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FEB 18 1992

MEMORANDUM FOR: Edward L. Jordan, Chairman
Committee to Review Generic Requirements

FROM: Eric S. Beckjord, Director
Office of Nuclear Regulatory Research

SUBJECT: PROPOSED REVISION OF 10 CFR PART 100, REACTOR SITE CRITERIA, REVISIONS TO 10 CFR PART 50, NEW APPENDIX B TO 10 CFR PART 100 AND APPENDIX S TO 10 CFR PART 50, AND ASSOCIATED REGULATORY GUIDES

Enclosed for CRGR review are the subject documents which the NRC staff is recommending that the Commission issue for comment in the Federal Register.

The paper contains recommendations on two related but separate areas involving revisions to 10 CFR Part 100 and the relocation of plant design requirements to 10 CFR Part 50. Implementation of these changes is intended to help provide a more stable regulatory basis for the siting of nuclear power plants by decoupling decisions of site suitability from those involving plant design. The first part of this proposed rule change primarily involves specifying site criteria (e.g., exclusion area and population distribution) directly and removing source terms and dose calculations from the evaluation of site suitability. The requirement for dose calculations (and related source term) will be relocated from Part 100 to Part 50 of the regulations on an interim basis until such time as a more comprehensive revision to Part 50 incorporating updated source term and severe accident insights can be made.

The second part of the proposed change will involve updating the seismic and geological siting criteria (Appendix A to Part 100) to reflect current understanding. Earthquake engineering criteria will be relocated to a new appendix (Appendix S) to Part 50.

The enclosed <u>Federal Register Notice</u> describes each of the proposed changes which are intended to accomplish the following:

1. The proposed regulatory action will apply to applicants for power reactors who apply for a construction permit, operating license under 10 CFR Part 50, early site approval, design certification, or combined license (construction permit and operating license) under 10 CFR Part 52 on or after the effective date of the revised regulation. The

current regulation will remain in place and be applicable to all licensees and applicants prior to the effective date of the revised regulation.

2. Part 100 will specify the criteria applicable to the site (e.g., exclusion area distance, population distribution, establishment of the safe shutdown earthquake ground motion).

3. Source term and dose calculations would not be used for evaluating site suitability under Part 100. Instead, they will, on an interim basis, be placed into Part 50 consistent with the location in the regulation of other plant design requirements.

4. Also placed into Part 50 are the earthquake engineering criteria currently in Section VI of Appendix A to Part 100.

5. The revised Appendix A to Part 100 (now designated as Appendix B) describes requirements, while the detailed guidance has been moved to a regulatory guide. The revised regulation requires both deterministic and probabilistic analyses.

6. The specification that the Operating Basis Earthquake (OBE) is one-half the Safe Shutdown Earthquake has been deleted and replaced with two options.

7. Section 50.54 has been revised to state that plant shutdown is required if vibratory ground motion exceeding the OBE or significant plant damage occurs.

The ACRS has reviewed the reactor siting criteria portion of this package and has written a letter to the Commission, dated January 15, 1992. The ACRS Reactor Safeguards Extreme External Phenomena Subcommittee has reviewed the proposed revision of Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants," to Part 100 on December 10, 1991. The Subcommittee Chairman stated, during the concluding remarks, that Proposed Appendix B to Part 100, Proposed Appendix S to Part 50, and the three supporting engineering related regulatory guides (DG-1016, DG-1017 and DG-1018) could be issued for public comment. The regulatory guide supporting Proposed Appendix B, (DG-1015) was discussed at the February 5, 1992, Subcommittee meeting. The ACRS Full Committee discussed the revision of Appendix A to Part 100 on February 7, 1992, and a letter recommending issuance for public comment is expected.

The proposed rule changes are scheduled to be discussed with the Commission by mid-March. Therefore, we request that the CRGR review these rule changes late in February to support this schedule.

FEB 18 1992

For further information contact Dr. Andrew Murphy, RES 492-3860 on issues related to seismic and earth sciences and Leonard Soffer, RES 492-3916 on the other issues related to site suitability.

ORIGINAL SIGNED BY

Eric S. Beckjord, Director
Office of Nuclear Regulatory Research

Enclosures:
1. Commission Paper
2. Federal Register Notice of Rulemaking
3. Regulatory Analysis
4. Environmental Assessment
5. OMB Reporting Review Package
6. Federal Register Notice of Regulatory Guide and Standard Review Plan Section Availability
7. Proposed Revised Regulatory Guide 4.7, (General Site Suitability Criteria)
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11. Proposed Draft Regulatory Guide DG-1018, (Plant Restart)
12. Proposed Revision 3 to Standard Review Plan Section 2.5.2 (Vibratory Ground Motion)

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NRR J. Richardson 2/12/92

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*See previous concurrence

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For: The Commissioners

From: James M. Taylor
Executive Director for Operations

Subject: REVISION OF 10 CFR PART 100, REACTOR SITE CRITERIA; REVISIONS TO 10 CFR PART 50; AND NEW APPENDIX B TO 10 CFR PART 100 AND APPENDIX S TO 10 CFR PART 50

Purpose: To obtain Commission approval to publish for public comment proposed revisions to reactor siting regulations and associated Regulatory Guides for future applicants that will decouple siting from plant design and reflect advancements in the state—of—the-art of earth sciences and earthquake engineering with regard to siting power reactors.

Summary: This proposed rule change to 10 CFR Part 100, "Reactor Site Criteria," is intended to accomplish three major changes. The first change would be to add a new section to Part 100 (designated Subpart B) for future plants eliminating the use of a postulated accident source term and the use of dose calculations in the determination of acceptability of a nuclear power plant site. The existing requirements would be retained for existing plants and non—power reactors. This proposed rule change would set a minimum size for the exclusion area and would set population density criteria around future reactor sites. The requirement for a low population zone (LPZ) would be de[illegible]d from 10 CFR Part 100 for future plants. Requirements re[illegible]ing the evaluation of man-related hazards and the feas[illegible]ty of carrying out protective actions in the event of [illegible]diological emergency are incorporated into 10 CFR Part 1[illegible]

The second change is to revise Ap[illegible]x A, "Seismic and Geologic Siting Criteria for Nuclear [illegible]lants," to 10 CFR Part 100 to reflect current un[illegible]ing and the advancements in the state—of—the—a[illegible]th sciences and earthquake engineering with regard t[illegible]r siting. The proposed regulation would requir[illegible] use of both probabilistic and deterministic analyses in reactor siting. Also, detailed guidance on what constitutes an acceptable investigation or design bases would be deleted from the regulation and placed into a regulatory guide. The revised criteria will not be applied to existing plants. Therefore

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Dr. Andrew J. Murphy, RES
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For: The Commissioners

From: James M. Taylor
Executive Director for Operations

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The second change is to revise Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants," to 10 CFR Part 100 to reflect current understanding and the advancements in the state—of—the—art of earth sciences and earthquake engineering with regard to reactor siting. The proposed regulation would require the use of both probabilistic and deterministic analyses in reactor siting. Also, detailed guidance on what constitutes an acceptable investigation or design bases would be deleted from the regulation and placed into a regulatory guide. The revised criteria will not be applied to existing plants. Therefore

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the proposed revised criteria will be designa ed Appendix B so that the licensing bases for existing plants is maintained.

The third part of this rulemaking is revisions to Part 50. One portion of the Part 50 revision is to add, on an interim basis, the source term and dose calculations being deleted from Part 100. The source term and dose calculations to be added to Part 50 would be for evaluating plant features, not site suitability. A second portion is to transfer all seismic criteria not associated with the selection of the site or establishment of the Safe Shutdown Earthquake (SSE) from Part 100 Appendix A to Part 50 Appendix S. Section 50.54 has been revised to require plant shutdown if vibratory ground motion exceeding that of an Operating Basis Earthquake (OBE) ground motion or significant plant damage occurs.

Background: A. Reactor Siting Criteria (non—seismic):

The present criteria regarding reactor siting were issued in April 1962. There were only a few small power reactors operating at that time. The present regulation requires that every reactor have an exclusion area which normally has no permanent residents; transient use is permitted. A low population zone immediately beyond the exclusion area is also required within which protective actions can be taken. The regulation recognizes the importance of accident considerations in reactor siting; hence a key element in it is the determination of the size of the exclusion area via the postulation of a large accidental fission product release within containment and the evaluation of the radiological consequences, in terms of doses. Doses are calculated for two hypothetical individuals located at any point (generally, the closest point) on the exclusion area boundary, and at the outer radius of the low population zone, and are required to be within specified limits (25 rem to the whole body and 300 rem to the thyroid gland). In addition, the nearest population center, containing about 25,000 or more residents, is required to be no closer than one and one-third times the outer radius of the low population zone. The effect of these requirements is to set both individual and, to some extent, societal limits on dose (and implicitly on risk); without setting numerical criteria on exclusion area and low population zone size. Numerical limits on population are also not specified. However, since 1975, Regulatory Guide 4.7, "General Site Suitability Criteria for Nuclear Power Stations," has provided guidelines on acceptable exclusion area distance and population density and has been used in the review of sites.

On June 1, 1976, the Public Interest Research Group (PIRG) filed a petition for rulemaking (PRM-100-2) requesting that the NRC incorporate minimum exclusion area and low population zone distances and population density limits into the regulations. In August 1978, the Commission directed the staff to develop a general policy statement on nuclear power reactor siting. The "Report of the Siting Poilcy Task Force," (NUREG-0625) was issued in 1979 and provided recommendations in this regard. On July 29, 1980, the NRC issued (45 FR 50350) an Advance Notice of Proposed Rulemaking (ANPR) regarding revision of the reactor siting criteria which discussed the recommendations of the Siting Policy Task Force and sought public comments. The proposed rulemaking was deferred by the Commission in December 1981 to await development of the Safety Goal and improved research on accident source terms. On August 4, 1986, the Policy Statement on Safety Goals was issued (51 FR 23044). On November 29, 1988, the PIRG petition was denied (28 NRC 829) on the basis that it would unnecessarily restrict NRC's regulatory siting policies and would not result in a substantial increase in the overall protection of the public health and safety. Although the PIRG petition proposed more restrictive criteria than those being proposed by the staff, a decision to proceed with a rulemaking in this area represents a partial granting of the PIRG petition.

In SECY-90-341, dated October 4, 1990, and a subsequent memorandum from J. Taylor to the Commissioners, dated December 13, 1990, the staff proposed to decouple siting from plant design for future plants via a two step rulemaking. Step one is to modify Part 100 to address directly the site criteria while moving the dose requirements currently in Part 100 to Part 50 on an interim basis. Step two is to update Part 50 to reflect current source term information and to replace the interim dose requirements with updated design criteria. The Commission, in a Staff Requirements Memorandum (SRM) dated January 25, 1991, approved the staff recommendation. This paper presents step one of the proposed regulation change.

B. Seismic Siting and Earthquake Engineering Criteria:

Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants," to 10 CFR Part 100, "Reactor Siting Criteria," was originally issued as a proposed rule on November 25, 1971 (36 FR 22601), published as a final rule on November 13, 1973 (38 FR 31279), and became effective on December 13, 1973. There have been two amendments to 10 CFR Part 100, Appendix A. The first amendment, issued November 27, 1973 (38 FR 32575), corrected the final rule by adding the legend under the diagram. The second amendment resulted from a petition for rule making (PRM 100-1) requesting that an opinion interpreting and clarifying Appendix A with respect to the determination of the Safe Shutdown Earthquake be issued. A notice of filing of the petition was published on May 14, 1975 (40 FR 20983). The substance of the petitioner's proposal was accepted and published as an immediately effective final rule on January 10, 1977 (42 FR 2052).

Discussion: The proposed regulation changes included with this paper primarily involve two related but basically separate changes. The first change involves the non-seismic portion of the reactor siting criteria, 10 CFR Part 100. The second change involves updating the siting seismic and earth sciences criteria in Appendix A to Part 100.

A. Reactor Siting Criteria (non-seismic):

The proposed revision to Part 100 retains, for existing plants and non-power reactors, the current criteria, including the dose requirements. The current criteria are designated subpart A and apply to non-power reactors and to plants currently licensed or applying for a license prior to the effective data of the proposed regulation. A new subpart B is added to Part 100. Subpart B contains the proposed new requirements for power reactor applicants after the effective date of the proposed regulation. Part 52 Appendix Q would be amended to note the potential for revisiting the population density and man-made hazard potential for renewal of early site permits.

These proposed changes are based on current staff practice and for the most part are derived from the guidelines in Regulatory Guide 4.7, "General Site Suitability Criteria for Nuclear Power Stations." Experience over the past 15 years has generally shown the existing practice to result in low risk to the public while not overly restricting the siting of nuclear power plants. It also reflects the Commission's desire to maintain defense in depth by prohibiting metropolitan siting. In addition, information developed over the past 12 years on radioactive material releases under accident conditions confirms the acceptability of present practice in limiting risk to the public. In developing the proposed changes, the staff considered the Commission's Safety Goal Policy Statement along with the recommendation of the Siting Policy Task Force (NUREG-0625) of 1979. The proposed regulation would require a minimum exclusion area distance of 0.4 miles for stationary power reactors. The proposed regulation states that at the time of initial site approval, offsite population density values averaged over any radial distance out to 30 miles should not exceed 500 people per square mile. In addition, the projected offsite population density 40 years after the time of site approval should not exceed 1000 people per square mile out to a radial distance of 30 miles.

The proposed regulation adds or modifies existing requirements for obtaining information to characterize meteorological and hydrological factors at a site. This information will then be reviewed by the staff for evaluating plant design features in matching a proposed design to the site.

The proposed regulation reflects the requirement currently in 10 CFR Part 52.17 for review of emergency planning considerations for early site permits. The rule would require that important site factors, such as population distribution, topography, and transportation routes be considered and examined in order to determine whether there are any site characteristics that could pose a significant impediment to the development of an emergency plan. Limitations of access or egress in the immediate vicinity of a nuclear power plant should be identified at the site approval phase.

A proposed revision to Regulatory Guide 4.7, for consistency with the proposed regulation, is also included in the package.

<u>B. Seismic Siting and Earthquake Engineering Criteria</u>:

The staff proposes to amend its regulations to update the seismic siting and engineering criteria for new nuclear power plants. The proposed regulatory action is applicable only to applicants that apply for a construction permit, operating license, early site permit, design certification, or combined license (construction permit and operating license) on or after the effective date of the regulations.

The proposed regulation would allow NRC to benefit from experience gained in the application of the procedures and methods set forth in the current regulation, the difficulties encountered, and the [illegible] advancement in the state-of-the-art of the earth sciences. Detailed guidance that has created difficulty for applicants and the staff in terms of inhibiting the use of needed judgement, latitude, and the use of evolving methods of analyses. It has been deleted from the proposed regulations and placed into a proposed regulatory guide. Also, the proposed regulation will require the use of probabilistic as well as deterministic analyses to determine the vibratory ground motion at the site. Probabilistic analyses will provide an explicit expression of the overall uncertainty in the derived ground motion.

The proposed regulations would better reflect industry design practices and the associated staff review procedures that have evolved since the regulation was issued. The proposed regulation would move the location of the seismic input motion control point from the foundation level to the ground surface.

Criteria not associated with the selection of the site or establishment of the SSE ground motion have been placed into Part 50. This action is consistent with the location of other design requirements in Part 50.

The specification that the OBE (the vibratory ground motion that will assure safe continued operation) is one—half the SSE has been deleted from the proposed regulation and replaced with two options; either one—third of the SSE ground motion, or greater. There are two issues the applicant should consider in selecting the value of the OBE; first, plant shutdown is required if vibratory ground motion exceeding that of the OBE occurs and second, the amount of analyses associated with the OBE. With the OBE ground motion level set at one—third of the SSE, requirements for OBE specific plant analyses and design are drastically reduced. This change responds to one of the major criticisms with the existing regulations, that the OBE controls the design of some parts of the plant.

The proposed regulation would treat plant shutdown associated with vibratory ground motion exceeding the OBE (or significant plant damage) as a condition in every operating license. Section 50.54 is proposed to be revised accordingly.

Because the revised criteria presented in the proposed regulation will not be applied to existing plants, the licensing bases for existing nuclear power plants must remain part of the regulations. Therefore, the proposed revised criteria on seismic and geologic siting would be designated as a new Appendix B to 10 CFR Part 100 and would be added to the existing body of regulations. In addition, earthquake engineering criteria will be located in 10 CFR Part 50, Appendix S. Since Appendix S is not self executing, applicable sections of Part 50 (§50.8 and §50.34) are revised to reference Appendix S. The proposed regulation would also make conforming amendments to 10 CFR Parts 52 and 100. Sections 52.17(a)(1), §52.17(a)(1)(vi), §100.8, and §100.20(c)(1) and (3) would be amended to note Appendix B to Part 100 or Appendix S to Part 50.

The staff has developed the following draft regulatory guides and standard review plan section to provide prospective licensees with the necessary guidance for implementing the proposed regulations:

DG-1015, "Identification and Characterization of Seismic Sources, Deterministic Source Earthquake and Ground Motion." The draft guide provides general guidance and recommendations, describes acceptable procedures and provides a list of references that present acceptable methodologies to identify and characterize capable tectonic sources and seismogenic sources.

DG-1016, Second Proposed Revision 2 to Regulatory Guide 1.12, "Nuclear Power Plant Instrumentation for Earthquakes." The draft guide describes seismic instrumentation type and location, operability, characteristics, installation, actuation, and maintenance that are acceptable to the NRC staff.

DG-1017, "Pre-Earthquake Planning and Immediate Nuclear Power Plant Operator Post-Earthquake Actions." The draft guide provides guidelines that are acceptable to the NRC staff for a timely evaluation of the recorded seismic instrumentation data and to determine whether or not plant shutdown is required.

DG-1018, "Restart of a Nuclear Power Plant Shut Down by a Seismic Event." The draft guide provides guidelines that are acceptable to the NRC staff for performing inspections and tests of nuclear power plant equipment and structures prior to restart of a plant that has been shut down due to a seismic event.

Draft Standard Review Plan Section 2.5.2, Proposed Revision 3 "Vibratory Ground Motion." The draft describes procedures to assess the ground motion potential of seismic sources at the site and to assess the adequacy of the Safe Shutdown Earthquake Ground Motion.

General

The draft guides and standard review plan section are being presented along with, and should be issued simultaneously with, the proposed revision to the regulations.

During the development of this proposed rule the staff benefitted from two public meetings with interested industry groups. Principal attendees included staff from the Nuclear Management and Resources Council (NUMARC), Electric Power Research Institute (EPRI), Department of Energy (DOE) and industry. During the first meeting (March 6, 1991) the staff discussed schedule and technical topics for potential inclusion in the revision of Appendix A to Part 100. The second meeting (April 17, 1991) provided industry and other interested members of the public with an opportunity to express their views on the Appendix A revision.

The enclosed Federal Register Notice contains information on the scope of this rulemaking and requests public input. The Federal Register Notice also addresses actions related to new and revised Regulatory Guides and Standard Review Plan Sections.

The ACRS subcommittees were briefed on the staff's approach on December 10, 1991 (seismic), January 7, 1992 (non-seismic), and February 5, 1992 (seismic). The ACRS full committee was briefed on January 10, 1992 (non-seismic) and on February 7, 1992 (seismic). The ACRS provided comments to the Commission in letters dated January 15, 1992 (Enclosure 14) and February __, 1992 (Enclosure 15).

In the January 15, 1992 letter, the ACRS stated that they believed that the staff's proposed revision to Part 100 and proposed interim revision to Part 50 were reasonable and should proceed. However, they recommended further work with regard to both Part 100 and Part 50 as part of the staff's longer term efforts to revise Part 50. Regarding Part 100, the ACRS recommended further work to reexamine or justify the basis for key requirements such as the exclusion zone, emergency planning zone (EPZ), and the maximum population density in light of the large amount of experience and information that has been accumulated since 1962. Further, the ACRS recommended that the relation of these requirements to the Safety Goal Policy should be established. Finally, the ACRS recommended that meteorological requirements be incorporated into Part 100 to exclude "unacceptable" sites.

The staff considered the issues raised by the ACRS in the development of the proposed Part 100 regulation. A single revision of Part 100 was proposed in SECY-90-341 as well as in a memorandum to the Commission dated December 13, 1990. The purpose is to complete the Part 100 update prior to the expected submittal date of an application for an early site permit, as part of a Department of Energy sponsored initiative. This proposal was approved by the Commission in its Staff Requirements Memorandum (SRM) dated January 25, 1991. The staff still believes this approach is appropriate and is working to have all Part 100 revisions completed in one revision. In this regard, the staff is requesting comments on those issues raised by the ACRS in order to resolve these issues in a single rulemaking effort.

Regarding the basis for the exclusion area radius and population density in the proposed regulation, codifying the guidance of Regulatory Guide 4.7 is appropriate and reflects the large amount of experience gained in licensing reviews. The basis for the exclusion area radius is that staff experience has shown that a typical plant having available engineered safety features will likely meet the dose values of Part 100. In addition, the staff has evaluated the proposed radius in relation to the Safety Goals and has confirmed that the proposed value will meet the quantitative health objectives for a 3800 MW_{th} light water reactor. The proposed population density values have served to keep large population centers away from the plant and in practice accomplished what the LPZ is intended to accomplish, while still allowing for a reasonable selection of sites on all regions of the nation. The staff also confirmed that for a plant similar to those evaluated in NUREG—1150, the quantitative health objectives (QHO) would be met at the recommended population density. However, because the QHO is based on individual risk, the QHO do not provide a measure of the appropriateness of any specific population density.

