U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

2.5.1 BASIC GEOLOGIC AND SEISMIC INFORMATION

REVIEW RESPONSIBILITIES

Primary - Civil Engineering and Geosciences Branch (ECGB)

Secondary - None

I. AREAS OF REVIEW

ECGB reviews the geological, seismological, and geophysical information submitted in the applicant's early site evaluation report (ESR) or safety analysis report (SAR), Sections 2.5.1, 2.5.2, and 2.5.3. The technical information presented in these sections of the SAR or ESR results largely from surface and subsurface geological, seismological, geophysical, and geotechnical investigations performed in progressively greater detail closer to the site, within each of the areas described by radii of 320 km (200 mi), 40 km (25 mi), 8 km (5 mi), and 1 km (0.6 mi) around the site. The following specific subjects are addressed: tectonic and seismic information, nontectonic deformation information, and conditions caused by human activities, with respect to regional geology (Subsection 2.5.1.1) and site geology (Subsection 2.5.1.2).

Because there is a strong overlap among these areas of review and those of geotechnical engineering and geohydrology, the reviewers of these sections of the SARs should also carefully review Standard Review Plan (SRP) Section 2.5.4 and Section 2.4.12 and closely coordinate their reviews and findings with those of the geotechnical engineering and the geohydrology reviewers. For example, coordination with geotechnical engineers is required when verification of geological processes affecting the site, such as the preloading history of the plant's soil foundations by means of glacial and

other geologic processes, can be determined through various geotechnical testing methodologies.

References 1 through 8 (regulations and regulatory guides) provide guidance to the ECGB reviewers in evaluating potential nuclear power plant sites. The principal regulation that will be used by ECGB to determine the scope and adequacy of the submitted geological, seismological, and geophysical information for nuclear power plant sites is 10 CFR Part 100, Section 100.23, "Seismic and Geologic Siting Factors" (Ref. 2). Specific guidance for implementing this regulation can be found in Regulatory Guide 1.165, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion" (Ref. 3). Guidance regarding the geotechnical engineering aspects is found in Regulatory Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants" (Ref. 4). Additional information is available to the ECGB reviewers through published and unpublished scientific literature. As the state of the art in the geosciences is advancing rapidly, it is the responsibility of the reviewers to stay abreast of changes by reviewing the current scientific literature on a regular basis, attending professional meetings, etc.

Using the knowledge derived from these activities and the geosciences reviewers' own aggregate academic backgrounds and experience, ECGB judges the adequacy of the geological, seismological, and geophysical information cited in support of the applicant's conclusions concerning the suitability of the plant site.

The geological, seismological, and geophysical information that must be provided by applicants for the site review to proceed is divided into the following three basic categories:

1. Tectonic or Seismic Information. Information regarding tectonics, (particularly Quaternary tectonics), seismicity, correlation of seismicity with tectonic structure, characterization of seismic sources, and ground motion. Seismicity and vibratory ground motions are primary review responsibilities addressed in SRP Section 2.5.2. However, the review and acceptance of the applicant's basic data-gathering processes and findings that are presented in support of these topics, and their completeness, are also integral parts of the review responsibilities covered in this section. There must be close coordination among geologists, geophysicists, and seismologists in reviewing these sections.

   Sufficient information must be provided to estimate the potential for strong earthquake ground motions or surface deformation at the site, such as the proximity and nature of potential seismic sources, Quaternary geological evidence for faulting, folding, prehistoric earthquakes (i.e., paleoliquefaction features), and other seismically induced features. A complete presentation, including supporting basic data, of the characteristics of the subsurface materials beneath the site must be provided (or cross-referenced with SRP Section 2.5.4) and reviewed by the staff so that an assessment of the potential for amplification of vibratory ground motion or ground failure under dynamic loading can be made. Potential ground failure modes may include liquefaction, excessive settlement, differential settlement, and those caused by high tectonic stresses. Additionally, for sites adjacent to

large bodies of water, information pertinent to estimating tsunami and seiche hazards must be provided or cross-referenced to SRP Section 2.4.12.

2. Nontectonic Deformation Information. Adequate information must be provided for an assessment of other nontectonic geological hazards, such as landsliding and other mass-wasting phenomena, subsidence (including differential subsidence), growth faulting, glacially induced deformation, chemical weathering, the potential for collapse or subsidence in areas underlain by carbonate rocks, evidence of preconsolidation, etc.

