (CAA, 1977). Radioactive air emissions are addressed by U.S. Environmental Protection Agency regulations and are the subject of preclosure radiological safety requirements of 10 CFR Part 960 presented in Section 3.3.1."

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes Items 1 - 9.)

1. Comment 14 of 14
2. Date November 6, 1991
3. Reviewer Steven W. Carothers
4. Organization SWCA, Inc.
5. Revision Draft/Date August 1991
6. Section 3.3.2.1.3.1
7. Page 3.3.2-7
8. Paragraph 1

9. Comment

(Terrestrial Ecosystems)

The first sentence, "Additional future studies may include evaluating the effects of increased soil temperature on biological resources and monitoring terrestrial resources at Ash Meadows" should be modified to recognize the aquatic ecosystems at Ash Meadows and perhaps be expanded to include consideration for the aquatic ecosystems in Death Valley.

In addition, the presentation by W. Kent Ostler (Presentation to the Nuclear Waste Technical Review Board, 8-10 October, 1991) indicates that a 2.3-3.0 sq. mi. immediately above the repository will undergo an increase in soil temperature and decrease in soil moisture for a period of thousands of years should probably be discussed in the "Soils" Section as an impact.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The ESSE Core Team partially agrees with the comment. The potential for the Yucca Mountain Project to affect the ecosystem in the Ash Meadows area is low; it is our understanding that the DOE, is committed to studying those biological resources, if warranted. The studies would consist of both terrestrial and aquatic evaluations. The sentence in question will be modified to include "aquatic" studies. We will recommend the DOE consider if the ecosystems in Death Valley should be added to the list of studies; however, given that the potential for impacts on Ash Meadows is marginal, impacts on Death Valley appears even more unlikely.

The "Soils" section referenced by the reviewer addresses information from a preclosure perspective; however, a statement will be added to the discussion that reads as follows:

"During the preclosure time period, soil resources in the area are not

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 14 of 14

2. Page 2 of 2

3. Name Steven W. Carothers
(Print Name)

4. Date November 6, 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

10 Proposed Resolution ( continued )

expected to be significantly impacted. During the postclosure period, there is the possibility that the area immediately above the proposed repository will undergo an increase in soil temperature and decrease in soil moisture for a period of thousands of years (Ostler, 1991). This potential soil temperature change does not represent a significant impact because the change would be very localized."

A new reference to the bibliography for the report has been added.

END OF TEXT

## REFERENCES FOR DR. STEVEN CAROTHERS

Benson, L. V., and R. S. Thompson, 1987. The Physical Record of Lakes in the Great Basin, Chapter 11, North America and Adjacent Oceans During the Last Deglaciation, The Geology of North America, W.F. Ruddiman and H. E. Wright, Jr. (eds.), Vol. K-3, Geological Society of America, Boulder, CO, pp. 241-260.

Benson, L. V., D. R. Currey, R. I. Dorn, K. R. Lajoie, C. G. Oviatt, S. W. Robinson, G. I. Smith, and S. Stine, 1990. Chronology of Expansion and Contraction of Four Great Basin Lake Systems During the Past 35,000 Years, Palaeogeography, Palaeoclimatology, Palaeoecology, Vol. 78, pp. 241-286.

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COHMAP (Cooperative Holocene Mapping Project) Members, 1988. Climatic Changes of the Last 18,000 Years: Observations and Model Simulations, Science, Vol. 241, pp. 1043-1052.

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Mattson, S. R., B. R. Judd, S. R. Simmock, and D. T. Hoxie, 1991. Testing Priorities at Yucca Mountain: Recommended Early Tests to Detect Potentially Unsuitable Conditions for a Nuclear Waste Repository, YMP/91-25, 2 volumes, Yucca Mountain Site Characterization Project, Las Vegas, NV.

Ostler, W. K., 1991. Biological Resource Concerns, Presentation to the Nuclear Waste Technical Review Board, October 8-10, 1991, Los Alamos, NM.

Quade, J., 1986. Late Quaternary Environmental Changes in the Upper Las Vegas Valley, Nevada, Quaternary Research, Vol. 26, pp. 340-357.

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Ryder, E., December 11, 1991. Personal Communication.

SAIC/DRI (Science Applications International Corporation/Desert Research Institute), 1991. Special Nevada Report, unnumbered report, Las Vegas, Nevada, available from National Technical and Information Services, Springfield, VA.

Stine, S., 1990. Late Holocene Fluctuations of Mono Lake, Eastern California, Palaeogeography, Palaeoclimatology, Palaeoecoloygy, Vol. 78, pp. 333-381.

Younker, J. L., W. B. Andrews, G. A. Fasano, C. C. Herrington, S. R. Mattson, R. C. Murray, L. B. Ballou, M. A. Revelli, A. R. Ducharme, L. E. Shepard, W. W. Dudley, D. T. Hoxie, R. J. Herbst, E. A. Patera, B. R. Judd, J. A. Docka, and L. D. Rickertsen, 1992. Report of Early Site Suitability Evaluation of the Potential Repository Site at Yucca Mountain, Nevada, SAIC-91/8000, Las Vegas, NV.

10 CFR 960 (Code of Federal Regulations), 1984. Title 10, Energy, Part 960, General Guidelines for the Recommendation of Sites for Nuclear Waste Repositories, U.S. Government Printing Office, Washington, DC, pp. 518-551

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# *Dr. James Drever*

## GEOCHEMISTRY

University of Wyoming
Laramie, WY

## EARLY SITE SUITABILITY EVALUATION
## COMMENT RESOLUTION RECORD

Peer Reviewer's Statement:

I have reviewed the ESSE Integrated Evaluation Package in accordance with ESSE Peer Review Plan. My conclusions with respect to the review criteria of the ESSE Peer Review Plan are:

| Review Criteria | Adequate Yes: See Comment(s) Nos.* | Adequate No: See Comment(s) Nos. |
|---|---|---|
| In my areas of expertise: | | |
| A. The content of the ESSE Integrated Evaluation Package provides an unbiased and objective presentation of information relevant to the suitability issues covered by each guideline. | X | |
| B. The conclusions about the status of lower and higher-level findings on the siting guidelines are balanced and defensible. | X | |

Comments 1 through 18 are attached.

Peer Reviewer Jan Y. Drew Date 12-11-91

Comment Resolution Record

Yes X The revised ESSE Integrated Evaluation Package adequately addresses my comments

No _____ The following comments have not been adequately addressed:

Peer Reviewer Jan Y. Drew Date 12-11-91.

Comments not resolved between the Peer Reviewer and the ESSE Core Team have been noted by the T&MSS Task Manager.

T&MSS Task Manager Jan L Yarbor Date 12-11-91

* Note: May explain adequacy of comment(s) if needed.

ESSEFIG4.MISC.5-21-91

Figure B-3. Early Site Suitability Evaluation (ESSE) Comment Response Record.

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 1 of 18
2. Date November 12, 1991
3. Reviewer J. I. Drever
4. Organization University of Wyoming
5. Revision Draft/Date August 1991
6. Section General
7. Page
8. Paragraph

9. Comment

The purposes of this review are laid out on p. 1-18 of the ESSE Document: (1) to evaluate the completeness and adequacy of information presented in support of conclusions in the report and (2) to determine if the report presents an objective and technically defensible view of the suitability of the Yucca Mountain site.

The ESSE document is itself a summary of many reports and publications, and cannot be properly reviewed without reference to a very voluminous supporting literature. In several instances where items appeared to be overlooked by the ESSE, other documents showed that the topics were indeed receiving proper consideration. On the other hand, the ESSE does not (to me) give a clear view of the research priorities of the Yucca Mountain Project. It might have been valuable if the Peer Review Panel had had sufficient time to consider questions of focus and direction.

10. Proposed Resolution *(To be completed by ESSE Core Team)*

As pointed out by Dr. Drever, the ESSE Core Team was faced with trade-offs between including summaries of the supporting literature in the ESSE Report, versus creating a document so lengthy that it would be difficult to use efficiently. Clearly, the detailed rationale and justification for most of the conclusions presented in the ESSE Report can only be fully understood in conjunction with the voluminous supporting references. Some of the peer reviewers had familiarity in the region, with respect to their areas of expertise, which provided an advantage given the time limits on the peer review.

Dr. Drever also correctly points out that the ESSE Report does not present the research priorities of the Yucca Mountain Project (see also Dr. Vogel's Comment #7). This was not the responsibility of the ESSE Core Team; our mission was to identify technical guidelines for which information is inadequate to support a higher-level finding. These topics will serve as input

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 1 of 18

2. Page 2 of 2

3. Name J. I. Drever
(Print Name)

4. Date November 12, 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

9 Comment ( continued )

The document was received on August 27, 1991. Three members of the Task Group that prepared the report visited me in Laramie on September 24, 1991, and meetings involving reviewers and project personnel were held in San Diego, California on October 23, 1991 and October 24, 1991. Apart from these meetings in San Diego, there have been no opportunities for the Review Panel to meet as a group. These comments thus represent the opinions of one individual, and they have not had the benefit of the interaction that normally takes place with a peer review panel. While I recognize the time constraints involved, I feel the review would have been a more valuable document if we had the opportunity to interact and synthesize our views.

As a summary statement, I believe the ESSE is a well-prepared and technically sound document. I have no serious disagreement with any of the Findings regarding Qualifying or Disqualifying conditions for the site. The task group has taken a conservative approach, and there is no instance where an inappropriate Higher Level Finding has been made.

END OF TEXT

10 Proposed Resolution ( continued )

to establishing overall priorities. There are a number of reasons for conducting site characterization activities. These include gathering information needed to (1) design the waste package and repository; (2) evaluate performance of the natural and engineered barriers, both individually and collectively; (3) gain scientific confidence and regulatory assurance; (4) provide support for other testing activities; and, as required by the NRC (10 CFR 60, Subpart F), (5) confirm, to the extent possible, that the natural setting and the engineered components are performing as intended and expected. Some testing activities serve many of these "end uses" while others have a relatively specific objective. Because of these multiple needs and uses for information, prioritization of the research program is a very complicated task.

It is recognized that opportunities for peer reviewers to meet as a panel and exchange ideas were limited. Given the high proportion of academics on the panel and the overlap with the academic-year calendar, it was determined that the peer review panel would not be able to act as a consensus-making body except in a very limited sense. This situation was also exacerbated because the specialities of the panel members had to be sufficiently diverse to cover the complete suite of technical guidelines in 10 CFR Part 960. Unlike most peer review panels, which have a relatively narrow scope, this panel was required to be extremely broad in its coverage.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 2 of 18
2. Date November 12, 1991
3. Reviewer J. I. Drever
4. Organization University of Wyoming
5. Revision Draft/Date August 1991
6. Section 2.3.1
7. Page 2-7 to 2-24
8. Paragraph general

9. Comment

The first key issue is travel-time through the unsaturated zone. There are few (if any) quantitative studies in the literature of actual solute transport over large distances in fractured, porous rock. As a result, there are no data sets against which to calibrate or validate theoretical models. The modeling work appears to be state-of-the-art, but I would have limited confidence in it unless it can be validated against field data. My concern would be, conceptually, that individual discrete features (as discussed or implied on p. 2-18 & 2-19) may significantly affect solute transport, and that such discrete features would not be well represented by continuum models. Will it be technically possible to validate the models adequately, and to "characterize the site" adequately for prediction of unsaturated flow? This is a difficult question,and obviously comes down to one's concept of "adequately". I am skeptical that physical measurements of fractures, porosity etc. in the ESF will be sufficient. Plot-scale irrigation experiments will certainly help, but the vertical and temporal scale that can be studied is limited, and there is a

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The authors share the concerns about model validation and site characterization expressed by the reviewer. Developing the capabilities to quantify the conditions at Yucca Mountain in models that correctly approximate the geohydrologic system is a technically challenging and complex problem that requires a systematic, interdisciplinary approach coupling laboratory and site-scale investigations with theoretical studies and hypothesis testing. Glass and Tidwell (1991) present an approach toward developing and validating conceptual models for flow and transport through unsaturated fractured rock that is being pursued as part of the Yucca Mountain Project. This approach is predicated on the development of a firm understanding of the basic physics governing flow through fractured media, specifically emphasizing unsaturated flow in fractures and fracture-matrix interactions. Similarly, other approaches are being pursued that emphasize specific aspects of the geohydrologic system (e.g., infiltration processes) or are directed at acquiring specific types of data that are intended to provide

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION COMMENT RESPONSE FORM (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 2 of 18
2. Page 2 of 3
3. Name J. I. Drever (Print Name)
4. Date November 12, 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

9 Comment ( continued )

hit-or-miss element as to whether they capture the effects of specific "discrete features". In my opinion, the most important validation will come from natural tracers, particularly tritium, 14C and 36Cl. Tritium and 36Cl were mentioned briefly (p. 2-17); I did not see any reference to 14C. Stable isotopes in the water of the unsaturated zone (deuterium and 18O) may also indicate recharge under different climatic regimes, and may constrain models of vapor-phase transport in the unsaturated zone. The Study Plan for Study 8.3.1.2.2.7 (Revision Number R 0, July 1990) addresses most of my concerns on this point, even though I still have questions regarding adequacy of sample volumes and possible contamination during sampling.

In summary, modeling flow in the unsaturated zone is an enormously complicated problem, and a crucial issue in the future will be establishing confidence in the models that are developed. The distribution of isotopic tracers should document more or less adequately the present-day (or historically recent) transport regime and provide some sort of validation of the unsaturated-zone flow models. A further question will be predicting the effect of climate change, specifically increased recharged, on travel times. Here I would be reasonably confident in the use of a low model that had been calibrated (validated is probably too optimistic a word) against both the isotopic tracers and the artificial irrigation experiments.

END OF TEXT

10 Proposed Resolution ( continued )

additional insight into the dominant processes and mechanisms controlling flow. Collectively, these data may be useful for calibrating flow models and for developing the requisite confidence that these models correctly approximate the conditions at the site.

We agree that a very important element in developing confidence in the models used to predict ground-water travel times is to use natural and environmental tracers and stable isotopes. Although only limited site-specific data have been acquired over the last 5 years, some of these data (i.e., chlorine-36 and tritium) have clearly demonstrated the utility of using tracers to develop an understanding of the flow processes and mechanisms operational at the site. Carbon-14 data (personal communication, 1991, unpublished results from D.C. Thorstenson) suggest differences in the gas flow system between the Topopah Spring unit and the overlying Tiva Canyon unit, which appears to be operating on a much faster time scale. These results require verification through additional testing planned as part of Study Plan 8.3.1.2.2.7. Contingent upon availability of funds, this work will continue in

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5. Comment or Proposed Resolution or Resolution *(Circle one)*

10 Proposed Resolution ( continued )

the future as drilling is reinitiated and as access to the primary subsurface units is gained by underground construction. Additionally, a program is being implemented to identify tracers that will be used and that have utility as a means to develop further understanding of these complex processes.

To address this comment, we will add the following text to Section 2.3.1.5, Recommendations for Future Activities:

"Chemical and environmental tracers and dating techniques should be used as an independent means to estimate travel times and to develop confidence in the models that are used to simulate flow processes and mechanism. Water chemistry data from both the unsaturated and saturated zones should be obtained to better understand and constrain the assumptions associated with chemical processes and gaseous flow in the unsaturated zone and to provide boundary conditions for modeling these processes."

This additional text will be inserted in a longer addition responding to Dr. Vogel's Comment #1. (See the response to that comment for the full text of the changes to Section 2.3.1.5.)

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

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(Reviewer completes Items 1 - 9.)

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2. Date November 12, 1991
3. Reviewer J. I. Drever
4. Organization University of Wyoming
5. Revision Draft/Date August 1991
6. Section 2.3.1 & 2.3.2 general
7. Page NA
8. Paragraph NA

9. Comment

2.3.1 Geohydrology and 2.3.2 Geochemistry

As the Freeze Panel (Freeze et al., 1991 [DOE, 1991g]) and others have pointed out, the division between "Hydrology" (movement of water) and "Geochemistry" (movement of solutes in the water, in part at least) is artificial and to some extent counterproductive. The distinction is perhaps overemphasized by the structure of 10 CFR 960. I would hope that as emphasis shifts more towards performance assessment the fields will become more closely integrated.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

Dr. Drever correctly identifies an important difficulty in addressing site characteristics in a compartmentalized fashion. Note, however, that although these issues were compartmentalized in the text, the considerations were made in a more coherent manner. Therefore, the evaluation of the geochemistry was made in the context of the particular pathways involved. This does not mean, however, that a detailed, integrated evaluation of the characteristics of the site was made in this effort. Such integration is part of a system performance assessment, as is explained in the following paragraphs, which will replace the first three paragraphs of Section 2.2 on page 2-2:

"The site is evaluated against the Postclosure System and Technical Guidelines by considering first the technical guidelines, followed by the system guideline. The technical guideline evaluations are conducted with two objectives in mind. The first objective is to

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

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10 Proposed Resolution ( continued )

determine if there are any specific features or conditions of the site, within the scope of those guidelines, that would indicate the site is not suitable. If no such features or conditions can be identified, then lower-level suitability findings on the technical guidelines can be supported. The second objective is to determine whether additional information would be likely to change the conclusion. If not, then a higher-level suitability finding can be supported. If the uncertainties are such that the conclusion could change, then the objective is to identify issues that may provide a focus for testing during site characterization and that must be resolved before a high-level finding can be supported. The technical guidelines are evaluated individually and the results of the evaluation of each guideline are discussed in Section 2.3.

The evaluation of the Postclosure System Guideline determines whether the system performance requirements specified in the guideline can be met. This requires an integrated assessment of the issues identified in the technical guideline evaluations and other issues related to waste isolation and containment identified in the performance assessments, themselves. For example, many of the technical guidelines focus only on specific aspects of site performance, such as hydrology, which addresses the movement of water, or geochemistry, which addresses the movement of solutes in the water. Such distinctions are eliminated when these issues are considered together in the system guideline evaluation.

The evaluation of the system guideline involves system and subsystem performance assessments. These assignments are generally accomplished through the following types of analyses:

1. Identification of system performance measures

2. Development of models needed to evaluate the performance measures

3. Evaluation of the performance measures

4. Conduct of sensitivity and uncertainty analyses to identify critical model parameters and to evaluate the importance and role of uncertainties in site information.

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10 Proposed Resolution ( continued )

These analyses are explained in the following paragraphs."

END OF TEXT

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2. Date November 12, 1991
3. Reviewer J. I. Drever
4. Organization University of Wyoming
5. Revision Draft/Date August 1991
6. Section 2.3.1.1.1
7. Page 2-7
8. Paragraph (discussion)

9. Comment

2.3.1.1.1 Discussion, p. 2-7:

This discussion brings up a whole range of unresolved issues, including rigorous definitions of travel time and words such as "likely" and "significant." Rather than these issues individually, it would seem sensible to resolve the critical ones in the context of performance assessment under the Postclosure System Guideline.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

Dr. Drever has identified an important issue for the site evaluations. The terms "likely" and "significant" should be defined in the context of the overall postclosure performance objectives. Because the evaluations of system performance cannot be definitive at this time, the ESSE Core Team believed it inappropriate to define those terms precisely for this evaluation. However, precise definitions in the context of the postclosure performance objectives will be important in future evaluations.