The staff also reexamined the ten mile EPZ in SECY—90—341, in response to the Commission's SRM of February 13, 1990, and noted that today's methodologies tended to indicate that radiation doses and consequences would generally be lower at a given distance than previously predicted. However, the staff recommended that the present EPZ be maintained in order to provide assurance that an adequate planning base be maintained.

Staff experience, as well as contractor studies regarding site meteorology, have shown that while meteorological conditions at a given site vary significantly over time, there is much less variation from site to site. The differences in site meteorology should be reflected in the design requirements for certain plant features. However based on the above studies, the staff concludes that the average meteorological characteristics between one site and another are sufficiently similiar that characterization of individual site meteorology is not a good discriminator with regard to site suitability. However, to obtain additional views on this matter, the proposed regulation package has included a question on the inclusion of a meteorological criteria in Part 100.

Finally, the ACRS raised several concerns regarding the staff's long term effort to update Part 50 and the development of a replacement for the TID—14844 source term. These concerns are being considered by the staff and will be addressed in these longer term efforts.

The Office of the General Counsel has reviewed this paper and has no legal objections.

Recommendation: That the Commission:

1. Approve the issuance of the enclosed draft documents for a 90 day public comment period.

2. Certify that this rule, if promulgated, will not have a significant economic effect on a substantial number of small entities pursuant to the Regulatory Flexibility Act of 1980 (5 U.S.C. 605 (b)).

3. Note:

   a. The proposed regulation and draft federal register notice (Enclosure 1) and notice of availability of draft regulatory guides and draft standard review plan section (Enclosure 5) will be published in the Federal Register for a 90-day public comment period.

   b. A notice of availability of a Regulatory Analysis (Enclosure 2) and an Environmental Assessment and Finding of No Significant Environmental Impact (Enclosure 3) will be supplied concurrently to the Public Document Room (Enclosure 2).

   c. Because Appendix S to Part 50, Appendix B to Part 100 are new, an "information collection requirement" is being submitted to OMB for review (Enclosure 4). It is noted that the overall estimated burden on the staff and industry remains essentially the same; the proposed revisions have added requirements to use probabilistic analyses in seismic and geologic siting while potentially reducing the required earthquake engineering analyses.

   d. A public announcement (Enclosure 12) will be issued when the notice of proposed rulemaking and notice of availability of the draft regulatory guides and draft standard review plan section are filed with the Office of the Federal Register.

   e. The appropriate Congressional committees will be informed (Enclosure 13).

   f. Copies of the Federal Register notices will be distributed to all power reactor permittees and licensees. The notices will be sent to other interested parties upon request.

g. The Chief Counsel for Advocacy of the Small Business Administration will be notified of the Commission's determination, pursuant to the Regulatory Flexibility Act of 1980 (5 U.S.C. 605 (b)), that these proposed regulations, draft regulatory guides, and draft standard review plan section will not have a significant economic effect on a substantial number of small entities.

h. A Backfit Analysis is not required for this proposed rule, because these amendments do not involve any provisions which would impose backfits as defined in §50.109(a)(1).

Scheduling: If scheduled on the Commission agenda, we recommend this paper be considered at an open meeting. No specific circumstance is known to the staff which would require Commission action by any particular date in the near term.

James M. Taylor
Executive Director
for Operations

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10. Proposed Draft Regulatory Guide DG-1018, (Plant Restart)
11. Proposed Revision 3 to Standard Review Plan Section 2.5.2 (Vibratory Ground Motion)
12. Draft Public Announcement
13. Draft Congressional Letters
14. ACRS January 15, 1992 Letter
15. ACRS February ??, 1992 Letter

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DRAFT FEDERAL REGISTER NOTICE

PROPOSED REVISION OF

10 CFR PART 100

AND

APPENDIX A TO 10 CFR PART 100

NUCLEAR REGULATORY COMMISSION

10 CFR Parts 50, 52 and 100

RIN 3150—AD93

Reactor Site Criteria Including Seismic and Earthquake Engineering Criteria for Nuclear Power Plants

AGENCY: Nuclear Regulatory Commission.

ACTION: Proposed regulation.

SUMMARY: The Nuclear Regulatory Commission is proposing to amend its regulations to update the criteria used in decisions regarding power reactor siting including geologic, seismic, and earthquake engineering considerations for future nuclear power plants. The proposed regulation would allow NRC to benefit from experience gained in the application of the procedures and methods set forth in the current regulation, and to incorporate the rapid advancement in the state—of—the—art of earth sciences and earthquake engineering. The proposed regulation primarily consists of two separate changes, namely the source term and dose considerations, and seismic and earthquake engineering considerations of reactor siting. The proposed regulatory action is applicable only to applicants that apply for a construction permit, operating license, preliminary design approval, final design approval, manufacturing license, early site permit, design certification, or combined license (combined construction permit and operating license) on or after [EFFECTIVE DATE OF THE REGULATION].

DATE: Comment period expires 90 days after date of publication in the Federal Register. Comments received after this date will be considered if it is practical to do so, but the Commission is able to assure consideration only for comments received on or before this date.

ADDRESSES: Mail written comments to: Secretary, U.S. Nuclear Regulatory Commission, Washington, DC 20555, Attention: Docketing and Service Branch.

Deliver comments to: 11555 Rockville Pike, Rockville, Maryland, between 7:45 am and 4:15 pm Federal workdays.

Copies of the regulatory analysis, the environmental assessment and finding of no significant impact, and comments received may be examined at: the NRC Public Document Room at 2120 L Street NW. (Lower Level), Washington, DC.

FOR FURTHER INFORMATION CONTACT: Dr. Andrew J. Murphy, Office of Nuclear Regulatory Research, Mail Stop NLS-217A, U.S. Nuclear Regulatory Commission, Washington, DC 20555, Telephone (301) 492-3860 concerning the seismic and earthquake engineering aspects. Mr. Leonard Soffer, Office of Nuclear Regulatory Research, Mail Stop NLS-324, U.S. Nuclear Regulatory Commission, Washington, DC 20555, telephone (301) 492-3916 concerning other siting aspects.

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I. Background

The present regulation regarding reactor site criteria (10 CFR Part 100) was promulgated April 12, 1962 (27 FR 3509). Staff guidance on exclusion area and low population zone sizes as well as population density was issued in Regulatory Guide 4.7, "General Site Suitability Criteria for Nuclear Power Stations," published as a draft in September 1974. Revision 1 to this Guide was issued in November 1975. On June 1, 1976, the Public Interest Research Group (PIRG) filed a petition for rulemaking (PRM—100—2) requesting that the NRC incorporate minimum exclusion area and low population zone distances and population density limits into the regulations. In August 1978, the Commission directed the NRC staff to develop a general policy statement on nuclear power reactor siting. The "Report of the Siting Policy Task Force," (NUREG—0625) was issued in August 1979 and provided recommendations regarding siting of future nuclear power reactors. On July 29, 1980 (45 FR 50350), the NRC issued an Advance Notice of Proposed Rulemaking (ANPR) regarding revision of reactor site criteria which discussed the recommendations of the Siting Policy Task Force and sought public comments. The proposed rulemaking was deferred by the Commission in December 1981 to await development of a Safety Goal and improved research on accident source terms. On August 4, 1986 (51 FR 23044), the NRC issued its Policy Statement on Safety Goals which stated quantitative health objectives with regard to both prompt and latent cancer fatality risks. On November 29, 1988, the NRC (28 NRC 829) denied the PIRG petition on the basis that it would unnecessarily restrict NRC's regulatory siting policies and would not result in a substantial increase in the overall protection of the public health and safety. Because of possible renewed interest in power reactor siting, the NRC is proceeding with a rulemaking in this area. This should be regarded as a partial granting of the petition which requested incorporation of exclusion area size and population density via rulemaking.

Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants," to 10 CFR Part 100, "Reactor Siting Criteria," was originally issued as a proposed regulation on November 25, 1971 (36 FR 22601), published as a final regulation on November 13, 1973 (38 FR 31279), and became effective on December 13, 1973. There have been two amendments to 10 CFR Part 100, Appendix A. The first amendment, issued November 27, 1973 (38 FR 32575), corrected the final regulation by adding the legend under the diagram. The second amendment resulted from a petition for rulemaking (PRM 100—1) requesting that an opinion interpreting and clarifying Appendix A with respect to the determination of the Safe Shutdown Earthquake be issued. A notice of filing of the petition was published on May 14, 1975 (40 FR 20983). The substance of the petitioner's proposal was accepted and published as an immediately effective final regulation on January 10, 1977 (42 FR 2052).

II. Objectives

The objectives of this proposed regulatory action are to:

1. state directly criteria for future sites which, through experience and importance to risk, have been shown key to protecting public health and safety;
2. provide a stable regulatory basis for seismic and geologic siting and applicable earthquake engineering design of future nuclear power plants that will update and clarify regulatory requirements and provide a flexible structure to permit consideration of new technical understandings; and
3. relocate from Part 100 to Part 50 those requirements which apply to plant design, effectively decoupling siting from plant design.

III. Genesis

The proposed regulatory action reflects changes which are intended to (1) benefit from the experience gained in applying the existing regulation and from research; (2) resolve interpretative questions; (3) provide needed regulatory flexibility to incorporate state—of—the—art improvements in the geosciences and earthquake engineering; (4) simplify the language to a more "plain English" text~~; and (5) acknowledge various internal staff and industry comments.~~

The proposed regulatory action will apply to applicants who apply for a construction permit, operating license, preliminary design approval, final design approval, manufacturing license, early site permit, design certification, or combined license after the effective data of the final regulations.

Criteria not associated with the selection of the site or establishment of the safe shutdown earthquake ground motion have been placed into Part 50. This action is consistent with the location of other design requirements in Part 50.

Because the revised criteria presented in the proposed regulation will not be applied to existing plants, the licensing bases for existing nuclear power plants must remain part of the regulations. Therefore, the proposed revised reactor siting criteria would be designated Subpart B in 10 CFR Part 100 for site applications after the effective data of the final regulations and the criteria on seismic and geologic siting would be designated as a new Appendix B to 10 CFR Part 100. These new sections would be added to the existing body of regulations. The dose calculations and the earthquake engineering criteria will be located in 10 CFR Part 50 (§50.34(a) and Appendix S, respectively). Since Appendix S is not self executing, applicable sections of Part 50 (§50.34 and §50.54) are revised to reference Appendix S. The proposed regulation would also make conforming amendments to 10 CFR Parts 52 and 100. Sections 52.17(a)(1), 52.17(a)(1)(vi), and 100.20(c)(1) and (3) and Part 52 Appendix Q would be amended to note Appendix B to Part 100.

IV. Alternatives

The first alternative considered by the Commission was to continue using current regulations for site suitability determinations. This is not considered an acceptable alternative. Although the siting related issues for nuclear power plants currently being licensed are closed or are expected to be closed soon, there is good reason to initiate the proposed regulatory action in light of the current and future staff review of future reactors (particularly certified designs) so that a certified design would not be dependent on site parameters to establish the fission product retention characteristics of the design. Further, the current regulation has created difficulty for applicants and the staff in terms of inhibiting flexibility in applying updated information and using updated methods of analysis in the licensing process.

A second alternative considered was replacement of the existing regulation (LPZ and dose calculations from Part 100 and Appendix A to Part 100) with an entirely new regulation. This is not considered an acceptable alternative because the provisions of the existing regulations form part of the licensing bases for many of the operating nuclear power plants and others that are in various stages of obtaining their operating license.

For seismic and earthquake engineering, a third alternative considered was the replacement of the entire regulation with a regulatory guide. This is not considered acceptable because a regulatory guide is non—mandatory. The Commission believes that there could be an increase in the risk of radiation exposure to the public if the siting and earthquake engineering criteria were non—mandatory.

The approach of establishing the revised requirements in new sections of Part 100 and relocating plant design requirements to Part 50 while retaining the existing regulation was chosen as the best alternative. The public will benefit from a clearer, more uniform, and more consistent licensing process which incorporates updated information and is subject to fewer interpretations. The NRC staff will benefit from improved regulatory implementation (both technical and legal), fewer interpretive debates, and increased regulatory flexibility. Applicants will derive the same benefits in addition to avoiding licensing delays due to unclear regulatory requirements.

V. Major Changes

V.A Reactor Siting Criteria (non—seismic).

The site criteria contained in the proposed regulation are based upon previous guidance issued in Regulatory Guide 4.7, "General Site Suitability Criteria for Nuclear Power Stations," and the risk insights and accident release characteristics of present light water reactors (LWR's), and particularly those plants analyzed in NUREG—1150, "Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants," dated December 1990. However, the proposed criteria decouple siting from plant design and, as such, are independent of the plant type to be built in the site. The Commission considers this a reasonable position since it is expected that future reactors licensed under Part 50 or under Part 52 of the Commission's regulations will reflect through their design, construction and operation an extremely low probability for accidents that could result in release of significant quantities of radioactive fission products. In addition, the recommendations of the Siting Policy Task Force were considered in making these changes as discussed in Section XII.

Rationale for Individual Criteria

A. <u>Exclusion Area</u> - An exclusion area surrounding the immediate vicinity of the plant has been a requirement from the very beginning for siting power reactors. This area has been found to provide a high degree of protection to the public from a variety of potential plant accidents and also affords protection to the plant from potential man--related hazards.

The present regulation has no numerical size requirement for the exclusion area, in terms of distance, and instead assesses the consequences of a postulated radioactive fission product release within containment, coupled with assumptions regarding containment leakage, performance of certain fission product mitigation systems and dispersion factors for a hypothetical individual located at any point on the exclusion area boundary. The plant and site combination is considered to be acceptable if the calculated consequences do not exceed the dose values given in the present regulation. Regulatory Guide 4.7 suggests an exclusion area distance of 0.4 miles, since this has been found, in conjunction with typical engineered safety features, to meet the dose values in the existing regulation.

The Commission considers an exclusion area to be an essential feature of a reactor site, and is retaining this requirement for future reactors. However, in keeping with the recommendation of the Siting Policy Task Force to decouple site requirements from reactor design, the proposed regulation would eliminate the use of a postulated source term, assumptions regarding mitigation systems and dispersion factors, and the calculation of radiological consequences to determine the sizes of the exclusion area and low population zone. It would instead require a minimum exclusion area distance of 0.4 miles for power reactors.

This distance, together with typical engineered safety features previously reviewed by the staff, has generally been found to satisfy the dose guidelines in the present regulation. An exclusion area of this size or larger is fairly common for most power reactors in the U.S., and has not been unduly difficult for most prospective applicants to find and obtain.

Finally, this distance has also been found to readily satisfy the prompt and latent fatality quantitative health objective of the Commission's Safety Goals Policy, when coupled with plant designs as reflected by those in NUREG—1150. Hence, the minimum exclusion area distance proposed would assure a very low level of risk to individuals, even for those located very close to the plant at the population density proposed in the regulation.

Although an exclusion area size of about 0.4 miles is considered appropriate for reactor power levels of current designs, the Commission is also considering whether or not this size unduly penalizes potential reactors having significantly lower power levels. Hence, the Commission requests comments on whether the minimum size of the exclusion area should be fixed at 0.4 miles regardless of reactor power level, or whether it should vary according to reactor power level with a minimum value (for example, 0.25 miles).

B. <u>Low Population Zone</u> - The present regulation requires that a low population zone (LPZ) be defined immediately beyond the exclusion area. Residents are permitted in this area, but the number and density must be such that there is a reasonable probability that appropriate protective measures could be taken in their behalf in the event of a serious accident. In addition, the nearest densely populated center containing more than about 25,000 residents must be located no closer than one and one—third times the outer radius of the LPZ. Finally, the dose to a hypothetical individual located at the outer radius of the LPZ over the entire course of the accident must not be in excess of the dose values given in the regulation. Regulatory Guide 4.7 suggests that an outer radius of about three miles for the LPZ has been found to satisfy the dose values in the present regulation.

Several practical problems have arisen in connection with the low population zone. Before 1980, the LPZ generally defined the distance over which public protective actions were contemplated in the event of a serious accident. Part 50.47 now requires plume exposure Emergency Planning Zones (EPZ) of about ten miles for each plant.

The low population zone also places restrictions on the proximity of the nearest densely populated center of 25,000 or more residents. However, without numerical requirements for the outer radius of the low population zone, this requirement has little practical effect. Typical low population zones for existing power reactors have several thousand residents. If Regulatory Guide 4.7 were followed and a distance of three miles were selected as the low population zone outer radius, a maximum population within the low population zone at the time of site approval would be about 14,000 residents. Finally, the staff has sometimes experienced difficulty in defining "densely populated center."

The Commission considers that the functions intended for the "low population zone", namely, a low density of residents and the feasibility of taking protective actions, have been accomplished by other regulations, or can be accomplished by other means. Protective action requirements are defined via the use of the EPZ's, while restrictions on population close to the plant can be assured via proposed population density criteria. For these reasons, the Commission is proposing to eliminate the requirement of a low population zone for future power reactor sites for purposes of determining site suitability.

C. Population Density Criteria - The present regulation contains no population density requirements other than the requirement, noted above, that the distance to the nearest population center containing more than about 25,000 residents must be no closer than one and one-third times the outer radius of the LPZ. This was recognized as a potential concern when the present regulation was promulgated. As the Commission in 1962 noted in its Statement of Considerations (27 FR 3509) accompanying the issuance of the regulation, "...in some cases where very large cities are involved, the population center distance may have to be greater than those suggested by these guides."

As a result of the significant increase in reactor power levels during the 1960's, the staff issued Regulatory Guide 4.7 in 1974. With respect to population density this guide states as follows:

> "Areas of low population density are preferred for nuclear power station sites. High population densities projected for any time during the lifetime of a station are considered during both the NRC staff review and the public hearing phases of the licensing process. If the population density at the proposed site is not acceptably low, then the applicant will be required to give special attention to alternative sites with lower population densities.
>
> If the population density, including weighted transient population, projected at the time of initial operation of a nuclear power station exceeds 500 persons per square mile averaged over any radial distance out to 30 miles (cumulative population at a distance divided by the area at that distance), or the projected population density over the lifetime of the facility exceeds 1000 persons per square mile averaged over any radial distance out to 30 miles, special attention should be given to the consideration of alternative sites with lower population densities."

The basis for this guide was that it provided reasonable separation of reactor sites from large population centers, while also assuring an adequate selection of sites, even in the Northeastern U.S. However, no comparison with explicit risk criteria were provided at that time.

An illustration of the degree of separation distance provided by this Guide for population centers of various sizes may be useful. Under this guide, a population center of about 25,000 or more residents may be no closer than 4 miles from a reactor, since a density of 500 persons per square mile within this distance would yield a total population of about 25,120 persons. Similarly, a city of 100,000 or more residents may be no closer than about 10 miles; a city of 500,000 or more persons may be no closer than about 20 miles, and a city of 1,000,000 or more persons may be no closer than about 30 miles from the reactor.

The Commission has examined these guidelines with regard to the Safety Goal. The Safety Goal quantitative health objective in regard to latent cancer fatality states that, within a distance of ten miles from the reactor, the risk to the population of latent cancer fatality from nuclear power plant operation, including accidents, should not exceed one—tenth of one percent of the likelihood of latent cancer fatalities from all other causes. In addition to the risks of latent cancer fatalities, the Commission has also investigated the likelihood and extent of land contamination arising from the release of quantities of long—lived radioactive species such as Cesium—137, in the event of a severe reactor accident.

The results of these analyses indicate that the latent cancer fatality quantitative health objective noted above is met for current plant designs. Since the population density values of Regulatory Guide 4.7 have been in use since 1975, since these afford an adequate supply of sites in every region of the nation, the Commission sees no merit in significantly relaxing these values by allowing nuclear power plants to be located significantly closer to population centers than has heretofore been the case. The Commission recognizes, however, that nuclear power plants meeting current safety standards could be located at sites significantly denser than 500 people per square mile and meet the latent cancer fatality Safety Goal. In addition, the Commission considers it reasonable to continue to specify the population distribution out to 30 miles, even though the Quantitative Health Objectives of the Commission's Safety Goal Policy only apply out to 10 miles, for latent fatalities. The 30 mile distance will ensure that no large population centers are located closer than about 30 miles from the site.

From analysis done in support of this proposed change in regulation, the likelihood of land contamination from a severe accident sufficient to require long term condemnation of land beyond 30 miles is very low. Thus, the proposed criteria provides assurance that the likelihood of long term condemnation of large population centers is very low.

For these reasons, the Commission is proposing that, at the time of initial site approval, population density values of no more than 500 people per square mile averaged over any radial distance out to 30 miles be used for judging the acceptability of new nuclear power plant sites. Similarly, in keeping with Regulatory Guide 4.7, the projected population density 40 years after initial site approval should not exceed 1000 people per square mile.

