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STAFF TECHNICAL POSITION ON

INVESTIGATIONS TO IDENTIFY FAULT DISPLACEMENT

AND SEISMIC HAZARDS AT A GEOLOGIC REPOSITORY

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ABSTRACT

10 CFR Part 60 does not specify the manner in which potential fault displacement and seismic hazards at a candidate site for a geologic repository are to be investigated. The purpose of this staff technical position (STP), therefore, is to provide guidance to the U.S. Department of Energy (DOE) on appropriate geologic repository investigations that can be used to identify fault displacement and seismic hazards. The U.S. Nuclear Regulatory Commission staff considers that a deterministic approach to investigations of fault displacement and seismic phenomena should be applied to DOE's site characterization program. Further, the staff considers that the approach taken in this STP to investigations of fault displacement and seismic phenomena is appropriate for the collection of sufficient data for input to analyses of the fault displacement and seismic hazards, both for the preclosure and postclosure periods of performance.

Section 2.0 of this staff technical position describes the 10 CFR Part 60 requirements that form the basis for investigations to describe the fault displacement and seismic hazards at a geologic repository. Staff technical position statements and corresponding discussions are presented in Sections 3.0 and 4.0 respectively. Staff technical positions are organized according to the following topics: (1) investigation considerations, (2) investigations for fault displacement hazard, and (3) investigations for vibratory ground motion hazard.

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STAFF TECHNICAL POSITION ON INVESTIGATIONS TO IDENTIFY FAULT DISPLACEMENT AND SEISMIC HAZARDS AT A GEOLOGIC REPOSITORY

1.0 INTRODUCTION

According to 10 CFR Part 60 (U.S. Code of Federal Regulations, Title 10, "Energy"), the applicant for a license to dispose of high-level radioactive waste (HLW) at a geologic repository shall investigate potential fault displacement and seismic hazards that may affect the design, operation, and performance of the geologic repository. However, 10 CFR Part 60 does not specify the manner in which these fault displacement and seismic hazards are to be investigated. The purpose of this Staff Technical Position (STP), therefore, is to provide guidance to the applicant, the U.S. Department of Energy (DOE), on appropriate investigations that can be used to identify fault displacement and seismic hazards at a geologic repository. The terms "fault displacement" and "seismic hazards," as used in this STP, are limited to the hazards resulting from fault displacement and vibratory ground motion that can directly affect the design and performance of the geologic repository.

1.1 Background

The objective of the investigations is to provide information needed for both deterministic and probabilistic analyses of the fault displacement and seismic hazards. Knowledge of the fault and seismic characteristics of the site and the region in which the site is located is fundamental to the development of design bases and in the evaluation of the performance of the repository. Consideration of the geologic history of faults that are thought to have the ability to generate displacements and earthquakes, in accordance with criteria described in this STP, contributes to the determination of the most severe displacement and earthquakes that can be associated with faults. Likewise, the investigations that provide input for the determination of the design basis for

the maximum vibratory ground motion should be conducted through evaluation of the geology, seismology, and the geologic and seismic history of the site and the surrounding region. These investigations would include consideration of historical earthquakes associated with tectonic structures or with seismic source zones to assist in identifying the most severe earthquakes associated with these features. An analysis of the information acquired through the investigations should lead to an estimation of the rates of fault displacement and of seismic activity.

Ultimately, data from these investigations provide input to the determination of the fault displacement and vibratory ground motion that need to be taken into account for the design of structures, systems, and components of a geologic repository, that are important to safety, containment, or waste isolation. Guidance on methods of analyses of fault displacement and seismic hazards will be provided in a companion document.

In general terms, this STP draws on experience gained in applying the concepts in Appendix A of 10 CFR Part 100 (U.S. Code of Federal Regulations, Title 10, "Energy"), to establish appropriate investigations for providing input for the determination of design basis fault displacement and vibratory ground motion hazards for a geologic repository. It is emphasized here that this STP does not suggest deferring to Appendix A of 10 CFR Part 100 for guidance in addressing the fault displacement and seismic hazards at a geologic repository. Rather, certain parts of Appendix A of 10 CFR Part 100 are, with modification, appropriate for conducting investigations of the fault displacement and seismic hazard at a geologic repository. This is particularly true for those sections of Appendix A of 10 CFR Part 100 that address the determination of the need to design for fault displacement and for vibratory ground motion.

The guidance presented in this STP is considered acceptable for candidate sites west of the Rocky Mountain Front, approximately 104 west longitude. Seismic activity can, in general, be better correlated with tectonic structures and seismic source zones in areas west of the Rocky Mountain Front, than can similar activity in areas east of the Rocky Mountain Front.

1.2 Scope

STPs are issued to describe and make available to the public criteria for methods acceptable to the U.S. Nuclear Regulatory Commission (NRC) staff, for implementing specific parts of the Commission's regulations, or to provide regulatory guidance to DOE. STPs are not substitutes for regulations, and compliance with them is not required. They suggest one approach that is acceptable to the staff for meeting regulatory requirements. Methods and solutions differing from those set out in the STP will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a permit or license by the Commission. Published STPs will be revised, as appropriate, to accommodate comments and to reflect new information and experience.

The objective of providing guidance to DOE on investigations to identify fault displacement and seismic hazards is to identify, at an early time, the potential for significant design and/or performance problems in the future so that they can be avoided.

By cooperating in the use of informal methods such as the submission of reports, technical meetings, the opportunity for on-site visits, or quality assurance audits, DOE can assist the staff in its review when and if DOE submits a license application. The Commission recognizes and has stated in this regard, it "cannot direct the Department to comply with the provisions for involving it during site characterization activities" (44 FR 70409). Although the Commission cannot direct the Department to comply with the provisions for involving it during site characterization activities, the Commission also noted that "... any failure to do so is likely to result in imprudent expenditures and subsequent delays, and ultimately could result in the denial of the application for the proposed site." (44 FR 70409).

2.0 REGULATORY FRAMEWORK

There are a number of regulatory requirements in 10 CFR 60 that form the basis for investigations to describe the fault displacement and seismic hazards at a geologic repository. For example, the criteria set forth in 10 CFR 60.21(c)(1)(ii) (see Appendix B) require a description and assessment of the site at which the proposed geologic repository operations area is to be located with appropriate attention to those features of the site that might affect geologic repository operations area design and performance. The description and assessment called for in 10 CFR 60.21(c)(1)(ii) must be in sufficient depth to support the assessment of the effectiveness of engineered and natural barriers called for in 10 CFR 60.21(c)(1)(ii)(D), as well as the analysis of design and performance requirements for structures, systems, and components important to safety called for in 10 CFR 60.21(c)(3).

Elsewhere in 10 CFR Part 60, NRC requirements related to siting, design criteria, and performance, establish additional bases for investigations related to fault displacement and seismic hazards (see Appendix B). These investigations apply to both the preclosure and postclosure periods of performance. For example, during the preclosure period, according to 10 CFR 60.111, the geologic repository operations area is to be designed to provide protection against radiation exposures and releases of radioactive material in accordance with standards set forth in 10 CFR Part 20 (see U.S. Code of Federal Regulations, Title 10, "Energy"). Also, during the preclosure period, 10 CFR 60.111 requires that the geologic repository operations area be designed so that the option to retrieve the emplaced radioactive waste is preserved. 10 CFR 60.131(b)(1) states that structures, systems, and components important to safety must be designed so that natural phenomena and environmental conditions expected at the geologic repository operations area will not interfere with necessary safety functions.

It is expected that much of the information needed to support the fault displacement and seismic hazard evaluation required by 10 CFR 60.131(b)(1), for the preclosure period, can also be used to support fault displacement and

seismic hazard evaluation after permanent closure, with due consideration given to the uncertainties associated with projections over the much longer period of postclosure performance. Accordingly, the investigations performed to address the requirements of 10 CFR 60.131(b)(1) should be conducted concurrently with investigations for postclosure evaluations, such as the potentially adverse conditions regarding the fault displacement and seismic hazards found in 10 CFR 60.122(c)(12), 60.122(c)(13), and 60.122(c)(14), and the fault displacement conditions addressed in 10 CFR 60.122(c)(3), 60.122(c)(4), and 60.122(c)(11). These potentially adverse conditions are to be addressed according to the provisions of 10 CFR 60.122(a)(2) (see Appendix B).

3.0 STAFF TECHNICAL POSITIONS

It is the NRC staff's position that a deterministic approach to investigations of fault displacement and seismic phenomena, defined in detail in succeeding parts of this section, should be applied to geologic repository investigations. The staff considers that probabilistic techniques (i.e., those based on the likelihood of occurence of fault displacement or seismicity) are not sufficiently conservative to be used as determining factors in identifying faults requiring detailed investigation. Further, it is the position of the staff that the approach to investigations for fault displacement and seismic phenomena described in this section are appropriate for the collection of sufficient data for input to analyses of the fault displacement and seismic hazards, both for the preclosure and the postclosure periods of performance.

An acceptable deterministic methodology for the identification and characterization of fault displacement and seismic hazards is described Subsections 3.1 through 3.4 and is illustrated in Figure 1.

3.1 Investigation Considerations

The guidance provided in this section provides the basis for more detailed investigations described in Sections 3.2 and 3.3.

3.1.1 Identification of the Region to be Investigated

The regional extent of fault displacement and seismic hazards that is used as the basis for geologic repository investigations should be identified.

(1) The boundaries of the region to be investigated should be determined by the nature of the geologic setting in which a geologic repository operations area (GROA) is or may be located. (For the purposes of this guidance the term "geologic setting" applies to both the preclosure and postclosure periods of performance.)

(2) Fault displacement and seismic hazards are interrelated, but separate components of the "geologic" system acting within the geologic setting. Therefore, the boundary of the region to be investigated for fault displacement (e.g., the boundary of the "faulting" component of the geologic system) need not coincide with the boundary of the region to be investigated for seismic hazards.

(3) With respect to the identification of the region to be investigated, the identification of the component settings for fault displacement and seismic hazards should be based on a review of the pertinent literature, relevant field investigations, and the consideration of alternative tectonic models.

3.1.2 Initial Identification of Faults to to be Considered for Detailed Investigation

Following the identification of the region to be investigated, consideration should be given to the initial identification of those faults in the geologic setting that may require detailed investigation.

(1) All faults inside the controlled area should be considered as candidates for detailed investigations based on the approach described in Section 3.1.3.

(2) Where fault displacement outside of the controlled area may affect isolation within the controlled area, faults outside of the controlled area should also be considered as candidates for detailed investigations, to the extent that they are material and relevant, based on the approach described in Section 3.1.3.

An acceptable approach to determining which faults outside of the controlled area are material and relevant to geologic repository investigations should be based on deterministic assessments of fault sizes (i.e., lengths) and locations. Also to be considered are the potential effects on the design and performance of structures, systems, and components important to safety, containment or waste isolation, or in the models used in assessing design and performance.

(3) Those faults outside of the controlled area not considered as candidates for detailed investigations will require no further investigation at this time (see Subsection 3.1.4).

3.1.3 Identification of Faults that Require Detailed Investigation (i.e., "Susceptible" Faults)

Following the initial identification of candidate faults to be considered for detailed investigation, further consideration should be given to the identification of those faults that require detailed investigation (i.e., "susceptible" faults).

(1) The staff considers that faults which require detailed investigation (i.e., "susceptible" faults) are those faults that:
   (a) are subject to displacement; and
   (b) affect the design and/or performance of structures, systems, and components important to safety, containment or waste isolation; and/or
   (c) will provide significant input into the models used in the design or in the assessment of the performance of structures, systems, and components important to safety, containment or waste isolation.

(2) The identification of "susceptible" faults can be described as a two-step, deterministic approach. This approach is described below and in Figure 2. Only those faults that meet the criteria described in both Step No. 1 and Step No. 2, below, need to be characterized in detail and be considered as "susceptible" faults.

Process to Identify "Susceptible" Faults

Step No. 1 -- Identification of Faults Subject to Displacement

The primary criterion for the identification of faults subject to displacement is evidence of displacement within the Quaternary Period. Any candidate fault identified in the screening process described in Section 3.1.2 and which has evidence of displacement in the Quaternary Period is considered to be subject to displacement and should continue to be a candidate for detailed investigation.

In cases where the geologic record is incomplete or unclear, the following additional criteria should be applied to the candidate faults (identified through the screening process described in Section 3.1.2) to determine if such faults are subject to displacement. Specifically, faults considered subject to displacement are those that:

(a) have seismicity, instrumentally determined with records of sufficient precision, that suggests a direct relationship with a candidate fault;

(b) have a structural relationship (i.e., displacement on one fault could cause displacement on another) to a fault that meets one or more of the aforementioned criteria; or

(c) are oriented such that they are subject to failure in the existing stress field.

Faults that do not meet any of the criteria of this step may require further investigation for reasons described in Subsection 3.1.4.

In order to assure that faults of potential significance to repository design and/or performance are not overlooked, prudence dictates that even in cases where no Quaternary displacement can be documented along a particular fault, that the other criteria in Step No. 1 be considered.