There is a particular problem with the Geohydrology Guideline, in that the requirements on ground-water travel time are different in the Siting Guidelines and in NRC's regulations. The NRC regulations place limits on travel time along the "<u>fastest</u> path of likely radionuclide travel," while the DOE Siting Guidelines limit travel time along paths of "likely and <u>significant</u> radionuclide travel." In the ESSE report, we tried to define a basis for the evaluation that would hopefully not depend strongly on subtle

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

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10 Proposed Resolution ( continued )

interpretations. The definitions on page 2-8 read as follows:

> "For purposes of this site suitability evaluation, ground-water travel time is defined as the cumulative displacement of a tracer particle divided by the ground-water velocity along a specified path of likely flow. 'Paths of likely and significant radionuclide travel' are defined to be those identifiable flow paths along which water bearing radionuclides released from the EBS could travel from the disturbed zone to the accessible environment."

We believe this is still the appropriate approach and prefer to maintain the text as it is. However, as stated above, the point is an important one to be addressed in future evaluations that depend more heavily on integrated performance assessments.

END OF TEXT

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3. Reviewer J. I. Drever
4. Organization University of Wyoming
5. Revision Draft/Date August 1991
6. Section 2.3.1.5
7. Page 2-24
8. Paragraph para. 2 of 2.3.1.5

9. Comment

2.3.1.5 Conclusions and Recommendations for Future Activities

I have no disagreement with the conclusion. I do have questions concerning the discussion. "These conditions can be best identified and characterized through in situ exploration of the potential repository host rock and surrounding units." Exactly what sort of characterization is envisioned? Have experiments been designed that will specifically evaluate the hydrologic models? How much in situ exploration will there be of the region below the repository? I would stress again that a key issue in the future is the extent to which hydrologic models can be validated, and this will not be straightforward even when the ESF is constructed.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

In direct response to Dr. Vogel's Comment #1 and other comments raised by the Peer Review Panelists, the Discussion (Section 2.3.1.5) will be replaced with the proposed resolution for Dr. Vogel's comment (see that comment for the complete text).

The testing program planned for the ESF is continuing to evolve as the design matures and as decisions on the phased construction approach are made. The most recent description of the ESF testing program is contained in the ESF Requirements Document, Appendix B (DOE, 1991), which shows the layout of the underground testing program currently planned for the new ESF configuration, augmented by the descriptions contained in the Site Characterization Plan. Although some new experiments are being considered, the current plans call for the tests described in the Site Characterization Plan. Note that a caisson experiment is being planned this spring that will acquire data designed to begin to calibrate flow and transport models for later use at Yucca Mountain.

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

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10 Proposed Resolution ( continued )

The present configuration (modified option 30 from Dennis, 1991) consists of two ramps entering the repository block from the east, a primary testing area in the northeast, and two northeast-southwest trending drifts located in the Calico Hills and Topopah Spring units. This configuration is expected to provide sufficient access to the Calico Hills and the major structural features located within and proximal to the block to provide for adequate characterization.

END OF TEXT

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5. Revision Draft/Date August 1991
6. Section 2.3.2.3.1 (new 2.3.2.2.1)
7. Page 2-26
8. Paragraph (Issue 1)

9. Comment

2.3.2 Geochemistry Technical Guideline

General comment and Issue 1 (p. 2-26):

The Qualifying Condition for the Postclosure Geochemistry Technical Guideline is much more vague than the corresponding conditions for the Geohydrology Technical Guideline. There are no absolute numbers such as a travel time of 1,000 years. In fact, if the Geohydrology guideline is met, much of the geochemistry becomes irrelevant. If the travel time for water is sufficiently long, the presence of absence of adsorption becomes unimportant. The main importance of the geochemical work this seems to be:

1. As a part of the geohydrological work (for example analysis of $^{36}Cl$). As I mentioned in Comment Number 3, the separation between geohydrology and geochemistry seems at times arbitrary.

10. Proposed Resolution *(To be completed by ESSE Core Team)*

Dr. Drever makes a good point in this comment. Radionuclide retardation by geochemical conditions and processes, however, is viewed as one component of a system of multiple barriers to migration. Its role may indeed be primary or secondary depending on the ground-water travel time. It may be possible, for the purposes of site suitability, to assign no performance criterion to retardation by these conditions and processes and to justify a higher-level finding on this guideline by arguing that there are no known or expected conditions and processes that are incompatible with waste isolation and containment. The ESSE Core Team explored this possibility, but the prevailing sentiment was that the current uncertainty in ground-water travel time estimates prohibits reaching this conclusion now; scenarios exist wherein minimum sorption of some radionuclides may be necessary to meet regulatory release limits.

The three points raised by Dr. Drever are addressed in the following

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

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9 Comment ( continued )

2. Adsorption and retardation may serve as a "redundant barrier." Even if the groundwater travel time is shorter than anticipated, adsorption may prevent the release of radionuclides to the accessible environment.

3. Adsorption and chemical reactions in the "disturbed zone" will have an important influence on the source term that defines the availability of soluble radionuclides for transport by groundwater.

As an editorial point, it would be useful to have a summary table (perhaps an updated summary of Tables 6-24 to 6-26 of the EA, or of Kerrisk, 1985) that shows: 1. A list of nuclides of concern in the waste and their half-lives, 2. the estimated solubility of each element, 3. A qualitative distribution coefficient/adsorption ratio (e.g. "strong", "medium", "weak", "not adsorbed") for each element (2. and 3. might include a range of values if speciation is unclear). Such a table would allow us to focus in immediately on the nuclides most likely to present a problem. The information is implied by the second paragraph on p. 2-30; it could be more explicit.

END OF TEXT

10 Proposed Resolution ( continued )

paragraphs:

1. The information and discussion in this guideline evaluation is based upon the narrow and specific definition of "geochemistry" suggested by the guideline statement, i.e., geochemical characteristics of the site...compatible with waste containment and isolation. Geochemical techniques, e.g., isotopic analyses for dating and tracing, are being widely used in support of geohydrology and tectonic investigations. The purpose and organization of this document detracts from an integrated presentation of all these initiatives. We regret that this exacerbates this frequent concern of reviewers and critics, i.e., the seeming inadequacy of horizontal integration between the various SCP investigations.

2. Redundant or multiple barrier (as we prefer) arguments have been the justification for continued investment in study of these processes as they may operate at the Yucca Mountain site.

3. We believe the source term is more influenced by chemical reactions than absorption. Mechanical, chemical, and thermal disturbances

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10 Proposed Resolution ( continued )

complicate study and understanding of these phenomenon in the near-field. The source term issue, however, is a Postclosure Rock Characteristics issue as the division of effort has been defined for the purposes of the this early site suitability evaluation.

Table 2-4 (previously Table 2.3.2-2) will be added to the text in Section 2.3.2 to address Dr. Drever's editorial point. A copy of that table is attached to this response.

END OF TEXT

Table 2-4. Important Radionuclides in High-Level Nuclear Waste[a,b]

| Radionuclide | Half-life, years | Inventory Percent | Inventory Limit[c] | (Dissolution Rate/ Limit)[d]/year | Probable Sorption Behavior |
|---|---|---|---|---|---|
| Ni-59 | $8.0 \times 10^4$ | 0.3 | 5.2 | $1.7 \times 10^{-4}$ | Strong |
| Zr-93 | $1.5 \times 10^6$ | 0.1 | (e) | (e) | |
| TC-99 | $2.1 \times 10^5$ | 0.7 | 1.3 | $1.3 \times 10^{-4}$ | Weak |
| Cs-135 | $3.0 \times 10^6$ | (e) | (e) | $3.5 \times 10^{-4}$ | Strong |
| U-234 | $2.4 \times 10^5$ | 0.1 | $2.0 \times 10^1$ | (e) | Weak |
| Np-237 | $2.1 \times 10^6$ | 0.05 | $1.0 \times 10^1$ | $1.0 \times 10^{-3}$ | Weak |
| Pu-238 | $8.8 \times 10^1$ | 0.02 | 9.7 | (e) | Moderate |
| U-238 | $4.5 \times 10^9$ | (e) | 3.2 | (e) | Weak |
| Pu-239 | $2.4 \times 10^4$ | 17 | $3.1 \times 10^3$ | $6.9 \times 10^{-4}$ | Moderate |
| Pu-240 | $6.6 \times 10^3$ | 27 | $4.8 \times 10^3$ | $1.1 \times 10^{-3}$ | Moderate |
| Am-241 | $4.3 \times 10^2$ | 51 | $9.0 \times 10^3$ | $4.5 \times 10^{-3}$ | Moderate |
| Pu-242 | $3.8 \times 10^5$ | 0.1 | $1.8 \times 10^1$ | (e) | |
| Am-243 | $7.8 \times 10^3$ | 0.9 | $1.6 \times 10^2$ | $7.8 \times 10^{-5}$ | Moderate |

[a]Data from Kerrisk (1985).
[b]Based upon pressurized water reactor (PWR) spent fuel 1,000 years after discharge, dissolution by Well J-13-type water, and sorption by Yucca Mountain tuffs.
[c]Radionuclide activity/Environmental Protection Agency (EPA) release limit.
[d]Estimated rate of dissolution of the nuclide in the waste form/EPA release limit.
[e]Unimportant per this ranking criterion.

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5. Revision Draft/Date August 1991
6. Section 2.3.2.4.1 (new 2.3.2.3.1)
7. Page 2-27 to 2-28
8. Paragraph Table 2-2

9. Comment

Table 2-2 (previously Table 2.3.2-1) Favorable Conditions:

1. "Sorptive minerals (zeolites) were present..." A key question is whether zeolites will adsorb all of the nuclides of concern. I am disturbed by possible over-generalizations.

Table 2-2 (previously Table 2.3.2-1) Potentially Adverse Conditions:

3. "Pre-waste-emplacement groundwater conditions in the host rock that are chemically oxidizing." I presume oxidizing conditions would be adverse from the point of view of corrosion of the canisters. From a geochemical point of view, oxidizing conditions may be favorable, as iron and manganese oxyhydroxides (which would not be present under reducing conditions) are an important substrate for adsorption (e.g. Means, J.L., D.A. Crerar, M.P. Borcsik, and J.O. Duguid: Adsorption of Co and selected actinides by Mn and Fe

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The ESSE Core Team understands Dr. Drever's concern; these statements, however, are not original prose by the ESSE authors but are verbatim quotations from the earlier EA and, therefore, text revisions are not possible.

We believe the ESSE report does not overgeneralize the importance or role of sorptive zeolites present at Yucca Mountain. In fact, this discussion tries to focus attention on real or potential exceptions to these generalizations, i.e., radionuclides and species that may not be sorbed or otherwise so retarded by geochemical conditions and processes. The mention in the ESSE report of occurrence at Yucca Mountain of sorptive minerals other than zeolites including iron and manganese oxides and hydroxides (see p 2-30) is an example. We will add the reference suggested to make it clearer which minerals and radionuclides are of interest. See attached text revision for page 2-34 to this effect.

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

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5. Comment or Proposed Resolution or Resolution *(Circle one)*

9 Comment ( continued )

oxides in soils and sediments. Geochim. Cosmochim, Acta 42, 1763-1774, 1978).

END OF TEXT

10 Proposed Resolution ( continued )

Dr. Drever's presumption regarding oxidizing, pre-waste-emplacement ground water is consistent with that of the Core Team. The Core Team decided to address the near-field effects of ground-water chemistry as a part of the Postclosure Rock Characteristics Guideline evaluation. We agree that oxidizing ground water may be a favorable condition in the far-field for the reason you state. This advantage may have to be balanced against the greater solubility of many radionuclides in oxidizing waters. In any case, the presence of oxidizing water in the far-field is not a disqualifying condition under the Postclosure Geochemistry Guideline.

The text on page 2-34, second paragraph, will be revised to read as follows:

"Several types of batch sorption experiments were carried out on pure mineral separates to identify which mineral phases present in tuffs at Yucca Mountain were most effective in sorption of each of the key radionuclides and to investigate the details of the sorption reactions for the most important radionuclide/mineral pairs. The sorption of anionic species of Tc ($TcO_4^-$) and Np ($NpO_2CO_3^-$) in J-13 water was studied on oxides, carbonates, clays, and zeolites. Of the phases studied, only the iron oxides, geothite and hematite, had any affinity for Tc and then only a small affinity. Iron and manganese oxides had large affinities for Np while clays, zeolites, and carbonates had relatively small affinities for Np (Meijer et al., 1989). These results for iron and manganese oxides corroborate earlier findings regarding the adsorption of actinides by iron and manganese oxyhydroxides (Means et al., 1978). The nature of the Np complex sorbed to the geothite surface was investigated with the Extended X-ray Absorption Fine-Structure (EXAFS) technique (Combes et al., 1990) and the results of this investigation were used in the development of a surface complexation model to explain retardation of the nuclide on geothite (Kohler et al., 1990). Evidence is accumulating that anionic species of key radionuclides released by the engineered barrier system are retarded somewhat by minerals other than zeolites present along potential flow paths."

END OF TEXT

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6. Section 2.3.2.4.2 (new 2.3.2.3.2)
7. Page 2-29
8. Paragraph 2

9. Comment

2.3.2.4.2, p. 2-29

"Dispersion and molecular diffusion also will slow the rate of travel of all species..." Dispersion (as the term is standardly used) will not slow the rate of travel. It will cause a spread in travel times about the mean, with some material arriving earlier and some later. It will in fact accelerate the "first arrival" (defined as some fraction of the peak concentration). Did the ESSE authors imply a different meaning for the term "dispersion" (perhaps involving matrix diffusion)?

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The text will be revised to omit reference to dispersion and to clarify the role of molecular diffusion. The text will be revised to read as follows:

"Two processes figure centrally in retardation by the geochemical barrier: (1) precipitation and (2) sorption by minerals along transport pathways. Sorption may occur as a result of several mechanisms, including ion exchange and surface complexation. Knowledge of mineral distributions along likely flow paths of water to the boundary with the accessible environment will allow a determination of the extent to which precipitation and sorption may occur. Molecular diffusion from fast transport pathways into the surrounding rock matrix also will slow the rate of travel of all species, i.e., ions and complexes. Species that do not..."

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

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6. Section 2.3.4.2.3 & 2.3.4.2.4
7. Page 2-32 to 2-33
8. Paragraph

9. Comment

2.3.4.2.3 Radionuclide Solubility; 2.3.2.4.2.4 Radionuclide Speciation

The speciation and hence solubility of the actinides is enormously complex (e.g., Nitsche, 1991), and the two cannot be considered in isolation; measured solubility will depend on speciation in solution, and there is no guarantee that speciation in solution will reflect equilibrium with ambient redox conditions or ligand concentrations. The problem can be approached empirically--see how total concentrations of an element behave in J-13 water with minor modifications--or mechanistically, in which all relevant species are studied by the traditional approaches of inorganic chemistry. In my opinion, the more-or-less empirical approach should be adequate for the Yucca Mountain Project at this time. However, sensitivity analyses as part of the performance assessment should provide an indication as to whether further specific studies are needed.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The ESSE Core Team agrees that speciation and solubility are closely interrelated. Sensitivity analyses by Kerrisk preceeded the Nitsche work cited by Dr. Drever, and, in fact, were used to focus and prioritize his work which, incidentally, is being done with direction and funding from Los Alamos National Laboratory as part of DOE's SCP geochemistry investigations. Dr. Nitsche plans continued sensitivity analyses as part of his solubility modeling activity. System and subsystem models for performance assessment are and will probably remain too gross to be useful for speciation sensitivity analyses. Detailed solubility, sorption, molecular diffusion, and coupled process transport/retardation models under development will be used for this purpose. Models are currently data starved or too immature to permit sensitivity analyses.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

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5. Revision Draft/Date August 1991
6. Section 2.3.2.4.2.4 (new 2.3.2.3.2.5)
7. Page 2-33
8. Paragraph para. 3&4 of S.2.3.2.4.2.4

9. Comment

2.3.2.4.2.4

(p. 2-33, second paragraph)

"Present-day groundwaters collected from the vicinity of Yucca Mountain do not contain a significant concentration of particulate matter." There was no specific reference given for this statement. My questions are: 1) How much does it have to be to be "significant"? 2) Have there been any systematic studies of the abundance of natural colloids, as, for example, at the Grimsel test site in Switzerland (Degueldre, C. et al.: Colloids in water from a subsurface fracture in granitic rock, Grimsel Test Site, Switzerland. Geochim. Cosmochim, Acta 53, 603-610, 1989)? It is not particularly likely that natural colloids <u>are</u> important, but consideration should be given to natural colloids during the water sampling program.

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The reference to this statement should have been Kerrisk (1987) it was misplaced at the end of the previous sentence. The text will be revised to correct this error.

"Significant" was an inappropriate choice of words. No systematic studies of the abundance of natural colloids have been done. However, as a result of this and other concerns regarding ground-water composition, ground-water samples will be analyzed for natural colloids. These data should provide the basis for a systematic study of natural colloid occurrence and abundance.

The text in the first full paragraph on page 2-33 will be revised to read as follows:

"Soluble radionuclide species can also sorb on natural or anthropogenically produced colloidal-sized particles forming a pseudocolloid, which may then

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
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1. Comment 10 of 18

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5. Comment or Proposed Resolution or Resolution *(Circle one)*

9 Comment ( continued )

(p. 2-33, third paragraph)

"Radionuclide transport as colloidal species remains an area of uncertainty." I agree that surrogate experiments with spherical particles are likely to be misleading. Is work underway to resolve the uncertainty? Filtration experiments with actual Pu colloids?

END OF TEXT

10 Proposed Resolution ( continued )

move with the impunity of natural colloids. Particulate concentrations in ground waters of the Yucca Mountain region are believed to be low based upon the results of a few preliminary filtration experiments with samples from pumped wells. The best documented of these experiments measured ~0.3µg/l of particulate material in the size range 0.005 µm to 0.4 µm in water from well J-13. At this concentration, a sorption ratio of ~4 x $10^6$ µl/g would have to be demonstrated for this material to contribute to more than 10 percent of the total waste element flux. Such ratios have been seldom approached in sorption experiments using Yucca Mountain tuffs (Kerrisk, 1987). Repository construction and waste emplacement effects may alter this situation unfavorably, however."

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

***(Instructions on back of form)***

(Reviewer completes items 1 - 9.)