The proposed regulation indicates that these population density levels are not to be exceeded for new nuclear power plant sites. The Commission is also requesting comments on whether sites exceeding these population densities should be approved, and, if so, under what conditions.

Several points regarding population projections and their application should be made. First, since the validity and reliability of population projections, particularly for relatively small regions, decreases markedly as the projection time period increases, population projections for the purpose of assessing site suitability are to be limited to a time period of 40 years after initial site approval. Population projections beyond this time period become unreliable and speculative.

Second, population projections are intended to be used as a factor in the siting process to evaluate a potential nuclear power plant site and to determine whether alternative sites having lower population densities should be considered. Because of uncertainties in population projections and because analyses have also shown that current plant designs can meet the Commission's Safety Goals and that other risks can be kept at a very low level at sites having significantly higher population densities than those being proposed for approval, the population density limits proposed in the regulation are to be applied at the time of initial site approval or early site permit renewal only, recognizing that they may be exceeded over the life of the plant.

D. Meteorological Factors - Radiological doses which incorporated site meteorological data need no longer be calculated for the purpose of determining site suitability. Meteorological data will still be needed for safety analysis and for assessing the adequacy of certain plant features, as well as to determine plant adequacy in regard to meteorological extremes, such as tornados and maximum probable precipitation. Therefore, the proposed regulation maintains the requirement to collect and characterize meteorological data representative of the site.

The Commission has examined the variations in site meteorology that have influenced dose calculations in past licensing reviews. Individual site meteorology characteristics have been used primarily to determine atmospheric dispersion or dilution factors, in order to evaluate doses to hypothetical individuals at the exclusion area and low population zone outer radius. The degree of dilution increases with increasing distance between the release point and any hypothetically exposed individual, but also is affected by other factors, including the time of day. In this regard, the dispersion factor could vary significantly at a given site, showing a pronounced diurnal variation. However, when the time averaged dispersion factor of a given site is compared with that of other sites, the variation between one site and another is much less. Analyses reported in NUREG/CR—2239, "Technical Guidance for Siting Criteria Development," dated December 1982, for example, show that calculated average individual consequences for an identical postulated release of radioactivity to the environment using data from weather stations throughout the United States yielded results that varied only by about a factor of two. Based upon these considerations, the Commission has determined that the average meteorological characteristics between one site and another are sufficiently similar that characterization of individual site meteorology is not a significant discriminator in determining site suitability, when compared to the uncertainties in other areas of the determination of risk to the health and safety to the public. However, site meteorological characteristics are needed in safety analysis and for assessing the adequacy of certain plant design features.

E. Hydrological Factors - This area is important in establishing the magnitude of external hazards from ground water contamination, such as by basemat melt through, which could contaminate aquifers and thereby affect large populations. The proposed regulation adds or modifies existing requirements for obtaining information to characterize hydrological factors at a site important to risk. This information will be reviewed by the staff and used as interface criteria in matching a proposed design to the site.

F. Nearby Industrial and Transportation Facilities - This area of review is proposed to be incorporated into the regulations for the purpose of site suitability. This area of review has, in fact, been a part of the staff review for many years. The acceptance standard is the same as that currently in staff review guidance documentation. Hence, the proposed regulation involves no substantive changes in this area and merely codifies what has been staff practice for a number of years.

G. Feasibility of Carrying out Protective Actions - The proposed regulation would require that important site factors, such as population distribution, topography, and transportation routes be considered and examined in order to determine whether there are any site characteristics that could pose a significant impediment to the development of an emergency plan.

Planning for emergencies is part of the Commission's defense—in—depth approach. The Commission concludes that site characteristics that may represent an impediment to the development of adequate emergency plans, such as limitations of access or egress in the immediate vicinity of a nuclear power plant should be identified at the site approval phase. This is consistent with the approach the Commission has taken in early site reviews under 10 CFR Part 52.

H. Periodic Reporting of Population and Other Activities - Conditions around a site may change. In addition to population changes, which may be estimated or projected for relatively near—term periods with some degree of confidence, significant changes in the nature of the industrial, military and transportation facilities may also occur. Population growth in excess of that anticipated could represent an unanticpated change in the potential risk to an individual or to society. Early identification of this potential change could permit timely changes in the procedures or plant features to minimize the change in the risk to the health and safety of the public.

Likewise, early identification of activities or facilities that are potentially hazardous could permit timely changes in the procedures or plant features to minimize the change in the risk to the health and safety of the public. Man—related activities potentially hazardous to a plant are typically major industrial or transport facilities such as major highways, large pipelines, major airports, etc. Relatively minor changes in industrial activity have been shown to be of little concern.

In regard to this area, the Commission is also requesting comments on whether periodic reporting of population and significant offsite activities should include all operating licensees, as well as site permit holders.

Interim Change to Part 50

The proposed change to 10 CFR 50 simply relocates the requirements previously contained in 10 CFR 100 for each applicant to calculate a whole body and a thyroid dose at specified distances. Since these requirements affect reactor design rather than siting, it is more appropriately located in 10 CFR 50, thus leaving 10 CFR 100 with site criteria only. For this proposed revision, the source term and methodology for performing the dose calculations remain unchanged from that stated in 10 CFR 100.

These requirements apply to all future applicants for a power reactor. They are intended to be interim requirements until such time as more specific requirements for future applicants are developed governing containment performance and other fission product cleanup systems.

V.B Seismic and Earthquake Engineering Criteria.

The following are major changes in the proposed revision to Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants," to Part 100, associated with the proposed seismic and earthquake engineering criteria rulemaking:

1. Separate Siting from Design. Criteria not associated with site suitability or establishment of the safe shutdown earthquake ground motion have

been placed into Part 50. This action is consistent with the location of other design requirements in Part 50. Because the revised criteria presented in the proposed regulation will not be applied to existing plants, the licensing basis for existing nuclear power plants must remain part of the regulations. The criteria on seismic and geologic siting would be designated as a new Appendix B, "Criteria for the Seismic and Geologic Siting of Nuclear Power Plants After [EFFECTIVE DATE OF THIS REGULATION]," to 10 CFR Part 100. Criteria on earthquake engineering would be designated as a new Appendix S, "Earthquake Engineering Criteria for Nuclear Power Plants," to 10 CFR Part 50.

2. Remove Detailed Guidance from the Regulation. The current regulation contains both requirements and guidance on how to satisfy the requirements. For example, in Section IV, Required Investigations, it is stated that investigations are required for vibratory ground motion, surface faulting, and seismically induced floods and water waves. After stating the purpose of the investigation, detailed guidance is provided on what constitutes an acceptable investigation. A similar situation exists in Section V, Seismic and Geologic Design Bases.

In making geoscience assessments, there is a need for considerable latitude and judgement. This latitude and judgement is required because of limitations in data and the state-of-the-art of geologic and seismic analyses, and because of the rapid evolution taking place in the geosciences in terms of accumulating knowledge and in modifying concepts. This need appears to have been recognized when the existing regulation was developed. The existing regulation states that these criteria are based on limited geophysical and geological information and will be revised as necessary when more complete information becomes available.

However, having geoscience assessments detailed and cast in a regulation has created difficulty for applicants and the staff in terms of inhibiting the use of needed judgement and latitude. Also, it has inhibited flexibility in applying basic principles to new situations and the use of evolving methods of analyses (for instance, probabilistic analyses) in the licensing process.

The level of detail presented in the proposed regulation would be considerably reduced. The proposed regulation would identify and establish basic requirements. Detailed guidance, that is, the procedures acceptable to the NRC for meeting the requirements, would be removed and placed in Draft Regulatory Guide, DG-1015, "Identification and Characterization of Seismic Sources, Deterministic Source Earthquakes, and Ground Motion."

3. Use of both deterministic and probabilistic analyses. The proposed regulation will require the use of both probabilistic and deterministic analyses. The existing approach for determining a Safe Shutdown Earthquake Ground Motion (SSE) for a nuclear reactor site, embodied in Appendix A to 10 CFR 100 relies on a "deterministic" approach. Using this deterministic approach, an applicant develops a single set of earthquake sources, develops for each source a postulated earthquake to be used as the source of ground motion that can affect the site, locates the postulated earthquake according to prescribed rules, and then calculates ground motions at the site. Although this approach has worked reasonably well for the past two decades, in the sense that SSEs for plants sited with this approach are judged to be suitably conservative, the approach has not recognized uncertainty in geoscience parameter. Specifically, because so little is known about earthquake phenomena (especially in the eastern U.S. but even in the west where much more is known), there have always been substantial differences of opinion among experts as to how the prescribed process in Appendix A is to be carried out. Experts of equivalent stature often delineate very different estimates of the largest earthquakes to be considered, and different ground-motion models.

Over the past decade, analysis methods for encompassing these differences have been developed and used. These "probabilistic" methods have been designed to allow explicit incorporation of different models for zonation, earthquake size, ground motion, and other parameters. Their advantage is their ability not only to incorporate different models and different data sets, but also to weight them using judgments as to the validity of the different models and data sets, and thereby to provide an explicit expression for the overall uncertainty in the ground motion estimates and means of assessing sensitivity to various different input parameters.

Probabilistic methods have been used by many groups, not only in the seismic—hazard area but in many other areas. In the seismic—hazard area, many of the practitioners participated in either the NRC—LLNL or the EPRI seismic—hazard projects over the past decade.

The advantages of these probabilistic methods are manifest, but their limitations are important too. In the seismic—hazard area, the most important limitation is that the "bottom—line" results from these analyses tend to be dominated by the tails rather than the central tendencies of the distributions of knowledge and expert opinion.

For these reasons, the proposed revision to Appendix A of 10 CFR 100 has adopted a mixed approach. The staff proposes to use both the deterministic (same as that being currently used) and the probabilistic approaches together, and to compare the results of each to provide insights unavailable if either were used alone. The principal limitation of the deterministic approach --- its ability to incorporate only one model and one data set at a time and its inability to allow weighted incorporation of numerous models --- can be assessed by comparing its results with the results of a probabilistic analysis accomplished in parallel. Similarly, the principal limitation of the probabilistic approach --- its tendency to allow its results to be dominated by the tails rather than the central tendency of distributions of uncertain knowledge or expert opinion --- can be assessed by comparing its results with the results of one or more deterministic analyses.

The staff believes that taken together these two approaches can allow more informed judgments as to what the appropriate Safe Shutdown Earthquake Ground Motion should be for a given site. Both the applicant's judgments and those of the staff will be improved. Therefore, it is the staff's opinion that this mixed approach is the best way to accomplish the objective of this aspect of the revised regulation, which is to arrive through analysis at a site—specific ground motion that appropriately captures what is known about the seismic regime. This dual approach will thus lead to a more stable and predictable licensing process than in the past.

In order to implement this dual approach, the staff has proposed a requirement that the probability of exceeding the Safe Shutdown Earthquake Ground Motion at a site be lower than the median probability of exceedance computed for the current population of the operating plants. This requirement assures that the design levels at new sites will be comparable to those at many existing sites, particularly more recently licensed sites. This criterion is also used to identify significant seismic sources, in terms of magnitude and distance, affecting the estimates of ground motions at a site.

4. <u>Safe Shutdown Earthquake</u>. The existing regulation states when the maximum vibratory accelerations of the SSE at the foundations of the nuclear power plant structures are determined to be less than one tenth the acceleration of gravity (0.1 g) ..... it shall be assumed that the maximum vibratory accelerations of the SSE at these foundations are at least 0.1 g, (Section V(a)(1)(v)). (Also, Section V(a)(1)(iv) contains the phrase "at each of the various foundation locations.") The location of the seismic input motion control point as stated

in the existing regulation has led to confrontations with many applicants that believe this stipulation is inconsistent with good engineering fundamentals.

The proposed regulation would move the location of the seismic input motion control point from the foundation—level to free—field, at the free ground surface or hypothetical rock outcrop, as appropriate. The 1975 version of the Standard Review Plan placed the control motion in the free—field. The proposed regulation is also consistent with the resolution of Unresolved Safety Issue (USI) A—40, "Seismic Design Criteria," (August 1989) that resulted in the revision of Standard Review Plan Sections 2.5.2, 3.7.1, 3.7.2, and 3.7.3.

5. Value of the Operating Basis Earthquake Ground Motion (OBE) and Required OBE Analyses. The existing regulation states that the maximum vibratory ground motion of the OBE is one—half the maximum vibratory ground motion of the Safe Shutdown Earthquake Ground Motion (Section V(a)(2)). Also, the existing regulation states that the engineering method used to insure that structures, systems, and components are capable of withstanding the effects of the OBE shall involve the use of either a suitable dynamic analysis or a suitable qualification test (Section VI(a)(2)). In some cases, for instance piping, these multi—facets of the OBE in the existing regulation made it possible for the OBE to have more design significance than the SSE ground motion. A decoupling of the OBE and SSE has been suggested in several documents. For instance, SECY—79—300 (Enclosure B) suggested that design for a single limiting event, and inspection and evaluation for earthquakes in excess of some specified limit may be the most sound regulatory approach; NUREG—1061, "Report of the U.S. Nuclear Regulatory Commission Piping Review Committee," Vol.5. ranked a decoupling of the OBE and SSE as third out of six high priority changes ; and SECY—90—16, "Evolutionary Light Water Reactor (LWR) Certification Issues and Their Relationship to Current Regulatory Requirements," states that the staff agrees that the OBE should not control the design of safety systems. For the evolutionary reactors, the staff will consider requests to decouple the OBE from the SSE on a design—specific basis.

Activities equivalent to OBE—SSE decoupling are also being done in foreign countries. For instance, in Germany their new design standard requires only one design basis earthquake (equivalent to the SSE). They require an inspection level earthquake (for shutdown) of 0.4 SSE. This level was set so that the vibratory ground motion should not induce stresses exceeding the allowable stress limits originally required for the OBE design.

The proposed regulation would allow the value of the OBE ground motion to be set at: (i) one—third of the SSE ground motion, or (ii) a value greater than one—third of the SSE ground motion. There are two issues the applicant should consider in selecting the value of the OBE; first, plant shutdown is required if vibratory ground motion exceeding that of the OBE occurs (discussed in Item 6, Required Plant Shutdown), and second, the amount of analyses associated with the OBE. An applicant may determine that at the one—third the SSE level, the probability of exceeding the OBE vibratory ground motion is too high; the cost associated with plant shutdown for inspections and testing of equipment and structures prior to restarting the plant is unacceptable. Therefore, the applicant may voluntarily select an OBE ground motion value at some higher fraction of the SSE to avoid plant shutdowns. However, if an applicant selects an OBE ground motion value at a fraction of the SSE higher than one—third, a suitable analysis shall be performed to demonstrate that the requirements associated with the OBE ground motion are satisfied. The design shall take into account soil—structure interaction effects and the expected duration of the vibratory ground motion. The requirement associated with the OBE is that all structures, systems, and components of the nuclear power plant necessary for continued operation without undue risk to the health and safety of the public shall remain functional and within applicable stress and deformation limits when subjected to the effects of the OBE ground motion in combination with normal operating loads. Subject to further confirmation, it is determined that if an OBE ground motion of one—third of the SSE is used, the requirements of the OBE can be satisfied without the applicant performing any explicit response analyses, and performing some minimal design checks (additional discussion below). There is high confidence that, at this ground motion level with other postulated concurrent loads, most critical structures, systems, and components will not exceed currently used design limits. There are situations associated with current analyses where only OBE ground motion is associated with the design requirements, for example, the ultimate heat sink (see Regulatory Guide 1.27, "Ultimate Heat Sink for Nuclear Power Plants"). In these situations a value expressed as a fraction of the SSE response would be used in the analyses. Section VIII of this Supplemental Information section identifies existing guides that would be revised, technically to maintain the existing design philosophy. With regard to piping analyses, positions on fatigue ratcheting and seismic anchor motion are being developed and will be issued in a draft regulatory guide separate from this rulemaking.

6. Required Plant Shutdown. The current regulation states that if vibratory ground motion exceeding that of the OBE occurs, shutdown of the nuclear power plant will be required, (Section V(a)(2). Supplemental information to the existing regulation (38 FR 31279, Item 6e) includes the following statement: "A footnote has been added to §50.36(c)(2) of 10 CFR Part 50 to assure that each power plant is aware of the limiting condition of operation which is imposed under Section V(2) of Appendix A to 10 CFR Part 100. This limitation requires that if vibratory ground motion exceeding that of the OBE occurs, shutdown of the nuclear power plant will be required. Prior to resuming operations, the licensee will be required to demonstrate to the Commission that no functional damage has occurred to those features necessary for continued operation without undue risk to the health and safety of the public." At that time, it was the intention of the Commission to treat the Operating Basis Earthquake as a limiting condition of operation. From the statement in the Supplemental Information, the Commission directed applicants to specifically review Part 100 to be aware of this intention in complying with the requirements of 10 CFR 50.36. Thus, the requirement to shutdown if an OBE occurs was expected to be implemented by being included among the technical specifications submitted by applicants after the adoption of Appendix A. In fact, applicants did not include OBE shutdown requirements in their technical specifications.

The proposed regulation would treat plant shutdown associated vibratory ground motion exceeding the OBE or significant plant damage as a condition in every operating license. The shutdown requirement would be a condition of the license (§50.54) rather than a limiting condition of operation (§50.36), because the necessary judgements associated with exceedance of the vibratory ground motion or significant plant damage can not be adequately characterized in a technical specification. §50.54(ee) would be added to the regulations to require plant shutdown for licensees of nuclear power plants that comply with the earthquake engineering criteria in Paragraph IV(a)(3) of Proposed Appendix S to 10 CFR Part 50. Draft Regulatory Guide DG—1017, "Pre—Earthquake Planning and Immediate Nuclear Power Plant Operator Post—Earthquake Actions," would provide guidance acceptable to the NRC for determining whether or not vibratory ground motion exceeding the OBE ground motion or significant plant damage had occurred and nuclear power plant shutdown is required. The guidance is based on criteria developed by the Electric Power Research Institute (EPRI) to avoid unnecessary prolonged shutdowns. Draft Regulatory Guide DG—1018, "Restart of a Nuclear Power Plant Shut Down by a Seismic Event," would provide guidelines that are acceptable to the NRC staff for performing inspections and tests of nuclear power plant equipment and structures prior to plant restart. This guidance is also based on EPRI reports.

7. Clarify Interpretations. In Appendix B to 10 CFR Part 100 changes have been made to resolve questions of interpretation. As an example, definitions and required investigations stated in the proposed regulation would be significantly changed to eliminate or modify phrases that were more applicable to only the western United States.

VI. Siting Policy Task Force Recommendations

The Siting Policy Task Force (NUREG—0625) made nine recommendations with regard to revision of the reactor siting criteria. The individual recommendations and the disposition and actions being taken in regard to each of these are discussed below.

Recommendation 1

Revise Part 100 to change the way protection is provided for accidents by incorporating a fixed exclusion area and protection action distance and population density and distribution criteria.

1. Specify a fixed minimum exclusion distance based on limiting the individual risk from design basis accidents. Furthermore, the regulations should clarify the required control by the utility over activities taking place in land and water portions of the exclusion area.
2. Specify a fixed minimum emergency planning distance of 10 miles. The physical characteristics of the emergency planning zone should provide reasonable assurance that evacuation of persons, including transients, would be feasible if needed to mitigate the consequences of accidents.
3. Incorporate specific population density and distribution limits outside the exclusion area that are dependent on the average population of the region.
4. Remove the requirement to calculate radiation doses as a means of establishing minimum exclusion distances and low population zones.

Disposition and Action

Recommendation 1 has been or is largely being adopted by the Commission. With regard to item 1, a fixed minimum exclusion area distance of 0.4 miles, commensurate with past staff experience in the review of design basis accidents, is being proposed. The Commission believes that the existing requirements regarding control over any land portion of the exclusion area together with current emergency planning requirements make any new requirements on exclusion area control unnecessary. The recommendations in item 2 were adopted by the Commission shortly after the Three Mile Island accident and are presently in 10 CFR Part 50.47. The recommendations in item 3 are being adopted, except that population density and distribution limits are proposed to be applicable nationwide. The recommendation of Item 4 is being adopted.

Recommendation 2

Revise Part 100 to require consideration of the potential hazards posed by man—made activities and natural characteristics of sites by establishing minimum standoff distances for:

1. Major or commercial airports,
2. LNG terminals,
3. Large propane pipelines,
4. Large natural gas pipelines,
5. Large quantities of explosive or toxic materials,
6. Major dams, and
7. Capable faults.

Disposition and Action

Recommendation 2 is being adopted in part and rejected in part. Part 100 is to be revised to include consideration of man—related hazards. However, establishment of minimum standoff distances by regulation for the hazards cited is considered infeasible because staff review has found that acceptable separation distances are not readily quantified and can depend upon many factors such as the topography, size and operational aspects of such facilities, as well as distance from the reactor. Accordingly, the proposed regulation will require that the hazards be identified and evaluated so that they can be adequately considered in the design of the reactor to be located on the site.

Recommendation 3

Revise Part 100 by requiring a reasonable assurance that interdictive measures are possible to limit groundwater contamination resulting from Class 9 accidents within the immediate vicinity of the site.

Disposition and Action

The Commission is not adopting this recommendation. However, requirements on future reactor designs will address the need to consider and minimize containment failure under severe accident conditions. Future reactor designs will need to address the potential for ground water contamination as part of their environmental review under 10 CFR Part 51.