An acceptable approach to performing the assessments indicated in Step No. 1 would include:

(a) investigation of geologic conditions within the component settings, such as lithology, stratigraphy, structural geology, stress field, and geologic history;

(b) determination of existence of Quaternary-age displacement on faults within the component settings;

(c) tabulation of each historically reported earthquakes that can reasonably be associated with a fault, including its date of occurrence, magnitude or highest intensity, and a plot of the epicenter or region of highest intensity; and

(d) consideration of alternative tectonic models.

Step No. 2 -- Assessment of the Effect on Performance of Faults Subject to Displacement

Assess the effect of fault size on performance. As fault size (i.e., length) was a discriminator used to screen faults outside of the controlled area for further investigation (item (2) in Subsection 3.1.2)), size also needs to be considered in determining which faults inside of the controlled area continue to be material and relevant to geologic repository investigations. The evaluation should be based on deterministic assessments, and take into account the potential effects of fault size on the design and performance of structures, systems, and components important to safety, containment or waste isolation, or in models used in assessing the design and performance of these structures, systems, and components. DOE should develop a defensible approach to determine what size fault needs to be characterized in detail.

Faults that do not meet the criterion of this step may require further investigation for reasons described in Subsection 3.1.4.

3.1.4 Consideration of the Results of Site Characterization Activities and Alternative Tectonic Models

The process of determining which fault displacement and seismic phenomena are material and relevant to geologic repository investigations is iterative. Therefore, faults that were eliminated from further consideration during early evaluations described in Subsections 3.1.2 and 3.1.3 should periodically be reconsidered based on the results of subsequent site characterization activities and/or development of alternative tectonic models for the site or region under consideration.

3.2 Investigations for Fault Displacement Hazard

Following the identification of "susceptible" faults, consideration should be given to the detailed investigation of "susceptible" faults. The investigations described in this section should provide sufficient data for input to analyses of the fault displacement for the preclosure and the postclosure periods of performance.

(1) An acceptable approach to the detailed investigation of "susceptible" faults should include:

(a) a description of the character of the fault or fault zone, including its length, width, and three-dimensional geometry;

(b) a description of the relationship of the fault to other tectonic structures in the controlled area and the region to be investigated;

(c) nature, magnitude, and geologic history of displacements along the fault, including particularly the estimated Quaternary-age displacement; and

(d) correlation of hypocenters, or locations of highest intensity, of historically reported earthquakes with faults, any part of which is within the region being investigated.

(These investigations apply to both "susceptible" faults expressed at the surface and those with no surface expression.)

(2) "Susceptible" faults encountered in the underground facility should be correlated with their expressions at the surface. If "susceptible" faults encountered in the underground facility cannot be correlated with surface expressions, then investigations should be performed in accordance with this subsection.

(3) For "susceptible" faults in the controlled area and those selected from beyond the controlled area for detailed investigation, the investigations should also include consideration of alternative tectonic models at the scale of the controlled area or larger area, as appropriate.

3.3 Investigations for Vibratory Ground Motion Hazard

The investigations described in this section should be conducted to obtain information needed to provide input for the analysis of the vibratory ground motion. In addition to the investigations described in Subsection 3.1.3, an acceptable vibratory ground motion hazard investigation should include the following:

(1) Tabulation of all historically reported earthquakes that have affected or that could reasonably be expected to have affected the site, including the date of occurrence and the following measured or estimated data: magnitude or highest intensity, and a plot of the epicenter or location of highest intensity. Where historically reported earthquakes could have caused a ground acceleration of at least one-tenth the acceleration of gravity (0.1g) at the site, the acceleration or intensity, time history (for those earthquakes that may be significant in an analysis of site foundation liquefaction and other design factors), and duration of ground-shaking at these facilities should also be estimated. (Since earthquakes have been reported in terms of various parameters such as magnitude, intensity at a given location, and effect on ground, structures, and people at a specific location, some of these data may have to be estimated by use of appropriate empirical relationships. Measured data are preferable to estimated data, when available).

(2) A description and comparison of the characteristics of the material underlying the epicentral location or region of highest intensity with the material underlying the site in transmitting earthquake vibratory motion. Investigations in this regard should include:

(a) a determination of the static and dynamic engineering properties of the materials underlying the site, as well as an assessment of the properties needed to determine the behavior of the underlying materials during earthquakes, and the characteristics of the underlying materials in transmitting earthquake-induced motions to those structures, systems, and components important to safety, containment, or waste isolation, such as seismic wave velocities, density, water content, porosity, and strength; and

(b) an assessment of the physical evidence concerning the behavior, during prior earthquakes, of the surficial geologic materials and the substrata underlying the site from the lithologic, stratigraphic, and structural geologic studies described in Section 3.2.

(3) A determination of the regional attenuation of vibratory ground motion.

(4) A correlation of epicenters or locations of highest intensity of historically reported earthquakes, where possible, with tectonic structures. Epicenters or locations of highest intensity that cannot be reasonably correlated with tectonic structures should be associated with seismic source zones.

(5) (a) A determination of which "susceptible" faults may be of importance in determining the design basis vibratory ground motion. The "susceptible" faults that should be considered are those faults that could generate an earthquake with the equivalent of 0.1g or greater ground acceleration at the location of the controlled area; and

(b) Determination of the fault parameters described in Section 3.2 for those "susceptible" faults that may be of importance in establishing the design basis vibratory ground motion.

It should be noted that vibratory ground motion determinations for a point on the surface using accepted attenuation functions, which are typically derived from surface observations, will generally be conservative for the underground facility beneath the surface point (except for cases of unusual channeling of the motion). However, if "susceptible" faults are located such that there is a potential for vibratory ground motion to impact the underground facility, investigations should be undertaken to determine if areas exist, within the underground facility, where vibratory ground motion at depth would be higher than at the surface. If feasible, vibratory ground motion should be monitored as early as possible during the site characterization phase of investigations, both on the surface above the proposed underground facility and at the level of the proposed underground facility itself, to observe possible differences in the motion between these locations. Observed differences should be used to estimate the vibratory ground motion attenuation with depth.

4.0 DISCUSSION

The reader of this STP will find that the elements of investigation presented in Sections 3.2 and 3.3 are similar to the elements presented in Section IV of Appendix A of 10 CFR Part 100. The NRC staff could have adopted Appendix A of 10 CFR Part 100 for guidance concerning geologic criteria, as it has done in 10 CFR Part 40 (see U.S. Code of Federal Regulations, Title 10, "Energy") with regard to tailings dams for uranium processing mills or in 10 CFR Part 72 (see U.S. Code of Federal Regulations, Title 10, "Energy") with regard to independent spent fuel storage installations or monitored retrievable storage systems. However, unlike other nuclear facilities that store, handle, or possess high-level radioactive materials, a geologic repository is unique in that it is a facility that not only processes the material, but also becomes

the site of the final disposal of this material. Other nuclear facilities, once they have served their usefulness, are decommissioned, and radioactive material associated with the facility is removed for appropriate disposal. Thus, because of the unique role of the geologic repository in the nuclear waste stream, (i.e., permanent waste disposal), there are significant differences in its performance assessment requirements when compared to other nuclear facilities covered by Appendix A-type investigations. For example, the very long performance period following permanent closure at a geologic repository results in requirements not addressed by the investigative approaches described in 10 CFR Part 100, Appendix A. For these and other reasons, Appendix A of 10 CFR Part 100 was not adopted for geologic repository investigations.

Moreover, it should also be noted that the staff considers that probabilistic techniques for defining an approach to the investigation of fault displacement and seismic hazards have not been shown to be adequately developed for licensing applications to a specific site (see, for example, 45 FR 74697). Therefore, the it is the staff's position that a deterministic approach to investigations of fault displacement and seismic phenomena, should be applied to geologic repository investigations.

Given the above considerations, there are several motivating factors behind the staff's position on an acceptable methodology for the identification and characterization of fault displacement and seismic hazards at a geologic repository. The suggested methodology illustrated in Figure 1 is acceptable because it encompasses a systematic approach to: (1) document the identification and assessment of all faults within the region identified for investigation; (2) identify those faults that are of potential importance to the design and performance of the geologic repository and, as a result, require detailed investigation; and (3) the disposition of those faults that are eliminated from further consideration but may require reexamination based on the results of site characterization. The various steps illustrated in Figures 1 and 2 should <u>not</u> be interpreted as an NRC staff suggestion that DOE develop separate evaluation documents corresponding to the particular steps in the

process. The process selected and the manner in which the effectiveness of that process is demonstrated are DOE management prerogatives.

The following discussion parallels the list of technical positions given in Section 3.0.

4.1 Investigation Considerations

This section provides supporting discussion for the identification of the region to be investigated and for the identification of faults requiring detailed investigation.

4.1.1 Identification of the Region to be Investigated

The areal extent of the region to be investigated should be such that the geologic and seismic characteristics are understood and described in sufficient detail so as to permit an evaluation of the proposed site, to support the determinations based on these investigations, and to provide input for engineering solutions to actual or potential geologic and seismic effects at the proposed site. The extent of the region to be investigated should be sufficient to adequately characterize the hazard to the site and to test alternative models of faulting and seismicity applicable to the site.

DOE is afforded the flexibility to establish the areal extent of the investigations needed to fully characterize the hazards posed to repository performance by faulting and by seismicity.

4.1.2 Initial Identification of Faults to be Considered for Detailed Investigation

10 CFR 60.122(c)(11) indicates that structural deformation such as uplift, subsidence, folding, and faulting during the Quaternary Period is a potentially adverse condition if it is characteristic of the controlled area or may affect isolation within the controlled area. The staff considers that if faulting during the Quaternary Period is characteristic of the controlled area, then in order to meet the investigative requirements of 10 CFR 60.122(a)(2)(i) and

60.122(a)(2)(ii), all faults within the controlled area should be considered as candidates for detailed investigation as outlined in Subsection 3.1.3.

For faults outside of the controlled area, 10 CFR 60.21(c)(1)(i) requires that information on subsurface conditions outside the controlled area should be collected to the extent that it is material and relevant. Therefore, this STP provides DOE with the flexibility to assess what information on faults outside of the controlled area is material and relevant by performing preliminary assessments of their possible impact on design, containment, and isolation within the controlled area. These preliminary assessments can be used as an initial screen to determine which candidate faults outside of the controlled area but within the geologic setting should undergo further consideration.

4.1.3 Identification of Faults that Require Detailed Investigation (i.e., "Susceptible" Faults)

The concept of "susceptible" fault is based on 10 CFR Part 60 requirements, and builds on past regulatory experience (i.e., Appendix A of 10 CFR Part 100). For the purposes of this STP, the definition of a "susceptible" fault serves only as an indicator (i.e., investigative tool) to identify faults or fault zones that should undergo detailed investigation. The term "capable fault," as defined in 10 CFR Part 100, Appendix A, was not used in this STP because the term "capable fault" was originated to help define the hazard posed to nuclear power facilities and thus was developed in a substantially different context than faults related to HLW repository performance. In contrast to the term "susceptible" fault defined in this STP, "capable fault" is used as a site suitability tool, with established criteria under which proposed nuclear power station sites could be evaluated for licensability (NRC, 1975 and 1979).

After an assessment of existing geologic data and alternative tectonic models for the site, faults that meet the criteria listed in Section 3.1.3 would be designated as "susceptible" faults. The identification of "susceptible" faults is considered to be an iterative process in that faults discovered during the characterization process must be evaluated using the criteria established in Subsections 3.1.1, 3.1.2, 3.1.3, and 3.1.4. Furthermore, where demonstrations

that faults subject to displacement will not affect repository design and/or performance are inconclusive under the criteria listed in Subsection 3.1.3, Step No. 2, these faults should be assumed to be "susceptible."

Process to Identify "Susceptible" Faults

Step No. 1 -- Identification of Faults Subject to Displacement

The approach to identifying "susceptible" faults considers the Quaternary Period as the basic time increment for the determination of fault significance. The staff does not believe that the use of this time increment as a baseline for characterization is unnecessarily conservative. The use of the entire Quaternary Period in characterization activities is based on requirements of 10 CFR Part 60 and supported by the staff analysis of public comments on the draft of 10 CFR Part 60 (see NRC, 1978, p. 373). Based on this analysis, it was concluded that in regard to the investigation of potentially adverse conditions, "...all that is important is that processes 'operating during the Quaternary Period' be identified and evaluated...." (48 FR 28211). The use of the entire Quaternary record also reflects technical points of view such as those expressed by Allen (1975), who indicates that "...the distribution of faults with Quaternary displacements seems to be a valid general guide to modern seismicity (p. 1046)" and "... understanding the Quaternary Period is much more important than understanding earlier periods, and this is where attention should first be concentrated (p. 1056)." In addition, Hays (1980, p. 10) indicates that "...stratigraphic offset of Quaternary deposits by faulting is indicative of an active fault." Finally, consideration of the record for the entire Quaternary Period is necessary to ensure that faults having long recurrence intervals (i.e., greater than 100,000 years) will be investigated.