1. Comment 11 of 18
2. Date November 12, 1991
3. Reviewer J. I. Drever
4. Organization University of Wyoming
5. Revision Draft/Date August 1991
6. Section 2.3.2.4.2.5 (new 2.3.2.3.2.5)
7. Page 2-33 to 2-35
8. Paragraph

9. Comment

2.3.2.4.2.5 Radionuclide Sorption

There are two major problems associated with adsorption work, and neither has an easy answer:

1. Adsorption is a function of the species in solution (e.g., $Am^{3+}$, $Am^{4+}$, $AmO_2^{+}$, $AmO_2^{2+}$, not to mention the effect of ligands) and not of the element Am. When adsorption is discussed simply in terms of elements, it is implicitly assumed either that the appropriate species is present in the experiment, or that equilibration among species is rapid on the time-scale of the experiment. To "do it right" by working out speciation in detail for all elements in all solutions of interest would be prohibitively expensive, and the usefulness of the results would be limited for other reasons (see 2. below). The "minimum $K_d$ strategy" (Radionuclide Adsorption Workshop, Los Alamos National Laboratory, Sept. 11-12, 1990) seems a reasonable and conservative approach. I suspect it

10. Proposed Resolution *(To be completed by ESSE Core Team)*

1. The text in paragraph 1 of Section 2.3.2.4.2.5 (now Section 2.3.2.3.2.5) will be revised to reflect the comment. As described in the text, it is difficult to envision the chemical mechanisms that would result in such a slow interconversion among species present in solution that the distribution coefficient determined by batch experiments is not conservative. However, if the kinetics of attaining equilibrium among species in solution phase are slow, we will be able to measure the elution of the different species in column experiments. The column experiments will allow us to calculate distribution coefficients for each chemical species. We utilize column experiments to assess the applicability of batch sorption experiments under dynamic conditions. Any discrepancies among the two types of experiments are resolved before distribution coefficients are utilized in performance assessment. Whether the speciation in the solutions utilized is the same as the speciation of the solutions that will be present at the proposed repository is a difficult point to address. We use ground waters from the

11. Resolution *(To be completed by original Reviewer)*

Comment resolutions accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION COMMENT RESPONSE FORM (CONTINUATION SHEET)

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9 Comment ( continued )

is over-conservative; it could be reviewed if performance assessment studies indicate. It appears at present that only a few elements (U, Np, Tc, I, and C) warrant significant effort at this time.

2. Transfer of laboratory-derived adsorption data to the field is an extremely complex problem. If solutions are percolating through a uniform permeable tuff, the problem is relatively straightforward. However if transport occurs through fractures (the likely situation for fast flow-paths) there is a large uncertainty in the mass/surface area of minerals that will contact the flowing solution. Presumably both fracture linings and matrix minerals (through matrix diffusion) will be involved. Here again is an area where hydrology and geochemistry overlap. If hydrologic field studies on fracture flow are instigated, I recommend that sorbing and non-sorbing tracers be included in the tests to provide some validation of related solute transport codes.

END OF TEXT

10 Proposed Resolution ( continued )

site, and many of the experiments reported by Thomas (1988) were performed under controlled atmosphere to simulate the amount of carbon dioxide present in the ground water at Yucca Mountain. All we can do is report the method of solution preparation and the chemistry of ground water utilized (as Thomas did in the 1988 sorption summary report) and evaluate those experimental parameters as more speciation data are obtained by Nitsche and as the field sampling plan to obtain ground-water samples and ground-water chemistry is carried out by the USGS and LANL.

The minimum $K_d$ strategy is perceived as both "reasonable and conservative" by its advocates. It is seen as deterministic, bounding, and inconsistent with regulations, policy, and common sense by its detractors who believe a stochastic approach to be reasonable, conservative, and practical. The minimum $K_d$ strategy capitalizes upon empirical sorption data and mineralogy and petrology information accumulated to date on rock units expected to occur along likely flow paths to the accessible environment. It is an admitted attempt to focus resources on key radionuclides and species in the limited time remaining before a decision on site suitability with the (perhaps, too obvious) objective of minimizing the uncertainty in this decision. Performance assessments are indeed expected to determine the conservatism of this position. Contention persists over these assessments because of (a) the dearth of data upon which they are currently based and (b) the idea that the expected value and range for many of the variables involved can be decided by "expert" opinion (this idea is

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1. Comment 11 of 18

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10 Proposed Resolution ( continued )
an anathema to experimentalists).

2. A saturated-zone pump test at three drill holes at the C-well complex is planned. Both conservative and reactive tracers will be used; however, tracers will not be radioactive because the use of radioactive material is prohibited. The tests will be modeled using multidimensional transport code, and the test results will be used to validate or suggest refinement of the code. In anticipation, detailed laboratory characterization of potential tracers and relevant rock has been done. Fracture network and reactive transport codes are also in place. Other tests of a similar nature are planned for the saturated and unsaturated systems.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
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(Reviewer completes items 1 - 9.)

1. Comment 12 of 18
2. Date November 12, 1991
3. Reviewer J. I. Drever
4. Organization University of Wyoming
5. Revision Draft/Date August 1991
6. Section 2.3.2.4.2.5 (new 2.3.2.3.2.5)
7. Page 2-34 & 2-36
8. Paragraph

9. Comment

2.3.2.4.2.5 Radionuclide Sorption

(p. 2-34)

"Evidence is accumulating that anionic species are retarded somewhat by minerals other than zeolites present along flow paths." When I first read this statement I was unclear as to which anionic species were meant. R.J. Herbst (pers. comm. September 24, 1991) clarified the meaning by explaining the sentence was simply a summary of the preceding paragraph. It is still potentially confusing for a reader.

Along the same lines, 2.3.2.4.3 Issue 1 (p. 2-36) could be more explicit. I would prefer to see a specific list of the radionuclides expected to be retarded (or rather a list of any not expected to be retarded.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The ESSE Core Team agrees with Dr. Drever's comment.

The revision to the second paragraph on p. 2-34 proposed in the response to Dr. Drever's Comment #7 addresses the first part of this comment.

The text under Issue 1 will be revised as follows:

"Improved knowledge of mineral abundances and distribution, particularly in fractures, strengthens the case for effective sorption of the radionuclides of concern at Yucca Mountain. The effectiveness is least for anionic species of Tc and Np. In general, known and expected geochemical characteristics and processes are expected to retard the rate of transport of radionuclides released to this setting relative to ground-water travel."

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

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(Reviewer completes items 1 - 9.)

1. Comment 13 of 18
2. Date November 12, 1991
3. Reviewer J. I. Drever
4. Organization University of Wyoming
5. Revision Draft/Date August 1991
6. Section 2.3.4.3.1
7. Page 2-56
8. Paragraph 1

9. Comment

2.3.4.3.1

(p. 2-56)

"Increased precipitation, however, also could lead to higher rates of erosion within the region resulting in overall base-level lowering that, ultimately, could lead to water-table declines and longer ground-water travel times." While the statement is true in principle, I find it implausible when applied to Yucca Mountain. Where is the base-level lowering going to occur? Certainly not at Furnace Creek, and significantly lowering at Ash Meadows seems unlikely.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The statement cited by Dr. Drever was intended to be general, that is, to identify possible effects and consequences of climatic change without specific reference necessarily to the Yucca Mountain site. The sentence will be removed from the text. It is interesting to note, however, that Winograd and Szabo (1988) consider that base-level lowering could have been a major component of the water-table decline inferred to have occurred at Ash Meadows during the past 750,000 years.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

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1. Comment 14 of 18
2. Date November 12, 1991
3. Reviewer J. I. Drever
4. Organization University of Wyoming
5. Revision Draft/Date August 1991
6. Section 2.3.7.3.2.4
7. Page 2-98 & 2-99
8. Paragraph

9. Comment

2.3.7.3.2.4 Strain-Response Models

Given the existing panels, I do not propose to spend time evaluating Szymanski's hypothesis. I would simply say that an inordinate amount of effort seems to have been expended on the origin of the deposits in Trench 14. I am convinced that they are pedogenic rather than hydrothermal.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

Although the ESSE Core Team agrees that additional review effort on the Szymanski hypothesis appears to be redundant, every additional expert opinion is welcome. The effort expended in evaluating the Trench 14 deposits has served as a training exercise to develop methods and criteria upon which to base judgments as to the origin of various deposits in the region.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

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1. Comment 15 of 18
2. Date November 12, 1991
3. Reviewer J. I. Drever
4. Organization University of Wyoming
5. Revision Draft/Date August 1991
6. Section 2.3.8.3.2.7
7. Page 2-120
8. Paragraph

9. Comment

2.3.8.3.2.7 Permanent Markers

In designing earthworks or markers, care should be taken to avoid configurations that might increase infiltration. Given the low rates of weathering in the area, natural rock should be perfectly adequate for permanent markers.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The following will be inserted as the last sentence in the first paragraph on page 2-121:

"Whichever type of surface marker or earthworks are used, care should be taken to avoid configurations that could increase infiltration."

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

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(Reviewer completes items 1 - 9.)

1. Comment 16 of 18
2. Date November 12, 1991
3. Reviewer J. I. Drever
4. Organization University of Wyoming
5. Revision Draft/Date August 1991
6. Section 2.4 general
7. Page 2-129ff
8. Paragraph na

9. Comment

2.4 Evaluation of the Postclosure System Guideline

Performance analysis is the key to provide focus to the site characterization effort. An apparent weakness of past work is that it has not necessarily been prioritized in the context of its contribution to the total system performance. I would advocate this approach, both for making the most effective use of research funds and for advancing the site characterization process as rapidly as possible.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

Dr. Drever emphasizes the importance of prioritizing site-characterization activities both in this comment and in his opening summary. Other reviewers have also made this point (see Dr. Vogel's Comment #7). As mentioned in our response to Dr. Drever's Comment #1, explicit prioritization was not the responsibility of the ESSE Core Team; rather, the mission was to identify technical guidelines for which information is inadequate to support a higher-level finding. These topics will serve as input to establishing overall priorities.

The report by Mattson et al. (1991) evaluated priorities for tests designed to detect potentially unsuitable site conditions early during site characterization. Prioritization in that report was based on detection of features and conditions that affect postclosure performance. However, there are a number of reasons for conducting site characterization activities. These include gathering information needed to (1) design the waste package and

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
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10 Proposed Resolution ( continued )

repository; (2) evaluate performance of the natural and engineered barriers, both individually and collectively; (3) gain scientific confidence and regulatory assurance; (4) provide support for other testing activities; and, as required by the NRC (10 CFR 60, Subpart F), (5) to confirm, to the extent possible, that the natural setting and the engineered components are performing as intended and expected. Some testing activities serve many of these "end uses" while others have a relatively specific objective. Because of these multiple needs and uses for information, prioritization of the research program is a very complicated task. (This point was also made in our response to Dr. Drever's Comment #1.)

The DOE's Test and Evaluation Plan (DOE, 1990) explicitly describes the steps the Project intends to take to ensure that the testing program focuses on those aspects of the site that are most important to system performance. The plan describes the role that performance assessments will play in helping to evaluate the results of the testing program and in providing essential input to those responsible for directing that program.

However, performance assessments that require detailed conceptual and numerical models can only be used to a limited extent early in the site characterization program when those models are not very well developed. Therefore, although the performance aspects have been considered in the evaluations and in developing the general testing plan described in the SCP (DOE, 1988a), it is too early to use them exclusively. The early site suitability evaluation was conducted with that same philosophy. The following paragraph will be added to page 2-5 in Section 2.2 to explain this limitation:

"Although quantitative assessments were considered, they did not provide the principal focus of this early site suitability evaluation. Ultimately, the evaluation of the suitability of the site will involve detailed, quantitative performance analyses to assess compliance with numerical criteria. These analyses will be based on conceptual models that are consistent with the information gathered during site characterization. Because it is too early in the site characterization program to have such information and models fully developed, the Core Team did not rely heavily on quantitative performance models. (A good example is in the area of geohydrologic processes. The models in this area are at a relatively early stage of development, and the Core Team did not consider it appropriate to rely heavily on them at this time.) Nevertheless, the Core Team did review the status of the quantitative assessments in their

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10 Proposed Resolution ( continued )

evaluation of the system guideline. The results of this review and the evaluation of the system guideline are presented in Section 2.4."

END OF TEXT

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(Reviewer completes items 1 - 9.)

1. Comment 17 of 18
2. Date November 12, 1991
3. Reviewer J. I. Drever
4. Organization University of Wyoming
5. Revision Draft/Date August 1991
6. Section 2.4.2
7. Page 2-138 & 2-139
8. Paragraph

9. Comment

2.4.2 Review of information obtained since...

Carbon-14 Studies

The question of C-14 migration seems to be falling through the cracks. It is mentioned in the Geochemistry and Hydrology sections, but I did not see any discussion of attenuation through gas-liquid partition in the vadose zone or consumption by silicate weathering reactions in the vadose zone. I do not know if either would be significant, but it would seem appropriate to conduct some preliminary modeling as fallback position in case the strategy of changing EPA release rates (Van Konyenburg, 1991) does not work out.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

Information reviewed by the ESSE Core Team strongly suggests that attenuation due to mechanisms listed by Dr. Drever is not well understood. Ross (1987) estimates the bounds of the retardation factor for C-14 to be between 2 and 2,000. Other calculations place the retardation factor between 30 and 70 with an approximately median at 50 (Ross et al., 1991). An important assumption in these calculations is that of thermodynamic equilibrium between the gas and liquid. Evidence from pore fluids and pore gases (Yang, 1991) suggests the possibility of a very low retardation, especially if the liquid is held in the smallest pores while the gas flows through the paths of least resistance.

Another important uncertainty regarding gaseous release--and the one most amenable to testing--is in the source term, or the rate at which the gas could be released from the engineered barriers. The third sentence of paragraph 2 on page 2-144 will be changed to reflect this point: "Current evidence also

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

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10 Proposed Resolution ( continued )

suggests that the probability of meeting the EPA release limits for carbon-14 does not depend strongly on uncertainties in site information. Rather, the major source of uncertainty appears to be the gaseous carbon-14 source term."

Although the performance of the site may be approaching the EPA 10,000 year release limit for carbon-14, the consequence of the gaseous releases (i.e., dose or health effects) is believed to be negligible. This reflects an inconsistency in the regulations, of which the regulatory agencies are aware. It is not clear at the present time if the regulations will be changed to correct this inconsistency, but it is clear that the margin needed to demonstrate compliance with the current regulation will be less than for other radionuclides where the consequences could be much greater. The text will be rewritten to reflect this broader view of the regulatory approach (replacing last three sentences of paragraph 3 on page 2-145):

"The EPA has recognized that this limit may not be consistent with the minimal public health and safety hazards associated with release of gaseous carbon-14 (Clark and Galpin, 1991; Van Konynenburg, 1991). Thus, the release limits for carbon-14 may change, or it is possible that additional information about releases could change the conclusion that the system guideline is met. Therefore, the Core Team feels that a lower-level suitability finding can be supported for the Postclosure System Guideline."

END OF TEXT

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6. Section 2.2.4
7. Page 2-145 to 2-150
8. Paragraph Table 2-14

9. Comment

Table 2-14 (previously Table 2.4-2): Site characterization studies

Again, I see very little prominence given to isotopic tracers. I think $^{14}C$ and tritium should be there along with $^{36}Cl$. Deuterium and $^{18}O$ should be included.

This lets me conclude with what I think is a fundamental point: the most critical issue for establishing confidence in the suitability of the site will be convincing the scientific community and the public that the hydrologic models for the unsaturated zone actually work--that they are capable of predicting realistically the future movement of fluids. This confidence will not come from increasing the sophistication of the models (desirable as this may be), but from devising tests to validate the models. I have mentioned isotopic tracers as one approach. I am sure there are others, and my final recommendation would be to elevate the whole question of model validation to a

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The ESSE Core Team agrees with Dr. Drever's concern regarding model validation. Transport model validation is a crucial concern of the geochemistry investigations. (Recognize that program parlance equates geochemistry to radionuclide transport.) Our approach to model validation begins with iterative laboratory studies and model revisions of separate processes and builds to full-scale field experiments in the Exploratory Studies Facility through a series of larger and increasingly complex laboratory and pseudo-field (caisson) experiments. This approach is embodied in current plans and, therefore, no revisions to the ESSE report text are proposed in response to this comment. The approach was also hinted at in our response to part 2 of Dr. Drever's Comment #11, and the concern as it relates to hydrologic models was addressed in our response to Dr. Drever's Comment #2. We propose no further amplification here except to call your attention to recommendation (2) of Section 2.3.2.4 (previously 2.3.2.5) of the report where

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

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5. Comment or Proposed Resolution or Resolution *(Circle one)*

9 Comment ( continued )

high priority.

END OF TEXT

10 Proposed Resolution ( continued )

we tried to make this same point as a recommendation for future activities.

END OF TEXT

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# *Dr. Marco T. Einaudi*

## ECONOMIC GEOLOGY

Stanford University
Stanford, CA

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESOLUTION RECORD

Peer Reviewer's Statement:

I have reviewed the ESSE Integrated Evaluation Package in accordance with ESSE Peer Review Plan. My conclusions with respect to the review criteria of the ESSE Peer Review Plan are:

| Review Criteria | Adequate Yes: See Comment(s) Nos.* | No: See Comment(s) Nos. |
|---|---|---|
| In my areas of expertise: | | |
| A. The content of the ESSE Integrated Evaluation Package provides an unbiased and objective presentation of information relevant to the suitability issues covered by each guideline. | yes, with resolution of my comments | |
| B. The conclusions about the status of lower and higher-level findings on the siting guidelines are balanced and defensible. | yes, with resolution of my comments. | |

Comments 1 through 29 are attached.

Peer Reviewer [signature] Date 12/12/91

Comment Resolution Record

Yes yes The revised ESSE Integrated Evaluation Package adequately addresses my comments.

No _____ The following comments have not been adequately addressed:

Peer Reviewer [signature] Date 12/12/91

Comments not resolved between the Peer Reviewer and the ESSE Core Team have been noted by the T&MSS Task Manager.

T&MSS Task Manager [signature] Date 12-12-91

* Note: May explain adequacy of comment(s) if needed.

ESSEFIG4.MSC/5-21-9

Figure B-3. Early Site Suitability Evaluation (ESSE) Comment Response Record.

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment _____ of _____
2. Date November 12, 1991
3. Reviewer Marco T. Einaudi
4. Organization Stanford University
5. Revision Draft/Date August 1991
6. Section 2.3.8
7. Page general
8. Paragraph _____

9. Comment

Summary

Based on my reading of the ESSE and many of the supporting documents, I judge that it is appropriate to extend the effort to characterize the Yucca Mountain site. Assessment of the suitability of the site with regard to the two disqualifying conditions appears to be well in hand, although some clarification and amplification is necessary in the ESSE to support a Level 2 finding with regard to Issue 2 (see below). I concur with the assessment that available evidence continues to support a lower level suitability finding for the qualifying condition. Considerable work remains to be done with regard to the qualifying condition (Issue 3), and these future tasks are reasonably laid out in the ESSE. Discussion of approaches and conceptualizations regarding these future tasks is a key focus of my detailed commentary, and I hope that these can be outlined in the ESSE. An important point that must be stressed in any discussion of resource assessment is the increased difficulty of predicting

10. Proposed Resolution *(To be completed by ESSE Core Team)*

No resolution required to Dr. Einaudi's summary and general commentary.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Not applicable.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment _____ of _____

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5. Comment or Proposed Resolution or Resolution *(Circle one)*

9 Comment ( continued )

the occurrence of mineral resources at depths greater than a few hundred meters below the surface. This difficulty is especially great in an area such as Yucca Mountain which contains no known mineral deposits and little or no sign of past hydrothermal activity at the surface. Judgemental knowledge becomes critical in such cases, pointing to the eventual need for review of data and approaches by a team of experts in mineral exploration.

