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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

JUN 23 1993

MEMORANDUM FOR: Joseph J. Holonich, Director
Repository Licensing and Quality Assurance Project Directorate
Division of High-Level Waste Management, NMSS

FROM: Ronald L. Ballard, Chief
Geology and Engineering Branch
Division of High-Level Waste Management, NMSS

SUBJECT: REVIEW OF DOE STUDY PLAN 8.3.1.8.2.1, "ANALYSIS OF WASTE PACKAGE RUPTURE DUE TO TECTONIC PROCESSES AND EVENTS"

Attached to this memorandum are the results of the Geology and Engineering Branch review of the subject Study Plan. This review was conducted in accordance with the guidance provided in the Review Plan for NRC Staff Review of Study Plans, Revision 2, dated February 1, 1993. The technical portion of this review was conducted by David Dancer, Abou-Bakr Ibrahim, and John Trapp of HLGE while the Quality Assurance aspects of this plan were reviewed by John G. Spraul of HLPD. As a result of this review it was determined that:

1. This study plan is substantially in agreement with the revised Level of Detail Agreement for Study Plans and there are no open items related to the Quality Assurance Program that could call into question the quality of this study plan.

2. No objections to the activities described were identified. There are no field investigations conducted under this study plan, therefore, activities of this plan could not affect repository performance or cause irreversible/unmitigatable effects. In addition there is no indication that the scheduling of activities under this plan could disrupt the characterization schedule, and there are no identified inadequacies of the Quality Assurance Program.

3. In the cover letter accompanying this study plan, DOE suggested that this study plan would address SCA comments 47, 48 and 59. While the staff considers that some progress has been made, the staff considers that these comments should still remain open. An evaluation of how these comments were addressed in this study plan is provided in Attachment 1.

4. Staff concerns relative to assuring sufficiency of data at licensing resulted in the development of 7 new comments and 2 new questions. While the objective of this study plan, as stated on page 6, is to "provide the data necessary for an analysis and assessment of repository performance with respect to the possibility of tectonic processes and events adversely affecting the lifetime of the waste packages", the plan only considers the 10 CFR 60.113 requirements, therefore only

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"anticipated processes and events". In other words, this plan only considers a subset of the concerns related to tectonics and waste package performance (See comment 1). In addition, this plan continues to use a definition of "substantially complete containment" which the staff finds unacceptable (See comment 2). The other comments and questions relate to assumptions and methodologies being used by DOE that may not provide sufficient and necessary data for licensing. The staff comments and questions are presented in Attachment 2.

5. While the DOE did not reference SCA comments 5, 44, and 80, the discussion of substantially complete containment appears to relate directly to these comments. Comment 2, Attachment 2, contains a discussion related to these SCA comments. In addition, comment 3, Attachment 2, raises concerns similar to those raised in comments 1, 4, and 8, (See Attachment 3) during the staff review of study plan 8.3.1.8.1.1.

If there are any questions regarding this study plan, please contact John Trapp at 504-2509.

/S/

Ronald L. Ballard, Chief
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Division of High-Level Waste Management, NMSS

Attachments:
As stated

cc: C. Abrams

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ATTACHMENT 1

NRC STAFF EVALUATION OF HOW DOE ADDRESSED NRC OPEN ITEMS

REVIEW OF SCA OPEN ITEMS:

Section 8.3.1.8 Overview of the postclosure tectonics program: Description of future tectonic processes and events required by the performance design issues

SCA COMMENT 47

The approach to incorporating data derived in the postclosure tectonics program into an assessment of whether performance issues related to the waste package and engineered barrier system (EBS) requirements 10 CFR 60.113(a) will be met is confusing and may result in inaccurate assessment of performance.

EVALUATION OF THE DOE RESPONSE

The primary thrust of this comment was to understand what data was to be collected, and what activities feed into determining how disruption of the waste package and engineered barrier system was assessed.

In general, section 3.2, subsection Data input requirements for the analysis supplies this information.

There remains a question as to the relationship of this study with activity 8.3.1.17.4.12.3 (Evaluate Tectonic Disruption Sequences), and Study 8.3.4.2.4.3 (Mechanical Attributes of the Waste Package Environment). It would appear that there is a general duplication of effort as the tectonic disruptive sequences which come from activity 8.3.1.17.4.12.3 should be the same sequences that come from this study (8.3.1.8.2.1). In addition, the mechanical attributes of the waste package environment from Study 8.3.4.2.4.3 should be considered under Study 8.3.1.8.2.1. The overall program of integration of activities appears lacking. The interrelationship of this study plan with the other study plans listed needs to be better defined.