The approach to identifying "susceptible" faults does not preclude an examination of the pre-Quaternary record. An assessment of the pre-Quaternary movement history may be necessary to establish whether temporal or spatial clustering of fault activity is of importance to the repository. DOE is afforded the flexibility to determine the need for an examination of the pre-Quaternary record of fault movements.

The approach to the identification of "susceptible" faults incorporates a criterion that faults subject to failure in the existing stress regime need to be considered for detailed investigation. This criterion reflects two separate conditions. First, this criterion reflects situations where the existing stress regime is interpreted to suggest that faults that trend in certain directions (i.e., favorably-oriented faults) are in a state of incipient failure. An example of this occurs at the proposed repository site at Yucca Mountain where Rogers and others (1987) have indicated that faults in the region with azimuths ranging from about north to east-northeast should be considered favorably oriented for activation in the current stress regime. The second condition reflected by this criterion is the possible perturbations to the stress regime by the emplaced radioactive waste. In the iterative process of the identification of "susceptible" faults in the underground facility, the term "existing stress regime" is intended to include the stress regime that will continue to exist in the repository after the emplacement of radioactive waste. Therefore, the effect(s) of emplaced radioactive waste should be considered in the identification of, and further study of "susceptible" faults.

Step No. 2 -- Assessment of the Effect on Performance of Faults Subject to Displacement

In this step, a second deterministic assessment is made of potential impact on repository design and/or performance, or the possibility that investigations will provide input into models used to assess potential impacts. The assessment made in this step need consider only fault size in the determination of whether faults identified in Step No. 1 as being subject to displacement may affect repository performance. A fault size and location assessment has previously been implemented to eliminate from further consideration faults outside of the controlled area that are not of a concern to repository performance (Subsection 3.1.2); however, fault size was not used as a discriminator for eliminating from detailed consideration faults occurring inside of the controlled area in Subsection 3.1.2.

This STP does not provide specific limits on the lengths of faults or fault zones that require detailed investigation. In Step No. 2, DOE is afforded the

flexibility to demonstrate that displacement along faults of a certain dimension will not adversely affect the performance of structures, systems, and components of a geologic repository that are important to safety, containment, or waste isolation and will not provide significant input into models used to assess performance. Faults that fall into this category are not considered to be "susceptible" faults and will require no further investigation except as prescribed by Subsection 3.1.4.

4.1.4 Consideration of the Results of Site Characterization Activities and Alternative Tectonic Models

The initial screening discussed in Subsection 4.1.2, and all subsequent screenings of faults, is considered to be an iterative process in that faults determined to require no further consideration under the guidance should be reconsidered if the results of subsequent site characterization activities indicate that assumptions used in the screening process have changed.

4.2 Investigations for Fault Displacement Hazard

The investigations described in Section 3.2 together with the evaluations described in Section 3.1 should be sufficient to provide input to the determination of fault displacement that need to be taken into account for the design of structures, systems, and components of a geologic repository, that are important to safety, containment, or waste isolation.

It is unlikely that fault displacement could occur at the surface above an underground facility without also occurring within the underground facility. If, however, faults are encountered in the underground facility, it may be impractical to study such faults in the manner described in Section 3.2. Instead, special emphasis should be given to the nature of the fault trace, its extent as observed in other openings, and its orientation relative to the trends of faults identified as "susceptible" faults in the vicinity of the underground facility.

4.3 Investigations for Vibratory Ground Motion

A key element driving the investigations for vibratory ground motion is the acceleration value of 0.1g, below which the staff does not have a regulatory concern. Using 0.1g as a discriminator to determine the scope of investi gations to be undertaken or the type of information to be gathered, facilitates the use of various relationships between maximum ground acceleration and parameters of interest. It should not be construed that maximum ground acceleration alone provides the necessary input for the determination of the design basis vibratory ground motion. A minimum value of 0.1g is reasonable when considering the uncertainties encountered in the earthquake data base, as well as in the various relationships that have been derived for earthquakes and faulting. This value has been cited in a number of regulatory and other guidance documents as a discriminator for the minimum value of consideration for the determination of design basis earthquakes and is so used here. (For example, see section IV, "Required Investigations" in 10 CFR Part 100, Appendix A.)

Earthquakes that have generated or can reasonably be assumed to generate an acceleration of 0.1g or greater at the site should be correlated with structures or associated with seismic source zones. In a similar fashion, the "susceptible" faults that should be characterized are those faults that lie within circles, centered on the location of the controlled area, whose radii are a function of earthquake magnitude and the vibratory ground motion attenuation determined for the region. Each radius represents the distance at which vibratory ground motion of a particular magnitude earthquake would be attenuated to the equivalent of 0.1g, the acceleration of minimum concern at the location of the controlled area.

It is generally observed that vibratory ground motion at depth is less than that observed on the surface above the underground observation point for sources at some distance from the observation points (Marine, 1982). Obviously, if the underground facility is to encompass "susceptible" faults, and these faults experience movement resulting in earthquakes, then there will exist some zone surrounding the faults where vibratory ground motion might

exceed that experienced at the surface. It might be necessary to identify the extent of such zones of potentially higher vibratory ground motion.

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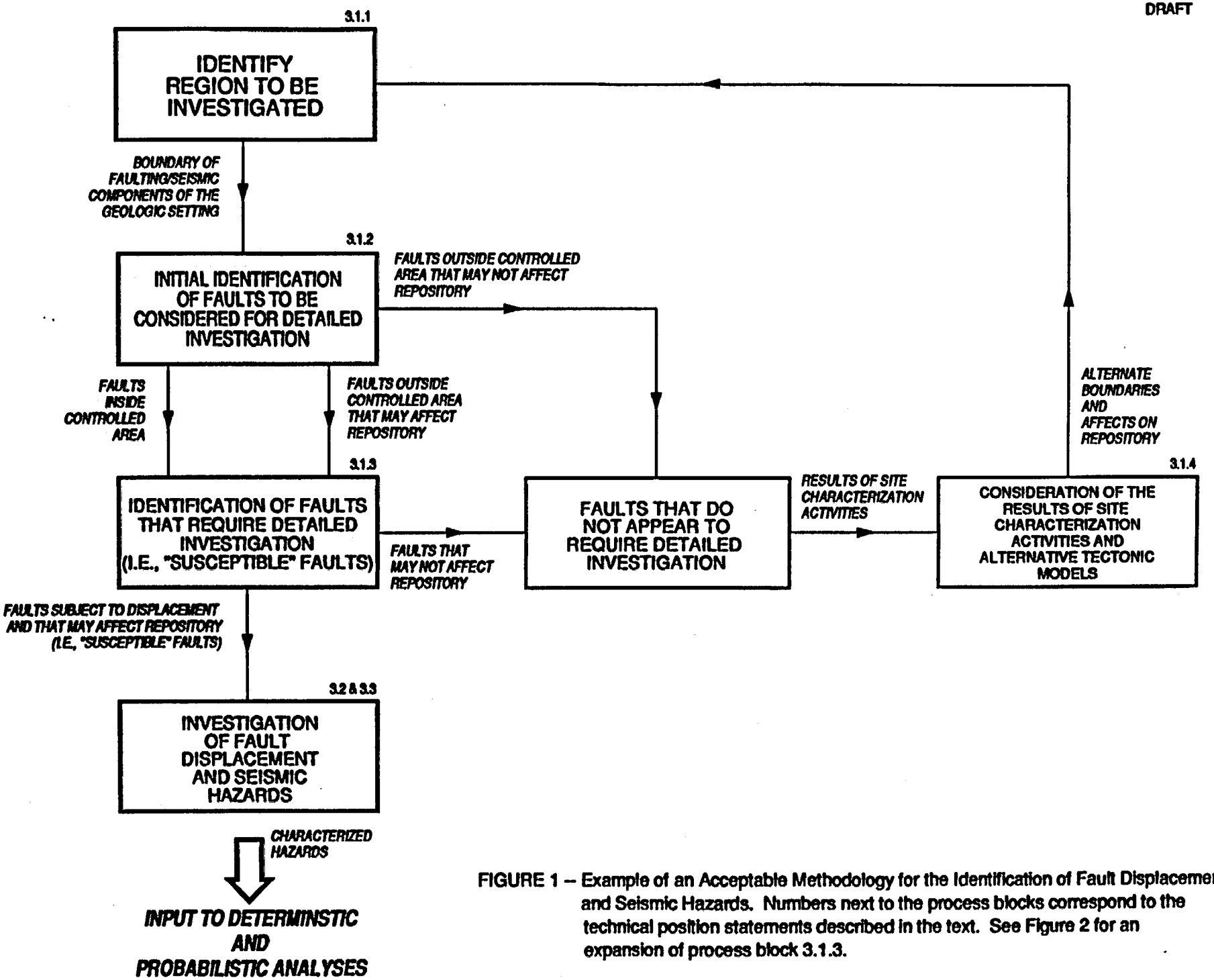

FIGURE 1 – Example of an Acceptable Methodology for the Identification of Fault Displacement and Seismic Hazards. Numbers next to the process blocks correspond to the technical position statements described in the text. See Figure 2 for an expansion of process block 3.1.3.

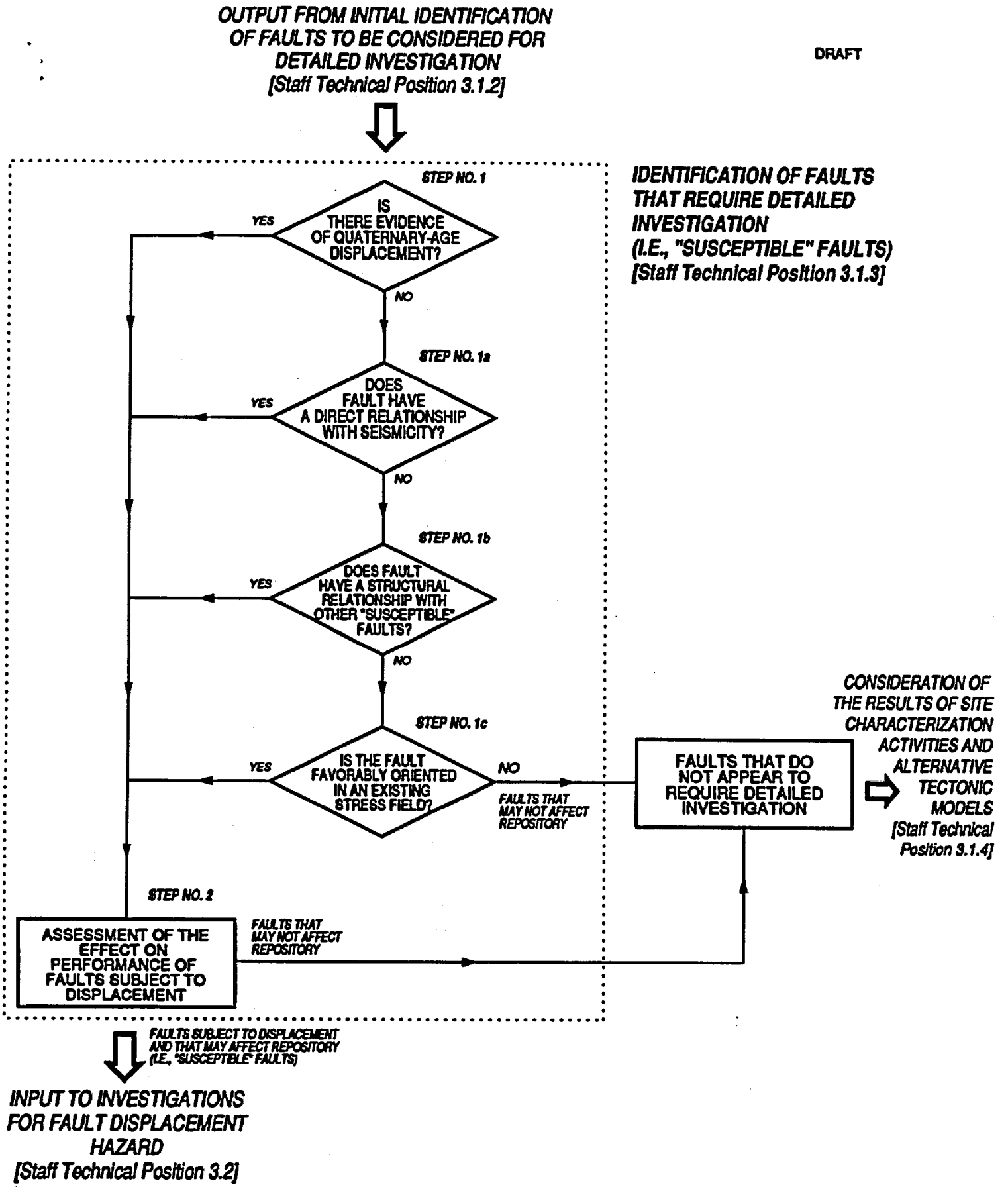

FIGURE 2 -- Staff Technical Position 3.1.3: Detail to the "Approach to the Identification of Faults that Require Detailed Investigation (i.e., "susceptible" faults)." Refer to the text for the discussion of this two-step process. Also see Figure 1.