General Commentary

In this section, I focus on what I consider to be the outstanding issues associated with the Human Interference technical guideline related to non-fuel natural resources. In the sections that follow this general commentary, I submit detailed comments on the ESSE and on several of the supporting documents cited in the ESSE (Castor et al., 1989; Site Characterization Plan).

Assessment of natural resources has a large uncertainty and the probability of false alarms can be high; testing of hypotheses related to potentially economic resources takes the form of exhaustive and expensive drilling campaigns. For these reasons, expert opinion (i.e., judgement) has to be relied on to a large extent. Numerical data involving probabilities of occurrence of certain types of mineral deposits as a function of geological environment can be useful. However, the ultimate assessment of potential loss of waste isolation due to exploration for, or mining of, mineral resources has to rely more on site-specific assessment than on regional probabilities of occurrence (which are not site-specific).

In spite of the above caveats, prioritization of tasks related to the technical guidelines on "Human Interference, Natural Resources" can be achieved. These tasks, in order of importance, include: establishment of specific methods to be used in the projection of resource value and technology into the future; assessment of the indirect effects on the repository of mining outside the controlled area; and establishment of occurrence models for mineral deposits and ore-forming systems that may occur at and near the site.

A major recommendation resulting from my review of the Natural Resources section is that separate panels of experts be convened to review the judgemental issues related to (1) assessment of future value, and (2) mineral deposit occurrence models. The former should involve an interdisciplinary team consisting of (for example) mineral economists, geostatisticians, economic geologists, and geochemists; the latter could be composed dominantly of

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
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9 Comment ( continued )

economic (exploration) geologists, but should coordinate closely with research teams of the Yucca Mountain Project, particularly in the areas of geochemistry, rock characteristics, and tectonics.

The outstanding problems that will require further study include (1) projections of future values of resources and future technologies; (2) indirect affects on the repository of potential future mining outside the controlled area; and (3) assessment of future resource potential based on concepts of ore-forming systems (or ore deposit models).

1. Future Mining Cut-offs, Values, and Technology.

The qualifying condition regarding human interference (natural resources) requires an assessment of future value of commodities, future scarcity of commodities, and future technology related to mining and beneficiation (ESSE, p. 2-107). Issue 3, which relates to this qualifying condition, states that this projection should extend into the "foreseeable future" (ESSE, p. 2-109). The ESSE further interprets "foreseeable future" as referring to "the next few years to 10 years, and occasionally as long as 30 years" (p. 2-108).

There are various approaches that can be used to assess the future economic viability of a metal concentration in the earth's crust.

(a) The simplest is to assume present value and technology, with reassessment taking place periodically until closure. This would establish a baseline, but fully confront the issue.

(b) An approach that would confront the issue more closely would be to conduct assessments for each of a series of declining mining cut-off grades down to a selected lower limit, as suggested by Mattson (1988). The lower limit selected, dependent on the commodity, could be based on the concept of "mineralogical barrier" (Skinner, 1986) or on the concept of "conservative cut-off" (Mattson, 1988). A comparison of these two approaches to setting lower limits to grade for the foreseeable future can be made for copper: Skinner's mineralogical barrier yields a lowest grade of 0.1 percent Cu. whereas Mattson's conservative cut-off yields a lowest grade of 0.03 percent Cu. Skinner's approach may be preferable, because it is based on a physical model for the distribution

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9 Comment ( continued )

of elements between minerals, and is linked to the cost of extraction. However, the mineralogical barrier is not well-known for many metals of interest. Neither approach specifically takes into account the question of future demand and future technology.

The issues raised above should be addressed and reviewed by a group of experts in the area of commodity forecasting and future technology. Such a group would have to interface closely with geochemists (crustal distribution of elements unconventional ores) and exploration geologists (mineral deposit characteristics, unconventional ores). Without such advice and guidance, it will be difficult to assess and obtain closure in the evaluation of issues related to this qualifying condition.

2. Indirect Effects of Future Mining.

The indirect effects on the repository of future exploration for, and mining of, mineral resources outside the controlled area will have to be assessed and is particularly important for resolution of the qualifying condition. Studies will have to develop knowledge of the effects of:

(a) introducing drilling fluids,

(b) infiltration of leach fluids from
  (1) surface leach pads,
  (2) underground (in-situ) leaching operations,

(c) withdrawal of groundwater due to mine dewatering activities or water production for mine and mill use,

(d) man-made underground pathways (fractures, openings) created by:
  (1) conventional open pit blasting
  (2) conventional underground blasting,
  (3) surface and underground drilling,
  (4) underground mine tunnels and stopes,
  (5) large-scale underground block caving with attendant rupture to the surface,
  (6) non-conventional underground mining involving large-scale fracturing by conventional or nuclear explosives for in-situ leaching.

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9 Comment ( continued )

Screening, assessment, and, perhaps, performance assessment calculations of the above factors (and there may be others that I, not being a mining engineer, have not thought of) is required before Issue 3 (qualifying condition) can be resolved. This process also could lead to a substantial reduction of the size of the area that needs to be considered in terms of potential for undiscovered deposits. Therefore, this study of indirect effects on the repository of future exploration and mining outside the controlled area preferably should take place before substantial investment of time on the assessment of mineral resources outside the controlled area. Expert judgement will likely play a large role in this analysis.

3. Ore Deposit Models.

A starting point for resource assessment is knowledge of the location of all past and current mining operations near the site. This knowledge presumably is in hand, although a detailed map showing such sites is absent from the ESSE or SCP. Such a map should become an integral part of Human Interference assessment package.

In assessing the mineral potential of an area, knowledge of location of past and present producers and commodities is insufficient; knowledge has to extend to include key geological and geochemical features of the known mineral deposits that can be used in a predictive manner in other, nearby areas. This type of knowledge commonly is cast in terms of geological "models" of mineral deposits. Ideally, such models deal not only with the immediate ore zone, but also with the broader issue of ore-forming "systems" that can include both numerous different ore zones of the same type or same commodity, and numerous different types of ores or commodities.

In general, the ESSE and SCP did not provide a conceptualization of the links between deposit types and between different commodities in the context of a hydrothermal system that is larger than any individual ore deposit or prospect that it might contain. Such an approach should be listed in the ESSE as a future goal. In the sections that follow this general commentary, specific comments are offered on the SCP which discuss this approach in some detail. Such conceptualization needs to be developed before Issue 3 (qualifying condition) can be resolved, and is a top priority item for future tasks.

Four future tasks related to assessment of resource potential are listed below in approximate order of accomplishment (although iteration between the

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9 Comment ( continued )

four efforts needs to take place):

(a) RANKED LIST OF TYPES OF MINERAL DEPOSITS. Based on (1) known geological environment of the site and of its surroundings (tectonic setting, rock types, and ages), and (2) presently known ore deposits (past and present producers) and prospects of the surroundings, a list should be established of all types of mineral deposits (as opposed to commodities, and as opposed to ore-forming systems [see below]) that do or could occur in the area. Such a list should include deposits that are presently economic as well as those that have been economic in the past. The list should be ranked in an order reflecting both likelihood of occurrence in the area and potential value. This task requires a knowledge of the geological environment and does not require the definition of a specific area. The ranked list must be made by economic geologists familiar with the Great Basin and ultimately should be reviewed by an expert panel.

(b) OCCURRENCE (DESCRIPTIVE) MODELS OF MINERAL DEPOSITS. For each of the types of deposits identified in (1), key geological, geochemical, and geophysical features need to be compiled. In developing the occurrence models, special weight should be given to characteristic features of ores in the SW Nevada Volcanic Field and in its basement rocks. Priority should be given to the development of models for the deposits ranked at the top of the list generated in Step 1 (above). Such descriptions should include, but not be restricted to, the following:

(1) age distribution,

(2) key rock associations (igneous rock types and textures, favorable sedimentary lithologies, etc.),

(3) alteration styles and their zoning (especially peripheral styles) and the size of alteration halos,

(4) structural controls and vein styles and their zoning,

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9 Comment ( continued )

(5) morphology and dimensions of ore zones,

(6) geochemical signatures (e.g., metal associations or correlations and ratios) and their zoning,

(7) typical tonnage and grade data, including co- and by-products.

(c) CONCEPTUAL BASE OF ORE SYSTEMS. The next step is to identify the known observational links (not speculative links) between deposit types, i.e., to establish a conceptual base of "ore systems," larger than individual ore deposits (ore bodies). Examples are the links between mercury deposits and gold deposits of both the Carlin and epithermal (volcanic-hosted) type; link between barite veins and Carlin-type Au; link between porphyry Cu deposits, Cu-skarn deposits, and base-metal vein deposits; link between fluorite deposits and porphyry-type deposits of lithophile elements (W, Sn, Mo, etc.). Links that at present are speculative (e.g., between Carlin-type Au and porphyry systems, or between detachment faults and base- and precious-metal deposits) should be considered, but will be difficult to assess. <u>The choice of conceptual systems to be assessed and the importance of "speculative links" ultimately should be reviewed by an expert panel</u>.

(d) REGIONAL RESOURCE ASSESSMENT (EXPLORATION) MAP. Following the integration of data collected in steps 1-3 above, and as a result of that integration, an exploration map can be constructed. Such a map would display, as a series of overlays on a geologic map base, the distribution of key mineral occurrences, prospects, past and present mines, hydrothermal wall-rock alteration, and structural trends. Such a series of overlays could then be used to construct summary maps indicating the location of highly prospective, moderately prospective, weakly prospective, and non-prospective areas for each of the deposit-types identified in task 1. <u>Again, a panel of experts should be involved in the review and finalization of this work</u>.

END OF TEXT

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4. Organization Stanford University
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6. Section 2.3.8.1
7. Page 2-107
8. Paragraph 1

9. Comment

(see comment (5)).

Qualifying condition (Issue 3) - "Reasonable projections of value, scarcity, and technology" are required in order to assess this qualifying condition and it would be useful if some elaboration of this point were made in the ESSE. For example, these projections are to be made over an unspecified period of time that commences on closure of the facility--are there plans to establish guidelines for such projections? Or, could this qualifying condition be assessed in the context of present value and technology, to be reassessed periodically until closure?

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

Much of this concern and discussion is covered in the Discussion Section (2.3.8.1.1). The last paragraph of this section states "For natural resources without current markets, but which could be marketable given credible projected changes in economic or technological, the resources shall be described by physical factors such as tonnage or other amount, grade, and quantity."

Additional discussion will be added to this section under the subheader of "Reasonable projections of value, scarcity, and technology." The following will be added to the text: "Reasonable projections will need to be made at several points during site characterization and, likely, during any period under which a license application may be pending in the future. The basis for these projections is likely to rely on the expert opinion of individuals in the field of natural resources and perhaps other technical fields.

In addition, the natural resource potential of the site may need to be

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

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10 Proposed Resolution ( continued )

reassessed at the time a closure decision is considered. This is because closure of any facility could be as far in the future as 150 years, a period much longer than current estimates of natural resource potential (foreseeable future) should be extended and considered credible. Definitions, terms, and assumptions will all need to be reviewed by qualified experts to aid in directing the program toward realistic goals and credible natural resource assessments and to establish that regulatory criteria have been defensibly evaluated."

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

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3. Reviewer M.T. Einaudi
4. Organization Stanford University
5. Revision Draft/Date August 1991
6. Section 2.3.8.1
7. Page 2-107
8. Paragraph 2

9. Comment

(see comment (5)).

The disqualifying condition (Issue 2) is that presently valuable natural resources outside the controlled area would be expected to give rise to interference activities now or in the future that would lead to an inadvertant loss of waste isolation. Thus, the disqualifying condition takes into account present value, whereas the qualifying condition takes into account projections of value into the future. Because future interference activities may involve natural resources that are not presently valuable but may be valuable in the future, the reasoning behind the different bases used to assess qualifying and disqualifying conditions should be clarified.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

Further clarification of the differences between the disqualifying and qualifying conditions will be added to the text (Section 2.3.8.2.1) for the Postclosure Guidelines concerning human interference. The following will be added to the text: "The disqualifying condition (Issue 2) is concerned with present day activities (e.g., mining, drilling, and blasting) conducted outside the controlled area that could affect the waste isolation capabilities of the site. This includes activities we expect to occur in the near future as a result of identified and presently known economic resources located outside the controlled area. Because these potential activities would be conducted outside the controlled area, a loss in waste isolation could only occur as result of indirect affects (See Section 2.3.8.1.2). In contrast, the qualifying condition is concerned with assessing the natural resource potential for both those resources that are presently valuable and those that are not presently valuable, but which may be valuable in the foreseeable future. The affects of inadvertent human interference could be direct or indirect affects (See section

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

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10 Proposed Resolution ( continued )
2.3.8.1.2)."

In addition, the following will be added to Section 2.3.8.2.2 under the heading "Resolution of Issue 2." "Indirect effects on long-term waste isolation could result from exploration activities, mining, or drilling. The possible effects include (1) creation of new hydrologic pathways along which waste could travel, (2) loss in the effectiveness of the natural barriers or the engineered barrier system, (3) introduction of fluids that could lead to faster dissolution and transport of waste. Specifically, indirect effects to be considered include (1) introduction of drilling fluids that increase the hydrologic flux or increase rates of dissolution of waste, (2) infiltration of fluids from surface or underground leaching, (3) withdrawal of ground water due to mine dewatering or water production for mine and mill use, and (4) affects related to man-made underground openings (fractures and other openings) created by, for example, open-pit blasting, underground blasting, surface and underground drilling, and large underground block caving."

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
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8. Paragraph 0

9. Comment

(see comment (5)).

I agree with this interpretation of "foreseeable future" as far as the mining industry is concerned. However, this term is not used in the qualifying and disqualifying conditions. Terms that are used include: "reasonable projections" (Qualifying Condition), and "likely future activities" (Disqualifying Condition). The term "foreseeable future" is used on p. 2-109 as part of the identification of issues (issue 3) related to the guideline and involves only the Qualifying Condition (it comes from 10 CFR 960.4-2-8-1(b)). Further discussion is needed here regarding the interpretation of "reasonable projections" and "likely future activities," with the goal of establishing specific criteria upon which the site is to be evaluated.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

This comment centers around the use of the term "foreseeable future." The term is not specifically used in the qualifying or disqualifying conditions, but is used in the favorable conditions and the potentially adverse conditions, which support and aid in the interpretation of the qualifying and disqualifying evaluations. Further, the term is used in the siting criteria of 10 CFR Part 60. Therefore the use of the term and its associated definition in evaluating the issues is considered to be germane and appropriate.

The evaluation and definition of the terms, such as, "reasonable projections" and "likely future activities" will receive considerable attention in the future and is likely to utilize the review of a panel of experts to establish that the assessments are reasonable and defensible. The spirit of this comment has been included in the text in Section 2.3.8.1.1 as a result of Dr. Einaudi's Comment #1 and as a result of Mr. French's Comment #10 in Section

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

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10 Proposed Resolution ( continued )

2.3.8.4.

END OF TEXT

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# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes Items 1 - 9.)

1. Comment 4 of 29
2. Date Sept. - Nov. 1991
3. Reviewer M.T. Einaudi
4. Organization Stanford University
5. Revision Draft/Date August 1991
6. Section 2.3.8.1
7. Page 2-108
8. Paragraph 1

9. Comment

Some clarification is needed of terminology from 10 CFR 60.21(c)(13): this states that the evaluation of natural resources shall be conducted (1) for the site and (2) for areas of similar size that are representative of and are within the geologic setting.

(1) The "site" presumably is the same as the "controlled area," which has specific boundaries. The point of clarification needed here is that in terms of natural resources, we are really considering a volume. This point is related to the fact that in the assessment of natural resources, the question of depth has to be taken into account because depth is important in deciding whether or not a mineral occurrence is economic. In the SCP (p. 1-258, para 1), it is stated that "it is standard practice to exclude evaluation of mineral resources below 1 km..." Yet, there are numerous mines around the world operating at depths greater than 1 km; there are several mines in the U.S. that hold marginal reserves at depths greater than 1 km (e.g., Bingham mining

10. Proposed Resolution *(To be completed by ESSE Core Team)*

Dr. Einaudi discusses several points that could be further addressed in the ESSE. First, the natural resource assessment needs to assess a volume of material. It is inappropriate to evaluate potential economic resources that lie at depths of, say, 5 km and have no surface indications of their presence, because assessment techniques and technologies are not available to evaluate such resources. In contrast, the Site Characterization Plan (DOE, 1988a) called for an evaluation to a depth of 1 km because of established precedent in the geologic literature. It is perhaps wise to reconsider such boundaries in light of the current worldwide depletion of resources, scarcity of resources, and the recognition that resources will need to evaluated to deeper depths in the near future. As an example, Brian J. Skinner was a keynote speaker at the annual Geologic Society of America conference in 1991 where he presented a talk entitled "A Kilometer and Deeper: Will Geologists Be Ready for the Tough Prospecting Challenges Ahead?"

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
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9 Comment ( continued )

district), and there are some exploration groups in the U.S. that presently are drilling ore targets at depths of 1 km. This question of depth needs to be discussed in the statements of issues and their resolution in order to underscore its importance so that it is dealt with systematically in the presentation and discussion of current understanding.

(2) 10 CFR 60.21(c)(13) states that natural resources shall be evaluated in the site and in "areas of similar size that are representative of and are within the geologic setting." Clarification of the intent of this statement is needed, and such clarification should lead to the establishment of actual (and conceptual) boundaries to the areas (and types of deposits) that need to be assessed. The need is to assess the natural resources in and near Yucca Mountain and compare them with those same resources potentially available outside the area. Given this requirement, determination has to be made of the specific physical boundaries (larger than those of the controlled area) within which the assessment of resources needs to be made. The boundary chosen will be dependent on the use to which the assessment will be put: 1) to establish the character and value of resources outside the area in order to contrast these in economic terms with resources within the controlled area (in this case the "area" would have no physical boundaries); 2) to define geological models of mineral deposits that could occur at Yucca Mountain (in this case the "area" could be the size of the Basin and Range province); or 3) to define areas where potential human incursion would result in release of radionuclides (in this case an "area" could be defined within "X" km of Yucca Mountain, with "X" partly dependent on resolution of my Comment #7 below).

END OF TEXT

10 Proposed Resolution ( continued )

Second, the ESSE Core Team agrees with Dr. Einaudi that some definition needs to be added to the text in relation to the types of deposits that should be compared to the Yucca Mountain site. This definition needs to include the size of the areas that need to be compared with the site, as well. The scope of these considerations are too detailed and involved to be include within the ESSE in their entirety, but the following statements are offered to clarify the intent to consider, evaluate, and better define assumptions.

