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WORKING GROUP ON CONCERNS RELATED TO SEISMIC AND FAULTING
INVESTIGATIONS FOR CHARACTERIZATION OF A HIGH LEVEL WASTE SITE

DECEMBER 17, 1991

The meeting was held on December 17, 1991. The purpose was to hear discussions on the NRC staff technical position (STP) on "The Identification of Fault Displacement and Seismic Hazards at a Geologic Repository" from groups that provided comments on the draft STP. NRC staff representatives also discussed their responses to the comments on the STP and representatives of the American society of Civil Engineers (ASCE) discussed a report, in preparation, on seismic and faulting design considerations.

The Working Group Chairman, Dr. Paul Pomeroy, called the meeting to order and made some introductory comments. Other members of the ACNW present were Dr. Dade Moeller and Dr. William Hinze. Dr. Pomeroy stated that the ACNW wished to hear some discussion of the substantive comments of each commenter on the STP. Those commenters included the Department of Energy, the State of Nevada, and the Edison Electric Institute (EEI). He noted that the proposed STP will provide partial guidance for the development of information needed for the determination of the hazard associated with faulting and/or seismic activity at any proposed repository.

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Invited participants at the Working Group included Dr. Leon Reiter, seismologist and staff member of the Nuclear Waste Technical Review Board; Dr. Clarence Allen, geologist and member of the Nuclear Waste Technical Review Board; Dr. Ardyth Simmons, geologist with the Department of Energy; Dr. Robert Hatcher, structural geologist with the University of Tennessee and Oak Ridge National Laboratory and ACNW consultant; Mr. Carl Johnson, Manager of Technical Projects for the State of Nevada Agency for Nuclear Projects; Dr. Jay Smith, engineering geology consultant to the EEI and Mr. Chris Henkel and Mr. Michael Bauser, EEI. Dr. Quazi Hossain, Chairman of the ASCE committee on High Level Waste Repository Seismic and Dynamic Design participated along with other members of that committee, Dr. Carl Stepp, Dr. Bert Swan, and Dr. Walter Silva. Participants from the NRC included Dr. Keith McConnell, Dr. Philip Justus, and Dr. Bakr Ibrahim.

The discussions were opened with a presentation from the representatives of the ASCE committee on High Level Waste Repository Seismic and Dynamic Design. Members of that committee described the objectives and the content of a guidelines report for seismic design. That report is being prepared as generic guidelines to benefit industry and is separate from NRC efforts on guidelines for seismic and faulting investigations and analyses. The ASCE report does use examples from the Yucca Mountain site. The report will consist of approximately 20 papers on various topics related to HLW repository seismic considerations. The ASCE

committee also plans to sponsor a symposium, to be held on August 19 and 20, 1992, where it hopes to receive comments on the ASCE guidelines report. Following that symposium, the ASCE will review the report and publish it as a ASCE special publication by July 1993.

Dr. Swan discussed methods and approaches for assessing the potential for fault displacement for a HLW repository, emphasizing the assessment of fault displacement within the repository boundaries. The recommendation of the ASCE committee is that a probabilistic approach, supported by a deterministic analysis, be the method by which the performance of the design be considered.

The ASCE approach is based on certain basic premises, the most controversial of which is that future fault slip will recur at the same locations (along the same faults) and in the same manner as geologically recent (Quaternary) displacements. The likelihood of a future displacement will be related to the frequency of the most recent past displacement. This premise is based on the assumption that the tectonic forces or the stress field will be constant for the period of time under consideration. As the time period is increased the degree of confidence will begin to diminish. Dr. Swan agreed that in cases of fault zones where there is a high density of faulting, the likelihood of recognizing every fault trace is minimal and therefore that entire zone would be avoided.

Some meeting participants disagreed with Dr. Swan's premise. It was noted that faults do grow in length over time. Dr. Allen noted that most earthquakes tend to recur in the same areas.

Dr. Swan explained the ASCE approach for assessing the potential for fault rupture. This includes determining the locations and three-dimensional geometry of faults that could affect a repository's performance and reconstructing the Quaternary displacement on those faults that could impact the site. The criteria for dealing with active faults should be flexible because of the varying functions of different parts of the repository (e.g., surface facilities, underground structures), the differences in the time for the post-closure and pre-closure periods, and the associated hazards. Also, criteria should be flexible enough to allow for different methods of mitigating potential risks such as allowing for fault setback or avoidance or designing for fault displacement.

Dr. Swan explained that the ASCE guidelines will not contain criteria for determining acceptable setback distances from active faults. The ASCE committee believes this to be a site-specific issue that is dependent on the style of faulting, type of rock, and other relevant parameters.