APPENDIX A GLOSSARY

As used in this guidance:

"Controlled Area[1] " means a surface location, to be marked by suitable monuments, extending horizontally no more than 10 kilometers in any direction from the outer boundary of the underground facility, and the underlying subsurface, which area has been committed to use as a geologic repository and from which incompatible activities would be restricted following permanent closure.

A "Susceptible fault" is a fault that is:
1) subject to displacement; and 2) affect the design or performance of structures, systems, and components important to safety, containment, or waste isolation; and/or (3) will provide significant input into models used in assessments of design or performance of structures, systems, and components facilities important to safety, containment, or waste isolation.

"Geologic Setting[1] " means the geologic, hydrologic, and geochemical systems of the region in which a geologic repository operations area is or may be located.

"Seismic hazard" is a set of conditions, based on the potential for the occurrence of earthquakes, that might operate against the health and safety of the public. Seismic hazard may be characterized in either deterministic or probabilistic terms.

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1 U.S. Code of Federal Regulations, Title 10, "Energy."

"Seismic source zone" is assumed to be a planar representation of a three dimensional domain with similar tectonic features in which all potential earthquakes occurring will have the same characteristics such as constant spacial and temporal occurrences and identical maximum magnitude (modified from Bernreuter, et al., 1988).

"Site' " means the location of the controlled area.

For definitions of other relevant terms, see 10 CFR 60.2.

APPENDIX B APPLICABLE 10 CFR PART 60 REGULATIONS

60.21(c)(1)

(c) The Safety Analysis Report shall include:

(1) A description and assessment of the site at which the proposed geologic repository operations area is to be located with appropriate attention to those features of the site that might affect geologic repository operations area design and performance. The description of the site shall identify the location of the geologic repository operations area with respect to the boundary of the accessible environment.

(i) The description of the site shall also include the following information regarding subsurface conditions. This description shall, in all cases, include such information with respect to the controlled area. In addition, where subsurface conditions outside the controlled area may affect isolation within the controlled area, the description shall include such information with respect to subsurface conditions outside the controlled area to the extent such information is relevant and material.

(ii) The assessment shall contain:

(A) An analysis of the geology [and] geophysics ... of the site[.]

60.21(c)(1)(ii)(D)

[The assessment of the site at which the proposed geologic repository operations area is to be located, that is to be included in the Safety Analysis Report of the license application, shall contain:] (D) The effectiveness of engineered and natural barriers, including barriers that may not be themselves a part of the geologic repository operations area, against the release of radioactive material to the environment. The analysis shall also include a comparative evaluation of alternatives to the major design features that are important to waste isolation, with particular attention to the alternatives that would provide longer radionuclide containment and isolation.

60.21(c)(3)

[The Safety Analysis Report of the license application shall include:] (3) A description and analysis of the design and performance requirements for structures, systems, and components of the geologic repository which are important to safety. This analysis shall consider -- (i) The margins of safety under normal conditions and under conditions that may result from anticipated operational occurrences, including those of natural origin; and (ii) the adequacy of structures, systems, and components provided for the prevention of accidents and mitigation of the consequences of accidents, including those caused by natural phenomena.

60.111 Performance of the geologic repository operations area through permanent closure.

(a) Protection against radiation exposures and releases of radioactive material. The geologic repository operations area shall be designed so that until permanent closure has been completed, radiation exposures and radiation levels, and releases of radioactive materials to unrestricted areas, will at all times be maintained within the limits specified in Part 20 of this chapter and such generally applicable environmental standards for radioactivity as may have been established by the Environmental Protection Agency.

(b) Retrievability of waste. (1) The geologic repository operations area shall be designed to preserve the option of waste retrieval throughout the period during which wastes are being emplaced and, thereafter, until the completion of a performance confirmation program and Commission review of the information obtained from such a program. To satisfy this objective, the geologic repository operations area shall be designed so that any or all of the emplaced waste could be retrieved on a reasonable schedule starting at any time up to 50 years after waste emplacement operations are initiated, unless a different time period is approved or specified by the Commission. This different time period may be established on a case-by-case basis consistent with the emplacement schedule and the planned performance confirmation program.

(2) This requirement shall not preclude decisions by the Commission to allow backfilling part or all of, or permanent closure of, the geologic repository operations area before the end of the period of design for retrievability.

(3) For purposes of this paragraph, a reasonable schedule for retrieval is one that would permit retrieval in about the same time as that devoted to construction of the geologic repository operations area and the emplacement of wastes.

60.112 Overall system performance objective for the geologic repository after permanent closure.

The geologic setting shall be selected and the engineered barrier system and the shafts, boreholes and their seals shall be designed to assure that releases of radioactive materials to the accessible environment following permanent closure conform to such generally applicable environmental standards for radioactivity as may have been established by the Environmental Protection Agency with respect to both anticipated processes and events and unanticipated processes and events.

60.113 Performance of particular barriers after permanent closure.

(a) General provisions -- (1) Engineered barrier system. (i) The engineered barrier system shall be designed so that assuming anticipated processes and events: (A) Containment of HLW will be substantially complete during the period when radiation and thermal conditions in the engineered barrier system are dominated by fission product decay; and (B) any release of

radionuclides from the engineered barrier system shall be a gradual process which results in small fractional releases to the geologic setting over long times. For disposal in the saturated zone, both the partial and complete filling with ground water of available void spaces in the underground facility shall be appropriately considered and analyzed among the anticipated processes and events in designing the engineered barrier system.

(ii) In satisfying the preceding requirement, the engineered barrier system shall be designed, assuming anticipated processes and events, so that:

(A) Containment of HLW within the waste packages will be substantially complete for a period to be determined by the Commission taking into account the factors specified in 10 CFR 60.113(b) provided, that such period shall be not less than 300 years nor more than 1,000 years after permanent closure of the geologic repository; and

(B) The release rate of any radionuclide from the engineered barrier system following the containment period shall not exceed one part in 100,000 per year of the inventory of that radionuclide calculated to be present at 1,000 years following permanent closure, or such other fraction of the inventory as may be approved or specified by the Commission; provided, that this requirement does not apply to any radionuclide which is released at a rate less than 0.1 percent of the calculated total release rate limit. The calculated total release rate limit shall be taken to be one part in 100,000 per year of the inventory of radioactive waste, originally emplaced in the underground facility, that remains after 1,000 years of radioactive decay.

(2) Geologic setting. The geologic repository shall be located so that pre-waste-emplacement ground water travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment shall be at least 1,000 years or such other travel time as may be approved or specified by the Commission.

(b) On a case-by-case basis, the Commission may approve or specify some other radionuclide release rate, designed containment period or pre-waste-emplacement ground-water travel time, provided that the overall system performance objective, as it relates to anticipated processes and events, is satisfied. Among the factors that the Commission may take into account are:

(1) Any generally applicable environmental standard for radioactivity established by the Environmental Protection Agency;

(2) The age and nature of the waste, and the design of the underground facility, particularly as these factors bear upon the time during which the thermal pulse is dominated by the decay heat from the fission products;

(3) The geochemical characteristics of the host rock, surrounding strata and ground water;and

(4) Particular sources of uncertainty in predicting the performance of the geologic repository.

(c) Additional requirements may be found to be necessary to satisfy the overall system performance objective as it relates to unanticipated processes and events.

60.122(a)(2) Siting Criteria.

[Selected requirements considered directly or indirectly related to seismic hazard]

(2) If any of the potentially adverse conditions specified in paragraph (c) [60.122(c)] of this section is present, it may compromise the ability of the geologic repository to meet the performance objectives relating to the isolation of waste. In order to show that a potentially adverse condition does not so compromise the performance of the geologic repository the following must be demonstrated:

(i) The potentially adverse human activity or natural condition has been adequately investigated, including the extent to which the condition may be present and still undetected taking into account the degree of resolution achieved by the investigations; and

(ii) The potentially adverse human activity or natural condition on the site has been adequately evaluated using analyses which are sensitive to the potentially adverse human activity or natural condition and assumptions which are not likely to underestimate its effect; and

(iii)(A) The potentially adverse human activity or natural condition is shown by analysis pursuant to paragraph (a)(2)(ii) of this section not to affect significantly the of the geologic repository to meet the performance objectives relating to the isolation of waste, or

(B) The effect of the potentially adverse human activity or natural condition is compensated for by the presence of a favorable combination of the favorable characteristics so that the performance objectives relating to the isolation of waste are met, or

(C) The potentially adverse human activity or natural condition can be remedied.

60.122(c) Potentially adverse conditions.

[Selected conditions considered directly or indirectly related to seismic hazard]

(c) Potentially adverse conditions. The following conditions are potentially adverse conditions if they are characteristic of the controlled area or may affect isolation within the controlled area.....

(3) Potential for natural phenomena such as landslides, subsidence, or volcanic activity of such a magnitude that large-scale surface water impoundments could be created that could change the regional ground-water flow system and thereby adversely affect the performance of the geologic repository.

(4) Structural deformation, such as uplift, subsidence, folding, or faulting that may adversely affect the regional ground-water flow system.

(11) Structural deformation such as uplift, subsidence, folding, and faulting during the Quaternary Period.

(12) Earthquakes which have occurred historically that if they were to be repeated could affect the site significantly.

(13) Indications, based on correlations of earthquakes with tectonic processes and features, that either the frequency of occurrence or magnitude of earthquakes may increase.

(14) More frequent occurrence of earthquakes or earthquakes of higher magnitude than is typical of the area in which the geologic setting is located.

60.131(b)(1) Protection against natural phenomena and environmental conditions.

[With respect to the general design criteria for the geologic repository operations area.]

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

APPENDIX C DISPOSITION OF PUBLIC COMMENTS ON AUGUST 24, 1989 DRAFT TECHNICAL POSITION

Notice: Throughout this comment response package "technical position (TP)" refers to the public comment draft technical position, dated August 24, 1989 (54 FR 35266), and "STP" refers to the current staff technical position.

DEPARTMENT OF ENERGY (DOE) COMMENTS

MAJOR DOE COMMENTS

1. As the draft technical position points out, 10 CFR Part 60 does not rely on 10 CFR Part 100, Appendix A for guidance regarding provisions for dealing with seismic hazard. There are two reasons that this omission was deliberate. (1) The provisions of Part 100 were written with operating nuclear power plants in mind, not waste disposal systems. Disposal systems lack the active cooling systems and energetic physical mechanisms for dispersing contaminates, which nuclear power plants possess. (2) Appendix A to Part 100, written over 25 years ago, no longer reflects state-of-the-art professional practice in characterizing seismic hazards and developing seismic design bases. Its application has been found to be too prescriptive in some areas, too vague in others, and generally difficult to apply without creating considerable controversy. In addition, some of the methodologies in Appendix A may be particularly inappropriate for application in the Basin and Range Province, where recurrence intervals for earthquakes on particular faults are typically tens of thousands of years.

   For the reasons given above, the DOE strongly disagrees with the proposition that 10 CFR Part 100, Appendix A should be considered as general guidance for the characterization of seismic hazards and the development of seismic design bases for a geologic repository. If the NRC believes there are specific methodologies from Appendix A that are directly applicable to a geologic repository and are more appropriate than

the studies described in the Site Characterization Plan (SCP), then those methodologies should be specifically identified in a "stand alone" guidance document without reference to Appendix A. This would eliminate many of the problems that are inherent in applying a rule designed for nuclear reactor regulation to a geologic repository.

RESOLUTION

This comment is noted. Neither the public comment draft nor the current STP should be construed to mean that the NRC staff is advocating the application of 10 CFR Part 100, Appendix A, to a geologic repository. Instead, 10 CFR Part 100, Appendix A, should be considered to be a departure point from which the NRC staff has developed specific guidance on investigations to identify fault displacement and vibratory ground motion hazards affecting a geologic repository. This concept has been clarified in the current STP.

2. Page 4, Section 2.4

The technical position states that: "Appendix A sets an important precedent that needs to be considered when new types of nuclear facilities that require seismic hazard review are considered for licensing."

We agree with this statement, however, there is no evidence that the other regulations which refer to Appendix A, (i.e., 10 CFR Part 72 and 10 CFR Part 40) or this draft technical position, have made that important consideration.

10 CFR Part 100, Appendix A, appears to have been used in licensing other nuclear facilities in the United States principally because it is the only regulation for nuclear facilities that provides detailed instructions for seismic-hazard investigations.

The Department notes that a recent revision of DOE Order 6430.1A (U.S. Department of Energy General Design Criteria), which is applicable to non-reactor DOE facilities, incorporates state-of-the-art criteria for seismic design, including specific criteria for vibratory ground motion input and seismic engineering analytical methods. The approach described in DOE Order 6430.1A may be of sufficient scope and conservatism to meet the appropriate 10 CFR 60 requirements.