The following text will be added to Section 2.3.8.2.2 under the header of "Resolution of Issue 3," paragraph 2:

"Resolution of Issue 3 will also involve providing additional information before the assessment can be considered complete. First, the volume of

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

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1. Comment 4 of 29

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5. Comment or Proposed Resolution or Resolution *(Circle one)*

10 Proposed Resolution ( continued )

material to be assessed for natural resources needs to be explicitly defined. The Site Characterization Plan (DOE, 1988a) called for an evaluation to a depth of 1 km for mineral resources because of established precedent in the geologic literature. Given current economic conditions and projections of natural resource demand in the near future, deeper depths will likely need to be considered. Natural resource assessments will, out of necessity, become less detailed with depth, but projections can be accomplished for progressively deeper depths; for example, assessments for potential resources that may occur at depths shallower than 1, 2, and 3 km for mineral resources. Second, further definition of the area that is to serve as a basis for comparison (e.g., the Great Basin, the region surrounding Yucca Mountain) is needed before a detailed comparison with the site can be accomplished. The area in which direct or indirect interference activities could affect the proposed repository needs to be more clearly constrained. Third, geologic models of mineral deposits that should be compared to the proposed Yucca Mountain site need to be prioritized and ranked before a detailed comparison is conducted. Consideration of the above factors as related to the oil or gas potential of the site will strongly depend on the likely presence or absence of potential source rocks in the region (See Section 2.3.8.4 for further information)."

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

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(Reviewer completes items 1 - 9.)

1. Comment 5 of 29
2. Date Sept. - Nov. 1991
3. Reviewer M.T. Einaudi
4. Organization Stanford University
5. Revision Draft/Date August 1991
6. Section 2.3.8.1.1
7. Page 2-108
8. Paragraph 1

9. Comment

(related to my comments (1), (2) & (3)).

10 CFR 60.21(c)(13) requires that "credible projected changes in economic or technological factors" be addressed. In order that the assessment of suitability (with regard to human incursion) can proceed beyond the compilation of a data base and arrive at a "finding," these projections need to be addressed and resolved. THIS ISSUE OF PROJECTED CHANGES IN ECONOMIC AND TECHNOLOGICAL FACTORS IS THE MOST DIFFICULT AND MOST PRESSING UNRESOLVED ISSUE RELATED TO THE "HUMAN INTERFERENCE TECHNICAL GUIDELINE." It is likely that "credible" projections made by "credible" people will extend no further than 5 or 10 years into the future.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The ESSE Core Team agrees with Dr. Einaudi that this is an important issue that the regulators, public, and others should be aware. This comment has been addressed in the response to Dr. Einaudi's Comment #1.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 6 of 29
2. Date Sept. - Nov. 1991
3. Reviewer M.T. Einaudi
4. Organization Stanford University
5. Revision Draft/Date August 1991
6. Section 2.3.8.2.1
7. Page 2-109
8. Paragraph 2

9. Comment

Issue 2 is an interpretation of Disqualifying Condition 2. Because of the problems I have with the wording of Disqualifying Condition 2 (see my point (2) above), I also have problems with the statement of Issue 2. The text should make it clear that "likely future mining" is not intended to include the mining in the future of undiscovered mineral deposits.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The following will be added to the text under Issue 2 in Section 2.3.8.2.1: "Issue 2 is concerned with present day activities (e.g., mining, drilling, and blasting) conducted outside the controlled area that could affect the waste isolation capabilities of the site. This includes activities we expect to occur in the near future as a result of identified and presently known economic resources located outside the controlled area, but does not include future mining of resources that are presently unknown."

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 7 of 29
2. Date Sept. - Nov. 1991
3. Reviewer M.T. Einaudi
4. Organization Stanford University
5. Revision Draft/Date August 1991
6. Section 2.3.8.2.2
7. Page 2-110
8. Paragraph 1

9. Comment

It would be useful to have various high-level scenarios for the indirect effects on waste isolation of mining outside the controlled area, because these could be used to place limits on the volume that needs to be considered. For example, if it can reasonably be shown that underground mining (at any depth) of ore by traditional means will have no adverse impact on waste isolation as long as the mining is located more than "X" km from the control perimeter, then presently known mineral resources beyond that limit need not be considered in terms of adverse effects.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

This comment has been addressed in developing responses to Dr. Einaudi's Comments #2 and #4.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 8 of 29
2. Date Sept. - Nov. 1991
3. Reviewer M.T. Einaudi
4. Organization Stanford University
5. Revision Draft/Date August 1991
6. Section 2.3.8.2.2
7. Page 2-110
8. Paragraph 1

9. Comment

Because Issue 3 related to the qualifying condition requires projections into the future, ultimately there will be a need to consider and screen non-traditional extraction methods for resources located near Yucca Mountain. The ESSE should contain a discussion or progress report on the possible effects of traditional (and non-traditional) mining outside the controlled area.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

This comment has been partially addressed in the response developed for Einaudi's Comment #2. In addition, the following changes are recommended for Section 2.3.8.4 and provide the mechanism for documentation and evaluation of indirect human interference activities and their likely effects on the waste isolation capabilities of the site:

"Documentation Needed to Finalize Issue 2: It is recommended that priority be placed on documenting the direct and indirect human interference activities that could potentially affect the waste isolation capabilities of the site. This report should contain (1) information on the kinds of activities, including nontraditional exploration or mining activities, that could occur, (2) in qualitative terms, a ranking of the affects of such activities including the probablility of such activities affecting the waste isolation capabilities of the site, (3) and definitions, assumptions, and direction to any future work to assess the affects of direct or indirect human interferences. Peer review

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
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10 Proposed Resolution ( continued )

or review of this report by a qualified team of experts may be valuable for enhancing its credibility."

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
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(Reviewer completes Items 1 - 9.)

1. Comment 9 of 29
2. Date Sept. - Nov. 1991
3. Reviewer M.T. Einaudi
4. Organization Stanford University
5. Revision Draft/Date August 1991
6. Section 2.3.8.3.2.1
7. Page 2-113 to 2-116
8. Paragraph

9. Comment

The section on Review of Information on Precious and Other Metals (2.3.8.3.2.1) should be expanded to include a summary and critique of information gathered since the EA and SCP and of the recent literature on mineral deposits in the SWNVF. A conceptualization of the factors that might control the occurrence of mineral deposits in the area is a future goal. The summary in the SCP on precious and base-metal deposits in the Yucca Mountain area, although more thorough, also lacks a conceptual framework and is out-of-date.

Major gaps in the ESSE presentation include the following:

(a) The ESSE (2.3.8.3.2.1) summary of the study by Castor et al. (1989) is not specific enough in stating that this study was conducted only on surface exposures and that, therefore, it has limited application to the assessment of subsurface potential for mineral resources in the Yucca Mountain Addition.

10. Proposed Resolution *(To be completed by ESSE Core Team)*

(a) Three sentences have been added to Section 2.3.8.3.2.1 as a result of the comments on the Castor et al. (1989) report. "Because the Castor et al. (1989) study was conducted for purposes of land withdrawal, the study did not provide a detailed basis on which to assess resources at depths greater than several hundred meters. In addition, Castor et al. (1989) focused the main detail of their report on the evaluation of precious metals. Studies are planned that will provide more detailed information and further assessments and evaluation of all the mineral resources of the site (see Section 2.3.8.4)."

(b) Paragraph 2 on page 2-114 described the new information available about ore deposits and general geology of the region of Yucca Mountain. This paragraph will be modified to reflect that these deposits can have an effect on the perceived potential of the site. In addition, each of the "zones" (i.e., ore zones for precious metals) described by Greybeck and Wallace (1991) and Castor et al. (1989) will be mentioned in the text. The following will be

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

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5. Comment or Proposed Resolution or Resolution *(Circle one)*

9 Comment ( continued )

Furthermore, the summary does not state that the study by Castor et al., (1989) largely is limited to assessing the potential for precious metals.

(b) The ESSE (2.3.8.3.2.1) summary does not state that significant exploration activity since the SCP (DOE, 1988a) has resulted in the discovery of new deposits in the area, and that such discoveries can have an effect on the perception of the exploration potential of the region in and near Yucca Mountain. These new deposits include: Mother Lode, South Zone, West Zone, and Secret Pass Zone (Castor et al., 1989; Greybeck and Wallace, 1991).

(c) Fig. 2-2 (previously Table 2.3-2). This figure is fine as far as it goes, but it doesn't go far enough. As background data for the ESSE, there should be an up-to-date map showing the location of all key mineral occurrences, prospects, past mining operations, present mining operations, and present drilling areas, catalogued by deposit-type, commodity, size, and dates.

END OF TEXT

10 Proposed Resolution ( continued )

added to the text: "Thus, significant exploration activity has been conducted and has resulted in new discoveries in the region of Yucca Mountain since publication of the SCP (DOE, 1988a). These discoveries influence the perceived resource potential of the region, including the Yucca Mountain area."

(c) Regarding the comment on the use of maps of the location of all key mineral occurrences, prospects, past mining operations, present mining operations, and present drilling areas that are cataloged by deposit-type, commodity, size, and dates, the work described has been accomplished to various degrees of detail and is described in the ESSE report. The work includes Bonham (1989a), Jones (1989), Bonham and Hess (1990), Raney (1990), and Mattson and Matthusen (1992). The most detailed report including maps can be found in a new reference by Bergquist and McKee (1991). Specific reference to the information contained in these reports will be added to the ESSE.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

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(Reviewer completes items 1 - 9.)

1. Comment 10 of 29
2. Date Sept. - Nov. 1991
3. Reviewer M.T. Einaudi
4. Organization Stanford University
5. Revision Draft/Date August 1991
6. Section 2.3.8.3.3
7. Page 2-121
8. Paragraph bottom

9. Comment

It is stated that the current status of findings with regard to Issue 2 (ongoing or future mining activities outside the site) indicates a higher level finding and that no further work is needed. This conclusion is repeated in the section on Conclusions and Recommendations for Future Assessments (p. 2-123, top of page). I am fundamentally in agreement with this conclusion, but believe that discussion of present understanding of indirect effects of mining activities on the site would strengthen the argument.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The last sentence of this paragraph will be modified to read: "No further work is needed to assess the suitability of the site with regard to this issue; however, the team believes that a DOE position on this issue should be developed and defended." In addition, appropriate changes will be made to the paragraph at the top of p. 2-123.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

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(Reviewer completes items 1 - 9.)

1. Comment 11 of 29
2. Date Sept. - Nov. 1991
3. Reviewer M.T. Einaudi
4. Organization Stanford University
5. Revision Draft/Date August 1991
6. Section 2.3.8.4
7. Page 2-122 to 2-123
8. Paragraph

9. Comment

It is stated that further work is needed to resolve Issue 3 (potential resources within the site). This further work with regard to non-fuel resources is stated to include:

1. downhole geochem data
2. soil geochem
3. geochem/petrology on anomalous rocks
4. comparison with surroundings and with similar geologic settings.

The reader is referred to SCP for further discussion. In the SCP, the following activities are planned in order to assess the natural resources of Yucca Mountain:

1. geochemical assessment (all done in conjunction with knowledge of known ore occurrences outside area): selection of elements, systematic and

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The following text will replace the material that discussed future work for mineral resources in Section 2.3.8.4:

"Mineral Resources Observational Data Base and Other Data Needs: The most important future work includes (1) the analysis of hydrothermal flow paths based on the detailed consideration of structure, lithology, wall-rock alteration features, and the occurrence of fractures/veinlets/veins, (2) surface and down-hole geochemistry, and (3) an identification, ranking, and comparison of ore-forming systems with the site-specific observational data base collected for the Yucca Mountain site. The term ore-forming systems is emphasized and used here in the context of conceptual ore-deposit types that are attributed to various ore-forming systems in contrast to an approach based on specific commodity types.

New observational data should enable the construction of map views,

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
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9 Comment ( continued )

biased sampling of surface and core samples, evaluation of analytical data in conjunction with geological and geophysical data obtained in other activities, evaluation of potential.

2. geophysical/geologic appraisal: evaluate available geophysical data (no procedures). "Possible hydrothermal alteration zones may be identified through the use of remote sensing (thematic myopia [sic]) and field mapping (reference to SCP section B.3.1.17.4.4). (but this section relates to Quaternary NE-trending fault study??)"

3. integration: mineral assessment of the site, comparison to known mineralized areas, potential for future exploration and undiscovered resources.

I concur that all the activities listed above are important. However, there are some key activities and products missing from this listing. The emphasis is placed (incorrectly, I think) on geochemical sampling, presumably because such an activity yields numbers that can be dealt with in terms of "quantitative" comparisons, statistical analysis, etc.; i.e., geochemical data are "hard" data. It suggests the view that if the analysis does not come back with values in the "ore" category, the potential for resources can be practically ruled out. However, this assessment will fail if it is not combined with other traditional approaches used in mineral exploration.

(a) Observational Data Base. The most important of these traditional approaches, probably as critical as geochemical sampling, is the analysis of hydrothermal fluid flow paths based on detailed mapping of structure, lithologies, fractures/veinlets/veins, and wall-rock alteration. The mapping should include both natural surface exposures, existing trenches, and drill core, and should be conducted as a single exercise by one experienced individual (or a well-coordinated team). Structure and lithology have been (or are planned to be) mapped in addressing other issues, but in my experience one cannot assume that a geologist whose expertise (and mental focus in the field) is igneous petrology or structure will map the evidence for hydrothermal flow paths. A data base on hydrothermal flow paths serves as the context within which the geochemical assays can be interpreted: without such a base, the geochemical assays could be compared out of context with assays from known deposits. One has to know (or be able to reasonably infer) where in a potential hydrothermal system (high-level fringe, central zone, or deep) a particular assay comes

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9 Comment ( continued )

from. To compare a Yucca Mountain assay, which may come from a high-level fringe, with a Rhyolite district sample that comes from the core of a deposit makes sense neither in terms of absolute values nor in terms of ratios or metal correlations. In sum, the local data base for mineral assessment of Yucca Mountain needs to include a set of map views and cross sections that display lithology and structure, with overlays for the following features:

1. wall-rock alteration
2. vein and veinlet attitudes
3. vein and veinlet mineralogies
4. sulfide and oxide mineral distribution
5. ore and pathfinder element maps (key ratios should be considered)

(b) Ore-forming Systems. The observational and analytical data base on Yucca Mountain then serves for comparison with (1) deposits known to occur in the area, and (2) deposits not known to occur in the area, but that are known to occur in similar geologic environments. I emphasize that the comparison needs to be made on the basis of deposit-types built on a conceptualization of ore-forming systems, rather than on the basis of commodities. Both the ESSE and the SCP overemphasize the use of commodities as the basis of comparison. Such an approach, involving, for example, comparisons between known mercury deposits and potential mercury deposits in the area of Yucca Mountain, misses the importance of potential genetic and spatial relationships between deposits of <u>different</u> commodities. For example, mercury anomalies cannot simply be assessed as potential mercury deposits; they also must be assessed as indicators of potential gold deposits. Numerous other examples of genetic links between deposits of different commodities exist for the Yucca Mountain area and will need to be assessed. This very important point is elaborated on below in the review of the SCP.

END OF TEXT

10 Proposed Resolution ( continued )

overlays, and cross sections that display information on (1) wall-rock alteration, (2) vein and veinlet attitudes, (3) vein and veinlet mineralogies, (4) sulfide and oxide mineral distribution, and (5) primary and pathfinder element and element ratio maps. In the SCP (Section 1.7.1.2.3), it was stated that rock alterations observed at the Yucca Mountain site are not the same mineral assemblages commonly found in epithermal mineral deposits. Some minerals do occur at Yucca Mountain that also occur in precious metal deposits, although the array of different types of wall-rock alteration styles commonly

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5. Comment or Proposed Resolution or Resolution *(Circle one)*

10 Proposed Resolution ( continued )

found in such deposits are not known to occur at Yucca Mountain. Collection of the observational data base will allow for more detailed and thorough assessments of rock alterations at the Yucca Mountain site.

Additional geochemical sampling will need to be conducted to fully evaluate the potential for natural resources. This includes sampling, with appropriate geochemical detection limits, for such elements as gold, silver, uranium, and mercury. Further discussions of the geochemical elements to be sampled and rock samples to be collected and analyzed have been presented in the SCP, Section 8.3.1.9 (DOE, 1988a). Geochemical soil survey and rock sample information will be important in assessing the potential for undiscovered deposits and help provide a basis on which to fully assess the mineral resource potential of the site. To date, no soil geochemical surveys are available for the proposed site. A large amount of information is currently available from surface outcrops (e.g., DOE, 1988a; Castor et al., 1989). However, few geochemical analyses are available from rock samples that come from areas of "anomalous" rock. In this case, "anomalous" rock refers to rock samples that could be obtained from fault zones, gouge zones, breccia zones, altered areas, or other rocks whose occurrence is limited in the area. Preparation of maps and overlays of chemical data can yield important information on structural trends. Such maps can also assist in definition of prospects by highlighting geochemical anomalies or anomalies in pathfinder elements (i.e., a mercury anomaly could be indicative of a gold deposit), or by identifying areas of alteration that could represent an ore deposit.

No significant gravity or magnetic anomalies have been identified, but for areas that are identified as having minor geophysical anomalies (e.g., induced polarizations anomalies) detailed petrological or geochemical sampling may be required (See Section 1.7 (DOE, 1988a) for additional discussion). Rock alteration maps may prove valuable when used in conjunction with the geological, geochemical, and geophysical surveys.

Very few of the cored drill holes at or near Yucca Mountain have been sampled geochemically for the express purpose of assessing natural resource potential. Available information on geochemistry and petrology has been reviewed by DOE (1988a) and Mattson (1991). Additional downhole information (geochemical and petrological) will be needed on new cored holes at the proposed site, and previously drilled holes may need to be sampled as well. However, much of the core from these holes has been used for other purposes and coverage would be of variable quality and quantity. All of the cored holes have been petrologically examined, and reports on their petrology published.

# EARLY SITE SUITABILITY EVALUATION
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5. Comment or Proposed Resolution or Resolution *(Circle one)*

10 Proposed Resolution ( continued )

Future cored holes should be used to produce rock alteration maps and can serve to identify areas that may require further detailed work. Areas that have been identified as containing alteration that occurs in some ore deposit types in the Basin-and-Range Province should be carefully examined. These areas have been partially identified in the Site Characterization Plan (DOE, 1988a) and in Castor et al. (1989). Downhole petrological and geochemical data will help provide a basis on which to fully assess the mineral resource potential of the proposed site.

Comparisons of the Proposed Site with Known Deposits in Similar Settings: Utilizing the above geologic, geochemical, and petrological information, systematic comparisons of the proposed site with known deposits in the region that occur in similar geologic settings will be necessary. This also includes a consideration of models for ore genesis, structural features of the proposed site, and the general geologic setting of the site. The identification, ranking, and comparison of ore-forming systems in comparison to the site-specific observational data base will be important in assessing undiscovered deposits.

The data that remain to be collected (described above) will be important in contrasting different areas of the site and in comparisons to conceptual ore-deposit types. This information will be used, in part, in assessing the potential for undiscovered deposits in the area of the site and should help provide a basis on which to fully assess the mineral or other resource potential of the proposed site."