3. Conditions Caused by Human Activities. Information on changes in groundwater conditions caused by the withdrawal or injection of fluids, subsidence or collapse caused by withdrawal of fluids, mineral extraction, induced seismicity and fault movement caused by reservoir impoundment, fluid injection or withdrawal must be included in the SAR or ESR and evaluated by the ECGB staff.

Acceptance criteria related to the above conditions are presented in SRP Subsections 2.5.1.1, "Regional Geology," and 2.5.1.2, "Site Geology." Information provided by the applicant in the SAR or ESR in support of its application for a license should be reviewed in terms of the regional and site tectonics, with emphasis on the Quaternary period, structural geology, physiography, geomorphology, stratigraphy, and lithology. In addition, with specific reference to site geology, the following subjects should be reviewed as they relate to the above-mentioned conditions: topography, slope stability, fluid injection or withdrawal, mineral extraction, faulting, solutioning, jointing, seismicity, and fracturing.

The information provided should be documented by appropriate references to all relevant published and unpublished materials. Illustrations such as maps and cross sections should include but should not be limited to structural, tectonic, physiographic, topographic, geologic, gravity, and magnetic maps; structural and stratigraphic sections; boring logs; and aerial photographs. Some sites may require maps of subsidence, irregular weathering conditions, landslide potential, hydrocarbon extraction (oil or gas wells), faults, joints, and karst features. Some site characteristics must be documented by reference to seismic reflection or refraction profiles or to maps produced by various remote sensing techniques.

Maps should include superimposed plot plans of the plant facilities. Other documentation should show the relationship of all Seismic Category I facilities (clearly identified) to subsurface geology. Core boring logs, logs and maps of trenches, aerial photographs, satellite imagery, and geophysical data should be presented for evaluation. In addition, plot plans showing the locations of all plant structures, borings, trenches, profiles, etc., should be included.

The review can be brought to an earlier conclusion if the ESR or SAR contains sufficient data to allow the reviewers to make an independent assessment of the applicant's conclusions. The reviewers should be led in a logical manner from the data and premises given to the conclusions that are drawn without having to make an extensive independent literature search. A literature search will be conducted by the staff at the appropriate level of detail,

depending on the completeness of the SAR or ESR. All pertinent data, including that which is controversial, should be presented and evaluated. The geologic terminology used should conform to standard reference works (Refs. 9 and 10).

The primary purposes for conducting the site and regional investigations are to determine the geological and seismological suitability of the site, provide the bases for the design of the plant, and determine whether there is significant new tectonic or ground motion information that could impact the seismic design bases as determined by a probabilistic seismic hazard analysis (PSHA) (Refs. 11 - 13). The objective of Section 2.5.1 of the SAR is to present the results of these investigations and to describe geologic and seismic features as they affect the site under review; all data, information, discussions, interpretations, and conclusions should be directed to this objective.

II. ACCEPTANCE CRITERIA

The applicable regulations (Refs. 1 and 2) and regulatory guides (Refs. 3 - 5) and basic acceptance criteria pertinent to the areas of this section of the Standard Review Plan are:

1. General Design Criterion (GDC) 2, "Design Bases for Protection Against Natural Phenomena," in Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50. This criterion requires that the structures, systems, and components important to safety be designed to withstand the effects of earthquakes, tsunami, and seiche without loss of capability to perform their safety functions (Ref. 1).

2. Section 100.23, "Geologic and Seismic Siting Factors," of 10 CFR Part 100. This section of Part 100 requires the applicant to determine the SSE and its uncertainty, the potential for surface tectonic and nontectonic deformations, the design bases for seismically induced floods and water waves, and other design conditions (Ref. 2).

3. Regulatory Guide 1.165, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion" (Ref. 3). This guide describes acceptable methods to: (1) conduct geological, seismological, and geophysical investigations of the site and region around the site, (2) identify and characterize seismic sources, (3) perform PSHA, and (4) determine the SSE for the site (see SRP Section 2.5.2.6 and Ref. 14).

4. Regulatory Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants." This guide describes programs of site investigations related to geotechnical aspects that would normally meet the needs for evaluating the safety of the site from the standpoint of the performance of foundations and earthworks under anticipated loading conditions, including earthquakes. It provides general guidance and recommendations for developing site-specific investigation programs as well as specific guidance for conducting subsurface investigations, such as borings and sampling (Ref. 4).