RESOLUTION

The TP states that: "Reliance on Part 100, Appendix A sets an important precedent that needs to be considered when new types of nuclear facilities that require seismic hazard review are considered for licensing." This concept was misquoted in the comment through the ommission of the text underlined above. It is the reliance on Appendix A, not Appendix A itself, that sets a precedent. This concept may be found in the statement of considerations for the proposed rule, 10 CFR Part 60, that was noticed in the Federal Register on July 8, 1981. In this notice, it is stated that, "DOE activities at a geologic repository operations area may in appropriate cases be licensed under other parts of NRC regulations and would then not be governed by these [10 CFR Part 60] technical criteria." Further on, the discussion states, "This allows an independent spent fuel storage installation [ISFSI] to be licensed under Part 72, even though located at a geologic repository operations area (provided, of course, it is sufficiently separate to be classified as 'independent')." If geologic repository operations area surface facilities are sufficiently similar to an ISFSI and are sufficiently independent of the underground facility, then it would seem that the surface facilities could be licensed under 10 CFR Part 72. In the current STP, this course was not followed. Instead, 10 CFR Part 100, Appendix A, was chosen as a point of departure to develop guidance on investigations to identify fault displacement and vibratory ground motion hazards.

3. Page 10, Section 4.3

The TP states that "a primary reason for taking the position that Part 100, Appendix A is an appropriate methodology for investigating the seismic hazard at a geologic repository is that much of the technology presented in Part 100, Appendix A is generic in nature."

We disagree; Appendix A is not generic. If it were, why would it apply to only some cases? For example, according to 10 CFR Part 72, Appendix A applies West of the Rocky Mountain Front, but does not apply East of the Front. Likewise, Appendix A applies to massive water basin and air-cooled canyon types of independent spent fuel storage installations (ISFSI), but may not apply to other types of ISFSI designs, such as canisters, casks, or silos. It appears that Appendix A applies only where potential risk warrants. In our opinion, Appendix A should not apply to a repository at Yucca Mountain, in part, because the potential risks are lower than most other nuclear facilities.

Any design methodology must reflect the risks associated with the engineered facility, as well as the hazards posed by the Earth. Although design-basis methodology prescribed by Appendix A is appropriate for nuclear power plants, it is not necessarily appropriate for lower-risk facilities, such as a high-level waste repository, or generic to all tectonic environments.

Even this TP admits that nuclear power plants (for which Appendix A was written) pose a greater risk than a repository. The TP states that, "in contrast to a nuclear power plant, a geologic repository is not likely to have components possessing high energy driving forces capable of broadly dispersing the contained radioactivity. Even with a gross failure of those components of a repository involved in containment, a loss of containment integrity would not be as likely to have as significant a consequence for public health and safety as a nuclear power plant, because the systems would be passive."

The NRC staff uses the above statement to explain why the TP does not consider the Appendix A requirements for an operating basis earthquake. We agree this statement, and suggest that it also justifies rejecting the concept of the applicability of 10 CFR 100, Appendix A.

In addition to its biased (rather than generic) nature, Appendix A has been criticized by the NRC and industry. Appendix A was codified in November 1973, and was largely based on professional practice and state-of-the-art in the 1960's and early 1970's. Since that time, there have been numerous technical advancements in evaluating fault and earthquake hazards, particularly in probabilistic evaluations. It would be counterproductive to ignore these advancements simply for the sake of complying with an less than current regulation.

In the late 1970's, the NRC considered revising Appendix A because, even at that time, the regulation was considered outdated, complicated and the cause of licensing delays. The NRC staff summarized these problems as follows:

> Having geoscience assessments detailed and cast in Appendix A, a regulation, has created difficulty for applicants and the staff in terms of inhibiting the use of needed judgment and latitude. Also, it has inhibited flexibility in applying basic principles to new situations and the use of evolving methods of analyses in the licensing process. Additionally, various sections of Appendix A lack clarity and are subject to different interpretations and dispute. Also, some sections in the Appendix do not provide sufficient information for implementation. As a result of being both overly detailed in some areas and not detailed enough in others, the Appendix has been the source of licensing delays and debate, has inhibited the use of some types of analyses, and has inhibited the development of regulatory guidance (SECY-79-300, April 27, 1979).

More recently, at an October 1986 symposium on seismic and geologic siting criteria for nuclear power plants, the technical community renewed the drive to revise Appendix A. The symposium found a number of problems with Appendix A, but the most important was the need to incorporate probabilistic concepts into the regulation with an appropriate mix of deterministic criteria. At that time, the NRC staff stated that their management may not endorse a rule-making until 1987 (Lawrence Livermore National Laboratory, Summary Report of the symposium on Seismic and Geologic Siting Criteria for Nuclear Power Plants, NUREG/CP-0087, June 1987).

Design notions, derived from Appendix A, can misstate the seismic hazards in some tectonic environments, because Appendix A specifies that design motions be estimated without specific consideration of the style of deformation particular to a tectonic environment. The Appendix A specification of the Safe Shutdown Earthquake requires a review of the historic distribution of earthquake magnitudes and intensities, the distribution of tectonic structures, and "capable faults". For an Appendix A site motion evaluation, the largest earthquake(s) would be placed at locations closest to the site on geologic structures or at seismotectonic boundaries. Where the largest historic earthquakes cannot be associated with a geologic structure, that earthquake will be located at the closest point within the tectonic province. For an application of Appendix A to a critical facility in the vicinity of a major fault, a "maximum" earthquake magnitude is determined from historical correlations between earthquake magnitude and corresponding surface fault rupture. A common way to estimate maximum earthquake magnitude is to take a point estimate from a statistical distribution of empirical correlations between earthquake magnitude and the length of mapped surface fault traces.

Application of this methodology to active fault segments in the Southern Great Basin could lead to unconservative or uncertain design earthquakes because of the relatively complicated nature of faulting in an extensional

environment, and the corresponding difficulty of estimating, a priori, maximum fault rupture lengths.

Yucca Mountain has been characterized as having a number of closely spaced (2-4 km) anastomosing normal faults (Scott and Bonk, 1984). Thus, estimating maximum fault length and correspondingly "maximum" earthquake magnitude for any surface rupture scenario is extremely difficult, and could easily be under or overestimated. This difficulty is compounded as a result of the paucity of instrumental seismicity to define continuity in a fault trace.

Given these problems with application of Appendix A, we disagree with its imposition for the repository. The SCP offers an approach and methodology, based on a Cumulative Slip Earthquake (CSE), that would better postulate a design basis earthquake. A CSE is defined in the SCP to be a postulated earthquake that occurring every 10,000 years, would produce the observed or estimated average Quaternary slip rate on a fault. The CSE approach results in a design basis with a corresponding exceedance probability between 10-3 and 10-4 per year.

Preliminary information indicates that the CSE methodology will produce a sufficient seismic design basis for surface facilities important to safety during the preclosure period of repository operation. Specifically, preliminary analysis indicates the resulting seismic design basis would correspond to a postulated earthquake on the Paintbrush Canyon fault (an apparently normal fault located about 1 kilometer east of prospective surface waste-handling facilities) with a magnitude of about 6 to 6 and a peak ground acceleration at the site of about 0.5 to 0.6g. A recent analysis of alternative seismic design levels (SAND 88-1600, "Preliminary Seismic Design Cost-Benefit Assessment of the Tuff Repository Facilities") suggests that the accident risks associated with a seismic design level of 0.2g or greater for surface waste-handling facilities would be extremely small. Important factors which contribute to this finding are that the surface facility cells would be inherently "hard" against seismic loading,

because of shielding requirements and the resulting thick shear-wall construction, the low probability of severe ground motion during the operating life of the facility and the lack of an energetic mechanism for dispersing contaminants during an accident. In addition, the target range of exceedance probabilities 10-3 to 10-4 per year) for the design basis has been found to correspond to the accepted design bases for a number of U.S. nuclear power plants (Reiter and Jackson, 1983, NUREG-0967), lending further confidence that the CSE methodology will provide more than sufficient conservatism.

Before the NRC issues this TP, we would like an opportunity to build on the concept of a CsE and offer an alternative to Appendix A. Basically, we propose a more risk-based approach to assessing hazards where risk is the integrated product of event probability and consequences. Hazard would then be defined as the probability of exceeding a specified event magnitude.

Although it postdates Appendix A, there is nothing new about a risk based approach. The Environmental Protection Agency (EPA) Standards for geologic repository (50 FR 38066 September 19, 1985) translates an acceptable risk (1,000 health effects to a world population) into limits for cumulative releases and recommends a complementary cumulative distribution function to express the hazard (1 chance in 10 and 1 chance in 1,000) of exceeding multiples of those limits. More recently, the EPA proposed "National Emissions Standards for Hazardous Air Pollutants; Regulation of Radionuclides; Proposed Rule and Notice of Public Hearing" (40 CFR Part 61, 54 FR 9612 March 7, 1989). Here, the EPA proposes three levels of risk, each corresponding to a radiation dose. The final rule will codify one of these doses to limit the radioactive emissions from nuclear and non-nuclear industries.

This risk based approach has clear advantages over Appendix A. Collegial recommendations, such as those made by the International committee on Radiation Protection, have established values for an acceptable risk.

However, various licensing boards, as well as utilities, have never agreed to what constitutes the maximum earthquake that Appendix A expounds. Risk takes into account the nature of the facility and its site. Appendix A examines only the site and was written for nuclear power plant sites, not repositories. Finally, risk assessments can more equitably allocate the design precautions needed to protect the public health and safety. Appendix A would force an unnecessary (and expensive) design basis on a repository without a commensurate benefit to the public.

Unlike Appendix A, a risk-based approach would account for the reduced seismic hazards in areas, such as Yucca Mountain, where the deformation rate is low. The historic rate of seismicity in the Southern Great Basin (SGB) can be characterized by the average annual number of earthquakes of magnitude 4.0 and greater (denoted N4) per 1,000 sq km. For the SGB, N4 is approximately 0.01 events/1,000 sq km (Greensfelder et al., 1980). This rate of seismicity is extremely low compared to interplate seismotectonic environments, (i.e. southern California), where seismic hazards are common design considerations. Using a conservative value for N4 of 0.015 earthquakes per 1,000 sq km for the rate of seismicity in the Yucca Mountain area, this value of seismicity is about a factor of ten less than the Los Angeles Basin area of southern California. An example of the critical nature of relative deformation rates are comparisons of the preliminary probabilistic hazards between southern California and the Yucca Mountain vicinity. Preliminary estimates of the probability of exceeding peak ground motion indicates return periods an order of magnitude greater than that estimated for similar levels of motion for the Los Angeles Basin, a region that supports a variety of critical facilities. Preliminary geologic trenching data in the vicinity of the site also supports low deformation rates: apparent vertical slip rates on Quaternary faults are between 0.001 to 0.0001 cm/yr (SCP section 1.5.2.2). The pre- and postclosure design methodology should account for the tectonic deformation rate, otherwise an inconsistent design basis will occur. For example, a maximum earthquake magnitude cannot define the difference in seismic hazard between a fault that can produce a magnitude

7 earthquake in 100 years, and one that produces a magnitude 7 every 100,000 years. A consistent and defensible design basis must account for the level of hazard.

RESOLUTION

This comment only briefly addresses matters of consideration in this STP. The purpose of this STP is to identify fault displacement and vibratory ground motion hazards that can affect a geologic repository. Consideration of the development of design bases for fault displacement and vibratory ground motion is the subject of an ongoing staff effort. This STP does not defer to the prescriptions of 10 CFR Part 100, Appendix A, as guidance for conducting investigations to identify the hazards affecting a geologic repository. Instead, this STP considers 10 CFR Part 100, Appendix A, as a point of departure from which guidance on adequate investigations for a geologic repository may be developed. No matter what type of method is employed to develop design bases, that method must be based on sound data gathered through adequate investigations of the nature of the seismicity and tectonic deformation in the vicinity of a proposed geologic repository. This pursuit is not unlike that set forth in the requirements of 10 CFR Part 100, Appendix A. The current draft STP makes the distinction between investigations for a geologic repository and those for a nuclear power plant more clear. The design considerations present in the public comment draft of the STP have been removed from this draft of the STP, and these considerations will be addressed in an ongoing staff effort.

4. Page 13, Section 4.3.2

The TP states that "Section V(a)(1) (of Part 100, Appendix A) prescribes a set of specific steps to take in evaluating the data gathered through the required investigations, to arrive at the earthquake that produces maximum vibratory acceleration at the site above a threshold of 0.1g. This earthquake is termed the Safe Shutdown Earthquake (SSE). These basic

procedures form the framework for establishing the determination of the maximum vibratory motion at any site at relevant times and are therefore considered to be appropriate to a geologic repository.

The underscored phrases have little meaning when applied to a repository that has been closed and decommissioned.

The TP states that the maximum vibratory ground motion would be predicted "at the site." Appendix A, in contrast, states that the motion would occur at each of the various foundation locations of the nuclear power plant structures at a given site" (10 CFR 100, Appendix A, Section V(a)(1)(iv)).

The repository site would be at least as large as the controlled area, which according to 40 CFR 191.12(g), encompasses 100 square kilometers and would extend underground. The foundation locations are smaller, more discrete and lie on the surface. Conceivably, Appendix A could be applied to repository surface facilities, but Appendix A could not be applied to a large mass of earth. Moreover, a closed repository has no surface facilities.