While much of the requested information has been supplied, the NRC staff considers this comment still open.

REVIEW OF SCA OPEN ITEMS:

Section 8.3.1.8	Overview of the postclosure tectonics program: Description of future tectonic processes and events required by the performance design issues
Section 8.3.1.8.2.1.4	Activity: Assessment of waste package rupture due to faulting
Section 8.3.1.17	Overview of preclosure tectonics: Description of tectonic and igneous events required by performance and design requirements
Table 8.3.1.17-3a	Design and performance parameters related to surface facilities and preclosure fault displacement
Section 8.3.1.17.2	Studies to provide required information on fault displacement that could affect repository design or performance

SCA COMMENT 48

The use of fault slip rates to determine the level of hazard posed to repository facilities by faults does not appear to be a conservative approach and may result in overly optimistic predictions about the effects of faulting on system performance.

EVALUATION OF THE DOE RESPONSE

This comment is primarily concerned with the use of slip rate calculations to determine the hazard of disruption of the waste packages and engineered barrier system.

On page 19, it is recognized that there is uncertainty in projecting known faults, detecting new faults, determining if Quaternary offset has occurred along the various known faults, and determining if new faulting might occur during the period of performance. The staff does not consider that DOE has demonstrated that these various sources of uncertainty can be adequately addressed in slip rate calculations.

As has been stated in Stock, et al., 1985, stress measurements at Yucca mountain indicate that favorably oriented faults are in a state of incipient failure. The approach outlined within this section does not explain how this information would be factored into analysis of the probability of displacement, along with the slip rate data.

It has not been demonstrated that movements of less then 5 cm will not affect the canister performance.

There is no indication that the effects of repository thermal loading will be considered in the analysis.

The staff considers that the methodology proposed within this study plan will provide overly optimistic predictions of the effects of faulting on repository performance.

The staff considers this comment still open.

REFERENCES:

Stock, J.M., J.H. Healy, S.H. Hickman, and M.D. Zoback, 1985, Hydraulic fracturing stress measurements at Yucca Mountain, Nevada, and relationship to the regional stress field: Journal of Geophysics Research, Vol. 90, pp. 8691-8706.

REVIEW OF SCA OPEN ITEMS:

Section 8.3.1.17 Overview of preclosure tectonics: Description of tectonic and igneous events required by performance and design requirements

SCA COMMENT 59

The information presented for the program of investigations for faulting does not allow the NRC staff to determine what investigations will actually be conducted. In addition, the sequencing of many geophysical and geologic activities related to faulting may lead to data collection activities that are inadequate to support assessments of performance and design bases.

EVALUATION OF THE DOE RESPONSE

This comment is primarily concerned with determination of what actual exploration programs will be conducted and the sequencing of these programs in relationship to their end use.

While this study plan provides some information on exploration activities that will provide input into this study, it provides no actual description of the exploration activities themselves.

The staff notes that Figure 5-1, "Schedule showing planned completion dates of constraining data gathering activities," is out of date. For example, the NRC staff has not yet received the study plan for activity 8.3.1.8.1.2, and this data is shown to be needed in early 1992.

The staff considers this comment open.

ATTACHMENT 2

NRC STAFF COMMENTS AND QUESTION ON DOE STUDY PLAN 8.3.1.8.2.1

Section 1.3 Objective of the Study

Section 1.4 Regulatory Rationale and Justification

COMMENT 1

Investigation 8.3.1.8.2, of which this study is a part, does not appear to completely address the possible effects on the waste package from tectonic processes and events. The limitations placed on the study in Section 1.4 will provide an incomplete subset of the tectonic processes and events needed for the design and analysis of waste package performance.

BASIS

The objective of the study, as stated in Section 1.3, is to provide the data necessary for an analysis and assessment of repository performance with respect to the possibility of tectonic processes and events adversely affecting the lifetime of the waste package by rupturing or unacceptable deformation.

The goal of the activities, as stated in Section 1.4, is to provide information on those tectonic processes and events that should be considered "anticipated"....

While it is true that 10 CFR 60.113 requires analysis for anticipated processes and events, 10 CFR 60.112 requires analysis of the performance of the total system under both anticipated processes and events and unanticipated processes and events. In this total system analysis the possibility of tectonic processes and events adversely affecting the lifetime of the waste package by rupturing or unacceptable deformation, thus providing an accessible source term for flow and transport, must be considered.