5. Regulatory Guide 4.7, "General Site Suitability Criteria for Nuclear Power Stations." This guide discusses the major site characteristics

related to public health and safety that the NRC staff considers in determining the suitability of sites for nuclear power stations (Ref. 5).

The information in the SAR or ESR must be complete and thoroughly documented, and it must be consistent with the requirements of Reference 2 and should conform to the format suggested in Reference 6. Information from varied sources, including the United States Geological Survey (USGS) and other Federal or State agencies' published and open file papers, maps, aerial photographs, geophysical data, and similar data from nongovernmental sources covering the region in which the site is located, are used by the staff in evaluating the completeness and acceptability of the SAR or ESR.

The ECGB reviewers must ensure that investigations, as described in Regulatory Guide 1.165 (Ref. 3) and Regulatory Guide 1.132 (Ref. 4), are conducted with the appropriate level of thoroughness within the 4 areas designated in Regulatory Guide 1.165, based on distances from the site: 320 km (200 mi), 40 km (25 mi), 8 km (5 mi), and 1 km (0.6 mi). There must be sufficient information presented in the ESR or SAR on which to base a comparison between the new data derived from the regional and site investigations and that used in the tectonic and ground motion models of the PSHA (Ref. 3).

Specific criteria necessary to meet the relevant requirements of General Design Criterion 2, Part 50, and 10 CFR 100.23 are as follows:

Subsection 2.5.1.1, "Regional Geology." In meeting the requirements of References 1 and 2, the subsection will be considered acceptable if a complete and documented discussion is presented of all geological, seismological, and geophysical features, as well as conditions caused by human activities. This subsection should contain a review of the regional tectonics, with emphasis on the Quaternary period, structural geology, seismology, paleoseismology, physiography, geomorphology, stratigraphy, and geologic history within a distance of 320 km (200 mi) from the site (site region), to provide a framework within which the safety significance can be evaluated for the geology, seismology, and conditions brought about by human activities.

Subsection 2.5.1.2, "Site Geology." In meeting the requirements of References 1 and 2, and the regulatory positions of References 4 and 5 and certain recommendations of Reference 7, the subsection will be judged acceptable if it contains a description and evaluation of site-related geologic features, seismic conditions, and conditions caused by human activities, at appropriate levels of detail within areas approximately defined by radii of 40 km (25 mi), 8 km (5 mi), and 1 km (0.6 mi) around the site. This subsection should contain the following general site information:

1. The structural geology of the site, specifically the identification and characterization of local seismic sources and their relationship to the regional structural geology and seismic sources.

2. The seismicity of the site, including historical and instrumentally recorded earthquakes, and whether there is a relationship to tectonic structure.

3. The geological history, particularly the Quaternary period, of the site and its relationship to the regional history.

4. Evidence of paleoseismicity or lack of it.

5. The site stratigraphy and lithology and their relationship to those of the region.

6. The engineering significance of geological features underlying the site as they relate to:

   a. Dynamic behavior during prior earthquakes.

   b. Zones of alteration, irregular weathering, or zones of structural weakness.

   c. Unrelieved residual stresses in bedrock.

   d. Materials that could be unstable because of their mineralogy or unstable physical properties.

   e. Effects of human activities in the area.

7. The site groundwater conditions.

III. REVIEW PROCEDURES

The staff review is conducted in three phases. The first phase is the acceptance review, a brief review of the SAR or ESR to evaluate its completeness and to identify obvious safety issues that could result in delays at subsequent stages of the review. The judgments on acceptance or rejection of the SAR or ESR for review are governed by two criteria: (1) adherence to the Standard Format (Ref. 6) in identifying and describing the geological, seismological, and geophysical features and the conditions resulting from human activities that affect safety of the site, and (2) provision of adequate information and documentation as described in Regulatory Guide 1.165 (Ref. 3) to allow for an independent staff review of the conclusions made therein.

After an SAR or ESR is docketed, the staff conducts a thorough review of the material. In this second phase of the review an effort is made to identify all safety issues. The reviewer carefully examines the SAR or ESR to see that all interpretations are founded on sound geological and seismological practice and do not exceed the limits of validity of the applicant's data or of other data, such as that published in the scientific literature.
The SAR or ESR is also reviewed for any significant new information derived by the site-specific geological, seismological, and geophysical investigations that had not been applied to the tectonic and ground motion models used in the PSHA. Appendix E of Regulatory Guide 1.165 (Ref. 3) discusses an acceptable method to address significant new information in the PSHA.