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 12 of 29
2. Date Sept. - Nov. 1991
3. Reviewer M.T. Einaudi
4. Organization Stanford University
5. Revision Draft/Date August 1991
6. Section NA
7. Page
8. Paragraph

9. Comment

The following are comments on the paper by Castor et al. (1989), which may be important to consider during the completion of the ESSE.

In Castor et al., 1989, p. 9, para 3: "...because access to subsurface samples was not granted by the DOE due to quality assurance concerns, determinations of economic potential to depths greater than a few hundred meters were not possible."

This statement is critical to understanding the scope of the Castor et al., (1989) report. The ESSE does not adequately stress the fact that assessment was limited to surface manifestations of potential mineralization in the Yucca Mountain Addition.

Further, I question whether or not a reconnaissance study limited to the surface is capable of detecting hidden deposits located within a few

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The main proposed resolution to this comment can be found in the response to a similar comment by Dr. Einaudi (Comment #9). In addition, the following text will be added to the ESSE report as three final paragraphs in Section 2.3.8.3.2.1.

"New information on structural models in the Yucca Mountain region are also available and, in general, these have been reviewed in Sections 2.3.7 and 3.3.4 of this report. These sections describe classical Basin and Range style faulting (i.e., steep normal faults bounded by range front faults), pull-apart basin models, high-angle faults which have been rotated to low angles, and various detachment style faulting models. The SCP may have over-emphasized the importance of detachment models in ore genesis. For example, Einaudi (Comment #19 in Younker et al., 1992) states that, with regard to epithermal precious metal deposits, "In contrast, "detachment type"

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

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9 Comment ( continued )

hundred meters of the surface, unless the structural/lithological controls on mineralization are dominantly steep and/or the alteration/geochemical halos related to potential mineralization are dominantly steep. Certainly, structural controls in volcanic-hosted epithermal deposits tend to be steep, but there are numerous examples of vein systems with relative shallow dips, especially in extended terranes where early steep normal faults that have served as ore-fluid conduits have been rotated to shallower dips during continued rotation on younger faults (e.g., as low as 30 degrees at Goldfield (Ruetz, 1987) and as low as 15 degrees at Tonopah (T.B. Nolan, in Dreier, 1984)). Discussion of this question should be presented in the ESSE.

END OF TEXT

10 Proposed Resolution ( continued )

precious metal deposits have neither proved to be important (in relative terms) nor proved to be easily documented as fundamentally different types of deposit.....It can be pointed out that, although the literature on recent discoveries in the area of Bullfrog Hills and Fluorspar Canyon have emphasized the "detachment model" (e.g., Jorgensen et al., 1989), the discoveries of gold deposits near Yucca Mountain probably were made using standard observational and analytical approaches developed for the general class of epithermal precious metal deposits in volcanic rocks." Einaudi further states in Younker et al. (1992) that "Structural controls in volcanic-hosted epithermal deposits tend to be steep, but there are numerous examples of vein systems with relatively shallow dips, especially in extended terrains where early steep normal faults that have served as the ore-fluid conduits have been rotated on younger faults (e.g., as low as 30 degrees at Goldfield (Ruetz, 1987) and as low as 15 degrees at Tonopah (T.B. Nolan, in Dreier, 1984)." All of these models will need to be carefully evaluated in light of their significance to possible ore-forming flow conduits and the potential for hidden mineral deposits at the Yucca Mountain site.

Furthermore, the SCP emphasized new types of deposits discovered and mined in the last two decades. It will be necessary to establish a preliminary ranking or relative importance of these new types of deposits. New types of deposits include disseminated gold deposits in calcerous sedimentary rocks (e.g., Carlin-type gold deposits) that have been the focus of recent gold exploration activities in the Basin and Range because they are the most numerous and economically

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10 Proposed Resolution ( continued )

important. The discovery and exploration history of the Carlin deposit has been reviewed by Coope (1991). These deposits may not be very important in the area of Yucca Mountain because of the depth to the basement (greater than 3-4 km) according to Einaudi (in Younker et al., 1992). Other important types of deposits are epithermal disseminated gold-silver deposits in volcanic rocks (e.g., Round Mountain, Rawhide, and Paradise Peak deposits). The identification, ranking, and comparisons of ore-forming systems to site-specific data will be very important in assessing the potential for undiscovered deposits at the site.

The Site Characterization Plan (DOE, 1988a) stated that "Exploration and production of precious metals has recently centered around disseminated deposits that are not produced for base metals." While this statement is still generally true, it should also be pointed out that numerous gold discoveries have been made in districts that historically have been base metal producers and that copper-gold deposits have received considerable attention as a result of these discoveries. Discoveries in the Basin and Range include (1) the Fortitude gold skarn in the Battle Mountain porphyry copper district (Myers and Meinert, 1991); (2) the McCoy (Au) and Cove (Ag) deposits south of Battle Mountain (Brooks et al., 1991); (3) the disseminated gold deposits in sedimentary rocks (e.g., Star Pointer) on the immediate fringe of the Ely porphyry copper stocks (Einaudi in Younker et al., 1992); and (4) the Parnell gold shoot in Cu(Au) skarns of the Bingham district (Einaudi in Younker et al., 1992). This information makes it clear that a careful evaluation will be needed before final conclusions about the resource potential of the proposed site are made."

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 13 of 29
2. Date Sept. - Nov. 1991
3. Reviewer M.T. Einaudi
4. Organization Stanford University
5. Revision Draft/Date August 1991
6. Section
7. Page
8. Paragraph

9. Comment

In Castor et al., 1989, p. 97 para 4: "...methods used were mainly directed toward determination of precious metal potential.." Other commodities were considered solely on the basis of the geologic setting. This may not be a severe limitation, given that precious metals may be the only prospective metal resources in these ash flow tuffs. However, this limitation should be mentioned in the ESSE.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

This comment has been previously addressed in the response to Dr. Einaudi's Comment #9.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 14 of 29
2. Date Sept. - Nov. 1991
3. Reviewer M.T. Einaudi
4. Organization Stanford University
5. Revision Draft/Date August 1991
6. Section NA
7. Page
8. Paragraph

9. Comment

In Castor et al., 1989, p. 26-29: The summary of past work on subsurface core samples from drill holes in the area of Yucca Mountain indicates the presence of alteration and mineralization characteristic of some types of base- and precious-metal deposits. Such areas should be the focus of future studies and identified in the ESSE.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The intent of this comment has been addressed in the proposed response to Dr. Einaudi's Comment #9.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 15 of 29
2. Date Sept. - Nov. 1991
3. Reviewer M.T. Einaudi
4. Organization Stanford University
5. Revision Draft/Date August 1991
6. Section
7. Page
8. Paragraph

9. Comment

In Castor et al., 1989, p.33, para 3: The authors combine (1) a detachment fault hypothesis for Au-Ag ores in the Bullfrog district with (2) the suggestion that a detachment fault exists under Yucca Mountain to (3) conclude that "precious metal mineralization (sic) could occur there (at Yucca Mountain) at depth." I concur with the authors in the necessity to investigate interrelations of this type; my comment deals with the absence of critical review of alternate interpretations regarding hypotheses (1) & (2) and the effect that such alternate interpretations have on the resulting hypothesis (3).

Regarding hypothesis (1), it is true that many of the producing Au-Ag deposits near Yucca Mountain are located near flat faults (potential detachments), and it is true that some publications on these deposits stress the detachment model for these deposits (e.g., Jorgenson et al., 1989, p. 1). However, the genetic relation between the exposed flat faults

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The intent of this comment has been addressed in the proposed response to Dr. Einaudi's Comment #9. The Core Team agrees with the comment, and text has been added to the ESSE, but the Core Team does not believe that the ESSE is the appropriate place for a lengthy critique of the Castor et al. (1989) report. However, the text of this comment will be available to staff conducting research on the Yucca Mountain area for natural resources.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 15 of 29

2. Page 2 of 3

3. Name M.T. Einaudi
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4. Date Sept. - Nov. 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

9 Comment ( continued )

and the mineral deposits located nearby is far from clear; indeed there is evidence to suggest that mineralization postdated detachment faulting and was controlled by younger steep faults that cut the detachment. Such evidence is found in the relation between the timing of extension, magmatism, and hydrothermal activity. For example, at Fluorspar Canyon, Greybeck and Wallace (1991) suggest that "post-detachment Tertiary extension has resulted in high-angle, northerly striking faults that are important in the localization of gold..... the detachment surface is clearly offset along some younger, northerly-striking faults" (p. 941). At the north end of Bare Mountain, 10.5 Ma old volcanics lie unconformably across the detachment fault (Hamilton, 1988, p. 55). Noble et al., (1991) conclude that the Tuffs and Lavas of the Bullfrog Hills (late Timber Mountain magmatic stage), dated at 10 Ma, and subsequent Au-Ag mineralization in the Bullfrog Hills, dated at about 9 Ma, may have postdated movement on the Bullfrog Detachment which occurred prior to 10 Ma (the age of the detachment fault, based on 11.2 to 10.5 Ma K-Ar dates in Precambrian gneiss (McKee, 1983), is 11.2 to 10.5 Ma if the dates represent cooling on uplift of the footwall (Hamilton, 1988; Jorgenson et al., 1989), or may be older than 11.2 to 10.5 Ma if the dates represent a heating event related to the Timber Mountain magmatic stage (Noble et al., 1991. p. 931). These authors stress that likely pathways for magmas (and hydrothermal fluids?) that formed the Tuffs and Lavas of the Bullfrog Hills are steeply dipping faults that cut (and therefore postdate) the detachment surface. This interpretation is in sharp contrast with the interpretation of Jorgenson et al., (1989, p. 7) that mineralization and detachment faulting were synchronous at the Bullfrog and Montgomery-Shoshone deposits. In sum, the genetic link between detachment faults and ore deposits in the Yucca Mountain area remains controversial and unresolved.

Regarding hypothesis (2), the presence of a flat fault (possible detachment) under Yucca Mountain, as suggested by Hamilton (1988) and Scott (1990), is speculative. These latter authors conclude that the Bare Mountain-Fluorspar Canyon detachment is a domal structure that extends eastward under Crater Flat and Yucca Mountain. The dip and depth of this inferred detachment under Yucca Mountain depends on the interpreted projection eastwards past the eastern range front of Bare Mountain: Hamilton (1988, p. 55) prefers an uninterrupted eastward projection at 30 degrees, whereas Scott (1990, p. 276, Fig. 15) accepts the evidence for Quaternary movement on east-facing range-front faults as presented by Reheis (1988) and this leads him to a model in which a west-dipping detachment surface at depths of 4 km below Yucca Mountain projects to the surface in the Calico Hills. In contrast with these structural

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 15 of 29

2. Page 3 of 3

3. Name M.T. Einaudi
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4. Date Sept. - Nov. 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

9 Comment ( continued )

interpretations, Carr (1990) concludes that the Fluorspar Canyon detachment is one of a series of down-to-the west, scallop-shaped faults that dip moderately to steeply west at their eastern termination. Where last exposed, the Fluorspar Canyon fault strikes NE and dips 57 to 70 degrees to the NW, apparently precluding both a sharp right-angle bend to the south (Carr, 1990, p. 296, Fig. 9) and a reversal of dip, as required by the interpretations of Hamilton (1988) and Scott (1990). Both Carr (1990) and Jorgenson et al., (1989, Fig. 1) terminate the Original Bullfrog-Fluorspar Canyon detachment in a breakaway zone located north of Bare Mountain and west of the Timber Mountain caldera. In sum, the presence or absence of a detachment fault under Yucca Mountain remains controversial and unresolved. The high degree of uncertainty regarding both hypothesis (1) (genetic links between detachments and Au-Ag deposits in the Bullfrog-Fluorspar Canyon area) and hypothesis (2) (presence of detachments under Yucca Mountain), results in a higher level of uncertainty for a third hypothesis (presence of detachment-related gold deposits under Yucca Mountain) that is dependent on the first two. Likely alternative hypotheses should be considered in the evaluation of Yucca Mountain.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 16 of 29
2. Date Sept. - Nov. 1991
3. Reviewer M.T. Einaudi
4. Organization Stanford University
5. Revision Draft/Date August 1991
6. Section
7. Page
8. Paragraph

9. Comment

In Castor et al., 1989, p. 33-34: "Direct surface observations indicate that no areas of hydrothermal alteration similar to those in the Wahmonie and Bullfrog districts, or at the Mother Lode deposit, occur within the Yucca Mountain Addition." This may be true, but it is based only on surface observations. Also in Castor et al., 1989, p. 34, para 2 & 3, comparison is made between the surface samples at Yucca Mountain Addition and those collected in known areas of mineralization in the vicinity. This comparison is misleading because the implication is that the lack of similarity rules out mineralization at Yucca Mountain, whereas it only rules out mineralization at the surface at Yucca Mountain. The key comparison that needs to be made might be between Yucca Mountain samples and samples collected on the fringe of the producing districts. Finally, the conclusion by these authors that "no significant areas of strongly bleached, limonitized ... rock are present in the Yucca Mountain Addition" is true only for surface. Such sweeping conclusions should be prefaced by

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The intent of this comment has been addressed in response to Dr. Einaudi's Comment #9. The ESSE Core Team agrees with the comment, and text has been added to the ESSE, but we do not believe that the ESSE is the appropriate place for a critique of the Castor et al. (1989) report. However, the text of this comment will be available to staff conducting research on the Yucca Mountain area for natural resources.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 16 of 29

2. Page 2 of 2

3. Name M.T. Einaudi
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5. Comment or Proposed Resolution or Resolution *(Circle one)*

9 Comment ( continued )

their associated assumptions and limitations. As in Comment #13, mention of these factors should be made in the ESSE.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 17 of 29
2. Date Sept. - Nov. 1991
3. Reviewer M.T. Einaudi
4. Organization Stanford University
5. Revision Draft/Date August 1991
6. Section SCP, 1.7
7. Page 1-261
8. Paragraph 2

9. Comment

"Detailed knowledge of a particular site (e.g., Yucca Mountain) or regional geologic information on a particular site is probably more important than the large scale characteristics and localization of ore deposits discussed previously." I heartily concur with this statement.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The ESSE Core Team agrees with this comment. No text changes were necessary as a result of this comment.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

***(Instructions on back of form)***

(Reviewer completes items 1 - 9.)

1. Comment 18 of 29
2. Date Sept. - Nov. 1991
3. Reviewer M.T. Einaudi
4. Organization Stanford University
5. Revision Draft/Date August 1991
6. Section SCP 1.7.1.1
7. Page 1-266
8. Paragraph 1

9. Comment

This paragraph contrasts Yucca Mountain with the area of Calico Hills and Wahmonie. The wording is overly biased in favor of the conclusion that there is no potential mineralization at Yucca Mountain. For example, it is stated that Yucca Mountain does not have "alteration characteristic of mineralization at the surface or at depth (Sec 1.7.1.2.3)." Because different styles of alteration accompany different types of mineralization, such a blanket statement is unsupported. It may well be true that Yucca Mountain does not display, at the surface, alteration characteristic of the Calico Hills or Wahmonie area. But the evidence is not yet in whether or not Yucca Mountain (1) displays alteration at the surface that is characteristic of mineralization that is of a different type and style than Calico Hills and Wahmonie, and (2) contains altered areas at depth.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The intent of this comment has been addressed in response to Dr. Einaudi's Comment #11. The ESSE Core Team agrees with the comment, and some text has been added to the ESSE, but the Core Team does not believe that the ESSE is the appropriate place for detailed responses to comments directed at the SCP. However, the text of this comment will be available to staff conducting research on the Yucca Mountain area for natural resources.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes Items 1 - 9.)

1. Comment 19 of 29
2. Date Sept. - Nov. 1991
3. Reviewer M.T. Einaudi
4. Organization Stanford University
5. Revision Draft/Date August 1991
6. Section SCP 1.7.1.1
7. Page 1-268
8. Paragraph 1

9. Comment

This paragraph summarizes new types of deposits discovered and mined in the past two decades, but it fails to place the relative importance of these new deposits (or "models") in perspective. The first example and main emphasis should be on disseminated gold deposits in calcareous sedimentary rocks (Carlin-type gold deposits), because these have been the most numerous and most economically important, although it could be pointed out that these types of deposits may not be important for Yucca Mountain itself because of the depth to basement. The Carlin-types should be followed by disseminated gold-silver deposits in volcanic rocks (e.g., Round Mountain, Rawhide, Paradise Peak). In contrast, the "detachment-type" precious metal deposits, although mentioned first in this paragraph, have either proved to be important (in relative terms) nor proved easily documented as fundamentally different types of deposit. Although these deposits should be discussed here, especially because of present speculation regarding the presence of detachments in the area of Yucca

10. Proposed Resolution *(To be completed by ESSE Core Team)*

This comment has been addressed in the proposed response to Dr. Einaudi's Comment #12.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 19 of 29

2. Page 2 of 2

3. Name M.T. Einaudi
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4. Date Sept. - Nov. 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

9 Comment ( continued )

Mountain, the discussion should place this deposit-type in a secondary position with respect to importance. It can be pointed out that, although the literature on recent discoveries in the area of Bullfrog Hills and Fluorspar Canyon have emphasized the "detachment model" (e.g., Jorgensen et al., 1989), the discoveries of gold deposits near Yucca Mountain probably were made using standard observational and analytical approaches developed for the general class of "epithermal precious metal deposits in volcanic rocks."

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes Items 1 - 9.)

1. Comment 20 of 29
2. Date Sept. - Nov. 1991
3. Reviewer M.T. Einaudi
4. Organization Stanford University
5. Revision Draft/Date August 1991
6. Section SCP 1.7.1.1
7. Page 1-268
8. Paragraph 2

9. Comment

"However, 93 percent of all major metal-mining districts in Nevada are in lithologies other than silicic tuff." Implicit in this statement is that Yucca Mountain, being made up of silicic tuff, may be less prospective than surrounding areas. This statement is an over-simplification, or appears biased toward supporting a favorable conclusion for the site, for several reasons.

(1) Rather than using numbers of major districts, it might be more instructive to examine production from major districts.

(2) Given the present emphasis on precious metals exploration, perhaps a more relevant statistic would be to compare host rock lithology for precious metal deposits, including separate comparisons for both historical production and present production. Present-day perceptions of prospectiveness are colored largely by present-day producers and recent discoveries.

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The following will be added to the text of the ESSE on page 2-114, second full paragraph, as the second to the last sentence: "In addition, Einaudi (Comment #20) suggests in Younker et al. (1992) that in comparing precious metal occurrences as a function of host rock lithologies, it would be more germane to compare production statistics from major mining districts than to compare the number of districts." This added text should fulfill the intent of this comment. The ESSE Core Team agrees with the comment, but we do not believe that the ESSE is the appropriate place to respond to detailed comments on the SCP. However, the text of this comment will be available to staff conducting research on the Yucca Mountain area for natural resources.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 20 of 29

2. Page 2 of 2

3. Name M.T. Einaudi
(Print Name)

4. Date Sept. - Nov. 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

9 Comment ( continued )

(3) Also hidden in this statement is the long-standing view that intermediate volcanics are more productive than silicic volcanics (e.g., Silberman et al., 1976). I wonder if this remains true for the Great Basin, given the new discoveries in silicic volcanics (has the balance between silicic and intermediate tuffs changed?) More importantly, this long-standing view of the link between intermediate volcanics and epithermal deposits can be questioned on the basis of increased knowledge of the link between extension, magmatism, and ore deposits (e.g., Seedorff, 1991). . .