The ASCE believes that the main focus of faulting investigations should be on the area within the repository block and on faults

that extend to within ten kilometers of the site. For the investigation of faults as earthquake sources, the main focus should be on Quaternary faults within approximately 20 kilometers of the site. Dr. Swan added that although the site of the Cedar Mountain earthquake is outside of this area, it would be considered for its importance as an analog. Structural models would also be used as a predictive tool.

The ASCE committee recommends that a probabilistic approach be used to identify the issues most likely to impact the repository and then analyze those issues in a deterministic manner. The emphasis is on probabilistic as the primary approach substantiated by deterministic analyses.

Dr. Swan noted that areas of uncertainty that should be considered in the hazard analysis include earthquake recurrence models and the relationship between surface displacement and what will be found at depth. Most data for the assessment of fault displacement is from surface studies. This could be different at the depth of the repository and this uncertainty should be taken into consideration.

The ASCE committee recommended that by characterizing the Quaternary fault history, geometry, slip direction, and likelihood of occurrence one can assess the fault displacement hazard. By using a probabilistic and deterministic approach, one can identify and quantify the uncertainty in the parameters and analytical

methods, test the sensitivity of results to analytical methods, prioritize the related issues, and better focus the investigations and analyses on the most significant factors. If this is done, more focused analyses can be conducted in a deterministic manner. Finally, it is necessary to define the relationship between hazard and risk in order to assess the acceptable hazard and determine the design measures needed to mitigate the unacceptable effects of fault rupture.

Dr. Walter Silva continued the ASCE presentation with a discussion of the assessment of seismic design loads with respect to vibratory ground motion. For vibratory ground motion due to thermal loading, the ASCE committee recommends a combined analytical approach using modeling to calculate changes to the stress field and then the study of analogs. The committee advocates the use of deterministic and probabilistic approaches with the primary emphasis on the probabilistic. They believe that the probabilistic approach allows formal treatment of alternative models and uncertainty in those models, and the deterministic approach requires explicit identification and evaluation of all seismic sources in terms of magnitudes and distances. The recommended approach would be to place a strong emphasis on empirical and statistical analyses of the recorded ground motions; then use stochastic methods. If this concern becomes a design issue with the need to reduce uncertainty, the committee recommends using semi-empirical methods.

Dr. Silva stated that the reasons for the emphasis on the probabilistic approach are that alternate models can be explicitly included and the probabilistic approach is a formal treatment of uncertainty. Steps in this approach include examination of the earthquake location, recurrence, frequency of occurrence of given magnitudes, and maximum magnitude of expected events and then conducting a probabilistic analysis.

In response to a question by Mr. Johnson, Dr. Swan clarified that the ASCE believes the data for the deterministic and probabilistic approaches are the same, but how that data are analyzed should be in a probabilistic manner, not deterministic. He noted that the investigation process advocated by the ASCE and the NRC staff in the STP are much the same, but iterative probabilistic analyses can help the investigative process by focusing investigations on the parameters and analyses that will impact the design and performance of the repository.

Dr. McConnell stated that he did not believe that the ASCE's methods were in conflict with those of the STP. The only disagreement appeared to be in the emphasis. He noted that the staff's position is that deterministic analyses should be supported by probabilistic analyses. He also noted that the staff believed that there is a likelihood that there will be stress field changes due to the emplacement of waste. He also stated that for investigations to identify fault displacement and seismic hazard,

expert judgement combined with existing data will not take the place of the collection of data if those data are reasonably collectable.

The ASCE presentation was followed by presentations from commenters on the STP. Mr. Chris Henkel introduced the EEI presentation and noted EEI's interest in the STP. EEI's technical presentation was by Dr. Jay Smith who provided some historical background on reasons leading up to Appendix A to 10 CFR Part 100.

Dr. Smith noted that Appendix A provided a orderly reference to the applicant for the identification of geologic and seismic issues. After Appendix A was issued the emphasis in selecting power plant sites was directed to locating those sites where geologic and seismic conditions could be adequately demonstrated. He stated that although Appendix A did not prohibit a site near a capable fault and did not state that faulting could not be accommodated through design, these issues did become "de facto exclusionary functions" to the siting of nuclear power plants.

Dr. Smith stated that it will be difficult to avoid faults entirely in a repository located in an area of complex geology. He stated that the STP is unclear as to whether a fault may be accommodated through design or if it should be avoided through some amount of setback of the canister from the fault. The EEI position, according to Dr. Smith, is that the staff needs to indicate, as

soon as possible, whether a site with susceptible faults will be acceptable or not.

Dr. Justus of the NRC staff noted that at this time the staff has no plans to establish specific setback distance requirements. If DOE contemplates designing the repository facilities on or near susceptible faults, the staff would expect the DOE to meet with the NRC at an early date to discuss the need for demonstration of reasonable assurance that the DOE design would meet the performance objectives and design requirements.

Dr. Smith also noted that, without the companion STP on analyses, it is difficult to understand how the data from investigations will be used.