At the beginning of this phase of the review, the staff usually seeks assistance from the USGS and decides to what extent consultants should be involved. The necessary information is then made available to the USGS advisors and consultants. Advisors from the USGS and consultants are asked to perform such varied tasks as reviewing the tectonic setting of plants in regions of complex geology, evaluating the potential for surface displacement, verifying an applicant's mineral identifications and geochronology, or

providing advice on the proper level of earthquake ground motion in the seismic evaluation of selected sites.

A review of relevant references is conducted by the staff, USGS advisors, and consultants. Pertinent references, such as published geological reports, professional papers, open-file material, university theses, physiographic and geological maps, and aeromagnetic and gravity maps, are ordered from the appropriate sources and reviewed. Several basic general references used in the past by the staff are References 9, 15, and 16. The GeoRef data base (American Geological Institute, Falls Church, Virginia) and other data bases, such as the American Petroleum Institute Data Base (accessible through RECON system) and the Department of Energy's RECON/Energy Data Base, are used to identify specific references.

As publication usually lags behind the completion of research or construction investigation projects by months or years, the reviewers should not rely entirely on information submitted by the applicant or in the published literature. The reviewers should make an effort to identify any pertinent studies that may be under way in the site region and any preliminary findings of these studies. This may be accomplished by contacting the USGS or other Federal agencies, State geological surveys, universities, and industry, to obtain current information about the site. Some pertinent information may be of a proprietary nature, and special provisions may be required to examine the data.

The staff members will conduct a geological reconnaissance of the site and region around the site as part of the second phase of the review to examine geological features, soil and rock samples from core borings or test pits, trenches excavated across the site, and actual excavations for the plant facilities, if present at this stage. This site reconnaissance is especially important in view of the requirement of 10 CFR Part 52 (Ref. 8), which allows for a combined license as an alternative to the previous two-step requirement of a construction permit followed by an operating license. In the previous procedure, many geologic features, such as faults (as at North Anna, Summer, Byron, Catawba, Seabrook, Watts Bar) that had the potential to impact the safety of the plant were not identified until the actual construction excavations for the plant were made. Additionally, unanticipated engineering problems have occurred during and after construction (as at North Anna, WNP-2, Nine Mile Point 2). For example, larger-than-expected settlements have frequently occurred in engineered backfill, even though the design had been approved by the staff during the construction permit review. Under 10 CFR Part 52, the construction excavations for a plant will not be made until after the staff has prepared the site safety evaluation report (SER).

During the second phase of the review, questions and comments are developed from items that have not been adequately addressed by the applicant, those which become apparent during the detailed review, or those which develop from the additional information provided as a result of the acceptance review. These first-round questions usually require the applicant to conduct additional investigations or to supply clarifying information. Questions may result from the reviewer's discovery of references not cited by the applicant that contain conclusions that are in conflict with those made by the applicant. When the applicant provides insufficient data to support its interpretations and conclusions and there are reasonable, technically supported, more conservative alternative interpretations in the literature,

the staff will request additional investigations, or require that the applicant adopt the more conservative interpretation. This phase of the review will usually involve public meetings with the applicant to clarify questions and allow the applicant to present new data to justify its position. The applicant's responses to questions are reviewed and any remaining issues are settled either by a second round of questions or by staff positions.

The third review phase is the staff evaluation of the applicant's responses to questions raised in the second phase. At the end of the third phase, the staff takes positions on all safety-related issues, either concurring with the applicant's positions or taking more conservative positions as may be necessary in the staff's view to assure the required degree of safety.

A staff position is usually in the form of a requirement to provide confirmatory information or to design for a specific condition in a way that the staff considers to be sufficiently conservative and consistent with the requisites of Reference 2. When all safety issues have been resolved, the staff provides its input to the safety evaluation report (SER).

A staff position that has characterized licensing during the past two decades is that all Seismic Category I excavations are required to be geologically mapped by the applicant and examined by the staff before backfill is placed or concrete poured. These activities were usually accomplished before the SER was made final. This procedure should continue in the future regarding sites that are licensed under the 10 CFR Part 50 two-phase construction permit and operating license procedure.