Recommendation 4

Revise Appendix A to 10 CFR 100 to better reflect the evolving technology in assessing seismic hazards.

Disposition and Action

The Commission is adopting this recommendation in this rulemaking.

Recommendation 5

Revise Part 100 to include consideration of post—licensing changes in offsite activities.

1. The NRC staff shall inform local authorities (planning commission, county commissions, etc.) that control activities within the emergency planning zone (EPZ) of the basis for determining the acceptability of a site.
2. The NRC staff shall notify those federal agencies as in item 1 above that may reasonably initiate a future federal action that may influence the nuclear power plant.
3. The NRC staff shall require applicants to monitor and report potentially adverse offsite developments.
4. If, in spite of the actions described in items 1 through 3, there are offsite developments that have the potential for significantly increasing the risk to the public, the NRC staff will consider restrictions on a case—by—case basis.

Disposition and Action

This recommendation is already in effect or being adopted. Item 1 is already covered by existing emergency planning requirements. Item 2 is accomplished by issuance of a Significant Hazard Consideration statement by the NRC staff. The Commission is requesting comments on Item 3. With regard to item 4, the Commission retains the right to order restrictions on a case—by—case basis.

Recommendation 6

Continue the current approach relative to site selection from a safety viewpoint, but select sites so that there are no unfavorable characteristics requiring unique or unusual design to compensate for site inadequacies.

Disposition and Action

The Commission is not adopting this recommendation. In the current and proposed Part 100 regulations applicants may provide specific plant design features to compensate for site inadequacies. As long as these design features adequately account for the conditions at the site, public health and safety will be protected. These specific design features may represent some economic consideration. However, the Commission has concluded that any economic consideration should be left for the utility or applicant.

Recommendation 7

Revise Part 100 to specify that site approval be established at the earliest decision point in the review and to provide criteria that would have to be satisfied for this approach to be subsequently reopened in the licensing process.

Disposition and Action

The Commission considers that the early site permit provisions of 10 CFR Part 52 accomplishes this recommendation.

Recommendation 8

Revise Part 51 to provide that a final decision disapproving a proposed site by a state agency whose approval is fundamental to the project would be a sufficient basis for NRC to terminate review. Such termination of a review would then be reviewed by the Commission.

Disposition and Action

The Commission is not adopting this recommendation since incorporation of it is considered inappropriate. This recommendation would effectively give the state the arbitrary authority to prevent construction of a nuclear facility. The federal government only has this authority. Furthermore, the Commission has concluded that state approval is not required when the applicant has reasonable measures within his means to comply with the regulations related to interactions with state and local governments.

Recommendation 9

Develop common bases for comparing the risks for all external events.

Disposition and Action

The Siting Policy Task Force's primary recommendation in this area was that an interdisciplinary effort should be undertaken with the objective of developing quantitative risk comparisons of all external events and natural phenomena. The Commission considers this to be a desirable objective but notes that the Siting Policy Task Force made no specific recommendations with regard to siting criteria or rulemaking. The Commission therefore considers this recommendation inapplicable in the present context of examination of siting criteria, but notes that recent developments in probabilistic risk analysis (PRA) have considered examination of the risk from external events in detail.

VII. Related Regulatory Guides and Standard Review Plan Section

The NRC is developing the following draft regulatory guides and standard review plan section to provide prospective licensees with the necessary guidance for implementing the proposed regulation. The notice of availability for these materials is published elsewhere in this Federal Register:

1. DG—1015, "Identification and Characterization of Seismic Sources, Deterministic Source Earthquakes, and Ground Motion." The draft guide provides general guidance and recommendations, describes acceptable procedures and provides a list of references that present acceptable methodologies to identify and characterize capable tectonic sources and seismogenic sources.

2. DG—1016, Second Proposed Revision 2 to Regulatory Guide 1.12, "Nuclear Power Plant Instrumentation for Earthquakes." The draft guide describes seismic instrumentation type and location, operability, characteristics, installation, actuation, and maintenance that are acceptable to the NRC staff.

3. DG—1017, "Pre-—Earthquake Planning and Immediate Nuclear Power Plant Operator Post—Earthquake Actions." The draft guide provides guidelines that are acceptable to the NRC staff for a timely evaluation of the recorded seismic instrumentation data and to determine whether or not plant shutdown is required.

4. DG—1018, "Restart of a Nuclear Power Plant Shut Down by a Seismic Event." The draft guide provides guidelines that are acceptable to the NRC staff for performing inspections and tests of nuclear power plant equipment and structures prior to restart of a plant that has been shut down due to a seismic event.

5. Draft Standard Review Plan Section 2.5.2, Proposed Revision 3 "Vibratory Ground Motion." The draft describes procedures to assess the ground motion potential of seismic sources at the site and to assess the adequacy of the SSE.

6. Draft Regulatory Guide 4.7, designated as Revision 2, dated December 1991, "General Site Suitability Criteria for Nuclear Power Plants." This guide discusses the major site characteristics related to public health and safety and environmental issues which the NRC staff considers in determining the suitability of sites.

VIII. Future Regulatory Action

Several existing regulatory guides will be revised to incorporate editorial changes or maintain the existing design or analysis philosophy . These guides will be issued to coincide with the publication of the final regulations that would implement this proposed action.

The following regulatory guides will be revised to incorporate editorial changes or to be consistent with changes in Part 100. For example, the type of changes contemplated would be to reference new paragraphs in Appendix B to Part 100 or Appendix S to Part 50. No technical changes will be made in these Regulatory Guides.

1. 1.57, "Design Limits and Loading Combinations for Metal Primary Containment System Components"
2. 1.59, "Design Basis Floods for Nuclear Power Plants"
3. 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants"
4. 1.83, "Inservice Inspection of Pressurized Water Reactor Steam Generator Tubes"
5. 1.92, "Combining Modal Responses and Spatial Components in Seismic Response Analysis"

6. 1.102, "Flood Protection for Nuclear Power Plants"
7. 1.121, "Bases for Plugging Degraded PWR Steam Generator Tubes"
8. 1.122, "Development of Floor Response Spectra for Seismic Design of Floor—Supported Equipment or Components"

The following regulatory guides will be revised technically to maintain existing design or analysis philosophy. For example, the types of changes contemplated would be to change OBE to a fraction of the SSE:

1. 1.27, "Ultimate Heat Sink for Nuclear Power Plants"
2. 1.100, "Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants"
3. 1.124, "Service Limits and Loading Combinations for Class 1 Liner—Type Component Supports"
4. 1.130, "Service Limits and Loading Combinations for Class 1 Plate—and—Shell—Type Component Supports"
5. 1.132, "Site Investigations for Foundations of Nuclear Power Plants"
6. 1.138, "Laboratory Investigations of Soils for Engineering Analysis and Design of Nuclear Power Plants"
7. 1.142, "Safety—Related Concrete Structures for Nuclear Power Plants (Other than Reactor Vessels and Containments)"
8. 1.143, "Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light—Water—Cooled Nuclear Power Plants"

During the revision of the regulatory guides cited above, if additional changes are made, the applicable guide(s) will be distributed for public comment.

IX. Electronic Format Submittal of Public Comments

The comment resolution process will be improved if each comment is identified with the document title, section heading and paragraph number to which it responds. Commenters may submit, in addition to the original paper copy, a copy of the letter in an electronic format on IBM PC DOS compatible 3.5 or 5.25 inch double sided double density (DS/DD) diskettes. Data files should be provided in Wordperfect 5.1 format. ASCII code is also acceptable or if formatted text is required, data files should be provided in IBM Revisable — Form Text Document Content Architecture (RFT/DCA) format.

X. Questions

In addition to soliciting comments on all aspects of this rulemaking, the Commission specifically requests comment on the following questions.

1. Should an exclusion area distance smaller than 0.4 miles be allowed for plants with a lower reactor power level than 3800 MW_{th}?

2. The Commission intends to codify the guidelines in Regulatory Guide 4.7 which identifies population density to be 500 people per square mile out to a distance of 30 miles at the time of site approval and 1000 people per square mile 40 years after site approval. Should these population densities continue to be used for siting purposes? If not, what value(s) would be appropriate and what is the basis for a different value?

3. Should the Commission approve sites that exceed the proposed population values of 10 CFR Part 100.21, and if so, under what conditions?

4. Should holders of early site permits, construction permits, and operating license permits be required to periodically report changes in the population and offsite hazards? If so, what regulatory purpose would such reporting requirements serve?

5. What continuing regulatory significance should the safety requirements in 10 CFR Part 100 have after granting the initial operating license or combined operating license under 10 CFR Part 52?

6. Are there certain site meteorological conditions which should preclude the siting of a nuclear power plant? If so, what are the conditions that can not be adequately compenstated for by design features?

7. From the discription of the disposition of the recommendations of the Siting Policy Task Force report (NUREG-0625), it was noted that the Commission was not adopting every element of each recommendation. Are there compelling reasons to reconsider any recommendation not adopted and, if so, what are the bases for reconsideration?

The proposed guide, DG-1015, outlines, for the first time, concepts and procedures to be used in conjunction with the probabilistic/deterministic seismic hazard analyses. Rationale for the approach is discussed in Section V.B(3) of this federal register notice.

The staff is currently performing confirmatory studies to evaluate and refine these proposed procedures. A limited study has been completed demonstrating the feasibility of procedures and the validity of the concepts. However, the staff would like to solicit comments on the concepts outlined in the proposed guide at this time. To facilitate the review, results of the application of the proposed procedure to four test sites are published separately (Letter report from D. Bernreuter of LLNL to A. Murphy of NRC).

There are some divergent views on the role probabilistic seismic hazard analysis should play in the licensing arena. Within the staff it appears that there is a general consensus that the revised seismic and geological siting criteria should allow considerations for a probabilistic hazard analysis. There is also a general belief that the probabilistic analysis should be calibrated against the past practices for siting and licensing the current generation of nuclear power plants. There is a general consensus that ground motions should be calculated using deterministic methods once the controlling earthquakes are determined. With regards to the role of the probabilistic analysis, views range from an advocacy of a predominantly probabilistic analysis to the probabilistic/deterministic dual approach proposed here to a predominantly deterministic approach as used currently. Given these divergent views, the staff would like to invite comments regarding the use of probabilistic seismic hazard analysis and balance between the deterministic and probabilistic analyses. This and other associated issues are itemized below. (As the detailed technical studies are completed some of the staff positions may be confirmed, but specific comments would be helpful at this time.)

8. Should both deterministic and probabilistic approaches be used in siting nuclear power plants? If both are used how should they be combined or weighted, i.e., should one control over the other?

9. If the dual probabilistic/deterministic approach as proposed in this draft guide is to be used, is the proposed procedure in Appendix C adequate to determine controlling earthquakes from a probabilistic analysis?

10. In determining the controlling earthquakes should the median values of the seismic hazard analysis be used to the exclusion of other statistical measures such as mean or 85th percentile?

(The staff has selected probability of exceedance levels associated with the median hazard analysis estimates as they provide more stable estimates of controlling earthquakes.)

11. Should the median target level of 1E-4 for LLNL or 3E-5 for EPRI be raised or lowered, i.e., should the next generation of NPPs have design levels for seismic events approximately equal to, greater than, or less than the current NPPs?

(The NRC has made a policy statement that stated the current NPPs are at the appropriate level of safety.)

12. For the probabilistic analysis, should and how many controlling earthquakes be generated to cover the frequency band of concern for NPPs?

(For the four trial plants used to develop the criteria presented in this regulatory guide, the average of results for the 5 Hz and 10 Hz spectral velocities was used to establish the probability of exceedance level. Controlling earthquakes were evaluated for this frequency band, for the average of 1 and 2.5 Hz spectral responses, and for peak ground acceleration.)

XI. Finding of No Significant Environmental Impact: Availability

The Commission has determined under the National Environmental Policy Act of 1969, as amended, and the Commission's regulations in Subpart A of 10 CFR Part 51, that this proposed regulation, if adopted, would not be a major Federal action significantly affecting the quality of the human environment and therefore an environmental impact statement is not required.

The revisions associated with the reactor siting criteria in 10 CFR Part 100 and the relocation of the plant design requirements from 10 CFR Part 100 to 10 CFR Part 50 has been evaluated against the current requirements. The staff's evaluation has concluded that relocating the requirement for a dose calculation to Part 50 and adding more specific site criteria to Part 100 does not decrease the protection of the public health and safety over the current regulations. The proposed ammendments do not affect non—radiological plant effluents and have no other environmental impact.

The amendment of Appendix A to 10 CFR Part 100 as stated in 10 CFR Part 100, Appendix B and 10 CFR Part 50, Appendix S will not change the radiological environmental impact offsite. Onsite occupational radiational exposure associated with inspection and maintenance will not change. These activities are principally associated with base line inspections of structures, equipment and piping, and maintenance of seismic instrumentation. Base line inspections are needed to differentiate between pre—existing conditions at the nuclear power plant and earthquake related damage. The structures, equipment and piping selected for these inspections are comprised of those routinely examined by plant operators during normal plant walkdowns and inspections. Routine maintenance of seismic instrumentation assures its operability during earthquakes. The location of the seismic instrumentation is similar to that in the existing nuclear power plants. The proposed amendments do not affect non—radiological plant effluents and have no other environmental impact.

The environmental assessment and finding of no significant impact on which this determination is based are available for inspection at the NRC Public Document Room, 2120 L Street, NW. (Lower Level), Washington, DC. Single copies of the environmental assessment and finding of no significant impact are available from Mr. Leonard Soffer, Office of Nuclear Regulatory Research, Mail Stop NL/S-324, U.S. Nuclear Regulatory Commission, Washington, DC 20555, telephone (301) 492-3916 or Dr. Andrew Murphy, Office of Nuclear Regulatory Research, Mail Stop NL/S-217A, U.S. Nuclear Regulatory Commission, Washington, DC 20555, telephone (301) 492-3860.

XII. Paperwork Reduction Act Statement

This proposed regulation amends information collection requirements that are subject to the Paperwork Reduction Act of 1980 (44 U.S.C. 3501 et seq.). This proposed regulation has been submitted to the Office of Management and Budget for review and approval of the paperwork requirements.

There is no public reporting burden related to the non—seismic siting criteria. Public reporting burden for the collection of information related to the seismic and earthquake engineering criteria is estimated to average 800,000 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information.

Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to the Information and Records Management Branch (MNBB 7714), U.S. Nuclear Regulatory Commission, Washington, DC 20555; and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB—3019, (3150—0011 and 3150—0093), Office of Management and Budget, Washington, DC 20503.

XIII. Regulatory Analysis

The Commission has prepared a draft regulatory analysis on this proposed regulation. The analysis examines the costs and benefits of the alternatives considered by the Commission. The draft analysis is available for inspection in the NRC Public Document Room, 2120 L Street, NW. (Lower Level), Washington, DC. Single copies of the analysis are available from Mr. Leonard Soffer, Office of Nuclear Regulatory Research, Mail Stop NL/S-324, U.S. Nuclear Regulatory Commission, Washington, DC 20555, telephone (301) 492-3916 or Dr. Andrew J. Murphy, Office of Nuclear Regulatory Research, Mail Stop NL/S-217A, U.S. Nuclear Regulatory Commission, Washington, DC 20555, telephone (301) 492-3860.

The Commission requests public comment on the draft regulatory analysis. Comments on the draft analysis may be submitted to the NRC as indicated under the

ADDRESSES heading.

XIV. Regulatory Flexibility Certification

In accordance with the Regulatory Flexibility Act of 1980, (5 U.S.C. 605(b)), the Commission certifies that this proposed regulation will not, if promulgated, have a significant economic impact on a substantial number of small entities. This proposed regulation affects only the licensing and operation of nuclear power plants. Nuclear power plant site applicants do not fall within the definition of small businesses as defined in Section 3 of the Small Business Act (15 U.S.C. 632), the Small Business Size Standards of the Small Business Administrator (13 CFR Part 121), or the Commission's Size Standards (50 CFR 50241; December 9, 1985).

XV. Backfit Analysis

The NRC has determined that the backfit rule, 10 CFR 50.109, does not apply to this proposed regulation, and therefore, that a backfit analysis is not required for this proposed regulation, because these amendments do not involve any provisions which would impose backfits as defined in 10 CFR 50.109(a)(1). The proposed regulation would be applicable only to applicants for future nuclear power plant construction permits, preliminary design approval, final design approval, manufacturing license, early site reviews, operating licenses, and combined operating licenses.

List of Subjects

10 CFR Part 50 — Antitrust, Classified information, Criminal penalty, Fire protection, Incorporation by reference, Intergovernmental relations, Nuclear power plants and reactors, Radiation protection, Reactor siting criteria, Reporting and recordkeeping requirements.

10 CFR Part 52 — Administrative practice and procedure, Antitrust, Backfitting, Combined license, Early site permit, Emergency planning, Fees, Inspection, Limited work authorization, Nuclear power plants and reactors, Probabilistic risk assessment, Prototype, Reactor siting criteria, Redress of site, Reporting and recordkeeping requirements, Standard design, Standard design certification.

10 CFR Part 100 — Nuclear power plants and reactors, Reactor siting criteria.

For the reasons set out in the preamble and under the authority of the Atomic Energy Act of 1954, as amended, the Energy Reorganization Act of 1974, as amended, and 5 U.S.C. 553, the NRC is proposing to adopt the following amendments to 10 CFR Parts 50, 52 and 100.

PART 50 — DOMESTIC LICENSING OF PRODUCTION AND UTILIZATION FACILITIES

1. The authority citation for Part 50 continues to read as follows:

AUTHORITY: Secs. 102, 103, 104, 105, 161, 182, 183, 186, 189, 68 Stat. 936, 937, 938, 948, 953, 954, 955, 956, as amended, sec. 234, 83 Stat. 1244, as amended (42 U.S.C. 2132, 2133, 2134, 2135, 2201, 2232, 2233, 2236, 2239, 2282); secs. 201, as amended, 202, 206, 88 Stat. 1242, as amended, 1244, 1246, (42 U.S.C. 5841, 5842, 5846).

Section 50.7 also issued under Pub. L. 95—601, sec. 10, 92 Stat. 2951 (42 U.S.C. 5851). Section 50.10 also issued under secs. 101, 185, 68 Stat. 936, 955 as amended (42 U.S.C. 2131, 2235), sec. 102, Pub. L. 91—190, 83 Stat. 853 (42 U.S.C. 4332). Sections 50.13, 50.54(dd) and 50.103 also issued under sec. 108, 68 Stat. 939, as amended (42 U.S.C. 2138). Sections 50.23, 50.35, 50.55, and 50.56 also issued under sec. 185, 68 Stat. 955 (42 U.S.C. 2235). Sections 50.33a, 50.55a and Appendix Q also issued under sec. 102, Pub. L. 91—190, 83 Stat. 853 (42 U.S.C. 4332). Sections 50.34 and 50.54 also issued under sec. 204, 88 Stat. 1245 (42 U.S.C. 5844). Sections 50.58, 50.91 and 50.92 also issued under Pub. L. 97—415, 96 Stat. 2073 (42 U.S.C. 2239). Section 50.78 also issued under sec. 122, 68 Stat. 939 (42 U.S.C. 2152). Sections 50.80 — 50.81 also issued under sec. 184, 68 Stat. 954, as amended (42 U.S.C. 2234). Appendix F also issued under sec. 187, 68 Stat. 955 (42 U.S.C. 2237).

For the purposes of sec. 223, 68 Stat. 958, as amended (42 U.S.C. 2273), §§ 50.46(a) and (b), and 50.54(c) are issued under sec. 161b, 68 Stat. 948, as amended (42 U.S.C. 2201(b)); §§ 50.7(a), 50.10(a)—(c), 50.34(a) and (e), 50.44(a)—(c), 50.46(a) and (b), 50.47(b), 50.48(a), (c),(d), and (e), 50.49(a), 50.54(a)(i), (i)(1), (l)—(n), (p), (q), (t), (v), and (y), 50.55(f), 50.55a(a), (c)—(e), (g), and (h), 50.59(c), 50.60(a), 50.62(b), 50.64(b), 50.65 and 50.80(a) and (b) are issued under sec. 161i, 68 Stat. 949, as amended (42 U.S.C. 2201(i); and §§50.49d, (h), and (j), 50.54(w),(z),(bb),(cc), and (dd), 50.55(e), 50.59(b), 50.61(b), 50.62(b), 50.70(a), 50.71(a)—(c) and (e), 50.72(a), 50.73(a) and (b), 50.74, 50.78, and 50.90 are issued under sec. 161(o), 68 Stat. 950, as amended (42 U.S.C. 2201(o)).

2. In §50.2, the following definitions should be added:

"Exclusion area" is as defined in §100.3(a).
"Low population zone" is as defined in §100.3(b).
"Population center distance" is as defined in §100.3(c).

3. In §50.8, paragraph (b) is revised to read as follows:

§50.8 Information collection requirements: OMB approval

(a) * * *

(b) The approved information collection requirements contained in this part appear in 50.30, 50.33, 50.33a, 50.34, 50.34, 50.34a, 50.35, 50.36, 50.36a, 50.48, 50.49, 50.54, 50.55, 50.55a, 50.59, 50.60, 50.61, 50.63, 50.64, 50.65, 50.71, 50.72, 50.80, 50.82, 50.90, 50.91, and Appendices A, B, E, G, H, I, J, K, M, N, O, Q, P, and S.