(4) Given that the SWNVF is composed of a range of rock types, including dominant silic ash flow tuffs but also some tuffs and lavas of intermediate composition and local basalt, there is no reason to presume that the SWNVF (including Yucca Mountain) is less prospective for precious metals than any of the other extension-related volcanic fields in the Great Basin. Specifically, the presence of intermediate (and local basaltic) and silicic volcanism related to the Timber Mountain caldera (11-12 Ma) and the tuffs and lavas of the Bullfrog Hills (10 Ma), which are the "classic" types of volcanics associated with epithermal precious metals in the Basin and Range, and which are younger than the silicic tuffs exposed at Yucca Mountain, would support the idea that the latter could be mineralized by younger events.

A brief synopsis of these ideas should be presented in the ESSE.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes Items 1 - 9.)

1. Comment 21 of 29
2. Date Sept. - Nov. 1991
3. Reviewer M.T. Einaudi
4. Organization Stanford University
5. Revision Draft/Date August 1991
6. Section SCP, 1.7.1.1
7. Page 1-268
8. Paragraph 3 & 4

9. Comment

These paragraphs on the relation between precious metal deposits and ash-flow tuffs have been taken to task elsewhere, with the conclusion that such deposits can occur outside, on the margins, and within calderas (Raney, 1988; Price, 1988). I agree in general with the assessment by these authors, but there are additional points that need to be made with respect to these paragraphs.

One, the use of percentages ("only 2 of Nevada's 31 recognized calderas (6 percent) have produced..." and "only 5 percent of 98 total districts...") may be valid in attempting to assess probabilities of undiscovered resources, but is not a valid argument in the context of the perception, by a given exploration group, of the exploration potential of the Yucca Mountain setting. The reason is that these percentages are based, by necessity, on historical data, rather than on present views or new exploration models. Explorationists do not examine only historical

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The following will be added to the text of the ESSE on page 2-114, second full paragraph, as the second to the last sentence (and prior to the text inserted as result of Dr. Einaudi's Comment #20: "These reviewers agreed that the statistical percentages cited in McKee were problematical." This added text should satisfy the intent of this comment. Thus, the ESSE Core Team agrees with the comment, but we do not believe that the ESSE is the appropriate place for detailed responses to comments on the SCP. However, the text of this comment will be available to staff conducting research on the Yucca Mountain area for natural resources.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 21 of 29

2. Page 2 of 2

3. Name M.T. Einaudi
(Print Name)

4. Date Sept. - Nov. 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

9 Comment ( continued )

production statistics; given one new discovery in a new setting, and the exploration community is off and running. New ideas yield new exploration activities that do not fit statistical molds.

Two, the statement that "strongly altered and metamorphosed" rocks in a caldera setting are the most likely environments for mineralization is slightly misleading, in that ore-bearing volcanic rock need not be (or appear to be) "strongly" altered. For example, the majority of ore at Round Mountain, Nevada, is in weakly altered ash-flow tuff, whereas the large areas of strongly altered tuff contain only a small percentage of the total ore reserve (Sander and Einaudi, 1989). (A final, nit-picking, point, is that the term "metamorphosed" strikes a discordant note; "metasomatized" would be more appropriate in this context.)

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes Items 1 - 9.)

1. Comment 22 of 29
2. Date Sept. - Nov. 1991
3. Reviewer M.T. Einaudi
4. Organization Stanford University
5. Revision Draft/Date August 1991
6. Section SCP, 1.7.1.2.1
7. Page 1-269
8. Paragraph 1

9. Comment

"Exploration and production of precious metals has recently centered around disseminated deposits that are not produced for base metals." This may be generally true, but the statement is misleading if left without the additional statement that numerous gold discoveries have been made in districts that historically have been base-metal producers and that the Cu-Au associated has received considerable new attention as a consequence of these discoveries. In the Basin and Range, these recent discoveries include: (1) the Fortitude gold skarn in the Battle Mountain porphyry copper district (Myers and Meinert, 1991); (2) the McCoy (Au) and Cove (Ag) deposits south of Battle Mountain (Brooks et al., 1991) that are pluton-related skarn and replacement deposits with locally significant base-metals; (3) the disseminated gold deposits in sedimentary rocks (e.g., Star Pointer) on the immediate fringe of the Ely porphyry copper stocks; and (4) the Parnell gold shoot in Cu(Au) skarns of the Bingham district.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

This comment has been addressed in the proposed response to Dr. Einaudi's Comment #12.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes items 1 - 9.)

1. Comment 23 of 29
2. Date Sept. - Nov. 1991
3. Reviewer M.T. Einaudi
4. Organization Stanford University
5. Revision Draft/Date August 1991
6. Section SCP, 1.7.1.2.1
7. Page 1-269
8. Paragraph 2 & 3

9. Comment

These paragraphs summarizing elemental abundances in tuff at Yucca Mountain are overly biased toward supporting a conclusion that Yucca Mountain does not contain undiscovered mineral deposits. It must be pointed out that the samples that were analyzed most likely were the freshest tuff available, given that these analyses were "collected to evaluate petrogenetic models of magma evolution." The fact that such samples would yield values at or near crustal abundance is not surprising, and this fact has limited application in the assessment of resource potential. The ESSE should emphasize that appropriate rock and core samples will be taken during site characterization.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The paragraphs written in the Site Characterization Plan (SCP) concerning elemental abundances serve several purposes. First, the elemental abundances for tuffs at and near Yucca Mountain serve as a elemental baseline for ash-flow tuffs of the region. Second, the SCP was written to a nontechnical, as well as a technical audience, where it was important to establish expectations of elemental abundances. Third, at the time of the SCP, this was the only data available and we would have been remiss not to have reported the data. Some samples were collected for purposes of studying the classical petrology of the rocks, and others where sampled at intervals regardless of their petrologic characteristics. Nonetheless, the SCP clearly identifies these samples as not being adequate for resource assessment. It is emphasized in the SCP, in Sections 1.7 and 8.3.1.9, as well as in the ESSE (Section 2.3.8.4) that appropriate rock samples should be taken for mineral resource assessment. Bias sampling (sampling of fault zones, breccias, rock alterations, and veins) has been strongly encouraged in the SCP and the ESSE. Thus, the ESSE Core Team

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM
# (CONTINUATION SHEET)

*(Instructions on back of form)*

1. Comment 23 of 29

2. Page 2 of 2

3. Name M.T. Einaudi
(Print Name)

4. Date Sept. - Nov. 1991

5. Comment or Proposed Resolution or Resolution *(Circle one)*

10 Proposed Resolution ( continued )

believes this comment has been adequately addressed, and no text change is proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

***(Instructions on back of form)***

(Reviewer completes items 1 - 9.)

1. Comment 24 of 29
2. Date Sept. - Nov. 1991
3. Reviewer M.T. Einaudi
4. Organization Stanford University
5. Revision Draft/Date August 1991
6. Section SCP, 1.7.1.2.1
7. Page 1-269
8. Paragraph 4

9. Comment

"Because Yucca Mountain is composed of tuff, the Au and Ag resource potential in volcanic-hosted deposits will be the main focus..." True, this needs to be the main focus, but the Paleozoic basement at 1.2 km depth also needs to be confronted and discussed in the ESSE.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

This comment has been addressed in the proposed response to Dr. Einaudi's Comment #4.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

# EARLY SITE SUITABILITY EVALUATION
# COMMENT RESPONSE FORM

*(Instructions on back of form)*

(Reviewer completes Items 1 - 9.)

1. Comment 25 of 29
2. Date Sept. - Nov. 1991
3. Reviewer M.T. Einaudi
4. Organization Stanford University
5. Revision Draft/Date August 1991
6. Section SCP, 1.7.1.2.1
7. Page 1-276
8. Paragraph 1

9. Comment

"Generally, the mineralization (in epithermal precious metal deposits) is thought to be the result of hydrothermal solutions from epizonal plutons..." This is an oversimplification. This question, which bears on the source of metals and other components in the ore fluid, is best approached by considering two broad categories of epithermal Au-Ag deposits: the "silica-alunite type" and the "sericite-adularia type" (the features of these two types have recently been summarized by Heald et al., 1987).

The silica-alunite type, with examples including Pyramid, Paradise Peak, and Goldfield, Nevada, are thought to be linked genetically to porphyry systems; i.e., a magmatic source may be important for at least a significant portion of the metals. The case for this link is made in general for the Great Basin by Wallace (1979) and specifically for Goldfield by Ashley (1979) and Vikre (1989) and for Paradise Peak by John

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The ESSE Core Team recognizes that the SCP text represented a "snapshot" in time and thus will be viewed as outdated, or simplistic, as new information becomes available. However, we do not believe that the ESSE is the appropriate place for responding to comments on the SCP. The text of this comment will be available to staff conducting research on the Yucca Mountain resource potential. Future studies will benefit from these comments on epithermal Au-Ag deposits.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

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9 Comment ( continued )

et al. (1991). Host rocks tend to be dacitic to rhyodacitic (quartz latite), are commonly porphyritic, and are part of flow-domes complexes, some containing epizonal plutons. More silicic or more mafic precursors can also be mineralized.

The vast majority of epithermal precious metal deposits in the Great Basin, however, are of the sericite-adularia type, and the majority opinion to date remains that these are not genetically linked to magmatic or hydrothermal fluids, but, rather, to convecting meteoric water driven by magmatic heat input. If this is correct, it would indicate that host lithology is not a critical factor (e.g., andesite versus rhyolite) in the formation of sericite-adularia type deposits (e.g., Heald et al. 1987). Such deposits are found most commonly within the intermediate volcanics of the high-K calc-alkaline suite of andesite-dacite, but they also occur within the silicic endmembers of such suites. Epizonal plutons, if required as heat engines, are unrecognized in most districts.

In sum, a magmatic source of components and an epizonal pluton may not be a critical factor in the genesis of many epithermal precious metal deposits. Many of these deposits are not known to be associated with epizonal plutons, so that the absence of epizonal plutons (say at Yucca Mountain) cannot be taken as evidence that this style of mineralization is not present. This information should be considered in future assessments of Yucca Mountain.

END OF TEXT

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(Reviewer completes items 1 - 9.)

1. Comment 26 of 29
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3. Reviewer M.T. Einaudi
4. Organization Stanford University
5. Revision Draft/Date August 1991
6. Section SCP, 1.7.1.2.2
7. Page 1-278
8. Paragraph 2, last sentence

9. Comment

Because the age of ore-forming events in the area of Yucca Mountain is an important factor in evaluating potential ore-forming environments, a table listing the available age dates would be very useful. The wording of this sentence results in non-specific information and lacks a follow-up; although it may be possible to separate pre-13.9 Ma dates from post-13.9 Ma dates, one wonders why such a division is important. More recent information cited in Noble et al. (1991) suggests division of volcanic and ore-forming events into:

(1) a "Main Magmatic Stage (e.g., Crater Flat and Paintbrush tuffs), 15.2 to 12.8 Ma, in which ores of Au-F association are related (genetically?) to stocks and dikes of silicic to intermediate composition that are emplaced and altered late in the volcanic cycle, at 13-11 Ma. Bare Mountain, Wahmonie, and possibly Calico Hills are the main sites of hydrothermal activity.

10. Proposed Resolution *(To be completed by ESSE Core Team)*

This report is cited in the text of the ESSE in the first paragraph of page 2-114. This report has not been strongly referenced because it is unclear what the authors are dating (magmatic events or hydrothermal events). Some dates do not correspond with what is known about the regional geology. Nonetheless, the ESSE Core Team agrees with the suggestion that this type of information should be compiled and reported. The text of this comment will be available to staff conducting research on the resource potential of the Yucca Mountain area.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

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9 Comment ( continued )

(2) a "Timber Mountain Magmatic Stage" (e.g., Timber Mountain Tuff and tuffs and lavas of Bullfrog Hills), 11.7 to 10.1 Ma, in which sericite-adularia Au-Ag epithermal ores generally post-date emplacement of silicic to intermediate volcanics, at 10-9 Ma. Bullfrog (Rhyolite), Calico Hills, Mine Mountain, and northern Yucca Mountain are the main sites of hydrothermal activity.

A discussion of this new work should be included in the ESSE, and an effort should be made to compile new work as it becomes available.

END OF TEXT

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5. Revision Draft/Date August 1991
6. Section SCP, 1.7.1.2.3
7. Page 1-282
8. Paragraph 2

9. Comment

Some emphasis is placed in this paragraph on the apparent difference between alteration minerals observed at Yucca Mountain and those that are found in epithermal mineral deposits. This difference probably is real but as stated, the implication is that alteration minerals found at Yucca Mountain are not characteristic of any portion of epithermal precious metal deposits. Because there is some resemblance between the minerals known to occur at Yucca Mountain and some portions of known precious metals deposits, a point of clarification would be to state that the array of different types of wall-rock alteration styles commonly found in known deposits is absent at Yucca Mountain.

END OF TEXT

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The following text will be added to Section 2.3.8.4: "In the SCP (Section 1.7.1.2.3), it was stated that rock alteration observed at the Yucca Mountain site is not the same mineral assemblages commonly found in epithermal mineral deposits. Some minerals do occur at Yucca Mountain that also occur in precious mineral deposits, although the array of different types of wall-rock alteration styles commonly found in such deposits are not known to occur at the Yucca Mountain site. Collection of the observational data base will allow for more detailed and thorough assessments of rock alterations at the Yucca Mountain site."

END OF TEXT

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END OF TEXT

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5. Revision Draft/Date August 1991
6. Section SCP, 1.7.1.3
7. Page 1-284
8. Paragraph 3

9. Comment

The discussion regarding presence or absence of mercury mineralization in and near Yucca Mountain is restricted to the assessment of the potential for undiscovered mercury deposits. However, because mercury is linked to other types of deposits mined for other metals, the discussion should be broadened to include these links and to explore their meaning in terms of resource assessment. In general, the SCP lacks a conceptualization of the links between deposit types and between different commodities, in the context of a "hydrothermal system" larger than any individual ore deposits that it might contain.

The presence of mercury mines near Yucca Mountain, at the Harvey and Tip Top, can be taken as suggestive of the presence of precious metal deposits in the same area(s). In fact, the Harvey (Telluride) mine, in Paleozoic sediments, is reported to contain some gold (Cornwall, 1972, p. 36) and two new gold discoveries (the Mother Lode and an unnamed prospect

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The intent of this comment has been addressed in response to Dr. Einaudi's Comment #11. The ESSE Core Team agrees with the comment and text has been added to the ESSE, but we do not believe that the ESSE is the appropriate place for detailed responses to comments on the SCP. However, the text of this comment will be available to staff conducting research on the resource potentialof the Yucca Mountain area.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

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9 Comment ( continued )

1 km SE of Mother Lode) were outlined nearby in 1988 (Castor et al., 1989, p. 4, 30). The gold mineralization at Mother Lode occurs in both Paleozoic sediments and in Tertiary silicic tuffs. The Daisy (Crowell) fluorite mine also displays a mercury-gold association (Cornwall, 1972, p. 35).

Thus, the presence of mercury near Yucca Mountain is important from the point of view of "perceptions" of resource potential in the area by the exploration community. Beyond the local Yucca Mountain scene, there are numerous examples of the use of mercury as a pathfinder element in the search for gold deposits (e.g., the McLaughlin gold deposit in California was discovered by assaying for gold in an abandoned mercury mine), and there are numerous examples of gold deposits in Nevada in which mercury is present in relatively high concentrations, in both volcanic-hosted deposits (e.g., Paradise Peak; John et al., 1991) and sediment-hosted deposits (e.g., Carlin mine).

The question of the link between mercury and gold needs to be addressed not only because it affects perceptions of resource potential by the exploration community, but also because it has a direct bearing on the ultimate conclusion by DOE regarding the likelihood of potential gold deposits at and near Yucca Mountain (presumably, this likelihood is higher in a region with known mercury mineralization than in a region lacking mercury mineralization, other factors being equal).

As a data base for assessing the resource potential of Yucca Mountain and the surrounding area, it would be very useful to compile a map overlay that displays all of the reported occurrences of mercury, catalogued by type, amount, etc. Such an overlay, in conjunction with similar overlays for other mineralogical features (e.g., silicified tuffs, silica-filled fractures, quartz veins, fluorite, etc.) represents part of the process of recognizing trends and associations, that (if combined with some knowledge of structural and lithologic controls, the factor of time, and the links between deposit types) are clues to hydrothermal fluid flow and location of potential mineral resources.

END OF TEXT

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6. Section SCP
7. Page Various
8. Paragraph Various

9. Comment

The comments that follow are on different sections of the SCP. They should be considered in developing future efforts that assess the potential for natural resources at Yucca Mountain and may be appropriate in considering minor changes to the ESSE. No specific responses to these comments are expected as a result of the ESSE process.

(A) SCP, 1.7.1.1, p. 1-266, 3rd para. Division of Nevada into a western precious metal and eastern base-metal belt may be overly simplistic in terms of exploration tendancies. Although not stated, the implication of this paragraph is that because Yucca Mountain falls in the "eastern base-metal province," the potential for precious metals may be lower than that for base-metals. In fact, numerous precious-metal deposits have been discovered in the eastern belt, including porphyry-related (PRD), volcanic-hosted epithermal (VHED) and Carlin-type deposits (CTD), including: (Bullfrog Hills (VHED), near Yucca Mountain; Fluorspar Canyon

10. Proposed Resolution *(To be completed by ESSE Core Team)*

The ESSE Core Team appreciates Dr. Einaudi's comments on the SCP text on mineral resources, and will recommend that staff conducting research on the resource potential of the Yucca Mountain area utilize this input to improve future studies.

END OF TEXT

11. Resolution *(To be completed by original Reviewer)*

Comment resolution accepted as proposed.

END OF TEXT

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9 Comment ( continued )

(VHED, CTD), near Yucca Mountain; Star Pointer (PRD), Ely district; Tecoma (CTD), Utah-Nev border; Melco and Barney's Canyon (PRD), Bingham district, Utah); furthermore, there are several important past producers of silver, including Park City, Utah; Taylor, Nevada.; Horn Silver, Utah.