The design of the waste package and engineered barrier system must consider, not only anticipated processes and events, but unanticipated processes and events, as well as such things as the design criteria of 10 CFR 60.130-135. Figure 8.3.1.8-4 (SCP page 8.3.1.8-65) does not clearly demonstrate how unanticipated tectonic processes and events will be addressed in considering the effects on the waste package.

The staff notes that the objective of Activity 8.3.1.17.4.12.3 is to "... evaluate disruptive sequences involving faulting, folding, uplift and subsidence, and volcanism that are of potential significance to design or performance of the repository" (SCP, page 8.3.1.17-205). It would appear that the information regarding tectonic processes and events necessary to resolve all design and performance issues may be available from Activity 8.3.1.17.4.12.3.

RECOMMENDATION

Either modify this study such that both anticipated processes and events and unanticipated processes and events are considered, as necessary, in both the design and analysis, or provide sufficient information so that the NRC staff can determine how, and in what other study plan, such processes and events will be considered. When providing this information DOE should demonstrate how it intends to address 10 CFR 60.112 and 10 CFR 60.130-135.

REFERENCES:

U.S. Department of Energy, 1988, Site Characterization Plan, Yucca Mountain Site, Nevada Research and Development area, Nevada, DOE/RW-0199

Section 2.1.1 Approach

COMMENT 2

The overall goal for the performance measure stated in this section is not consistent with DOE's response to Comment 5 of NRC's Site Characterization Analysis and is not consistent with the requirements of 10 CFR 60.113 for substantially complete containment.

BASIS

In Section 2.1.1 of the Study Plan, DOE stated that "The goal for all modes of container failure is divided into two time intervals. The goal for the first 300 years after repository closure is that less than 0.05 percent per year of the total population of emplaced containers will fail. The goal for the interval from 300 to 1,000 years after repository closure is that less than 0.1 percent per year of the total population of emplaced containers will fail (SCP page 8.3.5.9-35)."

In the Site Characterization Plan (SCP), DOE stated their approach to comply with the substantially complete containment requirement of 10 CFR 60.113. In Section 8.3.5.9 of the SCP, DOE arbitrarily defined container "failure" (i.e. a breach large enough to allow air flow of .0001 atm-cubic centimeters per second into the container), presented goals for the maximum fraction of containers that "failed" in any given year (i.e. the goal for the first 300 years after repository closure is that less than 0.05 percent per year of the total population of emplaced containers will fail and the goal for the interval from 300 to 1,000 years after repository closure is that less than 0.1 percent per year of the total population of emplaced containers will fail), and presented goals for the annual release of radionuclides from the waste packages (i.e. 1 part in 1,000,000 for certain isotopes and 1 part in 100,000 of the current inventory for all other isotopes). In Section 8.3.5.9 DOE did not present any goal for the maximum cumulative "failures" and noted that "a value for the limit of cumulative failures will be determined as part of the container material studies and will be consistent with regulatory intent." However, in Section 8.3.1.8 of the SCP, DOE stated the overall goal for the cumulative failures was less than 5 percent in 300 years and less than 20 percent in 1,000 years and erroneously cross-referenced Section 8.3.5.9 of the SCP as the source of this goal.

In Comments 5, 44, and 80 of the Site Characterization Analysis (SCA), NRC expressed reservations that DOE's goals in the SCP were not consistent with the substantially complete containment requirement, 60.113(a)(1)(ii)(A).

In its response to the SCA Comment 44, DOE indicated that the goal stated in Section 8.3.1.8 of the SCP for the cumulative failures was in error and that Section 8.3.5.9 gave the overall design objective for the waste package program . In its response to SCA Comment 5, DOE indicated that to satisfy the SCP radionuclide release goals, "breach during the containment period would be limited to 0.01% of the containers". In its response to SCA Comment 80, DOE discussed the basis for its radionuclide release rate goals for the containment period.

RECOMMENDATION

Reexamine the performance goals stated in Section 2.1.1 to assure that they are consistent with the requirements of 10 CFR 60.