We disagree that Appendix A applies during time periods that are relevant to a geologic repository. Appendix A was written for nuclear power plants which have an operational life of about 40 years. Because of the relative short lifetime of the facility and the safety concern being addressed (ability to safely shut down the reactor), the Appendix A methodology relies on the concept of designing for a single, large event ("maximum credible event occurring on a specific fault. While this concept may ensure power-plant safety for 40 years, it is not suitable for evaluating repository performance.

Instead of Appendix A, we propose a more probabilistic methodology that would take into account not only the effects of single, but also the cumulative effects of multiple events that are reasonably likely to occur

during the postclosure time period. We suggest that, if the TP is issued, the last sentence should be revised to read: "These basic procedures form the framework for establishing the seismic basis for determination of the maximum vibratory motion at repository surface facilities during the operational phase (Revisions are underscored.)

RESOLUTION

This comment addresses design issues, and not issues concerning investigations necessary to identify fault displacement and vibratory ground motion hazards. Text regarding guidance on design issues is not in the current STP. These issues are being addressed in an ongoing staff effort addressing fault displacement and vibratory ground motion hazard analysis.

5. Page 7, Section 3

The TP states that "...it is the position of the staff that the results of Part 100, Appendix A investigations can generally provide input for probabilistic and other methods of assessing seismic and faulting hazards for the postclosure period."

Appendix A recommends an investigative methodology that is not appropriate for assessing seismic and faulting hazards for the postclosure period. The prescribed investigations gather information that hypothesizes the vibratory ground motion produced by the Safe Shutdown Earthquake (SSE), which:

> "Produces the maximum vibratory ground motion for which certain structures, systems, and components are designed to remain functional. These structures, systems, and components are those necessary to assure: (1) The integrity of the reactor coolant pressure boundary, (2) The capability to shut down the reactor and maintain it is a safe shutdown condition, or (3) The capability to

RESOLUTION

This comment is noted. The purpose of this STP is to give guidance on investigations to identify fault displacement and vibratory ground motion hazards that affect a geologic repository. The input parameters, together with their uncertainties, which are the subject of this comment, are considered to be the products of such investigations. The topic of fault displacement and vibratory ground motion hazard analysis, which includes an assessment of the sensitivity of the input parameters, will be addressed in an ongoing staff effort.

5. Page 11, Section 4.3.1(6) and Page 13, Section 4.3.2

Appendix A requires the correlation of past earthquakes with capable faults, tectonic structures and tectonic provinces. However, Appendix A does not specify a method for quantifying future rates of activity, including determining a maximum credible earthquake. We believe that more definitive criteria than that provided in Appendix A are needed to avoid conflicting interpretations.

RESOLUTION

See staff response to DOE major comment #5.

6. Page 14, Section 4.3.2

The TP states that "...any guidelines [Section V(b) of Part 100, Appendix A] for surface faulting should be considered applicable to the underground facility of a geologic repository as well, since it is very unlikely that a fault that ruptures the surface above the underground facility would not also create a rupture within the underground facility."

prevent or mitigate the consequences of accidents which could result in potential off site exposures comparable to the guideline exposures of this Part" (10 CFR Part 100, Appendix A, III. Definitions).

The terms and concepts included in the definition of the SSE do not exist at a repository that has been permanently closed. A repository has no "coolant pressure boundary"; a closed repository cannot be "shut down"; and there can be no "accidents" at a closed repository, because the operations have stopped.

RESOLUTION

See staff reposnse to DOE major comment #1.

OTHER DOE COMMENTS

1. Page 1, Section 1

The introduction states that the technical position "...considers differences that may exist, during the preclosure, among the surface facilities and the underground facility." However, this consideration is not apparent in the remaining text of the technical position.

RESOLUTION

The staff notes DOE's concern and the statement that prompted it has been removed from the Introduction (in Section 1.0). Acceptable investigations for faulting and vibratory ground motion underground are discussed in Section 3.0 in the current STP.

2. Page 1, Section 1

Section 1 states that the purpose of the technical position is to provide: "...regulatory guidance to the U.S. Department of Energy (DOE) on appropriate methodologies that address seismic hazard at a geologic repository."

Later, in the same Section, it is stated that: "this position does not address probabilistic seismic hazard analysis...[which is] ...addressed in other technical positions...."

Additionally, Section 3 (page 7) states that: "...the results of Part 100, Appendix A investigations can generally provide input for probabilistic and other methods of assessing seismic and faulting hazards for the postclosure period." Based on such conflicting statements, we find it difficult to understand this draft technical position without understanding the NRC position on probabilistic seismic hazard evaluations, especially since the evaluations specified in 10 CFR Part 100, Appendix A are deterministic.

RESOLUTION

The staff notes DOE's concern. The intended distinction between this STP and an ongoing staff effort on faulting and seismic hazard analysis has been heightened in the current STP. Accordingly, the purpose of the STP (in Section 1.0) has been rewritten to clarify that the STP "...is to provide regulatory guidance to ... DOE on appropriate investigations that can be used to identify fault displacement and seismic hazards at a geologic repository." [Emphasis added] The types of investigations discussed in this STP are, by their nature, considered to be deterministic. The investigations are expected to establish where and to what extent fault displacement and vibratory ground motion hazards may be present in the vicinity of a proposed geologic repository based on relationships that have been developed by the fields of tectonics and seismology through the observation and measurement of past earthquakes and

tectonic deformation. The ongoing staff effort on fault displacement and seismic hazard analysis is concentrating on methods the NRC staff considers to be appropriate for assessing the risk involved in locating and operating a geologic repository amongst fault displacement and vibratory ground motion hazards. It is expected that these methods will involve probabilistic analysis. It can be argued that the types and extent of investigations used to identify the fault displacement and vibratory ground motion hazards should be driven by goals defined in the performance objectives. This is a reasonable approach if the performance of structures, systems, and components important to safety, containment, or waste isolation are well determined for a variety of fault displacement and vibratory ground motion hazards. If the performance is not well known, then the types and extent of investigations to be conducted should be determined in such a manner that they would conceivably lead to the identification of all fault displacement and vibratory ground motion hazards present that are sufficient to establish input to design bases that will assume that relevant performance objectives will be met.

3. Page 5, Section 2.5

The technical position states that: "10 CFR Part 60 does not specifically rely on Part 100, Appendix A for guidance regarding provisions for dealing with the seismic hazard nor does it specifically require the development of a design basis earthquake. Instead, the performance objectives and siting and design criteria described in 10 CFR Part 60 establish the bases for considering seismic hazard for both the preclosure and the postclosure periods."

We agree, with the above statement and consider that the omission of references to 10 CFR Part 100, Appendix A was deliberate.

10 CFR Part 100, Appendix A was codified in the regulations and available for consideration at the time 10 CFR Part 60 was promulgated. However, as stated in the supplementary information to the proposed 10 CFR Part 60

rule on disposal of high-level radioactive waste in geologic repositories dated July 8, 1981 (46 FR 35280), the Commission considered their past experience and practice with other facilities and acknowledged that there were important differences between a repository and those facilities. We must conclude that if the Commission believed Appendix A to be applicable to a geologic repository, it would have codified the Appendix in the regulation at that time.

Since 10 CFR Part 60 was promulgated more than eight years ago, the NRC has concurred on the DOE siting guidelines, commented on the DOE environmental assessments, and reviewed and commented on the SCP. On any of these occasions, the relevance of Appendix A to the repository program could have been raised, but was not. Moreover, the NRC staff agreed with the DOE that: "the need to consider specific pre-closure and post-closure events, processes, and phenomena should be based upon a consideration of their effects on compliance with the performance requirements of 10 CFR 60" (summary of the NRC/DOE meeting on seismic/tectonic investigations, December 3-4, 1985).

RESOLUTION

See staff reposnse to DOE major comment #5.

4. Page 10, Section 4.3.1

Since Appendix A details the required geoscience assessments, the use of evolving methods, such as probabilistic seismic hazard analysis (PSHA), which is a generally accepted procedure to describe the seismic hazard (National Research Council, 1988), is limited. State-of-the-art seismic zoning maps rely to some degree on probabilistic considerations to assess relative hazards at different sites. As described in the SCP, the DOE plans to use PSHA to assess the sensitivity of input parameters and examine uncertainties in ground motion estimates.

We agree that surface faulting would be expressed underground, but disagree that guidelines for one should apply to the other.

The guidelines in Appendix A clearly apply to the foundations of nuclear power plants. There are no "foundations" underground. Moreover, Appendix A was never written for mines, and the NRC has recognized this. Otherwise it would have referenced Appendix A in 10 CFR Part 60, instead of the Federal Mine Safety and Health Act of 1977 and the mining regulations of Title 30, the Code of Federal Regulations.

RESOLUTION

See staff reposnse to DOE major comment #4.

7. Page 14, Section 4.3.2

The technical position states that "...any faults discovered within the perimeter of the underground facility, through drifting or other means during site characterization, that cannot be associated with surface faults, require special investigation [given in Appendix A] similar to surface faults." It is not practical to investigate surface and subsurface faults in the same way. According to Section V(b) of 10 CFR Part 100, Appendix A fault traces "...are mapped along the trend of the fault for 10 miles in both directions from the point of its nearest approach to the nuclear power plant...." If a subsurface fault is not expressed on the surface, it cannot be mapped for more than a few feet.

RESOLUTION

The staff notes DOE's concern. However, the addition of the phrase "given in Appendix A" into the citation from the public comment draft subverts its intended meaning and only adds support to the conclusion in the following sentence. Faults encountered in the underground facility of a geologic

repository cannot be studied in the same manner as faults encountered on the surface. Instead, special emphasis should be given to the nature of the fault trace, its extent as observed in other openings, and its relation to the trends of faults identified as faults susceptible to displacement in the vicinity of the underground facility. Investigation of subsurface faults is discussed in Section 3.2 of the STP.

8. Page 7, Section 3

The TP states that: "...the NRC staff will review those sections of the SAR (Safety Analysis Report) addressing Subsections 60.21(c)(1)(ii)(B) and C and Subsection 60.21(c)(3) of 10 CFR Part 60, in light of Appendix A of 10 CFR Part 100. In addition, the methodology outlined in this TP can be used in developing seismic and geologic bases for earthquake design criteria pertinent to Subsection 60.131(b)(1) of 10 CFR Part 60 and in assisting in demonstrating compliance with sections 60.111, 60.112, and 60.113."

The underscored provisions require an assessment of repository postclosure performance. We fail to understand how these provisions could be reviewed "in light of Appendix A of 10 CFR Part 100" or how Appendix A could assist "in demonstrating compliance" with them.

Subsection 60.21(c)(1)(ii)(B) requires analyses of favorable and potentially adverse conditions as specified in 60.122. The right combination of these conditions will "provide reasonable assurance that the performance objectives relating to the isolation of the waste will be met" (10 CFR 60.122(a)(1)).

Note that the favorable and potentially adverse conditions are not related to repository construction and operation, but only to the "isolation of the waste". In contrast, the scope of Appendix A is to "provide reasonable assurance that a nuclear power plant can be constructed and

operated at a proposed site without undue risk to the health and safety of the public" (10 CFR 100, Appendix A, II Scope.)

We submit that the scope of 10 CFR 60.21(c)(1)(ii)(B) differs from the scope of 10 CFR 100 Appendix A, and therefore, compliance with the former cannot be demonstrated in light of the requirements of the latter.

Subsection 60.21(c)(1)(ii)(C) requires "an evaluation of performance of proposed geologic repository for the period after permanent closure, assuming anticipated processes and events, giving the rates and quantities of releases of radionuclides to the accessible environment as a function of time; and a similar evaluation which assumes the occurrence of unanticipated processes and events." As stated previously, the criteria in Appendix A were written for an operating nuclear facility; not one that has been permanently closed and decommissioned.

Also, 60.21(c)(1)(ii)(C) requires an assessment of anticipated processes and events, while Appendix A requires an assessment of a seismic event (the Safe Shutdown Earthquake) that originates along a "capable fault." Anticipated processes and events are based on "those processes operating in the geologic setting during the Quaternary Period" (last 1.8 million years) (pages A-1 and A-2). Capable faults, defined in Appendix A, exhibit one or more of the following characteristics:

1. At least one movement in the past 35,000 years, or multiple movements in the past 500,000 years;

2. Instrumental seismicity that can be correlated to a fault; and

3. A structural relationship to a fault described by 1 or 2 such that the movement on one could reasonably result in movement on the other.

There may be faults on which "anticipated" events have occurred in the Quaternary, but which occur at such low frequency (less than 2 events in the last 500,000 years) that the faults are not considered capable. This discrepancy between anticipated events and events originating along capable faults is particularly significant in the Basin and Range Province where intervals between faulting events may be 200,000 years or more on some faults. Thus, the postclosure performance evaluations in 10 CFR 60.21(c)(1)(ii)(C) are not congruent with the evaluations of capable faults prescribed in Appendix A.

Subsection 60.112 requires that releases of radioactive material following permanent closure "conform to such generally applicable environmental standards for radioactivity as may have been established by the Environmental Protection Agency [EPA] with respect to both anticipated processes and events and unanticipated processes and events."