Mr. Michael Bauser discussed EEI's position that a regulation, rather than an STP, is needed on the topic of seismic hazards and fault displacement. He stated that a regulation is necessary because it is legally binding and would provide a legal mechanism for the closure of issues, it is more permanent and will not change with changes in staff, and it would provide guidance equivalent to that provided by Appendix A for reactors. He noted that without a regulation there is a chance that a licensing board for the repository could apply another regulation such as Appendix A.

Mr. Bauser requested that NRC suspend work on the STP and shift its

focus to a rulemaking. By suspending work, Mr. Bauser also suggested that the NRC could also benefit from upcoming efforts such as the ASCE report and a proposed DOE position paper.

Dr. Smith stated that he believes that regulation comparable to Appendix A is critical for fault displacement in a repository, because faulting will be a "jugular issue" for a repository. Mr. Bauser noted that although the STP does not preclude accommodating fault displacement, the staff's position should be made clearer.

Dr. McConnell noted that EEI representatives were asking for the staff's position on setback as soon as possible, but a rulemaking would take three to five years.

Dr. Smith also stated that the STP still does not clearly state that Appendix A does not apply to a repository. He believes the staff should make such a statement in the text of the STP, rather than in an appendix to the STP.

Dr. Carl Stepp stated that the development of Appendix A was a lengthy process. Although he did not disagree with the need for a rule, Dr. Stepp stated that he believed that the staff should also go forward with the guidance provided by the STP.

Dr. Ardyth Simmons presented the DOE comments. She provided some history of the technical position back to 1986 with some discussion of the number of STP versions on which DOE had commented and the numerous technical exchanges with the NRC on this topic.

Dr. Simmons expressed DOE's concern about the related STPs and Dr. Justus stated that the STP on analyses of seismic and faulting hazards was in progress and a draft for public comment was expected sometime in 1993. That STP will address both probabilistic and deterministic components to the analyses. The staff has placed the tectonic models STP "on hold" until the EPA standards are released, because there is a need to address tectonic issues that deal with anticipated and unanticipated processes and events in that STP.

Dr. Simmons stated that the DOE is pleased that the staff has stated that Appendix A will not be used to apply to a repository and that the staff has endorsed both probabilistic and deterministic analyses. She stated that DOE's emphasis is on the probabilistic analyses with the deterministic analyses providing the framework for the data and the quantification of the uncertainties in those data through probabilistic analyses. DOE believes that probabilistic techniques to screen faults should be endorsed by the STP and that by using a probabilistic approach DOE would be able to better define which faults should be left out of its analyses.

Dr. McConnell stated that the NRC staff is concerned that faults will be eliminated from further investigation based on limited data and the use of expert judgement. In this way a potential hazard may be overlooked, particularly in the repository area.

Dr. John Whitney, U.S. Geological Survey Yucca Mountain Project Investigator, stated that it is unclear how NRC expects the faults within the site to be investigated versus those within a 100 kilometer radius. He noted that the USGS investigations of faults within the site area are almost entirely deterministic. Only those faults outside of that area are being examined with a more probabilistic approach.

DOE objects to the term "susceptible faults," Dr. Simmons stated. The DOE believes that this STP should not be issued without the companion STPs. DOE also recommends postponing the STP until the related STPs are released and the ASCE report and revisions to Appendix A are completed. Dr. Simmons also stated that the DOE has established a group to address faulting and seismic issues in a topical report. That report is still in preparation and a draft will not be available until late 1992.

Mr. Carl Johnson presented the position of the State of Nevada on the STP. He stated that the State supports finalization of the STP and it is satisfied with the staff's responses to the State's comments. The State is concerned with the use and definition of

the terms "susceptible fault" and "geologic setting." The State also believes that the analyses STP is needed in order to better understand the relationship between the two STPs.

Mr. Johnson stated that the State believes that the STP does not clearly define or provide criteria for the determination of what constitutes a geologic setting. The State is supportive of the use of Appendix A type methodologies to screen faults and is also supportive of a deterministic approach for fault screening rather than probabilistic evaluations. He urged additional criteria to fault length such as maximum surface and subsurface displacement and net tectonic slip and noted that Wells and Coppersmith state that subsurface fault lengths tend to be much longer than what may be viewed on the surface.

In addition, the State objected to the use of the term "material and relevant," believing its use to be inconsistent in the STP.

Mr. Johnson stated that the STP appears to require that susceptible faults have offset. He noted that is different from positive evidence of no Quaternary offset. He also stated that the STP needs to address the determination of a design basis earthquake and the acceptability of fault displacement in a repository.

Working group participants discussed whether the STP was generic or not. Dr. McConnell stated that the STP is generic for repositories

sited west of 104 degrees longitude. Sites east of that longitude would require some revision to the STP.