* * * * *

4. In §50.34, paragraph (a)(1) is revised to read as follows:

§50.34 Contents of applications; technical information.

(a) * * *

(1) A description and safety assessment of the site and a safety assessment of the facility should be performed. Site characteristics shall comply with Part

100 of this chapter. Special attention should be directed to plant design features intended to mitigate the radiological consequences of accidents. In performing this assessment, an applicant should assume a fission product release[1] from the core into the containment assuming that the facility is operated at the ultimate power level contemplated. The applicant should perform an evaluation and analysis of the postulated fission product release, using the expected demonstrable containment leak rate and any fission product cleanup systems intended to mitigate the consequences of such accidents, together with applicable site characteristics, including site meteorology, to evaluate the offsite radiological consequences. The evaluation should determine that:

(i) An individual located at any point on the boundary of the exclusion area for two hours immediately following the onset of the postulated fission product release would not receive a total radiation dose to the whole body in excess of 25 rem[2] or a total radiation dose in excess of 300 rem[2] to the thyroid from iodine exposure.

(ii) An individual located at any point on the outer radius of a low population zone who is exposed to the radioactive cloud resulting from the postulated fission product release (during the entire period of its passage) would not receive a total radiation dose to the whole body in excess of 25 rem or a total radiation dose in excess of 300 rem to the thyroid from iodine exposure. For purposes of this evaluation, a low population zone boundary of 3.0 miles should be assumed.

With respect to operation at the projected initial power level, the applicant is required to submit information prescribed in paragraphs (a)(2) through (8) of this section, as well as the information required by this paragraph, in support of the application for a construction permit.

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[1] The fission product release assumed for this evaluation should be based upon a major accident, hypothesized or determined from considerations of possible accidental events, that would result in potential hazards not exceeded by those from any accident considered credible. Such accidents have generally been assumed to result in substantial meltdown of the core with subsequent release into the containment of appreciable quantities of fission products.

[2] The whole body dose of 25 rem referred to above has been stated to correspond numerically to the once in a lifetime accidental or emergency dose for radiation workers which, according to NCRP recommendations may be disregarded in the determination of their radiation exposure status (see NBS Handbook 69 dated June 5, 1959). More recently, this whole body dose value has also been provided as guidance for radiation workers performing emergency services involving life saving activities or protection of large populations where lower doses are not practicable (see EPA, Manual of Protective Action Guides and Protective Actions for Nuclear Incidents, Draft, September 1990). However, neither its use nor that of the 300 rem value for thyroid exposure as set forth in this section are intended to imply that these numbers constitute acceptable [illegible] for emergency doses to the public under accident conditions. Rather, this 25 rem whole body value and the 300 rem thyroid value have been set forth in this section as reference values, which can be used in the evaluation of plant design features with respect to postulated reactor accidents, in order to assure that such designs provide assurance of low risk of public exposure to radiation, in the event of such accidents.

NOTE: Reference is made to Technical Information Document (TID) 14844, dated March 23, 1962, which contains a fission product release into containment which has been used in past evaluations. The fission product release given in TID—14844 may be used as a point of departure upon consideration of severe accident research insights available since its issuance, upon consideration of plant design features intended to mitigate the consequences of accidents, or upon characteristics of a particular reactor.

5. In §50.34, paragraph (a)(12) is added to read as follows:
§50.34 Contents of applications; technical information.

(a) * * *

(12) On or after [EFFECTIVE DATE OF THE REGULATION], applicants who apply for a construction permit pursuant to this part, or a design certification or combined license pursuant to Part 52 of this chapter, as partial conformance to General Design Criterion 2 of Appendix A to this part, shall comply with the earthquake engineering criteria in Appendix S of this part.

* * * * *

6. In §50.34, paragraph (b)(10) is added to read as follows:
§50.34 Contents of applications; technical information.

(b) * * *

(10) On or after [EFFECTIVE DATE OF THE REGULATION], applicants who apply for an operating license pursuant to this part, or a design certification or combined license pursuant to Part 52 of this chapter, as partial conformance to General Design Criterion 2 of Appendix A to this part, shall comply with the earthquake engineering criteria of Appendix S to this part. However, if the construction permit was issued prior to [EFFECTIVE DATE OF THE REGULATION], the applicant shall comply with the earthquake engineering criteria in Section VI of Appendix A to Part 100 of this chapter.

* * * * *

7. In §50.54, paragraph (ee) is added to read as follows:
§50.54 Conditions of licenses.

* * * * *

(ee) For licensees of nuclear power plants that have implemented the earthquake engineering criteria in Appendix S of this part, plant shutdown is required if the criteria in Paragraph IV(a)(3) of Appendix S are exceeded. Prior to resuming operations, the licensee shall demonstrate to the Commission that no functional damage has occurred to those features necessary for continued operation without undue risk to the health and safety of the public.

8. Appendix S to Part 50 is added to read as follows:

* * * * *

Appendix S To Part 50 - EARTHQUAKE ENGINEERING CRITERIA FOR NUCLEAR POWER PLANTS

GENERAL INFORMATION

This appendix applies to applicants who apply for a design certification or combined license pursuant to Part 52 of this chapter, or a construction permit or operating license pursuant to Part 50 of this chapter on or after [EFFECTIVE DATE OF THIS REGULATION]. However, if the construction permit was issued prior to [EFFECTIVE DATE OF THIS REGULATION], the operating license applicant shall comply with the earthquake engineering criteria in Section VI of Appendix A to Part 100 of this chapter.

This appendix and Appendix B to Part 100 of this chapter provide the seismic, geologic, and earthquake engineering criteria for nuclear power plants constructed pursuant to applications applied for on or after the effective date of this regulation.

revised see companion text

I. INTRODUCTION

Each applicant for a construction permit, operating license, design certification, or combined license is required by §50.34(a)(12), §50.34(b)(10), and General Design Criterion 2 of Appendix A to this Part to design nuclear power plant structures, systems, and components important to safety to withstand the effects of natural phenomena, such as earthquakes, without loss of capability to perform their safety functions. Also, a condition of all operating licenses for nuclear power plants, as specified in §50.54(ee), is plant shutdown if the criteria in Paragraph IV(a)(3) of this appendix are exceeded.

These criteria implement General Design Criterion 2 insofar as it requires structures, systems, and components important to safety to withstand the effects of earthquakes.

II. SCOPE

The evaluations described in this appendix are within the scope of investigations permitted by §50.10(c)(1) of this chapter.

III. DEFINITIONS

As used in these criteria:

(a) The <u>Safe Shutdown Earthquake Ground Motion</u> (SSE) is the vibratory ground motion for which certain structures, systems, and components shall be designed to remain functional.

(b) The <u>structures, systems, and components required to withstand the effects of the safe shutdown earthquake ground motion or surface deformation</u> 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 in a safe shutdown condition, or

(3) The capability to prevent or mitigate the consequences of accidents which could result in potential offsite exposures comparable to the guideline exposures of §50.34(a)(1) of this chapter.

(c) The <u>Operating Basis Earthquake Ground Motion (OBE)</u> is the vibratory ground motion for which those features of the nuclear power plant necessary for continued operation without undue risk to the health and safety of the public will remain functional. The value of the Operating Basis Earthquake Ground Motion is lower than the Safe Shutdown Earthquake Ground Motion and is set by the applicant.

(d) A response spectrum is a plot of the maximum responses (acceleration, velocity, or displacement) of a family of idealized single-degree-of-freedom oscillators as a function of the natural frequencies of the oscillators for a given damping value. The response spectrum is calculated for a specified vibratory motion input at the oscillators supports.

(e) Surface deformation is distortion of soils or rocks at or near ground surface by the processes of folding, faulting, compression, or extension as a result of various earth forces. Tectonic surface deformation is associated with earthquake processes.

(f) Combined license or design certification, as defined in Part 52 of this chapter.

IV. APPLICATION TO ENGINEERING DESIGN

The following are pursuant to the seismic and geologic design basis requirements of paragraphs V(a) through (f) of Appendix B to Part 100 of this chapter:

(a) **Vibratory Ground Motion**

(1) **Safe Shutdown Earthquake Ground Motion.** The Safe Shutdown Earthquake Ground Motion shall be characterized by free-field ground motion response spectra at the free ground surface or hypothetical rock outcrop, as appropriate. In view of the limited data available on vibratory ground motions of strong earthquakes, it usually will be appropriate that the design response spectra be smoothed spectra developed from an ensemble of response spectra related to the vibratory motions caused by more than one earthquake. As a minimum, the horizontal Safe Shutdown Earthquake Ground Motion at the foundation level of the structures shall be an appropriate response spectrum with a peak ground acceleration of at least 0.1g.

The nuclear power plant shall be designed so that, if the Safe Shutdown Earthquake Ground Motion occurs, certain structures, systems, and components will remain functional and within applicable stress and deformation limits. In addition to seismic loads, applicable concurrent normal operating, functional, and accident-induced loads shall be taken into account in the design of these safety-related structures, systems, and components. The design of the nuclear power plant shall also take into account the possible effects of the Safe Shutdown Earthquake Ground Motion on the facility foundations by ground disruption, such as fissuring, lateral spreads, differential settlement, liquefaction, and landsliding, as required in Paragraph V(f) of Appendix B to Part 100 of this chapter.

The required safety functions of structures, systems, and components shall be assured during and after the vibratory ground motion associated with the Safe Shutdown Earthquake Ground Motion through design, testing, or qualification methods.

The evaluation shall take into account soil-structure interaction effects and the expected duration of vibratory motion. It is permissible to design for strain limits in excess of yield strain in some of these safety-related structures, systems, and components during the Safe Shutdown Earthquake Ground Motion and under the postulated concurrent loads, provided the necessary the functions are maintained.

(2) **Operating Basis Earthquake Ground Motion.**

(i) When subjected to the effects of the Operating Basis Earthquake Ground Motion in combination with normal operating loads, all structures, systems, and components of the nuclear power plant necessary for continued operation without undue risk to the health and safety of the public shall remain functional and

10. In §52.17, paragraphs (a)(1) and (a)(1)(vi) are revised to read as follows:

§52.17 Contents of applications.

and 50.34(b)(10)

(a) * * *

(1) The application must contain the information required by 50.33(a)—(d), the information required by 50.34(a)(12), and, to the extent approval of emergency plans is sought under paragraph (b)(2)(ii) of this section, the information required by 50.33(g) and (j), and 50.34(b)(6)(v). The application must also contain a description and safety assessment of the site on which the facility is to be located, with appropriate attention to features effecting facility design; such assessment shall contain an analysis and evaluation of the major structures, systems, and components of the facility which bear significantly on the acceptability of the site under the radiological consequence evaluation factors identified in Part 50.34(a)(1) of this chapter. In addition, the application should describe the following:

(vi) The seismic, meteorological, hydrologic, and geologic characteristics of the proposed site (see Appendix A or B, as appropriate, to 10 CFR Part 100);

* * * * *

11. Part 52, Appendix Q, paragraph 8 is added to read as follows:

8. Notwithstanding paragraph 7, any application for extension of an early site permit is subject to a full site permit review.

* * * * *

PART 100 — REACTOR SITE CRITERIA

12. The authority citation for Part 100 continues to read as follows:

AUTHORITY: Secs. 103, 104 161, 182, 68 Stat. 936, 937, 948, 953, as amended (42 U.S.C. 2133, 2134, 2201, 2232); sec. 201, as amended, 202, 88 Stat. 1242, as amended, 1244 (42 U.S.C. 5841, 5842).

13. Part 100 is revised to read as follows:

* * * * *

<u>PART 100 REACTOR SITE CRITERIA</u>

Sec.
100.1 Purpose.
100.2 Scope.
100.3 Definitions.
100.8 Information collection requirements: OMB approval.

<u>Subpart A — Evaluation Factors for Stationary Power Reactor Site Applications before [EFFECTIVE DATE OF THIS REGULATION] and for Test Reactors.</u>

within applicable stress and deformation limits.

(ii) The Operating Basis Earthquake Ground Motion shall be characterized by response spectra. The value of the Operating Basis Earthquake Ground Motion shall be set to one of the following choices:

(A) One—third of the Safe Shutdown Earthquake Ground Motion. The requirements associated with this Operating Basis Earthquake Ground Motion in (i) can be satisfied without the applicant performing explicit response or design analyses, or

(B) A value greater than one—third of the Safe Shutdown Earthquake Ground Motion. Analysis and design shall be performed to demonstrate that the requirements associated with this Operating Basis Earthquake Ground Motion in (i) are satisfied. The design shall take into account soil—structure interaction effects and the expected duration of vibratory ground motion.

(3) **Required Plant Shutdown.**[3] If vibratory ground motion exceeding that of the Operating Basis Earthquake Ground Motion or significant plant damage occurs, shutdown of the nuclear power plant is required. Prior to resuming operations, the licensee shall demonstrate to the Commission that no functional damage has occurred to those features necessary for continued operation without undue risk to the health and safety of the public.

(4) **Required Seismic Instrumentation.** Suitable instrumentation shall be provided so that the seismic response of nuclear power plant features important to safety can be evaluated promptly after an earthquake.

(b) **Surface Deformation.** The potential for surface deformation shall be taken into account in the design of the nuclear power plant by providing reasonable assurance that in the event of such deformation certain structures, systems, and components will remain functional. In addition to surface deformation induced loads, the design of such safety features shall take into account seismic loads, including aftershocks, and applicable concurrent functional and accident—induced loads. The design provisions for surface deformation shall be based on its postulated occurrence in any direction and azimuth and under any part of the nuclear power plant, unless evidence indicates this assumption is not appropriate, and shall take into account the estimated rate at which the surface deformation may occur.

(c) **Seismically Induced Floods and Water Waves and Other Design Conditions.** Seismically induced floods and water waves from either locally or distantly generated seismic activity and other design conditions determined pursuant to Paragraphs V(e) and (f) of Appendix B to Part 100 of this chapter shall be taken into account in the design of the nuclear power plant so as to prevent undue risk to the health and safety of the public.

PART 52 — EARLY SITE PERMITS; STANDARD DESIGN CERTIFICATIONS;
AND COMBINED LICENSES FOR NUCLEAR POWER PLANTS

9. The authority citation for Part 52 continues to read as follows:

AUTHORITY: Secs. 103, 104, 161, 182, 183, 186, 189, 68 Stat. 936, 948, 953, 954, 955, 956, as amended, sec. 234, 83 Stat. 1244, as amended (42 U.S.C. 2133, 2201, 2232, 2233, 2236, 2239, 2282); secs. 201, 202, 206, 88 Stat. 1242, 1244, 1246, as amended (42 U.S.C. 5841, 5842, 5846).

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[3] Guidance is being developed in Draft Regulatory Guide DG-1017, "Pre-Earthquake Planning and Immediate Nuclear Power Plant Operator Post-Earthquake Actions."

100.10 Factors to be considered when evaluating sites.
100.11 Determination of exclusion area, low population zone, and population center distance.

<u>Subpart B — Evaluation Factors for Stationary Power Reactor Site Applications on or after [EFFECTIVE DATE OF THIS REGULATION].</u>

100.20 Factors to be considered when evaluating sites.
100.21 Determination of exclusion area and population distribution.
100.22 Evaluation of potential man--related hazards.

APPENDIX A — Seismic and Geologic Siting Criteria for Nuclear Power Plants.
APPENDIX B — Seismic and Geologic Siting Criteria for Nuclear Power Plants After [EFFECTIVE DATE OF THIS REGULATION]. ← Wrong title

AUTHORITY: Secs. 103, 104, 161, 182, 68 Stat. 936, 937, 948, 953, as amended (42 U.S.C. 2133, 2134, 2201, 2232); sec. 201, as amended, 202, 88 Stat. 1242, as amended, 1244 (42 U.S.C. 5841,5842).

100.1 <u>Purpose.</u>

(a) This part sets forth standards for evaluation of the suitability of proposed sites for stationary power and testing reactors subject to Part 50 or Part 52 of this chapter.

(b) This part identifies the factors considered by the Commission in the evaluation of reactor sites and the standards used in approving or disapproving proposed sites.

100.2 <u>Scope.</u>

(a) This part applies to applications filed under Part 50 or Part 52 of this chapter for early site permit, construction permit, operating license, or combined license (construction permit and operating license) for power and testing reactors.

(b) The site criteria contained in this part for which there is significant operating experience. This site criteria can also be applied to other reactor types, such as for reactors that are novel in design and unproven as prototypes or pilot plants. For plants without significant operating experience, it is expected that these basic criteria will be applied in a manner that safeguard features provide either site isolation or engineered features which reflects the lack of certainty that only experience can provide.

100.3 <u>Definitions.</u>

As used in this part:

(a) "Exclusion area" means that area surrounding the reactor, in which the reactor licensee has the authority to determine all activities including exclusion or removal of personnel and property from the area. This area may be traversed by a highway, railroad, or waterway, provided these are not so close to the facility as to interfere with normal operations of the facility and provided appropriate and effective arrangements are made to control traffic on the highway, railroad, or waterway, in case of emergency, to protect the public health and safety. Residence within the exclusion area shall normally be prohibited. In any event, residents shall be subject to ready removal in case of necessity. Activities unrelated to operation of the reactor may be permitted in an exclusion area under appropriate limitations, provided that no significant hazards to the public health and safety will result.

(b) "Low population zone" means the area immediately surrounding the exclusion area which contains residents, the total number and density of which are such that there is a reasonable probability that appropriate protective measures could be taken in their behalf in the event of a serious accident. These guides do not specify a permissible population density or total population within this zone because the situation may vary from case to case. Whether a specific number of people can, for example, be evacuated from a specific area, or instructed to take shelter, on a timely basis will depend on many factors such as location, number and size of highways, scope and extent of advance planning, and actual distribution of residents within the area.

(c) "Population center distance" means the distance from the reactor to the nearest boundary of a densely populated center containing more than about 25,000 residents.

(d) "Power reactor" means a nuclear reactor of a type described in section 50.21(b) or 50.22 of this chapter designed to produce electrical or heat energy.

(e) "Testing reactor" means a "testing facility" as defined in section 50.2 of this chapter.

100.8 Information collection requirements: OMB approval.

(a) The Nuclear Regulatory Commission has submitted the information collection requirements contained in this part to the Office of Management and Budget (OMB) for approval as required by the Paperwork Reduction Act of 1980 (44 U.S.C. 3501 et seq.). OMB has approved the information collection requirements contained in this part under control number 3150—0093.

(b) The approved information collection requirements contained in this part appear in Appendix A and Appendix B.

Subpart A — Evaluation Factors for Stationary Power Reactor Site Applications before [EFFECTIVE DATE OF THIS REGULATION] and for Test Reactors.

100.10 Factors to be considered when evaluating sites

Factors considered in the evaluation of sites include those relating both to the proposed reactor design and the characteristics peculiar to the site. It is expected that reactors will reflect through their design, construction and operation an extremely low probability for accidents that could result in release of significant quantities of radioactive fission products. In addition, the site location and the engineered features included as safeguards against the hazardous consequences of an accident, should one occur, should insure a low risk of public exposure. In particular, the Commission will take the following factors into consideration in determining the acceptability of a site for a power or testing reactor:

(a) Characteristics of reactor design and proposed operation including:

(1) Intended use of the reactor including the proposed maximum power level and the nature and inventory of contained radioactive materials;

(2) The extent to which generally accepted engineering standards are applied to the design of the reactor;

(3) The extent to which the reactor incorporates unique or unusual features having a significant bearing on the probability or consequences of accidental release of radioactive materials;

(4) The safety features that are to be engineered into the facility and those barriers that must be breached as a result of an accident before a release of radioactive material to the environment can occur.

(b) Population density and use characteristics of the site environs, including the exclusion area, low population zone, and the population center distance.

(c) Physical characteristics of the site, including seismology, meteorology, geology, and hydrology.

(1) Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants," describes the nature of investigations required to obtain the geologic and seismic data necessary to determine site suitability and 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. It describes procedures for determining the quantitative vibratory ground motion design basis at a site due to earthquakes and describes information needed to determine whether and to what extent a nuclear power plant need be designed to withstand the effects of surface faulting.

(2) Meteorological conditions at the site and in the surrounding area should be considered.

(3) Geological and hydrological characteristics of the proposed site may have a bearing on the consequences of an escape of radioactive material from the facility. Special precautions should be planned if a reactor is to be located at a site where a significant quantity of radioactive effluent might accidentally flow into nearby streams or rivers or might find ready access to underground water tables.

(d) Where unfavorable physical characteristics of the site exist, the proposed site may nevertheless be found to be acceptable if the design of the facility includes appropriate and adequate compensating engineering safeguards.