REFERENCES:

U.S. Department of Energy, 1988, Site Characterization Plan, Yucca Mountain Site, Nevada Research and Development Area, Nevada, DOE/RW-0199

Nuclear Regulatory Commission, 1989, NRC Staff Site Characterization Analysis of the Department of Energy's Site Characterization Plan, Yucca Mountain Site, Nevada, NUREG-1347

U.S. Department of Energy, 1990, Responses to Nuclear Regulatory Commission (NRC) Site Characterization Analysis, YMP/90-107

Section 2.2.1 Activity 8.3.1.8.2.1.1 -- Igneous Intrusion

Section 3.1 Activity 8.3.1.8.2.1.1 -- Igneous Intrusion

COMMENT 3

The event being considered in this activity provides an incomplete description of magmatic processes and, as such, does not provide a suitable basis for determining compliance with the performance objectives. This comment reflects outstanding open items related to Study Plan 8.3.1.8.1.1. In addition, the proposed calculational methodology used to obtained a "disruption parameter" is reflected in the NRC's open items.

BASIS

In Section 2.2.1 it is stated that the event being considered "... is similar to the one considered in investigation 8.3.1.8.1, but assumes that basaltic dikes or sills that might penetrate the repository do not feed a volcanic vent and do not directly result in releases at the ground surface." It is therefore recognized that the event being considered is only a subset of all dikes or sills that might penetrate the repository.

As the objective of study 8.3.1.8.2.1 is to determine if the waste packages will be disrupted by tectonic activity it makes no difference if the igneous feature comes to the surface or not but only if such a feature could disrupt the waste package. The design, and the analysis for 10 CFR 60.113 and 10 CFR 60.112, must consider a complete and comprehensive list of processes and events, not a subset.

In Section 3.1 it is stated that the principle source of information for this activity would come from Studies 8.3.1.8.1.1 and 8.3.1.8.1.2, and that the probability of an intrusion occurring will be derived from the probabilistic volcanic hazard analysis performed in Study 8.3.1.8.1.1

The concern that the magmatic investigations were not considering a complete set of processes and events was raised during the review of study plan 8.3.1.8.1.1 in Comments 1, 4, and 8. Comment 8 also raised concerns with the calculational methodology and proposed use of the "disruption Parameter." These comments related to Study 8.3.1.8.1.1 have not yet been resolved. In addition, the NRC has not yet received Study 8.3.1.8.1.2 for review and may have further comments and concerns.

RECOMMENDATION

Demonstrate how processes and events that need to be considered for the various design and performance requirements will be addressed.

REFERENCES:

U. S. Nuclear Regulatory Commission, 1992, Letter from Joseph J. Holonich, NRC, to John P. Roberts, DOE, transmitting the results of the U.S. Nuclear Regulatory Commission Staff Review of Study Plan For Probability of Magmatic Disruption of the Repository

Section 2.2.2 Activities 8.3.1.8.2.1.2, 8.3.1.8.2.1.3, and 8.3.1.8.2.1.4 - Faulting

COMMENT 4

The 5 cm performance parameter for faulting does not appear justified as it does not consider the effects on the waste package of secondary damage to the rock mass from fault displacement of lower magnitudes

BASIS

This section states that a value of 5 cm was selected as the performance parameter at which fault movement becomes significant over a 1,000 year-period, since at this value it is anticipated that the 7.6 cm air gap around the waste package would be partially closed and any additional displacement might result in an undesirable reduction of the air gap or possible waste package failure.

In Section 2.2.3, (Activity 8.3.1.8.2.1.5) it is recognized that earthquake induced ground motion occurring during the postclosure period could cause spalling or failure of the underground workings that could result in corrosion or mechanical failure of the waste package due to closure of the air gap around them or movement of the waste package in the emplacement hole.

While there is the possibility of aseismic creep, earthquakes are caused by displacement along fault planes, and conversely displacement along fault planes, even fault planes along which total displacement may be less them 5 cm, normally cause earthquake ground motion. There appears to be no basis, therefore, for assuming that a displacement of a fault less than 5 cm will cause no undesirable reaction of the rock mass including spalling, raveling of the rock, and closure of the emplacement borehole.

It is recognized that there are two different failure mechanisms which could operate through faulting; direct failure by shear, and indirect failure resulting from modification of the air gap. However the modification of the air gap, no matter what the actual magnitude of direct fault movement, should be considered in performance assessment and design.

RECOMMENDATION

The design and performance assessment of the waste package should consider the effects of fault displacement less than 5 cm.