However, under the 10 CFR Part 52 combined licensing procedure (COL), as described above, geological features such as faults that are not discovered until after the construction excavations are made and therefore after the license has been issued, will not have been assessed by the staff. Likewise, unanticipated engineering problems such as the presence of liquefiable materials, excessive settlement, heave, or groundwater flow that occur during or following construction will not have been evaluated by the staff. For these reasons, there must be a commitment in the site-specific portion of the SAR for a facility to (1) notify the staff immediately if previously unknown geologic features that could represent a hazard to the plant are encountered during excavation; (2) geologically map all excavations for Seismic Category I structures, as a minimum; and (3) notify the NRC staff when the excavations are open for examination and evaluation. The staff should conduct a followup site review when the excavations for the Seismic Category I structures are open to confirm the conclusions that the site parameters are within the envelope of the certified design.

IV. EVALUATION FINDINGS

On completion of the review of the geological and seismological aspects of the plant site and region, if the evaluation by the staff confirms that the applicant has met the requirements of applicable portions of References 1 and 2, and the guidance contained in References 3, 4, 5, and 6, the conclusion in the SER states that the information provided and investigations performed support the applicant's conclusions regarding the geological and seismological integrity of the proposed nuclear power plant site. Licensing conditions instituted by the staff to resolve any significant deficiency identified in

the applicant's SAR or ESR are stated in sufficient detail to make clear the precise nature of concern and required resolution.

Determinations with respect to the geological and seismological suitability of the site are made by the staff after the early site, construction permit, or operating license reviews. A conclusion regarding an operating license will include an evaluation of the excavations for Seismic Category I structures. A conclusion regarding the geological and seismological suitability of a site following a combined license review will be made when the applicant has committed to mapping excavations for Seismic Category I facilities and notifying the staff of their availability for examination. The staff will conduct this examination at the appropriate time after licensing to confirm that there are no previously unknown features such as potentially active faults, evidence for strong ground motions such as late Quaternary seismically induced paleoliquefaction features, unsuitable soil zones, or cavities in the excavations.

This final staff visit, in addition to determining whether there is any new information since the combined licensing review, ensures that the staff recommendations or conditions formulated by the staff during the combined licensing review have been implemented.

A typical staff finding at the conclusion of the licensing review follows.

> In its review of the geological and seismological aspects of the plant, the staff has considered pertinent information gathered in support of the application for a license. The information reviewed includes data from site and near-site investigations, as well as a geological reconnaissance of the site and region, an independent review of recently published literature, and discussions with knowledgeable scientists with the USGS and other Federal agencies, the State Geological Survey, local universities, consulting firms, etc.
>
> Based on its review:
>
> (1) The geological, geophysical, and seismological investigations and other information provided by the applicant and required by 10 CFR 100.23 have been combined with the staff's independent review of the data and other sources of information, including a geological reconnaissance of the site and region and examination of excavations for Seismic Category I structures at the site. These results provide an adequate basis to establish that no capable tectonic sources or seismogenic sources exist in the plant site area that have the potential of causing near-surface displacement or earthquakes to be centered there.
>
> (2) Based on the results of the applicant's regional and site geological, seismological, and geophysical investigations and the staff's independent evaluation, the staff concludes that all seismic sources significant to determining the SSE for the site have been identified and appropriately characterized by the applicant in accordance with Regulatory Guide 1.165 and SRP Section 2.5.2.

(3) Based on the applicant's geological, geophysical, and geotechnical investigations of the site vicinity and site area, the staff concludes that the site lithology, stratigraphy, geological history, structural geology, and characteristics of the subsurface soils and rocks have been properly characterized.

(4) There is no potential for the occurrence of other geological events (such as landsliding, collapse or subsidence caused by carbonate solutioning, differential settlement) that could compromise the safety of the site; or the applicant has mitigated such occurrences and has adequately supported the engineering solutions in the SAR.

(5) There is no potential for the effects of human activity, such as subsidence caused by withdrawal or injection of fluids or collapse due to mineral extraction, that compromises the safety of the site; or the applicant has taken steps to prevent such occurrences and has adequately supported these actions in the SAR.

(6) If this is a combined license review, the staff states that the conclusions stated under (1) above will be confirmed based on a detailed examination of the walls and floors of the excavations for the Seismic Category I facilities, the applicant's geological map of these exposures, and an examination by the staff of the applicant's engineering solutions to mitigate any nontectonic geological hazard.