100.11 <u>Determination of exclusion area, low population zone, and population center distance.</u>

(a) As an aid in evaluating a proposed site, an applicant should assume a fission product release[1] from the core, the expected demonstrable leak rate from the containment and the meteorological conditions pertinent to his site to derive an exclusion area, a low population zone and population center distance. For the purpose of this analysis, which shall set forth the basis for the numerical values used, the applicant should determine the following:

(1) An exclusion area of such size that an individual located at any point on its boundary for two hours immediately following onset of the postulated fission product release would not receive a total radiation dose to the whole

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[1]The fission product release assumed for these calculations should be based upon a major accident, hypothesized for purposes of site analysis or postulated from considerations of possible accidental events, that would result in potential hazards not exceeded by those from any accident considered credible. Such accidents have generally been assumed to result in substantial meltdown of the core with subsequent release of appreciable quantities of fission products.

body in excess of 25 rem[2] or a total radiation dose in excess of 300 rem[2] to the thyroid from iodine exposure.

(2) A low population zone of such size that an individual located at any point on its outer boundary who is exposed to the radioactive cloud resulting from the postulated fission product release (during the entire period of its passage) would not receive a total radiation dose to the whole body in excess of 25 rem or a total radiation dose in excess of 300 rem to the thyroid from iodine exposure.

(3) A population center distance of at least one and one—third times the distance from the reactor to the outer boundary of the low population zone. In applying this guide, the boundary of the population center shall be determined upon consideration of population distribution. Political boundaries are not controlling in the application of this guide. Where very large cities are involved, a greater distance may be necessary because of total integrated population dose consideration.

(b) For sites for multiple reactor facilities consideration should be given to the following:

(1) If the reactors are independent to the extent that an accident in one reactor would not initiate an accident in another, the size of the exclusion area, low population zone and population center distance shall be fulfilled with respect to each reactor individually. The calculated envelopes of each of the plants areas shall be overlayed of the areas such that the outermost composite boundary shall then be taken as the plant boundary.

(2) If the reactors are interconnected to the extent that an accident in one reactor could affect the safety of operation of any other, the size of the exclusion area, low population zone and population center distance shall be based upon the assumption that all interconnected reactors emit their postulated fission product releases simultaneously. This requirement may be reduced in relation to the degree of coupling between reactors, the probability of concomitant accidents and the probability that an individual would not be exposed to the radiation effects from simultaneous releases. The applicant would be expected to justify to the satisfaction of the Commission the basis for such a reduction in the source term.

(3) The applicant is expected to show that the simultaneous operation of multiple reactors at a site will not result in total radioactive effluent releases beyond the allowable limits of applicable regulations.

NOTE: For further guidance in developing the exclusion area, the low

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[2] The whole body dose of 25 rem referred to above corresponds numerically to the once in a lifetime accidental or emergency dose for radiation workers which, according to NCRP recommendations may be disregarded in the determination of their radiation exposure status (see NBS Handbook 69 dated June 5, 1959). However, neither its use nor that of the 300 rem value for thyroid exposure as set forth in these site criteria guides are intended to imply that these numbers constitute acceptable limits for emergency doses to the public under accident conditions. Rather, this 25 rem whole body value and the 300 rem thyroid value have been set forth in these guides as reference values, which can be used in the evaluation of reactor sites with respect to potential reactor accidents of exceedingly low probability of occurrence, and low risk of public exposure to radiation.

[2]

population zone, and the population center distance, reference is made to Technical Information Document 14844, dated March 23, 1962, which contains a procedural method and a sample calculation that result in distances roughly reflecting current siting practices of the Commission. The calculations described in Technical Information Document 14844 may be used as a point of departure for consideration of particular site requirements which may result from evaluation of the characteristics of a particular reactor, its purpose and method of operation.

Copies of Technical Information Document 14844 may be obtained from the Commission's Public Document Room, 2120 L Street, NW, Washington, D.C., or by writing the Director of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555.

Subpart B — Evaluation Factors for Stationary Power Reactor Site Applications on or after [EFFECTIVE DATE OF THE FINAL REGULATION].

100.20 Factors to be considered when evaluating sites.

The Commission will take the following factors into consideration in determining the acceptability of a site for a stationary power reactor:

(a) Population density and use characteristics of the site environs, including the exclusion area, the population distribution, and the compatibility of the site with the development of an emergency plan.

(b) The nature and proximity of man—related hazards (e.g. airports, dams, transportation routes, military and chemical facilities).

(c) Physical characteristics of the site, including seismology, meteorology, geology, and hydrology.

(1) Appendix B, "Criteria for the Seismic and Geologic Siting of Nuclear Power Plants (Revised)," describes the criteria and nature of investigations required to obtain the geologic and seismic data necessary to determine site suitability.

(2) Meteorological characteristics of the site that are necessary for safety analysis or that may have an impact upon plant design (such as maximum probable wind speed and precipitation) should be identified and characterized.

(3) Factors important to hydrological radionuclide transport (such as soil, sediment, and rock characteristics, adsorption and retention coefficients, ground water velocity, and distances to the nearest surface body of water) should be obtained from on—site measurements. The maximum probable flood along with the potential for seismic induced floods discussed in Appendix B should be estimated using historical data.

100.21 Determination of exclusion area and population distribution.

(a) Every reactor facility shall have an exclusion area, as defined in 100.3(a) of this part.

(1) For sites with a single reactor facility, the distance to the exclusion area boundary at any point (as measured from the reactor center point) shall be no less than 0.4 miles.

(2) For sites with multiple reactor facilities consideration should be given to the following: If the reactors are independent to the extent that an accident in one reactor would not initiate an accident in another, the size of each exclusion area shall be determined with respect to each reactor individually. The exclusion area for the site shall then be taken as the plan overlay of the sum of the exclusion areas for each reactor. If the reactors are

interconnected to the extent that an accident in one reactor would initiate an accident in another, the size of the exclusion area for each reactor shall be determined on a case by case basis.

(b) If the offsite population density at the proposed site exceeds the values given in paragraph (1) below, the applicant shall provide justification for not locating the facility at an alternative site having a lower population density.

(1) The population density, including weighted transient population, projected at the time of initial site approval or site renewal should not exceed 500 people per square mile averaged over any radial distance out to 30 miles (cumulative population at a distance divided by the total circular area at that distance). The projected population density, including weighted transient population, 40 years after the time of initial site approval or renewal should not exceed 1000 people per square mile averaged over any radial distance out to 30 miles.

(2) Transient population must be included for those sites where a significant number of people (other than those just passing through the area) work, reside part-time, or engage in recreational activities and are not permanent residents of the area. The transient population should be considered for siting purposes by weighting the transient population according to the fraction of the time the transients are in the area.

(c) Physical characteristics of the proposed site, such as egress limitations from the area surrounding the site, that could pose a significant impediment to the development of emergency plans, shall be identified.

100.22 <u>Evaluation of Man-related Hazards.</u>

Potential hazards to the plant from man-related activities associated with nearby transportation routes, military and industrial facilities shall be identified and their potential effects evaluated. Potential hazards to the plant include such effects as explosions, fires, toxic and/or flammable chemical releases, dams (both upstream and downstream), pipeline accidents, and aircraft crashes and impacts.

The effects of offsite hazards shall have a very low probability of affecting the safety of the plant. The likelihood and consequences of offsite hazards shall be estimated using data and assumptions that are as realistic and representative of the site as is practical. The design bases for which the plant shall be designed shall be specified.

14. Appendix B to Part 100 is added to read as follows:

* * * * *

Appendix B to Part 100 -- CRITERIA FOR THE SEISMIC AND GEOLOGIC SITING OF NUCLEAR POWER PLANTS AFTER [EFFECTIVE DATE OF THIS REGULATION]

GENERAL INFORMATION

This appendix applies to applicants who apply for an early site permit or combined license pursuant to Part 52 of this chapter, or a construction permit or operating license pursuant to Part 50 of this chapter on or after [EFFECTIVE DATE OF THIS REGULATION]. However, if the construction permit was issued prior to [EFFECTIVE DATE OF THIS REGULATION], the operating license applicant shall comply with the seismic and geologic siting criteria in Appendix A to Part 100 of this chapter.

This appendix and Appendix S to Part 50 of this chapter provide the seismic, geologic, and earthquake engineering criteria for nuclear power plants constructed pursuant to applications applied for on or after the effective date of this regulation.

Remove to be consistent with the OGC comment on Appendix S

I. PURPOSE

General Design Criterion 2 of Appendix A to Part 50 of this chapter requires that nuclear power plant structures, systems, and components important to safety be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions. It is the purpose of these criteria to set forth the principal seismic and geologic considerations which guide the Commission in its evaluation of the suitability of proposed sites for nuclear power plants and the suitability of the plant design bases established in consideration of the seismic and geologic characteristics of the proposed sites.[3]

These criteria are based on the current geophysical, geological, and seismological information concerning faults and earthquake occurrences and effects. They will be revised as necessary when more complete information becomes available.

II. SCOPE

These criteria, which apply to nuclear power plants, describe the nature of the investigations required to obtain the geologic and seismic data necessary to determine site suitability and 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. Geologic and seismic factors required to be taken into account in the siting and design of nuclear power plants are identified.

The investigations described in this appendix are within the scope of investigations permitted by § 50.10(c)(1) of this chapter.

Each applicant for a construction permit, operating license, early site permit, or combined license shall investigate all seismic and geologic factors that may affect the design and operation of the proposed nuclear power plant irrespective of whether such factors are explicitly included in these criteria. Both deterministic and probabilistic evaluations shall be conducted to determine site suitability and seismic design requirements for the site. Additional investigations or more conservative determinations than those included in these criteria may be required for sites located in areas with complex geology, recent tectonic deformation, or in areas of high seismicity. If an applicant believes that the particular seismic and geologic characteristics of a site indicate that some of these criteria, or portions thereof, need not be satisfied, the specific sections of these criteria should be identified in the license application, and supporting data to clearly

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[3] Considerations presented in this regulation are general. Acceptable methods and additional discussion are provided in regulatory guides and standard review plan sections.

justify such departures shall be presented. The Director, Office of Nuclear Reactor Regulation must approve such deviations.

III. DEFINITIONS

As used in these criteria:

(a) The magnitude of an earthquake is a measure of the size of an earthquake and is related to the energy released in the form of seismic waves. Magnitude means the numerical value on a standardized scale such as, but not limited to, Moment Magnitude, Surface Wave Magnitude, Body Wave Magnitude, or Richter Magnitude scales.

(b) A deterministic source earthquake (DSE) is the largest earthquake that can reasonably be expected to occur in a given seismic source in the current tectonic regime, and is used in a deterministic analysis. It is generally based on the maximum historical earthquake associated with that seismic source, unless recent geological evidence warrants a larger earthquake, or where the rate of occurrence of earthquakes indicates the likelihood of larger than the largest historical event.

(c) The Safe Shutdown Earthquake Ground Motion (SSE) is the vibratory ground motion for which certain structures, systems, and components shall be designed to remain functional.

(d) A fault is a tectonic structure along which differential slippage of the adjacent earth materials has occurred parallel to the fracture plane. A fault may have gouge or breccia between its two walls and includes any associated monoclinal flexure or other similar geologic structural feature.

(e) Surface faulting is differential ground displacement at or near the surface caused directly by fault movement and is distinct from nontectonic types of ground disruptions, such as landslides, fissures, and craters.

(f) Surface deformation is distortion of soils or rocks at or near the ground surface by the processes of folding, faulting, compression, or extension as a result of various earth forces. Tectonic surface deformation is associated with earthquake processes.

(g) A seismic source is a general term referring to both seismogenic sources and capable tectonic sources.

(h) A seismogenic source is a portion of the earth that has uniform earthquake potential (same deterministic source earthquake and frequency of recurrence) distinct from the surrounding area. A seismogenic source will not cause surface displacements. Seismogenic sources cover a wide range of possibilities from a well—defined tectonic structure to simply a large region of diffuse seismicity (seismotectonic province) thought to be characterized by the same earthquake recurrence model. A seismogenic source is also characterized by its involvement in the current tectonic regime as reflected in the Quaternary (approximately the last 2 million years) geologic history.

(i) A capable tectonic source is a tectonic structure that can generate both earthquakes and tectonic surface deformation such as faulting or folding at or near the surface in the present seismotectonic regime. It is characterized by at least one of the following characteristics:

(1) The presence of surface or near surface deformation of landforms or geologic deposits of recurring nature within the last approximately 500,000 years or at least once in the last approximately 50,000 years.

(2) A reasonable association with one or more large earthquakes or sustained earthquake activity that are usually accompanied by significant surface deformation.

(3) A structural association with a capable tectonic source having

characteristics in (1) of this paragraph such that movement on one could be reasonably expected to be accompanied by movement on the other.

In some cases, the geologic evidence of past activity at or near the ground surface along a particular capable tectonic source may be obscured at a particular site. This might occur, for example, at a site having a deep overburden. For these cases, evidence may exist elsewhere along the structure from which an evaluation of its characteristics in the vicinity of the site can be reasonably based. Such evidence shall be used in determining whether the structure is a capable tectonic source within this definition.

Notwithstanding the foregoing paragraphs III(i) (1), (2) and (3), structural association of a structure with geologic structural features that are geologically old (at least pre-Quaternary) such as many of those found in the Eastern region of the United States shall, in the absence of conflicting evidence, demonstrate that the structure is not a capable tectonic source within this definition.

(j) A <u>response spectrum</u> is a plot of the maximum responses (acceleration, velocity, or displacement) of a family of idealized single—degree—of—freedom oscillators as a function of the natural frequencies of the oscillators for a given damping value. The response spectrum is calculated for a specified vibratory motion input at the oscillators supports.

(k) <u>Combined license</u> or <u>early site permit</u>, as defined in Part 52 of this chapter.

IV. REQUIRED INVESTIGATIONS

The geological, seismological, and engineering characteristics of a site and its environs shall be investigated in sufficient scope and detail to permit an adequate evaluation of the proposed site, to provide sufficient information to support both probabilistic and deterministic determinations required by these criteria, and to permit adequate engineering solutions to actual or potential geologic and seismic effects at the proposed site. The size of the region to be investigated and the type of data pertinent to the investigations shall be determined by the nature of the region surrounding the proposed site. The investigations shall be carried out by a review of the pertinent literature and field investigations as identified in paragraphs (a) through (e) of this section:

(a) **Vibratory Ground Motion**.

The purpose of these investigations is to obtain information needed to assess the Safe Shutdown Earthquake Ground Motion. The seismic sources (capable tectonic sources and seismogenic sources) in the site region shall be identified and evaluated. The deterministic source earthquakes shall be evaluated for each seismic source.

(b) **Tectonic Surface Deformation**.

The purpose of these investigations is to assess the potential for tectonic surface deformation near the site and, if any, to what extent the nuclear power plant needs to be designed for these occurrences.

(c) **Non—Tectonic Deformation**.

The purpose of these investigations is to assess the potential for surface deformations not directly attributable to tectonics such as those associated with subsidence or collapse as in karst terrane, glacially induced offsets, and growth faulting. Paragraph IV(b) concerns investigations required for tectonic surface deformation that can occur coseismically. Nontectonic phenomena can represent significant surface displacement hazards to a site, but can in many cases be monitored, controlled, or mitigated by engineering, or it can be demonstrated that conditions that were the cause of the displacements no longer exist. Geological and geophysical investigations shall be carried out to identify and define nontectonic deformation features and, where possible, distinguish them from tectonic surface displacements. If such distinction is not possible, the questionable features shall be treated as tectonic deformation.

(d) **Seismically Induced Floods and Water Waves.**

The purpose of these investigations is to assess the potential for nearby and distant tsunamis and other waves that could affect coastal sites. Included in this assessment is the determination of the potential for slides of earth material that could generate waves. Information regarding distant and locally generated waves or tsunamis that have affected the site, and available evidence of runup and drawdown associated with these events, shall be analyzed. Local features of coastal or undersea topography which could modify wave runup or drawdown must be considered. For sites located near lakes or rivers, analyses shall include the potential for seismically induced floods or water waves, as, for example, from the failure during an earthquake of a dam upstream or from slides of earth or debris into a nearby lake.

(e) **Volcanic Activity.**

The purpose of these investigations is to assess the potential volcanic hazards that would adversely affect the site.

V. SEISMIC AND GEOLOGIC DESIGN BASES

(a) **Determination of Deterministic Source Earthquakes.**

For each seismogenic and capable tectonic source identified in Paragraph IV(a), the deterministic source earthquake shall be evaluated. As a minimum, the deterministic source earthquake shall be the largest historical earthquake in each source. The uncertainty in determining the deterministic source earthquakes shall be accounted for in the probabilistic analysis.

(b) **Determination of the Ground Motion at the Site.**

The ground motion at the site shall be estimated from all earthquakes, including the deterministic source earthquake associated with each source which could potentially affect the site using both probabilistic and deterministic approaches. In the deterministic approach, the deterministic source earthquake associated with each source shall be assumed to occur at the part of the source which is closest to the site. Appropriate models, including local site conditions, shall be used to account for uncertainty in estimating the ground motion for the site. The uncertainty in the ground motion shall be accounted for. The ground motion is defined by both horizontal and vertical free-field ground motion response spectra at the free ground surface or hypothetical rock outcrop, as appropriate.

(c) **Determination of Safe Shutdown Earthquake Ground Motion.**

The Safe Shutdown Earthquake Ground Motion is characterized by response spectra. These spectra are developed from or compared to the ground motions determined in Paragraph V(b). Deterministic and probabilistic seismic hazard analyses shall be used to assess the adequacy of the Safe Shutdown Earthquake Ground Motion. The probability of exceeding the Safe Shutdown Earthquake Ground Motion is considered acceptably low if it is less than the median probability computed from the current [EFFECTIVE DATE OF THIS REGULATION] population of nuclear power plants.

As a minimum, the horizontal Safe Shutdown Earthquake Ground Motion at the foundation level of the structures shall be an appropriate response spectrum with a peak ground acceleration of at least 0.1g.

(d) **Determination of Need To Design for Surface Tectonic and Non—Tectonic Deformations.**

Sufficient geological, seismological, and geophysical data shall be provided to clearly establish that surface deformation need not be taken into account in the design of a nuclear power plant. When surface deformation is likely, an assessment of the extent and nature of surface deformations must be characterized.

(e) **Determination of Design Bases for Seismically Induced Floods and Water Waves.**

The size of seismically induced floods and water waves that could affect a site from either locally or distantly generated seismic activity shall be determined, taking into consideration the results of the investigation required by paragraph (d) of section IV.

(f) **Determination of Other Design Conditions.**

(1) Soil Stability. Vibratory ground motions determined in Paragraph V(b) can cause soil instability from ground disruption such as fissuring, lateral spreads, differential settlement, and liquefaction, which is not directly related to surface faulting. Geological features that could affect the foundations of the proposed nuclear power plant structures shall be evaluated, taking into account the information concerning the physical properties of materials underlying the site and the effects of the vibratory ground motion determined in Paragraph V(b).

(2) Slope stability. Stability of all slopes, both natural and artificial, the failure of which could adversely affect the nuclear power plant, shall be considered. An assessment shall be made of the potential effects of erosion or deposition and of combinations of erosion or deposition with seismic activity, taking into account information concerning the physical properties of the materials underlying the site and the effects of the vibratory ground motion determined in Paragraph V(b).

(3) Cooling water supply. Assurance of an adequate cooling water supply for emergency and long—term shutdown decay heat removal shall be considered in the design of the nuclear power plant, taking into account information concerning the physical properties of the materials underlying the site, the effects of the Safe Shutdown Earthquake Ground Motion, and the design basis for tectonic and nontectonic surface deformation. Consideration of river blockage or diversion or other failures that may block the flow of cooling water, coastal uplift or subsidence, tsunami runup and drawdown, and failure of dams and intake structures shall be included in the evaluation, where appropriate.

(4) Distant structures. Those structures that are not located in the immediate vicinity of the site but are safety—related shall be designed to withstand the effect of the Safe Shutdown Earthquake Ground Motion. The design basis for surface faulting shall be determined on a basis comparable to that of the nuclear power plant, taking into account the material underlying the structures and the different location with respect to that of the site.

VI. APPLICATION TO ENGINEERING DESIGN

Pursuant to the seismic and geologic design basis requirements of paragraphs V(a) through (f), applications to engineering design are contained in Appendix S to Part 50 of this chapter for the following areas:

(a) Vibratory ground motion.

(1) Safe Shutdown Earthquake Ground Motion.

(2) Operating Basis Earthquake.
(3) Required Plant Shutdown.
(4) Required Seismic Instrumentation.
(b) Surface Tectonic Deformation.
(c) Seismically Induced Floods and Water Waves and Other Design Conditions.

Dated at Rockville, Maryland, this __ day of ________, 1992.

For the Nuclear Regulatory Commission.

Samuel J. Chilk,
Secretary of the Commission.

DRAFT REVISION TO 10 CFR PART 100

REACTOR SITE CRITERIA

PART 100 REACTOR SITE CRITERIA

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100.20 Factors to be considered when evaluating sites.
100.21 Determination of exclusion area and population distribution.
100.22 Evaluation of potential man—related hazards.

APPENDIX A — Seismic and Geologic Siting Criteria for Nuclear Power Plants.
APPENDIX B — Seismic and Geologic Siting Criteria for Nuclear Power Plants After [EFFECTIVE DATE OF THIS REGULATION].

AUTHORITY: Secs. 103, 104, 161, 182, 68 Stat. 936, 937, 948, 953, as amended (42 U.S.C. 2133, 2134, 2201, 2232); sec. 201, as amended, 202, 88 Stat. 1242, as amended, 1244 (42 U.S.C. 5841,5842).