Dr. McConnell stated that in addition to EEI, DOE, and the State of Nevada, the staff had received comments on the STP from the USGS and the Association of Engineering Geologists. He discussed how the staff had responded to all of the comments on the STP. He stated that the staff had received requests for clarifications and comments on the use of deterministic versus probabilistic techniques. He noted that NRC has always supported the use of deterministic techniques in the area of power plant siting. He also stated that the staff believed that a strong statement on deterministic techniques was needed in this STP based on the way DOE appeared to be relying on probabilistic techniques in the Site Characterization Plan (SCP). The staff also was concerned with the DOE's use of expert judgement which could eliminate certain faults from detailed investigation based on limited data.

With respect to faults inside the controlled area, the staff believes that all should be candidates for detailed investigation. For those outside the controlled area, the staff suggests that DOE come forward with some method of evaluation, preferably a more deterministic approach. If the DOE does decide to design on a fault, the NRC staff would expect the DOE to meet with them to discuss the matter.

Dr. McConnell stated that the staff received a number of comments on the use of the term "susceptible fault." He stated that the staff wanted a term that was different from that used for a power plant because of the differences in the length of the performance period and in the level of risk. The term's technical basis is the geologic criteria that was used to define it, but it is a regulatory term. The staff did not want to use the term "faults requiring further investigation" because faults could require investigation for reasons other than seismicity and fault displacement such as for mineral deposits or hydrologic pathways.

Dr. Hatcher suggested, that to avoid the prejudicial nature of a term such as susceptible fault, the staff should use a categorization scheme such as one, two and three or A, B, and C.

Dr. McConnell stated that a susceptible fault has the potential to disrupt the repository and cause the repository to exceed the EPA standards or cause the repository to fail one of the performance criteria. The STP provides criteria that would help to narrow those faults to be investigated. Faults that should be investigated are those faults that are subject to displacement, but could affect repository performance.

Dr. McConnell stated that the staff believes the STP is needed because the review of the SCP highlighted significant concerns related to the investigations for faulting and seismicity. The

staff also has had similar concerns related to DOE study plans. Therefore, the staff believes it is important to let the DOE know what NRC expects in the way of fault displacement and seismic investigations, now at the beginning of site characterization. He stated that the STP addresses the majority of the staff's SCP concerns related to faulting and seismic hazards, and if this guidance is followed, most of the staff's concerns will be addressed.

Dr. McConnell restated that the staff is not applying Appendix A to repositories. He also noted that STPs are not rules and can be revised. In response to Mr. Johnson's question of why not make the STP site specific, Dr. McConnell stated that the staff believes that would be inappropriate because it may imply that the staff has made a decision that Yucca Mountain is the chosen site.

Dr. McConnell stated that the staff believes that a more definitive statement on the geologic setting cannot be made until after site characterization data are available to define the boundaries. Those data would define the area that could impact the site. The geologic setting is the sum of the tectonic, hydrologic, geochemical, and other components.

Dr. McConnell explained that the staff has no position on setback distances nor do they have any plans to introduce a specific distance. Susceptible faults can be within the repository boundary

if reasonable assurance can be provided to demonstrate that the EPA standard and the other performance objectives can be met. If DOE decides to locate on faults it should ask for NRC's consideration in the design development. He stated that a susceptible fault should be avoided, but siting near one is not unacceptable. DOE would have to conduct an iterative analysis of the impact of the fault.

Dr. Reiter suggested that the staff issue a clarification to 10 CFR Part 60 stating that the presence of a fault in a repository does not necessarily mean that the repository is unacceptable. Dr. McConnell stated that faulting in the Quaternary is considered as an adverse condition in Part 60 and the regulation does not disqualify the site on the basis of the presence of an adverse condition.

Dr. McConnell addressed commenters concerns related to the stress field criterion. He stated that this criterion can be removed if, after a series of investigations, the determination is inconclusive. This decision has to be made on the basis of a documented record of investigation. If a fault has no evidence for Quaternary displacement, the other three criteria stated in the STP have to be considered before the fault can be considered not susceptible. After the data are collected the investigator should develop the likelihood of displacement on the fault using probabilistic techniques and determine if the fault will affect

repository performance.

In summary comments meeting participants restated their major concerns. Those were:

- The need for a statement on the acceptability of a site near a susceptible fault or whether a fault can be accommodated through design.
- The need for a term other than susceptible fault.
- The use of the stress field criterion.
- A better definition for geologic setting.
- The need for the companion STPs.

NOTE: A transcript of the meeting is available at the NRC Public Document Room, Gelman Building, 2120 "L" Street, N.W., Washington, D.C., Telephone: (202) 634-3383 or can be purchased from the Ann Riley & Associates, Ltd., 1612 K Street, N.W., Washington, D.C. 20006).