Section 2.2.2 Activities 8.3.1.8.2.1.2, 8.3.1.8.2.1.3, and 8.3.1.8.2.1.4 - Faulting

Section 2.2.3 Activity 8.3.1.8.2.5 -- Ground Motion

Section 2.2.4 Activities 8.3.1.8.2.1.6 and 8.3.1.8.2.1.7 -- Folding

Section 3.2 Activities 8.3.1.8.2.1.2, 8.3.1.8.2.1.3, and 8.3.1.8.2.1.4 - Faulting

Section 3.3 Activity 8.3.1.8.2.5 -- Ground Motion

Section 3.4 Activities 8.3.1.8.2.1.6 and 8.3.1.8.2.1.7 -- Folding

COMMENT 5

Calculations of the probability of faulting, ground motion, or folding in a repository must consider the effect of change in the stress field from repository induced loading.

BASIS

The definition of anticipated processes and events requires consideration of the perturbations caused by the presence of emplaced radioactive waste. While this phrasing is not explicit in the definition of unanticipated processes and events the staff recognizes that the effect of waste emplacement must be considered in analyzing unanticipated processes and events also.

One of the major perturbations which must be considered for analysis of potential faulting, ground motion, and folding is the change in the stress field around the repository due to thermal loading.

This study plan contains no indication that these effects will be considered in the analysis of probability and effects of faulting, ground motion, and folding.

RECOMMENDATION

Demonstrate that the effects of repository induced loading, and the interrelationship of this loading to faulting, vibratory ground motion, and folding, have been considered in both the design and analysis.

Section 3.1 Activity 8.3.1.8.2.1.1 -- Igneous Intrusion

COMMENT 6

The methodology used by Link et al. (1982) would appear to provide too simplistic a description of the emplacement process to adequately evaluate the potential disruption of the repository.

BASIS

The work of Link, et al., 1982, assumed that dike emplacement could be represented by a straight line intersecting a repository.

Work by the State of Nevada in Crater Flat, Smith, et al., 1990, indicates that the disruption pattern is much more complex than a straight line.

Previous work in areas such as Pahute Mesa and Piaute Ridge, as described in Crowe, 1990, also suggests that the straight line representation is overly simplistic.

The NRC staff notes, however, that the information presented within Link, et al., 1982, stated that under certain conditions up to 448 canisters could be contacted. The 8-9 value quoted within the text of this section is the average value from Link. et al.

It is unclear from review of this study plan, or from review of study plan 8.3.1.8.1.1, how the area of the repository or the number of waste packages that could be affected would be simulated. The use of procedures such as that shown by Link, et at., 1982, are not sufficient as there is no indication that such representation adequately reflects the igneous processes in the area of the site.

RECOMMENDATION

Models that more accurately represent the geologic processes in the area of the site should be used in the analysis. In addition, when the effects of these processes are presented they should include the range in values, not just the average values.

REFERENCES:

Crowe, B. M., Basaltic Volcanic Episodes of the Yucca Mountain Region, Proceedings of the First International Conference on High-Level Radioactive Waste Management,Las Vegas, Nevada, 19990

Link, R.L., S.E. Logan, H.S. Ng, F.A. Rockenbach, and K.J. Hong, 1982, Parametric Studies of Radiological Consequences of Basaltic Volcanism, SAND81-2375, Sandia National Laboratories, Albuquerque, New Mexico

Smith, E.I., D.L. Feuerbach, T.R. Nauman, and J.E. Faulds, The Area of Most Recent Volcanism Near Yucca Mountain Nevada: Implications of Volcanic Risk Assessment, Proceedings of the International Topical Meeting: High Level Radioactive Waste Management, April, 1990

Section 3.2 Activities 8.3.1.8.2.1.2, 8.3.1.8.2.1.3, and 8.3.1.8.2.1.4 - Faulting

COMMENT 7

In addition to the various methods proposed, consideration should be given to calculation of fault displacement hazard using other methodologies.

BASIS

Ongoing work by DOE, Spengler, 1992, demonstrate that the Ghost Dance Fault in the Yucca Mountain Area is best characterized by a complex zone over 600 feet wide, not by a simple, single fault strand.

On page 21 it is suggested that the analysis for fault hazard would be similar to that previously done by Subramanian, 1989.

While Link, et al., 1982, carried out a simplified calculation for a similar problem, the calculation by Link assumed a narrow dike which would equate to a narrow fault zone. Performing a similar calculation, with all assumptions the same except with a fault width of 600 feet, a much larger number of would be at risk. While it is unlikely that all canisters in such a fault zone would be contacted in a single event, the 8-9 average quoted on page 22 is considered overly optimistic as it does not appear to be based on a accurate representation of geologic conditions at Yucca Mountain.