100.1 Purpose.

(a) ~~It is the purpose of t~~This part ~~to describe criteria which guide the Commission in its~~ **sets forth standards for** evaluation of the suitability of proposed sites for stationary power and testing reactors subject to Part 50 **or Part 52** of this chapter.

(b) ~~Insufficient experience has been accumulated to permit the writing of detailed standards that would provide a quantitative correlation of all factors significant to the question of acceptability of reactor sites.~~ This part ~~is intended as an interim guide to~~ identif~~y~~**ies** ~~a number of~~ **the** factors considered by the Commission in the evaluation of reactor sites and the ~~general criteria~~ **standards** used ~~at this time as guides~~ in approving or disapproving proposed sites. ~~Any applicant who believes that factors other than those set forth in the regulation should be considered by the Commission will be expected to~~

~~demonstrate the applicability and significance of such factors.~~

100.2 <u>Scope.</u>

(a) This part applies to applications filed under Part 50 or Part 52 of this chapter for early site permit, construction permit, operating license, or combined comstruction permit and operating license for ~~stationary~~ power and testing reactors.

(b) The site criteria contained in this part apply to reactors for which there is significant operating experience. ~~apply primarily to reactors of a general type and design on which experience has been developed, but~~ These site criteria can also be applied to other reactor types. ~~In particular~~, such as for reactors that are novel in design and unproven as prototypes or pilot plants, ~~it is expected that these basic criteria will be applied in a manner that safeguard features~~ provided that either site isolation or engineered features are provided ~~should~~ which appropriately account for ~~reflect~~ the lack of certainty that only experience can provide.

100.3 <u>Definitions.</u>

As used in this part:

(a) "Exclusion area" means that area surrounding the reactor, in which the reactor licensee has the authority to determine all activities including exclusion or removal of personnel and property from the area. This area may be traversed by a highway, railroad, or waterway, provided these are not so close to the facility as to interfere with normal operations of the facility and provided appropriate and effective arrangements are made to control traffic on the highway, railroad, or waterway, in case of emergency, to protect the public health and safety. Residence within the exclusion area shall normally be prohibited. In any event, residents shall be subject to ready removal in case of necessity. Activities unrelated to operation of the reactor may be permitted in an exclusion area under appropriate limitations, provided that no significant hazards to the public health and safety will result.

(b) "Low population zone" means the area immediately surrounding the exclusion area which contains residents, the total number and density of which are such that there is a reasonable probability that appropriate protective measures could be taken in their behalf in the event of a serious accident. These guides do not specify a permissible population density or total population within this zone because the situation may vary from case to case. Whether a specific number of people can, for example, be evacuated from a specific area, or instructed to take shelter, on a timely basis will depend on many factors such as location, number and size of highways, scope and extent of advance planning, and actual distribution of residents within the area.

(c) "Population center distance" means the distance from the reactor to the nearest boundary of a densely populated center containing more than about 25,000 residents.

(d) "Power reactor" means a nuclear reactor of a type described in ss 50.21(b) or 50.22 of this chapter designed to produce electrical or heat energy.

(e) "Testing reactor" means a "testing facility" as defined in ss 50.2 of this chapter.

100.8 Information collection requirements: OMB approval.

(a) The Nuclear Regulatory Commission has submitted the information collection requirements contained in this part to the Office of Management and Budget (OMB) for approval as required by the Paperwork Reduction Act of 1980 (44 U.S.C. 3501 et seq.). OMB has approved the information collection requirements contained in this part under control number 3150—0093.

(b) The approved information collection requirements contained in this part appear in Appendix A, and Appendix B.

Subpart A — Evaluation Factors for Stationary Power Reactor Site Applications before [EFFECTIVE DATE OF THIS REGULATION] and for Test Reactors.

100.10 Factors to be considered when evaluating sites

Factors considered in the evaluation of sites include those relating both to the proposed reactor design and the characteristics peculiar to the site. It is expected that reactors will reflect through their design, construction and operation an extremely low probability for accidents that could result in release of significant quantities of radioactive fission products. In addition, the site location and the engineered features included as safeguards against the hazardous consequences of an accident, should one occur, should insure a low risk of public exposure. In particular, the Commission will take the following factors into consideration in determining the acceptability of a site for a power or testing reactor:

(a) Characteristics of reactor design and proposed operation including:

(1) Intended use of the reactor including the proposed maximum power level and the nature and inventory of contained radioactive materials;

(2) The extent to which generally accepted engineering standards are applied to the design of the reactor;

(3) The extent to which the reactor incorporates unique or unusual features having a significant bearing on the probability or consequences of accidental release of radioactive materials;

(4) The safety features that are to be engineered into the facility and those barriers that must be breached as a result of an accident before a release of radioactive material to the environment can occur.

(b) Population density and use characteristics of the site environs, including the exclusion area, low population zone, and the population center distance.

(c) Physical characteristics of the site, including seismology, meteorology, geology, and hydrology.

(1) Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants," describes the nature of investigations required to obtain the geologic and seismic data necessary to determine site suitability and 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. It describes procedures for determining the quantitative vibratory ground motion design basis at a site due to earthquakes and describes information needed to determine whether and to what extent a nuclear power plant need be designed to withstand the effects of surface faulting.

(2) Meteorological conditions at the site and in the surrounding area should be considered.

(3) Geological and hydrological characteristics of the proposed site may have a bearing on the consequences of an escape of radioactive material from the facility. Special precautions should be planned if a reactor is to be located at a site where a significant quantity of radioactive effluent might accidentally flow into nearby streams or rivers or might find ready access to underground water tables.

(d) Where unfavorable physical characteristics of the site exist, the proposed site may nevertheless be found to be acceptable if the design of the facility includes appropriate and adequate compensating engineering safeguards.

100.11 Determination of exclusion area, low population zone, and population center distance.

(a) As an aid in evaluating a proposed site, an applicant should assume a fission product release[1] from the core, the expected demonstrable leak rate from the containment and the meteorological conditions pertinent to his site to derive an exclusion area, a low population zone and population center distance. For the purpose of this analysis, which shall set forth the basis for the numerical values used, the applicant should determine the following:

(1) An exclusion area of such size that an individual located at any point on its boundary for two hours immediately following onset of the postulated fission product release would not receive a total radiation dose to the whole body in excess of 25 rem[2] or

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[1]The fission product release assumed for these calculations should be based upon a major accident, hypothesized for purposes of site analysis or postulated from considerations of possible accidental events, that would result in potential hazards not exceeded by those from any accident considered credible. Such accidents have generally been assumed to result in substantial meltdown of the core with subsequent release of appreciable quantities of fission products.

[2] The whole body dose of 25 rem referred to above corresponds numerically to the once in a lifetime accidental or emergency dose for radiation workers which, according to NCRP recommendations may be disregarded in the determination of their radiation exposure status (see NBS Handbook 69 dated June 5, 1959). However, neither its use nor that of the 300 rem value for thyroid exposure as set forth in these site criteria guides are intended to imply that these numbers constitute acceptable limits for emergency doses to the public under accident conditions. Rather, this 25 rem whole body value and the 300 rem thyroid value have been set forth in these guides as reference values, which can be used in the evaluation

a total radiation dose in excess of 300 rem[2] to the thyroid from iodine exposure.

(2) A low population zone of such size that an individual located at any point on its outer boundary who is exposed to the radioactive cloud resulting from the postulated fission product release (during the entire period of its passage) would not receive a total radiation dose to the whole body in excess of 25 rem or a total radiation dose in excess of 300 rem to the thyroid from iodine exposure.

(3) A population center distance of at least one and one—third times the distance from the reactor to the outer boundary of the low population zone. In applying this guide, the boundary of the population center shall be determined upon consideration of population distribution. Political boundaries are not controlling in the application of this guide. Where very large cities are involved, a greater distance may be necessary because of total integrated population dose consideration.

(b) For sites for multiple reactor facilities consideration should be given to the following:

(1) If the reactors are independent to the extent that an accident in one reactor would not initiate an accident in another, the size of the exclusion area, low population zone and population center distance shall be fulfilled with respect to each reactor individually. The calculated envelopes of each of the plants areas shall be overlayed ~~so calculated~~ of the areas such that the outermost composite boundary shall then be taken as the~~ir respective~~ plant boundary~~ies~~.

(2) If the reactors are interconnected to the extent that an accident in one reactor could affect the safety of operation of any other, the size of the exclusion area, low population zone and population center distance shall be based upon the assumption that all interconnected reactors emit their postulated fission product releases simultaneously. This requirement may be reduced in relation to the degree of coupling between reactors, the probability of concomitant accidents and the probability that an individual would not be exposed to the radiation effects from simultaneous releases. The applicant would be expected to justify to the satisfaction of the Commission the basis for such a reduction in the source term.

(3) The applicant is expected to show that the simultaneous operation of multiple reactors at a site will not result in total radioactive effluent releases beyond the allowable limits of applicable regulations.

NOTE: For further guidance in developing the exclusion area, the low population zone, and the population center distance, reference is made to Technical Information Document 14844, dated March 23, 1962, which contains a procedural method and a sample calculation that result in distances roughly reflecting current siting practices of the Commission. The calculations described in Technical Information Document 14844 may be used as a point of departure for consideration of particular site requirements which may result from evaluation of the characteristics of a particular reactor, its purpose and method

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of reactor sites with respect to potential reactor accidents of exceedingly low probability of occurrence, and low risk of public exposure to radiation.

of operation.

Copies of Technical Information Document 14844 may be obtained from the Commission's Public Document Room, 2120 L Street, NW, Washington, D.C., or by writing the Director of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555.

Subpart B — Evaluation Factors for Stationary Power Reactor Site Applications on or after [EFFECTIVE DATE OF THE FINAL REGULATION].

100.20 Factors to be considered when evaluating sites.

The Commission will take the following factors into consideration in determining the acceptability of a site for a stationary power reactor:

(a) Population density and use characteristics of the site environs, including the exclusion area, the population distribution, and the compatibility of the site with the development of an emergency plan.

(b) The nature and proximity of man—related hazards (e.g. airports, dams, transportation routes, military and chemical facilities).

(c) Physical characteristics of the site, including seismology, meteorology, geology, and hydrology.

(1) Appendix B, "Criteria for the Seismic and Geologic Siting of Nuclear Power Plants (Revised)," describes the criteria and nature of investigations required to obtain the geologic and seismic data necessary to determine site suitability.

(2) Meteorological characteristics of the site that are necessary for safety analysis or that may have an impact upon plant design (such as maximum probable wind speed and precipitation) should be identified and characterized.

(3) Factors important to hydrological radionuclide transport (such as soil, sediment, and rock characteristics, adsorption and retention coefficients, ground water velocity, and distances to the nearest surface body of water) should be obtained from on-site measurements. The maximum probable flood along with the potential for seismic induced floods discussed in Appendix B should be estimated using historical data.

100.21 Determination of exclusion area and population distribution.

(a) Every reactor facility shall have an exclusion area, as defined in 100.3(a) of this part.

(1) For sites with a single reactor facility, the distance to the exclusion area boundary at any point (as measured from the reactor center point) shall be no less than 0.4 miles.

(2) For sites with multiple reactor facilities, consideration should be given to the following: If the reactors are independent to the extent that an accident in one reactor would not initiate an accident in another, the size of each exclusion area shall be determined with respect to each reactor individually. The exclusion area for the site shall then be taken as the plan overlay of the sum of the exclusion areas for each reactor. If the

reactors are interconnected to the extent that an accident in one reactor would initiate an accident in another, the size of the exclusion area for each reactor shall be determined on a case by case basis.

(b) If the offsite population density at the proposed site exceeds the values given in paragraph (1) below, the applicant shall provide justification for not locating the facility at an alternative site having a lower population density.

(1) The population density, including weighted transient population, projected at the time of initial site approval or early site permit renewal should not exceed 500 people per square mile averaged over any radial distance out to 30 miles (cumulative population at a distance divided by the total circular area at that distance). The projected population density, including weighted transient population, 40 years after the time of initial site approval or early site permit renewal should not exceed 1000 people per square mile averaged over any radial distance out to 30 miles.

(2) Transient population must be included for those sites where a significant number of people (other than those just passing through the area) work, reside part—time, or engage in recreational activities and are not permanent residents of the area. The transient population should be considered for siting purposes by weighting the transient population according to the fraction of the time the transients are in the area.

(c) Physical characteristics of the proposed site, such as egress limitations from the area surrounding the site, that could pose a significant impediment to the development of emergency plans, shall be identified.

100.22 Evaluation of Man—related Hazards.

Potential hazards to the plant from man—related activities associated with nearby transportation routes, military and industrial facilities shall be identified and their potential effects evaluated. Potential hazards to the plant include such effects as explosions, fires, toxic and/or flammable chemical releases, dams (both upstream and downstream), pipeline accidents, and aircraft crashes and impacts.

The effects of offsite hazards shall have a very low probability of affecting the safety of the plant. The likelihood and consequences of offsite hazards shall be estimated using data and assumptions that are as realistic and representative of the site as is practical. The design bases for which the plant shall be designed shall be specified.

DRAFT REVISION TO 10 CFR PART 50

DOMESTIC LICENSING OF PRODUCTION AND UTILIZATION FACILITIES

50.2 <u>Definitions.</u>

"Exclusion area" is as defined in §100.3(a).
"Low population zone" is as defined in §100.3(b).
"Population center distance" is as defined in §100.3(c).

50.34 <u>Contents of applications; technical information</u>

(a) <u>Preliminary safety analysis report</u>. Each application for a construction permit shall include a preliminary safety analysis report. The minimum information[1] to be included shall consist of the following:

(1) A description and safety assessment of the site and a safety assessment of the facility should be performed. Site characteristics shall comply with Part 100 of this chapter.~~on which the facility is to be located, with appropriate attention to features affecting facility design.~~ Special attention should be directed to ~~the site evaluation factors identified in Part 100 of this chapter.~~ plant design features intended to mitigate the radiological consequences of accidents. In performing this assessment, an applicant should assume a fission product release from the core [2] into the containment assuming that the facility is operated at the ultimate power level contemplated. The applicant should perform an evaluation and analysis of the postulated fission product release, using the expected demonstratable containment leak rate and any fission product cleanup systems intended to mitigate the consequences of such accidents, together with applicable site characteristics, including site meteorology, to evaluate the offsite radiological consequences. The evaluation should determine that: ~~Such assessment shall contain an analysis and evaluation of the major structures, systems and components of the facility which bear significantly on the acceptability of the site under the site evaluation factors identified in Part 100 of this chapter assuming that the facility will be operated at the ultimate power level which is contemplated by the applicant.~~

(i) An individual located at any point on the boundary of

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[1] The applicant may provide information required by this paragraph in the form of a discussion, with specific references, of similarities to and differences from, facilities of similar design for which applications have previously been filed with the Commission.

[2] The fission product release assumed for this evaluation should be based upon a major accident, hypothesized or determined from considerations of possible accidental events, that would result in potential hazards not exceeded by those from any accident considered credible. Such accidents have generally been assumed to result in substantial meltdown of the core with subsequent release into the containment of appreciable quantities of fission products.

the exclusion area for two hours immediately following the onset of the postulated fission product release would not receive a total radiation dose to the whole body in exces of 25 rem [3] or a total radiation dose in excess of 300 rem to the thyroid from iodine exposure.

(ii) An individual located at any point on the outer radius of a low population zone who is exposed to the radioactive cloud resulting from the postulated fission product release (during the entire period of its passage) would not receive a total radiation dose to the whole body in excess of 25 rem or a total radiation dose in excess of 300 rem to the thyroid from iodine exposure. For applications for a construction permit, operating license, combination of construction permit and operatng license, preliminary design approval, final design approval, manufacturing license, or design certification filed after [THE EFFECTIVE DATE OF THIS RULE], a low population zone boundary of 3.0 miles shall be assumed. For applications and licenses prior to [THE EFFECTIVE DATE OF THIS RULE], a low population zone determined in accordance with 10 CFR Part 100, Subpart A, shall be used.

With respect to operation at the projected initial power level, the applicant is required to submit information prescribed in paragraphs (a)(2) through (8) of this section, as well as the the information required by this paragraph, in support of the application for a construction permit.

NOTE: Reference is made to Technical Information Document (TID) 14844, dated March 23, 1962, which contains a fission product

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[3] The whole body dose of 25 rem referred to above has been stated to correspond numerically to the once in a lifetime accidental or emergency dose for radiation workers which, according to NCRP recommendations may be disregarded in the determination of their radiation exposure status (see NBS Handbook 69 dated June 5, 1959). More recently, this whole body dose value has also been provided as guidance for radiation workers performing emergency services involving life saving activities or protection of large populations where lower doses are not practicable (see EPA, Manual of Protective Action Guides and Protective Actions for Nuclear Incidents, Draft, September 1990). However, neither its use nor that of the 300 rem value for thyroid exposure as set forth in this section are intended to imply that these numbers constitute acceptable limits for emergency doses to the public under accident conditions. Rather, this 25 rem whole body value and the 300 rem thyroid value have been set forth in this section as reference values, which can be used in the evaluation of plant design features with respect to ~~potential severe~~ **postulated** reactor accidents, in order to assure that such designs provide assurance of low risk of public exposure to radiation, in the event of such accidents.

release into containment which has been used in past evaluations. The fission product release given in TID-14844 may be used as a point of departure upon consideration of severe accident research insights available since its issuance, upon consideration of plant design features intended to mitigate the consequences of accidents, or upon characteristics of a particular reactor.

DRAFT REGULATORY ANALYSIS

PROPOSED REVISIONS OF 10 CFR PART 100,

AND 10 CFR PART 50

DRAFT REGULATORY ANALYSIS
PROPOSED REVISION OF 10 CFR PART 100
AND 10 CFR Part 50

STATEMENT OF THE PROBLEM

This Regulatory Analysis covers two considerations. First is the revision of the "Reactor Siting Criteria," 10 CFR Part 100, for future plants. The second consideration is the revision of 10 CFR Part 100, Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants." Both considerations address the relocation of plant design criteria from Part 100 to 10 CFR Part 50. This regulatory analysis is presented in two parts, corresponding to these two considerations.

Reactor Siting Criteria (non-seismic):

10 CFR Part 100, "Reactor Siting Criteria," sets forth a framework that guides the Commission in its evaluation of the suitability of proposed sites for stationary power and testing reactors. The present criteria regarding reactor siting were issued in April 1962. There were only a few small power reactors operating at that time. The present regulation requires that every reactor have an exclusion area which has no residents, although transient use is permitted. A low population zone immediately beyond the exclusion area is also required. The regulation recognizes the importance of accident considerations in reactor siting; hence a key element in it is the determination of the size of the exclusion area via the postulation of a large accidental fission product release within containment and the evaluation of the radiological consequences, in terms of doses. Doses are calculated for two hypothetical individuals located at any point (generally, the closest point) on the exclusion area, and at the outer radius of the low population zone, and are required to be within specified limits (25 rem to the whole body and 300 rem to the thyroid gland). In addition, the nearest population center, containing about 25,000 or more residents, is required to be no closer than one and one-third times the outer radius of the low population zone. The effect of these requirements is to set both individual and, to some extent, societal limits on dose (and implicitly on risk) without setting numerical criteria on exclusion area and low population zone size. In practice these siting criteria contained in 10 CFR 100 do more to influence reactor design than site criteria.

Since the issuance of Part 100 in 1962, there have been significant changes and developments in reactor technology. The nuclear power industry has developed and matured significantly; from the existence of a few small power plants generating a very small fraction of the nation's electrical energy, the industry has grown today to the point where there are presently about 110 power reactors in operation in the United States. These supply about 20 percent of the nation's electricity. Reactor power levels have also significantly increased. Early plants typically had reactor power levels of about 150 megawatts thermal, whereas today's plants have power levels about 20 to 25 times greater.

There has been increased development of and reliance upon fission product cleanup systems in modern plants to mitigate the consequences of postulated accidents. As a result, it is possible for present nuclear power plants to be located at sites with a very small exclusion area and still meet the dose criteria of Part 100.

There has also been an increased awareness and concern regarding the effect of potential nuclear accidents. Although accident considerations have been of key importance in reactor siting from the very beginning, major developments such as the issuance of the Reactor Safety Study (WASH-1400) in 1975, the occurrence of the Three Mile Island accident in 1979, the accident at Unit 4 of the Chernobyl reactor in the Soviet Union in 1986, and the issuance of NUREG-1150 "Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants" have greatly increased awareness, knowledge and concerns in this area.

Finally, since its initial promulgation in 1962, the Commission has approved more than 75 sites for nuclear power plants, and has had an opportunity to review a number of others. As a result of these reviews, much experience has been gained regarding the site factors that influence risk and their range of acceptability.

The major impetus for the proposed rule is increased interest in new nuclear power generation and the possibility that applicants will request site approval for new nuclear power plants. The Commission believes that, in the event such requests materialize, the criteria for siting power reactors should address directly those site factors important to risk and should reflect the significant experience learned since the regulation was first issued in 1962.