(B) SCP, 1.7.1.2.1, p. 1-272, para 1. "The compositional range of erupted tuffs (at Yucca Mountain) are different than the volcanic suites associated with vein deposits in the Great Basin." I disagree on two points. First, there is a misplaced emphasis on "vein deposits," because the most important epithermal precious metal deposits in the Great Basin today are disseminated deposits (associated with historical vein deposits). Second, and more important, this statement vastly oversimplifies a very complex and poorly understood aspect of the origin of epithermal Au-Ag deposits: the link between volcanic suites and epithermal systems. The volcanic suite at and near Yucca Mountain is not fundamentally different than other volcanic suites erupted during extension at other times and places in the Great Basin (Gans et al., 1989; Seedorff, 1991; Noble et al., 1991). Such suites typically include: (1) large volumes of silicic ash-flow tuffs and lesser volumes of intermediate to silicic lavas, predating extension or very early in the history of extension at any given place (in the SWNVF, these would include the Crater Flat-Paintbrush stage at 15-13 Ma); (2) a high-K, calc-alkaline "bimodal" suite of andesite-dacite and rhyolite lavas and small volume silicic tuffs, during the main period of rapid extension (in the SWNVF, these would include the Timber Mountain tuff and tuffs and lavas of Bullfrog Hills, 12-10 Ma); and (3) a strongly bimodal basalt-rhyolite suite, including basalt flows and peralkaline caldera complexes, topaz rhyolites, etc., during the waning stages of extension (in the SWNVF, these would include Black Mountain and Stonewall Mountain volcanic centers, 9-7 Ma). Precious metal deposits have been found with all 3 types of volcanic suites, and in association with either silicic or less-silicic endmembers of any of the suites. A partial list of these associations is: Rhyolites of suite 1 - Round Mountain. Andesites of suite 1 Virginia City. Andesite, dacite and rhyolite of suite 2-Paradise Peak, Rawhide. Trachyandesite/rhyodacite of suite 2 - Tonopah, Goldfield, Divide. Rhyolite of suite 2 - Wah-Wah (Stateline). Basalt of suite 3 - Hog Ranch, Buckhorn, Sulfur.

(C) SCP, 1.7.1.2.1, p. 1-273, Fig. 1-77. It is unclear from the figure caption whether this map is restricted to epithermal deposits only (the inclusion of Battle Mountain suggests that it includes other types). In any event, this map would be more useful if keyed to the suite of

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9 Comment ( continued )

volcanics associated with mineralization (rather than keyed to the individual rock type in which the deposit is located), according to a system such as that outlined in later comments. Alternately, given that such information is not available for a significant proportion of deposits, the full list of rock types that are mineralized in a given district should by included. For example, although Fig. 1-77 indicates that Tonopah is hosted by andesite, some mineralization also occurs in rhyolite. A wide variety of volcanic rock types are mineralized in sericite-adularia type epithermal systems; this observation supports the current favored hypothesis that sericite-adularia deposits are not linked genetically to magmatic-hydrothermal fluids. Also, the map would display relative importance to a greater degree if keyed to total contained gold (rather than keyed to production). A similar map could be included for sediment-hosted gold deposits to set the context for a discussion of Paleozoic basement potential at Yucca Mountain. All of the above discussion should be considered during the assessment of Yucca Mountain.

(D) SCP, 1.7.1.2.2, p. 1-277, para 1. "At Round Mountain... mineralization is in intracaldera tuff." More recent work (Tingley and Berger, 1985; Boden, 1986; Sander and Einaudi, 1987) suggests that Round Mountain is located in the outflow region of the Jeffarson Caldera and is not "intracaldera." However, it may be located above an older buried caldera located under valley fill to the southwest.

(E) SCP, 1.7.1.2.2, p. 1-277, para 2. Important mineralized areas near Yucca Mountain (e.g., Tonopah, Goldfield, and Bullfrog) are stated as being in volcanic rocks " related to andesitic volcanic rocks." This statement is not accurate and suggests that andesitic volcanics are more prospective than rhyolitic, which is not true (see my Comments S-10, S-12).

(F) SCP, 1.7.1.2.2, p. 1-277, para 3. "The associated bimodal and intermediate composition volcanic rocks of (Tonopah, Goldfield, and Bullfrog) ... are not typical of the volcanic rocks at Yucca Mountain." This statement is somewhat misleading and appears to be biased toward a positive outcome for the assessment because the emphasis is placed on the contrast between "bimodal and intermediate volcanics" (productive) and silicic tuffs such as exposed at Yucca Mountain (unproductive). The use of the term "bimodal" in reference to these districts, without qualification, is misleading; all of these districts are related to trachyandesitic and rhyolitic volcanism (suite 2 of earlier comment) which is characteristic of the middle stages of active extension in the Basin and Range (Gans et al.,

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1989; Seedorff, 1991), rather than to the bimodal basalt-rhyolite (suite 3 of earlier comment) which is characteristic of the waning stages of extension in any given place and time. Further, some very large epithermal systems appear to be located in volcanics of suite 1 (dominantly silicic ash-flow tuffs), as exposed at Yucca Mountain.

(G) SCP , 1.7.1.2.2, p. 1-278, para 1. "The (Round Mountain) district is associated with... tungsten and copper mineralization..." It is accurate to say that tungsten and copper mineralization occurs in the district, but this mineralization is significantly older (Shawe et al., 1986) and therefore unrelated to the Round Mountain gold-silver deposit. The shallow plutons also are older and unrelated to the genesis of the Round Mountain gold-silver deposit. Therefore, the absence of copper and tungsten mineralization and of shallow plutons at Yucca Mountain cannot be taken as evidence for the absence of a Round Mountain-type (or sericite-adularia) gold-silver deposit.

(H) SCP, 1.7.1.2.2, p. 1-280, para 0. "Exploration for precious metals in a deeply buried Paleozoic terrain, such as at Yucca Mountain, cannot be dismissed." I agree, and this statement should be followed up. It appears to contradict earlier statements (SCP, p. 1-269, para 4).

(I) SCR, 1.7.1.2.3, p. 1-281, Fig. 1-80. This figure requires some critical discussion of the methods used, and the uncertainties associated with the different methods. For example, reference to Bish (1987) indicates that fluid inclusion temperatures are based on fluid inclusions in calcite. Yet, neither Bish, nor the SCP points out that calcite is notorious for poor quality microthermometric data because of its tendency to leak (well-developed cleavage).

(J) SCP, 1.7.1.2.3, p. 1-282, para 1. It is stated that paleo-isotherms shift to higher elevations from south to north at Yucca Mountain (based on holes G-1, G-2 and G-3), yet, in the sentences that follow, the top of "more intense" hydrothermal alteration shifts to higher elevations from north to south (based on two drill holes, G-1 & G-2). There is no discussion of this apparent contradiction. Is the interpretation of paleotemperature data incorrect?

(K) SCP, 1.7.1.2.3, p. 1-282, para 1. The hydrothermal alteration in G-1 and G-2 is interpreted to be "regional in extent" on the basis of the 2 km distance between these two holes. The implication of this conclusion is

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not stated. However, because the term "regional alteration" commonly is used in the economic geology literature in contradistinction to local alteration genetically related to an ore-forming system, the use of the term here should be specified. It should be noted that hydrothermal alteration associated with mineral deposits commonly extends over distances considerably greater than 2 km (see summary of physical dimensions of epithermal systems in Heald et al., 1987, Table 6, p. 12).

(L) SCP, 1.7.1.2.3, p. 1-282, para 4. These gold analyses may be meaningless with regard to resource assessment, because they appear to come from fresh tuff (the analyses are reported to have been made for the purpose of modeling magma genesis, but there is no discussion regarding their degree of hydrothermal alteration). The single sample cited as coming from hole G-2, containing 0.06 ppm Au, was collected at 515 m depth, yet alteration increases abruptly below 914 m. Sampling and assaying should be focused on these deeper, altered intervals.

(M) SCP, 1.7.1.2.3, p. 1-283, para 1, no. 1. "Carlin-type gold deposits have the most potential for exploitation in the future." This may be true if the future is five years from now, but probably not true if 10 years is considered. The reason is simply that, given present technology, only oxidized portions of these deposits are economic. The majority of Carlin-type deposits that are economic are those that are located at or near the surface, and therefore oxidized. The majority of these surface deposits will probably have been found within the next few years to 5 years. Thus, their potential for exploitation in the future is limited. Attention is likely to focus once again on exploring for higher-grade epithermal vein deposits (bonanza types).

(N) SCP, 1.7.1.2.3, p. 1-283, para 1, no. 1. It is stated that Carlin-type deposits may be present in the Paleozoic basement under Yucca Mountain, but that the depth involved rules out mining because these deposits require open-pit methods. I concur with the first part of the sentence, but take issue with the second part. The assessment with regard to Carlin-type deposits cannot be based solely on the fact that Paleozoic rocks cannot be reached by open pit methods. Given the experience at Deep Post (Carlin Trend), some Carlin-type deposits are underlain by vein deposits of higher grade that, in spite of being sulfide ores, may be amenable to flotation extraction in the near future. Whether or not a similar deposit under Yucca Mountain would be economic or not obviously depends on the grade and size, given that depths of greater than 1 km

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9 Comment ( continued )

are involved. Also, we have limited ability to assess the presence of mineral deposits at these depths. In any event, future studies of Yucca Mountain should take into consideration that Carlin-type deposits, or at least higher grade portions of such deposits, may ultimately be mined by underground methods.

(O) SCP, 1.7.1.2.3, p. 1-283, para 1, no 3. See my comments regarding alteration minerals associated with epthermal precious metal ores. The conclusion in this paragraph is overstated.

(P) SCP, 1.7.1.2.3, p. 1-283, para 1, no. 4. See my comment regarding gold analyses. The conclusion in this paragraph is not supported by the data.

(Q) SCP, 1.7.1.3, p. 1-284, para 4. This paragraph contains a listing of "eight different types of (mercury) deposits..." Actually, this list is not a classification of types of deposits, because the "types" listed are not mutually exclusive, and, in terms of genetic concepts, many of the different "types" listed reflect the same hydrothermal environment and can occur within one deposit (e.g., opalite blankets, altered volcanic rocks, and altered interbedded sediment all occur together in the Cordero mine (McDermitt district). This point is important in terms of establishing the scientific credibility of the project's assessment, and in terms of the application of this classification to resource assessment at Yucca Mountain.

(R) SCP, 1.7.1.3, p. 1-286, para 2. This paragraph states that "only two of the eight potential mercury host rock environments are present at Yucca Mountain," including opalite blankets and altered volcanic rocks (Types 2 and 3 from p. 1-284). Considering the genetic tie between these two "types," there actually is only one mercury deposit type to be considered: volcanic hot-spring deposits. In this setting, many "opalite blankets" interpreted to be surface hot-spring deposits are simply opalized tuffs and volcaniclastic sediments.

(S) SCP, 1.7.1.3, p. 1-287, para 1. In addition to mercury occurrences at the Tip Top, Harvey (Telluride), Thompson, and Silicon mines mentioned in the text, mercury also has been reported from: Curly Wright prospect (near the Thompson mine; Holmes, 1965); Daisy (Crowell) fluorite mine (Cornwall, 1972, p. 35); and in quartz-barite-sulfide (Pb-Zn-Ag) veins in Pz seds of the Mine Mountain district (Cornwall, 1972, p. 39; Quade and

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Tingley, 1983, p. 6-7). The possibility of some mercury production from the Mine Mountain district is suggested by Quade and Tingley (1983).

(T) SCP, 1.7.1.3, p. 1-287, para 2. The conclusion that pyrite-bearing tuffs associated with alteration at depths of about 1000 m in drill holes at Yucca Mountain (in Crater Flat Tuff?) are too deep to be potential mercury-bearing zones is based on the observation that most mercury ores around the world are thought to have formed at shallower depths. However, the conclusion arrived at does not consider the possibility that sufficient time existed to form mercury deposit in these altered tuffs (Bullfrog and lower members of Crater Flat Tuff) <u>before</u> they were covered by subsequent tuffs (Paintbrush Tuff). The latter possibility might be discounted on the basis of K-Ar dates of illite-smectite clays (dates cited on p. 1-232, but not discussed in the present context) that arc "greater (sic) than 10 Ma old and equivalent to the timing of the Timber Mountain Tuff" (p. 1-282). (It is unclear why the actual dates reported by Bish (1987) are not cited here: these are 10.9 to 11.0 +/-0.5 Ma) However, use of these dates to discount potential mercury mineralization at depths greater than 1000 m at Yucca Mountain is dependent on the interpretation given to the K-Ar dates derived from illite-smectite. My gut feeling is that illite and clays are susceptible to low-temperature Ar loss. In fact, Bish (1987) suggests that one interpretation of the dates is that older alteration was reset to 11 Ma by Timber Mountain magmatism. Older dates for mercury occurrences in the vicinity of Yucca Mountain do exist and support the possibility of mercury mineralization occurring before emplacement of the upper units of the Paintbrush Tuff: K-Ar dates on alunite associated with mercury mineralization in silicified Paintbrush Tuff at the Thompson mine (Jackson et al., 1988) indicate that mercury mineralization at this locality occurred at about 13 Ma, within the range of dates for the lower members of the Paintbrush Tuff (i.e., broadly within the Main Magmatic Stage of Noble et al., (1991)).

(U) SCP, 1.7.1.3, p. 1-287, para 2 & 3. The conclusion that "there is very little potential for economic deposits of mercury at Yucca Mountain" is not well-supported by the data and discussion presented. (1) The "lack of alteration typically associated with mercury deposits" (e.g., opaline silica) is not supported by earlier statements (e.g., "Deposits of ... opaline silica are found locally along fault zones near Yucca Mountain" (p. 1-282)). (2) "The low alteration temperatures found in tuffs shallower than 1,148 m" does not rule out mercury at greater depth. (3) "The shallow depth of occurrence (rather, ' of formation') of mercury deposits" is not a

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9 Comment ( continued )

factor if mercury deposits formed during Crater Flat time. (4) The claim that there is a "lack of mercury mineralization in drill holes and at the surface" of Yucca Mountain can only be taken at face value, but shouldn't have to be; this claim needs to be supported by mercury analyses from altered tuff at depth or from opalized fissures.

(V) SCP, Section 1.7.1.4.1. I agree that the evidence to date discounts a high (or even moderate) likelihood of the presence of an undiscovered barite deposit at Yucca Mountain. However, the presence of barite veins in and near Yucca Mountain raises the question of linkage to other deposit types (see my Comment S-29)--e.g., does the presence of barite-quartz-calcite veins in drill hole G-2 at a depth of 1736 m (in an area of more intense alteration, see p. 1-282, para 1) suggest the presence of gold nearby? Barite is a common mineral in both sediment-hosted (Carlin-type) and volcanic-hosted precious metal deposits. The presence of barite at Yucca Mountain could be taken by some exploration geologists as mildly suggestive of precious metals, especially in the presence of wall-rock alteration styles not dissimilar to those found in epithermal systems. The question of the link between barite and precious-metals needs to be addressed not only because it affects perceptions of resource potential by the exploration community, but also because it has a direct bearing on the ultimate decision by DOE regarding the potential for precious metal deposits at and near Yucca Mountain. The likelihood of precious metals is higher in a region with known mercury mineralization, barite veins, and altered silicic tuff, than in a region lacking these occurrences, other factors being equal. As a data base for assessing the resource potential of Yucca Mountain and the surrounding area, it would be very useful to compile a map overlay that displays all the reported occurrences of barite, catalogued by type, amount, etc. Such an overlay, in conjunction with similar overlays Tor other mineralogical features (e.g., silicified tuffs, silica-filled fractures, quartz veins, fluorite, etc.), represents part of the process of recognizing trends and associations, that (if combined with some knowledge of structural and lithological controls, the factor of time, and links between deposit-types) are clues to hydrothermal fluid flow and location of potential mineral resources.

(W) SCP, 1.7.1.4.2, p. 1-293, para 1. Although the potential for economic fluorite deposits at Yucca Mountain may be very low, there is a well-known link between fluorite and gold (especially in this part of Nevada); therefore, the presence of fluorite, in conjunction with other

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favorable factors, can lead to certain conclusions about the potential for gold mineralization. For example, traces of gold were known to occur in clay-bearing envelopes on fluorite veins in dolomite at the Daisy fluorite mine (Smith and Tingley, 1983, p. BMD-4) and this knowledge, combined with Tingley's (1984) report on trace element associations in carbonate rocks at Bare Mountain, led to gold exploration activity. Recent assays from the lower levels of the Daisy mine yielded up to 6.7 m of 0.224 opt gold, and drilling south of the mine led to the discovery of a prospect (South Zone) containing 785,000 tons of 0.097 opt Au, some of it associated with weak fluorite mineralization (Greybeck and Wallace, 1991, p. 944). Drilling west of the Daisy mine led to the delineation of 670,000 tons of 0.027 opt Au (West Zone) associated with silicified shale and dolomite; here, "fluorite is commonly associated with higher gold values" (Greybeck and Wallace, 1991, p. 943). Other fluorite-gold associations also are known in the vicinity of Yucca Mountain. The Goldspar (Diamond Queen) fluorite mine in dolomite actually was first opened as a gold mine (Cornwall, 1972, p. 36) and may be continuous with the Stirling (Panama) gold mine (Bell and Larson, 1982, p. 26). At the latter mine, gold occurs in silicified, fluorite-cemented breccias (Smith and Tingley, 1983, p. BMD-5). The question of the link between fluorite and gold needs to be addressed not only because it affects perceptions of resource potential by the exploration community, but also because it has a direct bearing on the ultimate conclusion by DOE regarding the likelihood of potential gold deposits at and near Yucca Mountain. Presumably, this likelihood is higher in a region with known fluorite mineralization associated with silicified carbonate rocks and volcanic rocks than in a region lacking such features, other factors being equal. As a data base for assessing the resource potential of Yucca Mountain and the surrounding area, it would be very useful to compile a map overlay that displays all the reported occurrences of fluorite. See my similar remarks above, regarding mercury and barite.

(X) SCP, 1.7.1.4.2, p. 1-293, para 2 & 3. The occurrence of fluorite-bearing veinlets in altered tuff can be taken as suggestive of the presence of gold mineralization in tuff, based on the regional association of fluorite and gold. Further, the occurrence of fluorite veins in tuff might suggest a fluorite target in underlying Paleozoic carbonate rocks, given the likelihood that hydrothermal fluids were upwelling from the basement into the tuff and given the tendency for fluorite grades to be higher in carbonate sediments than in silicic tuffs.

(Y) SCP, Section 1.7.1.4.4. This section dealing with construction

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materials supports the conclusion that such materials are not prospective at or near Yucca Mountain. I concur with this view. However, the occurrences of materials such as silica and clay need to be assessed in terms of their potential relation to metalliferous deposits known to be associated with such materials, particularly mercury, fluorite, and precious metals. Again, a useful data base for assessment of resource potential of Yucca Mountain and the surrounding area, could include a map overlay displaying all the known occurrences of hydrothermal silica and hydrothermal clay.

(Z) SCP, 1.8.1.7.1, p. 1-341, para 2. This paragraph states that commodities classed as "other resources," including barite, fluorite, silica, and clays "will not receive further attention." I agree that these commodities probably should not receive further attention in the context of potential economic deposits of these commodities, but they should receive further attention in the context of their use as guides to other types of resources, particularly the precious metals.

END OF TEXT

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