While it is too early to judge the ability to detect faulting in the underground openings, the Subramanian methodology appears to be highly dependent on the ability to detect faults and by the ability to assign a slip rate to these faults. As is pointed out in this section of the study plan, this information may be hard to obtain at the Yucca Mountain site.

Other methods should be investigated. For example, Coppersmith, 1992, has used a methodology which has both similarities to and differences from the procedures used by Subramanian. This, and other methods, should be evaluated to determine if they provide a better representation of the fault displacement hazard at Yucca Mountain.

RECOMMENDATION

In addition to the methodologies proposed within this study, other methodologies should be examined to evaluate faulting hazard at Yucca Mountain.

REFERENCES:

Link, R.L., S.E. Logan, H.S. Ng, F.A. Rockenbach, and K.J. Hong, 1982, Parametric Studies of Radiological Consequences of Basaltic Volcanism, SAND81-2375, Sandia National Laboratories, Albuquerque, New Mexico

Subramanian, C.V., N. Abrahamson, A.H. Hadjian, L.J. Jardine, J.B. Kemp, O.K. Kiciman, C.W. Ma, J. King, W. Andews, and R.P. Kennedy, 1989, Preliminary Seismic Design Cost-Benefit Assessment of the Tuff Repository Waste Handling Facilities, SAND88-1600, Sandia National Laboratories, Albuquerque, New Mexico

Coppersmith, K.J., 1992, Seismic Hazard Studies for the Electric Power Research Institute,

High-Level Waste Project, Presentation to the U.S. Nuclear Waste Technical Review Board Panel on Structural Geology and Geoengineering, January 22-23, 1992, Irvine California.

Spengler, R., 1992, Recently Acquired Structural Information Along the Ghost Dance Fault in Trip Report for Midway Valley Site Visit - September 17 & 18, 1992, U.S. Nuclear Regulatory Commission Memorandum from Keith I. McConnell to Ronald L. Ballard, November 9, 1992

Section 3.1 Activity 8.3.1.8.2.1.1 -- Igneous Intrusion

QUESTION 1

Where will the potential chemical effects associated with magmatic intrusion be considered?

BASIS

On page 17 it is stated that the assessment will consider both the mechanical and thermal effects of an intrusion. There is no mention of the assessment of potential chemical effects.

During a magmatic intrusion, in addition to the corrosive effects of the magma itself, fluids can be introduced which could affect the rock mass, the waste package and the engineered barrier system. The introduction of such fluids could have a significant effect on both design and performance.

RECOMMENDATION

Indicate where chemical effects from igneous intrusion will be addressed.

Section 2.2.3 Activity 8.3.1.8.2.1.5 -- Ground Motion

Section 3.3 Activity 8.3.1.8.2.1.5 - Ground Motion

QUESTION 2

What is the magnitude range that will be considered by DOE for the multiple events that may cause failure to the corroded canister.

BASIS

On page 31, paragraph 4, it is stated "Consideration of multiple seismic events may be a significant factor if these suggestions are implemented."

The staff is concerned that the DOE methodology might use a lower magnitude cut-off in the analysis. Such a methodology might not consider a sufficient range of multiple, low magnitude events to resolve various performance concerns.

RECOMMENDATION

The type of analysis and the magnitude range used for the analysis should be provided.

ATTACHMENT 3

NRC STAFF COMMENTS 1, 4, AND 8 ON DOE STUDY PLAN 8.3.1.8.1.1

COMMENT 1

The use of the term "event" in this study plan appears to be limited to cone formation, and therefore provides an incomplete description of magmatic processes and events, and the requirement to determine consequence of the resultant activity.

BASIS

The objective of this study plan, as is stated in such places as the end of the first paragraph on page 8, is to evaluate the probability of magmatic activity penetrating the repository or controlled area during the next 10 ka. The activities described within this plan, however, appear to be of insufficient scope to accomplish this objective.

Each magmatic event consists of release of magma from a magma source with the released material being emplaced in the lithosphere and in some cases being released to the surface.

As a result of the magmatic event such features as dikes, sills, plugs, lava flows, and cones may be formed, or such things as hydrothermal fluids may be introduced.