The deterministic criteria in Appendix A are of limited utility, if any, for demonstrating compliance with the EPA's probabilistic standards. To determine compliance with 40 CFR 191.13, the EPA recommends a complementary cumulative distribution function "that indicates the probability of exceeding various levels of cumulative release" (40 CFR 191, Appendix B).

These release probabilities will be derived from the probabilities of processes and events that cause the releases. The EPA states that the DOE may discount certain processes and events of low probability or if omission does not significantly affect the remaining probability distribution of cumulative releases.

In contrast, Appendix A would compel the DOE to assess the consequences of a "maximum earthquake," the "maximum vibratory ground motion," and the epicenters of earthquakes of "greatest magnitude" or the locations of "highest intensity." The superlatives: "maximum"' "greatest," and "highest" loose meaning when signifying the types of events that may occur

in the next 10,000 years. This would lead to extended debate of limited practical utility regarding what such an event might be. Also, the superlatives connote a deterministic methodology that is antithetical to the probabilistic analyses prescribed by the EPA. In other words, Appendix A advances worst case scenarios regardless of probabilities or consequences, while the EPA effectively dismisses scenarios when probabilities are low or the resulting consequences are insignificant.

Finally, we fail to see how the criteria in Appendix A could assist the DOE in demonstrating compliance with 60.113, which identifies objectives for the performance of the waste package, the engineered barrier systems, and groundwater travel time.

The purpose of the investigations required by Appendix A is to obtain the information needed to describe the vibratory ground motion produced by the Safe Shutdown Earthquake. A safe shutdown earthquake is defined by terms and concepts that do not relate to a waste package or an engineered barrier system. The waste package and engineered barrier system have no "coolant pressure boundary"; cannot be "shut down"; and they cannot cause "accidents," because, according to 60.113, these function after the repository operations have stopped.

Even more so, the Safe Shutdown Earthquake has no bearing on calculating ground-water travel time. The Safe Shutdown Earthquake provides a design basis, and ground-water travel time cannot be designed. Moreover, Part 60 constrains ground-water travel time calculations to present-day conditions. The occurrence of a Safe Shutdown Earthquake would not be typical of current-day conditions.

For the above-mentioned reasons, NRC should delete references to 10 CFR 60.21(c)(1)(ii)(B) and (C), 60.112 and 60.113.

RESOLUTION

The staff has no objection to the revisions proposed by DOE. References to 10 CFR 60.21(c)(1)(ii)(B) and 60.21(c)(1)(ii)(C), 60.112, and 60.113 have been removed from the body of the STP. However, the text of 10 CFR 60.112 and 60.113 is presented in Appendix B, for the reader's convenience.

9. Page 8, Section 4.1

Although data used in assessing the preclosure seismic hazard may very well be used to assess the postclosure seismic hazard, there are distinct differences. For example 10 CFR Part 100, Appendix A offers no guidance for assessing the seismic hazard for a subsurface facility, where vibratory ground motion appears to be of little or no concern and only faulting through the repository or the effect of tectonic processes on site or regional hydrology may affect repository performance. Such considerations need to be addressed the technical position.

RESOLUTION

The staff agrees with DOE's comment. Acceptable investigations for faulting and vibratory ground motion underground are discussed in Section 3.2 of the current STP.

10. Page 13, Section 4.3.2

Regarding the determination of the Safe Shutdown Earthquake, the last sentence states that Appendix A provides for "...determination of the maximum vibratory motion at any site at relevant times...." We do not understand what is meant by the term "at relevant times." This implies that the Safe Shutdown Earthquake for nuclear power plants is applicable to the preclosure and postclosure periods of a geologic repository, even though it has different facilities, operating periods, and levels of risk. These differences in risk need to be addressed by the technical position.

RESOLUTION

The staff notes DOE's concern. Guidance regarding the development of a design basis earthquake has been removed from the current STP. However, guidance on the determination of a design basis earthquake is part of an ongoing staff effort.

11. Page 3, Section 2.2

The general design criteria of 10 CFR Part 50, Appendix A are applicable only to nuclear power reactors. Therefore, we suggest substituting "power" for "material" and "reactors" for "materials" in the first sentence.

RESOLUTION

The staff has no objection to the revision proposed by DOE. Discussion of the relevance of 10 CFR Part 50, Appendix A, to a geologic repository has been removed from the current STP.

12. Page 6, Section 2.5

The regulation referenced for input to the SAR [60.21(1)(ii)(B) and (C)) is incorrect. The correct citation is 60.21(c)(1)(ii)(B) and (C).

RESOLUTION

The staff has no objection to the revision proposed by DOE. The current STP now cites 10 CFR 60.21(c)(1)(i), 60.21(c)(1)(ii)(A), 60.21(c)(1)(ii)(D), and 60.21(c)(3).

13. Page 16, Section 6

We do not believe it is appropriate for a technical position to contain a bibliography. The usefulness of these documents in providing guidance to the DOE is questionable. Only those documents directly referenced in the technical position should be listed.

RESOLUTION

The staff notes DOE's concern. However, it is a policy of the Division of High-Level Waste Management to include a list of documents that, though not explicitly cited in the STP, may contain additional information, particularly for descriptive or critical notes relating to the subject. Therefore, the bibliography will remain in the STP.

14. Appendix A

Appendix A contains several minor errors that should be corrected to be consistent with 10 CFR Part 60. These include:

- Page A-1, Accessible Environment, insert "portion of the" between "the" and "Lithosphere;"

- Page A-6, Important to Safety, insert "the completion of" between "until" and "permanent;" and

- Page A-7, Retrieval, insert "10 CFR Part 60" as the reference for this term.

RESOLUTION

The staff has no objection to the revision proposed by DOE. The terms listed above are no longer in the glossary of the STP.

15. Appendix B, Page B-9, 10 CFR Part 72

It is not clear as to whether sites east of the Rocky Mountain Front have a minimum spectral anchor of 0.2g (Paragraph (a)) or 0.25g (Paragraph (a) (6) (ii)).

RESOLUTION

The staff notes DOE's concern. Text from 10 CFR Part 72 is no longer presented in the STP.

16. References

There are various useful documents that address seismic hazard evaluation and 10 CFR Part 100, Appendix A that appear to have not been considered in preparing the draft technical position. We suggest that the NRC consider the following documents when evaluating these comments on the draft technical position. These include:

1. Bernreuter, D.L., Savy, J.B., Chen, J.C. and B. Davis, Seismic Hazard Characterization of the Eastern United States, Lawrence Livermore National Laboratory, UCID-20421, Vols. 1 and 2, 1985.

2. Electric Power Research Institute, Development and Application of a Seismic Hazard Methodology for Nuclear Facilities in the Eastern United States, RP-P101-29, Vols. 1-3, 1985.

3. International Atomic Energy Agency, Earthquakes and Associated Topics in Relation to Nuclear Power Plant Siting: A Safety Guide, No. 50-SG-S1, 1979.

4. National Research Council, Probabilistic Seismic Hazard Analysis,

National Academy Press, 1988.

5. U.S. Nuclear Regulatory Commission, Geologic and Seismic siting Policy and Practice for Nuclear Power Plants, SECY-77-288A, 1977.

6. U.S. Nuclear Regulatory Commission, Identification of Issues Pertaining to Seismic and Geologic Siting Regulation, Policy and Practice for Nuclear Power Plants, SECY-79-300, 1979.

7. U.S. Nuclear Regulatory Commission, Regulatory Analysis for USI A-40, "Seismic Design Criteria", NUREG-1233, 1988.

8. U.S. Nuclear Regulatory Commission, Summary Report of the Symposium on Seismic and Geologic Siting Criteria for Nuclear Power Plants, NUREG/CP-0087, 1987.

RESOLUTION

Some of the documents listed were included in the public comment draft of the STP. Nevertheless, those documents listed that were not included in the public comment draft have been added to the current STP bibliography. All of the documents listed were considered in the preparation of the current STP.

EDISON ELECTRIC INSTITUTE/UTILITY NUCLEAR WASTE AND TRANSPORTATION PROGRAM (EEI/UWASTE)

DIFFERENCES AMONG FACILITIES:

1. The Technical Position "considers differences that may exist ... among the surface facilities and the underground facility" of a repository, but it is silent on what those differences are. Moreover, the Technical Position does not acknowledge the very significant difference between repositories on the one hand, and nuclear power plants, spent-fuel storage facilities,

and tailings ponds/dams for uranium mills on the other. In the latter context, the Technical Position offers some very weak justification for applying 10 CFR Part 100, Appendix A (Seismic and Geologic Siting Criteria for Nuclear Power Plants to repositories.

RESOLUTION

The staff notes EEI/UWASTE's concern. The statement regarding "...differences that may exist ... among the surface facilities and the underground facilities" has been removed from the introduction. The STP generally addresses investigations to identify fault displacement and vibratory ground motion hazards with regard to surface facilities. Faulting underground and vibratory ground motion underground are discussed in Section 3.0 of the current STP. Differences between geologic repositories and other nuclear facilities are acknowledged in Section 4.0 of the current STP. Neither the public comment draft of the STP nor the current STP should be construed to mean that the NRC staff is advocating the application of 10 CFR Part 100, Appendix A, to a geologic repository. Instead, 10 CFR Part 100, Appendix A, should be considered to be a departure point from which the NRC staff has developed specific guidance on investigations to identify fault displacement and vibratory ground motion hazards affecting a geologic repository. This concept has been clarified in the current STP.

2. If a seismic event exceeds the design basis for a nuclear power plant, there are high energy forces present within the plant that may result in release of radionuclides to the accessible environment. On the other hand, if a seismic event exceeds the design basis for a repository, the resulting interaction of the geologic and engineered-barrier systems is so complex that release of radionuclides to the accessible environment is not immediate, if ever, and not necessarily catastrophic as determined by performance assessment and probability analyses. Yet, this Technical Position specifically excludes addressing probabilistic seismic-hazard analysis. The Technical Position should directly acknowledge these differences and permit the use of probabilistic analyses.

RESOLUTION

As noted above, the STP has been modified to acknowledge general differences in general terms between nuclear power plants and geologic repositories. The purpose of this STP is to present guidance on investigations to identify fault displacement and vibratory ground motion hazards. An ongoing staff effort will address fault displacement and vibratory ground motion hazard analysis, including deterministic and probabilistic fault displacement and seismic hazard analysis.

INVESTIGATION VS. DESIGN FOR SEISMIC HAZARDS:

1. It may be appropriate for this Technical Position to describe the nature and scope of investigations into potential seismic hazards for repositories. However, Appendix A is sorely out-of-date with seismic-hazards knowledge and investigatory techniques. The Technical Position should require state-of-the-art investigations and not be limited to those that evolved in the 1960's and early 1970's when 10 CFR Part 100, Appendix A was promulgated.

RESOLUTION

Neither the public comment draft nor the current STP should be construed to mean that the NRC staff is advocating the application of 10 CFR Part 100, Appendix A, to a geologic repository. Instead, 10 CFR Part 100, Appendix A, should be considered to be a departure point from which the NRC staff has developed specific guidance on investigations to identify fault displacement and vibratory ground motion hazards affecting a geologic repository. This concept has been clarified in the current STP. It is assumed that methods and equipment used to carry out the investigations will be "state-of-the-art." However, NRC cannot require more than what is adequate to meet specific requirements.

2. The Technical Position states, "The term seismic hazard ... is meant to encompass the hazard due to either vibratory ground motion or coseismic faulting, or both, that can affect the design and performance of the geologic repository." The Technical Position also states that design criteria require "structures, systems, and components important to safety be designed so that their safety functions are preserved under the impact of the most severe, adverse natural phenomena." "In addition," it says, "the methodology outlined in this Technical Position can be used in developing seismic and geologic bases for earthquake design criteria ..." And finally, it introduces 10 CFR Part 100 Appendix A, and says that for a repository as for a nuclear power plant, "the determination of a need to design for faulting" is applicable. And yet, Appendix A implies that a facility can be designed for both vibratory ground motion and faulting.

   When the above statements are considered in the context of 10 CFR Part 100, Appendix A, they translate into a requirement that faulting-potential be investigated and either: (1) avoided by a setback distance, or (2) that the repository may be designed to accommodate faulting. However, the history of AEC/NRC licensing of nuclear power plants has established the precedent of absolutely rejecting designs to accommodate faulting (e.g., Bodega Bay, California, of Pacific Gas and Electric; and Malibu, California, of Los Angeles Department of Water and Power).

   Without specifically acknowledging the ability and the acceptability of accommodating fault displacement in design, the Technical Position is perpetuating a misleading impression given by 10 CFR Part 100, Appendix A. Furthermore, the Technical Position should indicate the criteria by which setback-distance from faults, and designs to accommodate faulting will be judged by the NRC staff.

RESOLUTION

The thrust of this comment seems to be directed at design decisions that need to be made with regard to avoidance or mitigation of fault displacement or

vibratory ground motion hazards rather than the issue at hand. As previously noted, the purpose of this STP is to present guidance on investigations to identify fault displacement and vibratory ground motion hazards that could affect a geologic repository. Issues related to design decisions are being considered by the staff.