The staff's evaluation of the geological and seismological information pertaining to this site, which is presented by the applicant in the SAR or ESR, is discussed in SER sections 2.5.1, 2.5.2, and 2.5.3.

The staff concluded that the site is acceptable from a geological and seismological standpoint and meets the requirements of (1) Appendix A (General Design Criterion 2) to 10 CFR Part 50 and (2) 10 CFR 100.23. This conclusion is based on the following:

1. The applicant has met the requirements of:

   a. Appendix A (General Design Criterion 2) to 10 CFR Part 50 with respect to protection against natural phenomena such as earthquakes, faulting, and collapse.

   b. 10 CFR 100.23, "Geologic and Seismic Siting Factors," with respect to obtaining the geologic and seismic information necessary to determine (1) site suitability and (2) the appropriate design of the plant. In complying with this regulation the applicant also meets the staff's guidance described in Regulatory Guide 1.165, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion" (Ref. 3); Regulatory Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants" (Ref. 4); and Regulatory Guide 4.7, "General Site Suability Criteria for Nuclear Power Stations" (Ref. 5).

V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this SRP section.

Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides.

The provisions of this SRP section apply to reviews of construction permits, operating licenses, early site permits, and combined license applications docketed pursuant to 10 CFR 100.23.

VI. REFERENCES

1. General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena," in Appendix A to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities."

2. Section 100.23, "Geologic and Seismic Siting Factors," in 10 CFR Part 100, "Reactor Site Criteria."

3. US NRC, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion," Regulatory Guide 1.165.[1]

4. US NRC, "Site Investigations for Foundations of Nuclear Power Plants," Regulatory Guide 1.132.[1]

5. US NRC, "General Site Suitability Criteria for Nuclear Power Stations," Regulatory Guide 4.7.[1]

6. US NRC, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants (LWR Edition)," Regulatory Guide 1.70.[1]

[1]Single copies of the regulatory guides, both active and draft, may be obtained free of charge by writing the Office of Administration, Attn: Distribution and Services Section, USNRC, Washington, DC 20555 or by fax at (301)415-2260. Copies are available for inspection or copying for a fee from the NRC Public Document Room at 2120 L Street NW., Washington, DC; the PDR's mailing address is Mail Stop LL-6, Washington, DC 20555; telephone (202)634-3273; fax (202)634-3343.

7. US NRC, "Report of the Siting Policy Task Force," NUREG-0625, August 1979.[2]

8. 10 CFR Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants,"

9. R.L. Bates and J. Jackson, editors, "Glossary of Geology," Second Edition, American Geological Institute, Falls Church, Virginia, 1980.

10. S.M. Colman, K. L. Pierce, and P. W. Birkeland, "Suggested Terminology for Quaternary Dating Methods," Quaternary Research, Volume 288, pp. 314-319, 1987.

11. J.B. Savy et al., "Eastern Seismic Hazard Characterization Update," Lawrence Livermore National Laboratory, UCRL-ID-115111, June 1993.

12. P. Sobel, "Revised Livermore Seismic Hazard Estimates for Sixty-Nine Nuclear Power Plant Sites East of the Rocky Mountains," US NRC, NUREG-1488, April 1994.[2]

13. Electric Power Research Institute, "Probabilistic Seismic Hazard Evaluation of Nuclear Power Plant Sites in the Central and Eastern United States," Volumes I through 10, NP-4726A, 1989.

14. Electric Power Research Institute, "Guidelines for Determining Design Basis Ground Motions," EPRI Report TR-102293, Vols. 1-4, May 1993.

15. A.L. Odom and R. D. Hatcher, Jr., "A Characterization of Faults in the Appalachian Foldbelt," US NRC, NUREG/CR-1621, September 1980.

16. G.V. Cohee (Chairman) et al., "Tectonic Map of the United States," U.S. Geological Survey and American Association of Petroleum Geologists, 1962.

[2]Copies are available for inspection or copying for a fee from the NRC Public Document Room at 2120 L Street NW., Washington, DC; the PDR's mailing address is Mail Stop LL-6, Washington, DC 20555; telephone (202)634-3273; fax (202)634-3343. Copies may be purchased at current rates from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20402-9328 (telephone (202)512-2249); or from the National Technical Information Service by writing NTIS at 5285 Port Royal Road, Springfield, VA 22161.