The resultant features from an event (the release of magma from the magma source) could be any grouping of features such as a series of dikes, a series of dikes and cones, or a series of dikes, cones, plugs, and sills. The resultant effects on a repository could range from no effect, to alteration of the host rock, modification of the groundwater system, disruption of the canisters, or breaching of the repository.

In parts of the study plan, such as Section 3.4.2.2, the term event, and the associated analysis which is described, appears to be restricted to events which resulted in the formation of volcanic cones while neglecting all other types of events. Not only is there the possibility of undercounting episodes of magmatic activity due to buried vents, but methods that only count a selected group of features that represent a narrow group of events could seriously undercount the total number of events which have occurred. While such data and analyses may provide an approximation of the probability for the formation of a certain feature, it can not provide a reasonable and conservative approximation of the probability that the repository will be affected by magmatic processes.

RECOMMENDATION

DOE should demonstrate that the program integration of exploration and analysis will be sufficient to account for the various types and sizes of magmatic events, differentiate between the various events, and provide a reasonable description of the complete magmatic process.

COMMENT 4

One of the main activities within this study plan, as stated on page 8, is to estimate the probability of future magmatic disruption of the Yucca Mountain site, however, the probability calculations that this study plan is intended to produce appear too limited to resolve the geologic and regulatory concerns.

BASIS

40 CFR 191 requires that all significant processes and events be considered in the evaluation of compliance.

Section 3.4.2.1, last paragraph, states that the effects of potential secondary effects will be considered in Study Plan 8.3.1.8.1.2, but will not be considered in the probability calculations.

Section 4.0 lists 5 required probability estimates which will come from this study plan, but does not include any probability estimates related to disruption of the engineered barrier system.

Formula 2, page 30, defines the disruption parameter as the probability that the repository is disrupted by the formation of a new volcanic center, given occurrence of a new volcanic center during the containment period of the repository.

The methodology description in section 3.2.2.2 refers to previous studies in which only surface cones, or potential buried cones or groups of cones, have been considered in the calculations. The methods described have not considered the possibility of such things as dikes, sills, hydrothermal fluids, or other non-surface-breaching disruptive effects.

The methods used to previously calculate disruption parameters, such as those presented on page 21, only attempted to calculated disruption through the formation of cones. They did not consider disruption due to formation of dike systems, sills, or the like, and did not consider the resultant effect on groundwater flow system.

The procedures, as presented in this study plan, can not provide the information required for the other investigation listed in Table 4.

RECOMMENDATION

The methods of analysis used to calculate the probability of disruption of a repository must include all significant processes and events that may effect the ability of the repository to meet the performance objectives.

COMMENT 8

The conditional probability of disqualification, Formula 2, Page 30, does not appear to be formulated such that the probabilities that will be necessary to demonstrate compliance with the performance objectives can be obtained.

BASIS

On page 30, DOE states that "The volcanic event of significance for the Yucca Mountain site is the formation of a new volcanic center."

E1 (the recurrence rate of future volcanic events) and E2 (the disruption parameter) from formula 2 are only related to formation of a new volcanic center.

The EPA standard, however, requires an evaluation of the releases from "all significant processes and events". This could include such things as both direct and indirect releases from volcanic events at "old" volcanic centers.

The EPA standard requires that release be determined for all processes and events which may occur during the period of performance, not just those releases from single events which occur during the period of performance.

Release of radioactive materials to the accessible environment must be evaluated for more than "release from ascending magma" as is stated under E3 (the release probability), to determine compliance with the performance objectives.

The EPA standard requires a comparison of all significant processes and events to be compared to the releases from these significant processes and events. In this evaluation the various hazards and the probabilities of the various hazard, which are considered to occur during the period of performance, are compared to the consequences which can result from the various hazards. This evaluation is not based on hazard times consequence (risk).

To determine compliance with the EPA standard it will be necessary to determine the total releases which will occur during the period of performance given a specific set of circumstances. It would include the summation of releases prior to a volcanic event, releases from the volcanic event and releases which occur after the volcanic event given the new set of boundary conditions. This is a larger group of processes and events than is incorporated in E3.

The staff notes that a detailed technical procedure on "Methods for Calculating the Disruption Parameter for Calculation of the Probability of Disruption of a Repository by Magmatic Activity" is to be developed. It is possible that some of the staff concerns could be resolved if this procedure was available for review.

RECOMMENDATION

DOE should consider modifying Formula 2 to reflect the requirements for demonstrating compliance with the performance objectives.