RECOMMENDED NRC ACTIONS:

1. This Technical Position should be carefully reconsidered, especially with respect to its implementation of 10 CFR Part 100, Appendix A as discussed above, and in DOE's letter of September 20, 1989.

RESOLUTION

See staff response to EEI/UWASTE comment #1 on investigation vs. design for seismic hazards.

2. In addition, since the establishment of seismic design and acceptance criteria is critical to the ultimate licensing and construction of the nation's first geologic repository for the disposal of civilian high-level waste and spent nuclear fuel, EEI/UWASTE strongly recommends that NRC develop a regulation for a generic repository and supplemental Regulatory Guides on this topic. Regulatory Guides will provide the technical rigor that is appropriate for the development of regulatory requirements and guidance in this area. In addition, requirements and guidance provided by regulations are durable and legally binding on all parties in any licensing proceeding.

RESOLUTION

The action recommended by this comment is unclear. There already is a regulation for a generic repository, namely 10 CFR Part 60. The STPs are

intended to provide additional guidance. Moreover, regulatory guides such as "Format and Content Guide for License Application" and "License Application Review Plans" are in preparation.

STATE OF NEVADA/AGENCY FOR NUCLEAR PROJECTS/NUCLEAR WASTE PROJECT OFFICE

GENERAL COMMENTS:

1. The draft Technical Position, for the most part, accomplishes its stated purpose of providing regulatory guidance on appropriate methodologies that address seismic hazard(s) at a geologic repository, however, the document contains little to justify its being titled a Technical Position. In effect, it constitutes a policy statement by the NRC staff that the methodologies and principles espoused in 10 CFR Part 100, Appendix A are appropriate for addressing the earthquake hazards at a geologic repository, and that the staff will rely on 10 CFR Part 100, Appendix A in its review of a geologic repository license application. What the Technical Position does not say (nor should it say) is that only 10 CFR Part 100, Appendix A methodologies are acceptable, or that the results from following the Appendix A methodologies will be treated the same way in application to the engineering design questions.

RESOLUTION

The concern raised by this comment is noted. The current draft of the STP has been rewritten to include more specific guidance on the type and extent of investigations to identify fault displacement and vibratory ground motion hazards affecting a geologic repository. 10 CFR Part 100, Appendix A should be considered to be a point of departure in the the development of these guidelines and should not be considered to be required geologic and seismic siting criteria for a geologic repository.

2. The Technical Position can be improved in content, particularly in regard to the critical issue of capable and active faults. Given that all capable faults are active faults, yet not all active faults are considered capable faults, a basic question arises regarding the extent to which the existence of capable and/or active faults at a repository site will be acceptable to the NRC staff under principles, including those espoused in 10 CFR 100, Appendix A. If a site which exhibits both capable and active faults is acceptable to the staff, the extensive studies associated with application of 10 CFR Part 100, Appendix A methodologies will provide little more to license review than some of the information eventually used in a probabilistic seismic hazards analysis. This would serve only to expose (as a matter of interest) the degree to which such faulting is acceptable to the staff, on a probabilistic basis, since acceptability of a site with both capable and active faults had already been established.

RESOLUTION

The approach to fault displacement hazard analysis presented in this STP does not use the terms "capable fault" and "active fault" because "capable fault" is a term with specific application to nuclear power facilities and "active fault" is strictly a scientific term with a variety of definitions. This STP introduces the concept of "faults susceptible to displacement" (i.e., "susceptible" faults) to specify which faults, from a regulatory perspective, need to be identified, investigated, and evaluated during site characterization. Implicit in the guidance presented in this STP is the staff's position that high-level waste repository sites containing "susceptible" faults are not inherently unsuitable. However, the approach presented in this STP does specify an extensive and thorough investigative effort (of at least the geologic record of the Quaternary Period and perhaps a longer time interval) in the identification and characterization of "susceptible" faults, particularly those "susceptible" faults that exist, or may exist but be undetected within the controlled area. DOE is afforded the flexibility to present data to suggest that certain faults will have no impact on the performance of the repository and, thus, require no further

investigation (unless the results of subsequent site characterization activities or alternative tectonic models suggest the need to reconsider their impact on performance).

The staff is currently considering additional guidance on an acceptable approach to setback of facilities important to safety, containment, and waste isolation from "susceptible" faults that may be present within the controlled area of a repository site.

3. While we know of no NRC regulation that prohibits siting a nuclear facility astride a capable fault, it is difficult to believe that the NRC would license a nuclear reactor if it were exposed to such a condition, nor would a prudent utility be likely to seek a reactor license in close proximity to a capable fault. Furthermore, it is even difficult to conceive of a utility seeking a reactor license for a facility astride an active (Quaternary) fault, in the western U.S., unless possibly there were unequivocal evidence that the fault could be demonstrated as not capable.

   Because of the licensing delays that almost certainly will develop if this issue of active and capable faults is not clarified, the NRC should consider providing more specific, early guidance on how known capable and/or active faults underlying, bounding and/or transecting a repository will be considered in meeting the requirements of 10 CFR Part 60. If the existence of capable and/or active faults underlying, bounding and/or transecting a repository is unacceptable to the NRC, as the reactor siting situation might suggest it should be, then potential repository sites where such conditions exist can be removed quickly from further consideration.

RESOLUTION

The concern raised by this comment is noted. However, the issue of whether or not NRC will accept the presence of a fault of the type described in the

comment, either in close proximity to, or transecting, a geologic repository, is beyond the scope of this STP. The purpose of the STP is to present guidance on investigations to identify fault displacement and vibratory ground motion hazards that may affect a geologic repository. The staff will review the issue raised in the comment and determine what is the most appropriate way to address it.

SPECIFIC COMMENTS:

1. Page 2, Line 1

Use of the term "coseismic" is too limiting in the sense that the term could be interpreted to exclude appropriate consideration of synthetic faulting.

RESOLUTION

The staff has no objection to the revision proposed by this comment. The term "coseismic" has been removed from the STP.

2. Page 2, Paragraph 1, Final Sentence

A number of terms important to understanding 10 CFR Part 100, Appendix A, 10 CFR Part 60, and their interrelationships, as discussed in this Technical Position, should be included in the glossary, eg. active fault, seismotectonic province, site region, and operations area.

RESOLUTION

In revising the public comment draft to produce the current STP, there is no longer any explicit reference to 10 CFR Part 100, Appendix A and technical terms embodied therein (e.g., "active fault," "seismotectonic province," "site region," and "operations area"). As regards any technical terms remaining in

the STP, care was taken to either use terms that were defined in 10 CFR Part 60 or that were commonly understood throughout the technical community. In the case of the latter, the technical terms that do appear should be readily understood in the light of the context in which they are used.

3. Page 5, Paragraph 1, Final Sentence

Documentation is provided on how 10 CFR Part 100, Appendix A and 10 CFR Part 40 are linked. There should be an explanation of why this approach is not taken with 10 CFR Part 60.

RESOLUTION

This comment is noted. NRC could have adopted 10 CFR Part 100, Appendix A, for guidance concerning fault displacement and vibratory ground motion criteria, as it has done in 10 CFR Part 40 with regard to tailings dams for uranium processing mills, but the very long performance period following permanent closure, the significant differences between preclosure and postclosure performance requirements, and the difference in nature between nuclear power plants and geologic repositories preclude such an adoption.

4. Page 5, Paragraph 2, First Sentence

It is stated that 10 CFR Part 60 does not specifically rely on 10 CFR Part 100, Appendix A for guidance regarding provisions for dealing with seismic hazards. This is in apparant conflict with the Technical Position, on page 7, which states that the NRC staff will rely on the principles of 10 CFR Part 100, Appendix A in its review of whether the requirements of 10 CFR Part 60 are met. This appearance of conflict should be clarified and resolved.

RESOLUTION

The staff agrees with this comment and the statements on page 5 and page 7 in the public comment draft TP have been removed from the current draft of the STP. The current draft clarifies this appearance of conflict.

5. Page 5, Paragraph 2, First Sentence

It is stated that 10 CFR Part 60 does not specifically require the development of a design basis earthquake. However, the Technical Position (page 7) and the following text strongly imply that a design basis earthquake (maximum vibratory ground motion) will be required. This ambiguity should be resolved, and there should be a specific statement of the kind of design basis earthquake (eg. SSE equivalent) that will be required.

RESOLUTION

This comment is noted. To adequately satisfy the requirements of 10 CFR 60.131(b)(1), the NRC staff believes that it will be necessary to develop a design basis earthquake. This STP addresses the investigations necessary to identify the fault displacement and vibratory ground motion hazards that may affect a geologic repository. There is an ongoing staff effort to address the kind of design basis earthquake the NRC staff believes DOE should develop. Once this effort is complete, the staff will determine the best form in which to provide the information to DOE.

6. Page 7, Final Sentence

This statement incorporates the 10 CFR 60 requirement to design the operations area in a manner so as to preserve the preclosure option of waste retrieval. Allowing for the existence of capable and active faults

within the repository seems to be in direct conflict with this requirement. Designing to accomodate a fault rupture that isolates a part of the subsurface operations area from surface access will present extreme difficulties and likely result in a compromise of safety.

RESOLUTION

This comment addresses a design issue, and not an issue concerning the investigations necessary to identify fault displacement and vibratory ground motion hazards. Designing for fault displacement is part of an ongoing staff effort. Once this effort is complete, the staff will determine the best form in which to provide the information to DOE.

7. Page 6, Paragraph 2, First Sentence

This sentence should be rewritten to reflect the 10 CFR Part 60 language regarding selection of the geologic setting and design of the remaining elements. The geologic setting cannot be designed to limit releases to the accessible environment.

RESOLUTION

The staff agress with this comment and has removed the subject sentence from the current draft of the STP.

8. Pages 12 and 13

For purposes of evaluating a geologic repository site, application of the general limitation of investigations of surface faulting to faults only within five miles of the site is arbitrary and excessively restrictive, as it neglects the fact that faults may be linked in space and time, especially over the time period that must be considered. To understand

the seismic behavior of a single fault, or set of faults commonly requires a thorough understanding of the entire system of faults, regardless of their exact distance from the site under consideration.

RESOLUTION

This comment is noted. The guidance regarding use of specific distances and lengths for determining which faults should be investigated has been removed from the current STP. This guidance has been replaced by guidance of a less prescriptive nature, which emphasizes investigations of faults near the proposed geologic repository, but allows for the investigation of faults more remote from the proposed geologic repository, which may have an impact on the proposed geologic repository.

9. Page 14, Paragraph 1

It seems a bit cavalier to dismiss so easily the need for determination of an Operating Basis Earthquake (OBE). The text seems to imply that risk to onsite personnel is unimportant and that there is no risk to the public in this context. Simply qualitatively comparing the level of risk of a repository containment failure to that of a reactor under earthquake conditions does not justify the assumption of no significant consequence. This is especially true, given the allowed possibility of a capable fault within the repository creating a gross and uncontrollable loss of containment.

RESOLUTION

This comment addresses a design issue, and not an issue concerning the investigations necessary to identify fault displacement and vibratory ground motion hazards. This topic is part of an ongoing staff effort addressing fault displacement and vibratory ground motion hazard analysis.

10. Page 15, Paragraph 1, First Sentence

Underground facilities important to safety should be included among elements that can be affected by faulting in a geologic repository.

RESOLUTION

This comment addresses a design issue, and not an issue concerning the investigations necessary to identify fault displacement and vibratory ground motion hazards. Designing for fault displacement with regard to underground facilities important to safety is part of an ongoing staff effort. Once this effort is complete, the staff will determine the most appropriate format for providing the information to DOE.

11. Page A-1

See earlier comment regarding the Glossary.

RESOLUTION

This comment is noted. In revising the public comment draft to produce the current STP, care was taken to use terms defined in 10 CFR Part 60 or terms commonly understood. Some terms that appear to be specific to this STP should be understandable in the light of the context in which these terms are used. If this is not the case, subsequent revisions of the STP will include definitions of such terms as may be needed.

12. Page A-3, Paragraph 1

At some point in the Technical Position, there should be a clear statement that, in the context of a geologic repository, generalizations regarding whether pre-Quaternary faults are capable faults are an unacceptable basis

for excluding the need for rigorous investigation of existing "geologically old" faults.

RESOLUTION

The staff has no objection to the revision proposed. Accordingly, an expanded position and discussion of faults susceptible to displacement has been added to the current STP. The essence of this comment is addressed in this expanded material.

13. Page C-1

The purpose of including an outline of 10 CFR Part 100, Appendix A, without supporting text is not clear. An annotated outline which may include summaries of past experiences (case histories) with 10 CFR Part 100, Appendix A, and references would be much more useful than the bare outline.

RESOLUTION

The staff has no objection to the revision proposed. The outline of 10 CFR Part 100, Appendix A, has been removed from the current STP.

APPENDIX D DISPOSITION OF PUBLIC COMMENTS ON XXXXX, 1991 DRAFT STAFF TECHNICAL POSITION