Seismic Siting and Earthquake Engineering Criteria:

Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants," to 10 CFR Part 100, "Reactor Siting Criteria," sets forth a framework that guides the staff in its evaluation of the adequacy of applicants' investigations of geologic and earthquake phenomena and proposed plant design parameters. The issuance of Appendix A was an important step in establishing a definitive regulatory framework for dealing with earth science issues in the licensing of nuclear power plants. The Appendix contains the following statement:

> "These criteria are based on the limited geophysical and geological information available to date concerning faults and earthquake occurrence and effect. They will be revised as necessary when more complete information becomes available."

The bases for Appendix A were established in the late 1960's and it became effective December 13, 1973. Since then, with advances in the sciences of seismology and geology, along with the occurrence of some licensing issues not foreseen in the development of Appendix A, a number of significant difficulties have arisen in the application of this regulation. Specific problematic areas include the following:

1. In making geoscience assessments, there is a need for considerable latitude and judgement. This latitude and judgement is required because of limitations in data and the state of the art of geologic and seismic analyses, and because of the rapid evolution taking place in the geosciences in terms of accumulating knowledge and in modifying concepts. This need was recognized when Appendix A was developed. However, having detailed geoscience assessments in Appendix A, a regulation, has created difficulty for applicants and the staff in terms of inhibiting the use of needed judgement 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.

2. 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 and has inhibited the use of some types of analyses such as probabilistic seismic hazard analysis.

3. In other siting areas, such as hydrology, regulatory guidance has been handled effectively through use of regulatory guides. Many problems encountered in implementing Appendix A could best be alleviated through the use of regulatory guides and a program for continuous updating.

4. The Operating Basis Earthquake (OBE) is associated with (1) the functionality of those features necessary for continued operation without undue risk to the health and safety of the public, (2) an earthquake that could reasonably be expected to affect the plant site during the operating life of the plant, (3) a minimum fraction of the Safe Shutdown Earthquake (SSE), and (4) [illegible] shutdown if vibratory ground motion is exceeded. These multi- aspects have resulted in seismic criteria that have led to overly stiff piping systems and excessive use of snubbers and supports which, in fact, could result in less reliable piping systems. Also, regulatory guidance defining an exceedance of the OBE, and plant shutdown or restart procedures have not been developed. Post earthquake evaluations are handled on an ad—hoc basis.

5. The stipulation in Appendix A that the SSE response spectra be defined at the foundation of the nuclear power plant structures has often led to confrontations with many in the engineering community who regard this stipulation as inconsistent with sound practice.

<u>OBJECTIVES</u>
<u>Reactor Siting Criteria (non-seismic)</u>:

The objective of the proposed regulatory action is to provide a stable regulatory basis for the siting of nuclear power plants by decoupling decisions of site suitability from those affecting plant design.

This will be accomplished by:

a. stating directly those site criteria which, through experience and importance to risk, future sites should meet and

b. relocating from Part 100 to Part 50 those requirements which apply to reactor design.

The major changes associated with the revision of the regulation are:

1. The proposed regulatory action will apply to applicants who apply for a construction or early site permit on or after the effective

date of the final regulations. The current regulation will remain in place and be applicable to all licensees and applicants prior to the effective date of the final regulations.

2. Part 100 will state directly those criteria applicable to the site (e.g. exclusion area distance, population distribution).

3. Criteria such as source term and dose calculations would be used for evaluating plant features and not for evaluating site suitability and will be placed into Part 50 consistent with the location in the regulation of other design requirements.

Since the revision to the regulation will not be a backfit, the licensing bases for existing nuclear power plants must remain in the regulation. Therefore, the revised regulation will be designated as a new subpart to Part 100 for future plants while maintaining the current Part 100 for existing plants.

Finally, in support of the above changes, Regulatory Guide 4.7 has been revised.

Seismic Siting and Earthquake Engineering Criteria:

The objectives of the proposed regulatory action are to:

1. Provide a stable regulatory basis for seismic and geologic siting and applicable earthquake engineering design of future nuclear power plants that will avoid licensing delays due to unclear regulatory requirements;

2. Provide a flexible structure to permit consideration of new technical understandings; and

3. Have the revision to the regulation completed prior to the receipt of an early site application.

The major points associated with the revision of the regulation are:

1. The proposed regulatory action will apply to applicants who apply for an early site permit, design certification, or combined license (construction permit and operating license) pursuant to 10 CFR Part 52, or a construction permit or operating license pursuant to 10 CFR Part 50 on or after the effective date of the revised regulation. However, if the construction permit was issued prior to the effective date of the regulation, the operating license applicant shall comply with the seismic and geologic siting and earthquake engineering criteria in Appendix A to 10 CFR Part 100.

2. Criteria not associated with the selection of the site or establishment of the safe shutdown earthquake ground motion have been placed into Part 50. This action is consistent with the location of other design requirements in Part 50.

Because the revised criteria presented in the proposed regulation will not be applied to existing plants, the licensing bases for existing nuclear power plants must remain in the regulations. Therefore, the proposed revised criteria on seismic and geologic siting would be designated as a new Appendix B to 10 CFR Part 100 and would be added to the existing body of regulations.

Earthquake engineering criteria will be located in 10 CFR Part 50, Appendix S. Since Appendix S is not self executing, applicable sections of Part 50 (i.e., §50.34, §50.54) are revised to reference Appendix S.

The proposed rule would also make conforming amendments to 10 CFR Parts 52 and 100.

Finally, in support of the above changes, regulatory guides and standard review plan sections will be revised or developed, as appropriate.

ALTERNATIVES

Reactor Siting Criteria (non-seismic):

The alternatives considered included:

- no action (e.g. continue to use existing Part 100)
- delete the existing Part 100 and replace it with an entirely new Part 100 which eliminates the dose calculation and specifies site criteria.
- retain the existing Part 100 for current plants and add a new section to Part 100 for future plants which eliminates the dose calculation and specifies site criteria.

The first alternative considered by the Commission was to continue using current regulations for site suitability determinations. This is not considered an acceptable alternative. Although the siting related issues for nuclear power plants currently being licensed are closed or are expected to be closed soon, there is good reason to initiate the proposed regulatory action in light of the current and future staff review of future reactors (particularly certified designs) so that a certified design would not be dependent on site parameters to establish the fission product retention characteristics of the design. Further, the current regulation has created difficulty for applicants and the staff in terms of inhibiting flexibility in applying updated information and using updated methods of analysis in the licensing process.

Deletion of the existing regulation also is not considered an acceptable alternative since it is the licensing bases for virtually all the operating nuclear power plants and those that are in various stages of obtaining their operating license.

Therefore, the last option is the preferable course of action and is the option evaluated further in this analyses.

Seismic Siting and Earthquake Engineering Criteria:

The first alternative considered by the Commission was to avoid initiating a rulemaking proceeding. This is not an acceptable alternative. Although the siting related issues associated with the current generation of nuclear power plants are completed or nearing completion, there is a renewed sense of urgency to initiate the proposed regulatory action in light of the current and future staff review of advanced reactor seismic design criteria. The current regulation has created difficulties for applicants and the staff in terms of inhibiting flexibility in applying basic principles to new situations and using evolved methods of analysis in the licensing process.

A second alternative considered was the deletion of the existing regulation (Appendix A to Part 100). This is not an acceptable alternative because these provisions form part of the licensing bases for many of the operating nuclear power plants and others that are in various stages of obtaining their operating license. Also, geologic and seismic siting criteria are needed for future plants.

A third alternative considered was the replacement of the entire regulation with a regulatory guide. This is not acceptable because a regulatory guide is non-mandatory. The staff believes that there could be an increase in the risk of radiation exposure to the public if the siting and earthquake engineering criteria were non-mandatory.

Since there are problems with implementing the existing regulation (Appendix A to Part 100), the only satisfactory alternative is to revise the regulation. The approach of establishing the revised requirements in a new Appendix B to Part 100 and Appendix S to Part 50 while retaining the existing regulation was chosen as the best alternative.

Finally, the following memoranda or reports provide further support for a revision to Appendix A to Part 100:

1. Staff Requirements Memorandum from Chilk to Taylor dated January 25, 1991, Subject: SECY-90-341 - Staff Study on Source Term Update and Decoupling Siting from Design.

   "The staff should further ensure that the revisions to Appendix A of Part 100 are available to support the time schedule shown in the paper [Commission Briefing on Source Term Update and Decoupling Siting from Design (SECY-90-341), dated December 13, 1990] for option 2, and are technically supportable with the information that will be available at the time the draft comes forward for Commission action."

2. Memorandum from Taylor to Beckjord dated September 6, 1990, Subject: Revision of Appendix A, 10 CFR Part 100, "Seismic and Geologic Siting Criteria for Nuclear Power Plants."

   "I approve of your plan to begin work on the development of a revised regulation and this activity should be assigned a high priority status."

3. NUREG-0625, Siting Policy Task Force.

   "Revise Appendix A to 10 CFR Part 100 to better reflect the evolving technology in assessing seismic hazards." —

4. NUREG-1061, "Report of the U.S. Nuclear Regulatory Commission Piping Review Committee," Vol 5, April 1985.

"The Committee recommends that

- o Rulemaking amending Appendix A to 10 CFR Part 100 be undertaken to permit decoupling of the OBE and SSE. ...."

CONSEQUENCES

a. Costs and Benefits

Benefits

Reactor Siting Criteria (non-seismic):

The revision to Part 100 will be beneficial to all. The industry and public will benefit from a clearer, more uniform and consistent licensing process.

Benefits to industry, the public and the NRC staff will result from the following changes:

1. Clear Statement Of Site Criteria. The proposed revision to Part 100 provides clear criteria regarding acceptable exclusion area distances and population distribution. Applicants will be able to select sites that meet these criteria without having to be dependent upon a reactor design. In addition, the criteria have been selected to be consistent with past experience and with the quantitative health objectives in the NRC Safety Goal Policy.

2. Current Practices Will Be Reflected. The proposed regulations reflect industry design practices and the associated staff review procedures that have evolved since Part 100 was issued in 1962. An example of this is the review of nearby industrial and transportation facilities which will be incorporated into the regulations for the purpose of site suitability and has been a part of the staff review for many years. The criteria and standards are the same as those currently in staff review guidance documentation (Standard Review Plan, etc.). Hence, the proposed rule involves no substantive changes in this area and merely codifies what has been staff practice for a number of years. Additionally, the numerical population density values and the exclusion area distance outlined in Regulatory Guide 4.7 will be codified in the proposed rulemaking.

3. Source Term And Dose Calculations. The proposed rule would eliminate the use of a postulated source term, assumptions regarding mitigation systems and dispersion factors, and the calculation of radiological consequences to determine the sizes of the exclusion area and low population zone. It would instead require a minimum exclusion area distance.

4. Text Clarification And Elimination of Low Population Zone. The Commission considers that the functions intended for the "low population zone",

namely, a low density of residents and the feasibility of taking protective actions, have in fact been overtaken by other regulations or can be accomplished by other means. Protective action requirements are defined via the use of the EPZ's, while restriction on population close to the plant can be assured via proposed population density criteria. For these reasons, the Commission is proposing to eliminate the requirement of a low population zone for future power reactor sites.

In addition, the proposed rule would require that important site factors, such as population distribution, topography, and transportation routes be considered and examined in order to determine whether there are any site characteristics that could pose a significant impediment to the development of an emergency plan. This proposed requirement is also consistent with 10 CFR Part 52.

Planning for emergencies is part of the Commission's defense-in depth approach. The Commission concludes that site characteristic that may represent an impediment to development of adequate emergency plans, such as limitations of access or egresses in the immediate vicinity of a nuclear power plant should be identified at the early stage of site approval rather than at a later date prior to operation thus avoiding significant licensing delays.

5. Risk To The Public. The NRC Staff has generated a reduced set of source terms based on the NUREG-1150 analyses and the Independent Risk Assessment Plant. These source terms were used in the MELCOR Accident Consequences Code System (MACCS) for six reactor-containment designs. The results of these analyses indicate that the risk to the public is acceptably low and the guidelines of the Commission's Safety Goal Policy are met for all plants up to 3[illegible] MW_{th}, the largest capacity plant considered in the analyses.

Seismic Siting and Earthquake Engineering Criteria:

The revision of Appendix A to Part 100 will be beneficial to all. The public will benefit from a clearer, more uniform and consistent licensing process subject to fewer interpretations. The NRC staff will benefit from improved regulatory implementation (both technical and legal), fewer interpretive debates, and increased regulatory flexibility. Applicants will derive the same benefits in addition to avoiding licensing delays due to unclear regulatory requirements.

The proposed regulatory action reflects changes intended to (1) benefit from the experience gained in applying the existing regulation; (2) resolve interpretative questions; (3) provide needed regulatory flexibility to incorporate state-of-the-art improvements in the geosciences and earthquake engineering; (4) simplify the language to a more "plain English" text; and (5) acknowledge various internal staff and industry comments.

Benefits to applicants or NRC staff will result from the following changes:

1. Define seismic sources. Better definition of seismic source types will eliminate a major source of licensing delays.

2. Use probabilistic analyses. The proposed regulation will require

the use of both deterministic and probabilistic analyses. The staff proposes to use both the deterministic (same as that being currently used) and the probabilistic approaches together, and to compare the results of each to provide insights unavailable if either were used alone. The principal limitation of the deterministic approach --- its ability to incorporate only one model and one data set at a time and its inability to allow weighted incorporation of numerous models --- can be assessed by comparing its results with the results of a probabilistic analysis accomplished in parallel. Similarly, the principal limitation of the probabilistic approach --- its tendency to allow its results to be dominated by the tails rather than the central tendency of distributions of uncertain knowledge or expert opinion --- can be assessed by comparing its results with the results of one or more deterministic analyses.

The staff believes that taken together these two approaches can allow more informed judgments as to what the appropriate SSEGM should be for a given site. Both the applicant's judgments and those of the staff will be improved. Therefore, it is the staff's opinion that this mixed approach is the best way to accomplish the objective of this aspect of the revised regulation, which is to arrive through analysis at a site—specific ground motion that appropriately captures what is known about the seismic regime. This dual approach will thus lead to a more stable and predictable licensing process then in the past.

3. Reflect current design practices. The proposed regulations would reflect industry design practices and the associated staff review procedures (for instance, the location of the control point for the seismic input) that have evolved since the initial regulation (Appendix A to Part 100) was issued in 1973. Many of these practices and procedures were incorporated into the revision of Standard Review Plan Sections 2.5.2, 3.7.1, 3.7.2, and 3.7.3 that are associated with the resolution of Unresolved Safety Issue (USI) A-40, "Seismic Design Criteria."

4. Clarify the multi-facets associated with the Operating Basis Earthquake (OBE). In the existing regulation, the OBE is associated with (1) the functionality of those features necessary for continued operation without undue risk to the health and safety of the public, (2) an earthquake that could reasonably be expected to affect the plant site during the operating life of the plant, (3) a minimum fraction of the Safe Shutdown Earthquake (SSE), and (4) plant shutdown if the vibratory ground motion is exceeded. In some cases, for instance, piping, the multi—facets of the OBE made it possible for the OBE to have more design significance than the SSE. The seismological basis, that is, the association of the OBE with a likelihood of occurrence has been removed from the proposed regulation. Other facets of the OBE, for instance, its value (percent of the SSE) and relationship with plant shutdown are discussed below. The functionality aspect of the OBE remains unchanged.

5. Value of the OBE and required analysis. The proposed regulation

would allow the value of the OBE ground motion to be set at: (i) one—third of the SSEGM, or (ii) a value greater than one—third of the SSEGM. There are two issues the applicant should consider in selecting the value of the OBE; first, plant shutdown is required if vibratory ground motion exceeding that of the OBE occurs (discussed in Item 6, Required Plant Shutdown), and second, the amount of analyses associated with the OBE. An applicant may determine that at the one—third the SSE level, the probability of exceeding the OBE vibratory ground motion is too high; the cost associated with plant shutdown for inspections and tests of equipment and structures prior to restarting the plant is unacceptable. Therefore, the applicant may voluntarily select an OBE ground motion value at some higher fraction of the SSE to avoid plant shutdowns. However, if an applicant selects an OBE ground motion value at a fraction of the SSE higher than one—third, a suitable analysis shall be performed to demonstrate that the requirements associated with the OBE ground motion are satisfied. The design shall take into account soil-structure interaction effects and the expected duration of the vibratory ground motion. The requirement associated with the OBE is that all structures, systems, and components of the nuclear power plant necessary for continued operation without undue risk to the health and safety of the public shall remain functional and within applicable stress and deformation limits when subjected to the effects of the Operating Basis Earthquake Ground Motion in combination with normal operating loads. Subject to further confirmation, it is determined that if an OBE ground motion of one—third of the SSE is used, the requirements of the OBE can be satisfied without the applicant performing any explicit response analyses, and minimal design checks (additional discussion below). There is high confidence that, at this ground motion level, with other postulated concurrent loads, most critical structures, systems, and components will not exceed currently used design limits. There are situations associated with current analyses where only OBE ground motion is associated with the design requirements, for example, the ultimate heat sink (see Regulatory Guide 1.27, "Ultimate Heat Sink for Nuclear Power Plants"). In these situations a value expressed as a fraction of the SSE response would be used in the analyses. The section Future Regulatory Action of this Regulatory Analysis identifies existing guides that would be revised to maintain the existing design philosophy. With regard to piping analyses, positions on fatigue ratcheting and seismic anchor motion are being developed and will be issued in a draft regulatory guide separate from this rulemaking.

Activities equivalent to OBE-SSE decoupling are also being done in foreign countries. For instance, in Germany their new design standard requires only one design basis earthquake (equivalent to the SSE). They require an inspection level earthquake (for shutdown) of 0.4 SSE. This level was set so that the vibratory ground motion should not induce stresses exceeding the allowable stress limits originally required for the OBE design.

6. Guidance for required plant shutdown. The proposed regulation would treat plant shutdown associated with vibratory ground motion

exceeding the OBE or significant plant damage as a condition in every operating license. The shutdown requirement would be a condition of the license (§50.54) rather than a limiting condition of operation (§50.36), because the necessary judgements associated with exceedance of the vibratory ground motion or significant plant damage can not be adequately characterized in a technical specification. §50.54(ee) would be added to the regulations to require plant shutdown for licensees of nuclear power plants that comply with the earthquake engineering criteria in Paragraph IV(a)(3) of Proposed Appendix S to 10 CFR Part 50. Draft Regulatory Guide DG-1017, "Pre—Earthquake Planning and Immediate Nuclear Power Plant Operator Post—Earthquake Actions," would provide guidance acceptable to the NRC for determining whether or not vibratory ground motion exceeding the OBE ground motion or significant plant damage had occurred and nuclear power plant shutdown is required. The guidance is based on criteria developed by the Electric Power Research Institute (EPRI) to avoid unnecessary prolonged shutdowns. Draft Regulatory Guide DG—1018, "Restart of a Nuclear Power Plant Shut Down by a Seismic Event," provides guidelines that are acceptable to the NRC staff for performing inspections and tests of a nuclear power plant equipment and structures prior to plant restart. This guidance is also based on EPRI reports.

7. Reduced level of detail. The level of detail presented in the proposed regulations has been limited to general guidance. The proposed regulations would identify and establish basic requirements. Detailed guidance, that is, the procedures acceptable to the NRC for meeting the requirements, has been removed and placed in Draft Regulatory Guide, DG—1015, "Identification and Characterization of Seismic Sources, Determinisitc Source Earthquake, and Ground Motion."

8. Provide greater flexibility. The proposed regulations would provide a flexible structure that will permit the consideration of new technical understandings and state—of—the—art advancements since the detailed guidance has been removed from the proposed regulation and placed into regulatory guides.

9. Clarify interpretations. Changes have been made to the seismic and geologic siting criteria to resolve past questions of interpretation. As an example, the definitions and required investigations sections of the proposed regulations have been significantly changed to eliminate or modify phrases that were more applicable to only the western United States.

10. Clarify text. The proposed regulations would use more explicit terminology. For instance, the Safe Shutdown Earthquake (SSE) and Operating Basis Earthquake are now referenced as the Safe Shutdown Earthquake Ground Motion (SSE) and the Operating Basis Earthquake Ground Motion (OBE). In addition, appropriate changes within the text highlight that the SSE ground motion used as the design basis is not associated with a single earthquake but may be a composite of several expected earthquakes.

Costs

Reactor Siting Criteria (non-seismic):

The costs associated with the revised regulations are subdivided into two categories; the first is associated with siting criteria modifications (Part 100), the second is associated with (Part 50) modifications.

Part 100

The overall cost impact associated with revising the siting criteria aspects of the regulation are neutral. Important factors in this regard are:

1. Defining a Minimum Exclusion Area Distance and Eliminating Dose Calculations. The present regulation has no numerical size requirement for the exclusion area, in terms of distance, and instead assesses the consequences of a postulated radioactive fission product release within containment, coupled with assumptions regarding containment leakage, performance of certain fission product mitigation systems and site meteorology for a hypothetical individual located at any point on the exclusion area boundary as well as hydrological information. The plant and site combination is considered to be acceptable if the calculated consequences do not exceed the values given in the present rule. Regulatory Guide 4.7 suggests an exclusion area distance of 0.4 miles, since this has been found, in conjunction with typical engineered safety features, to meet the dose values in the existing rule.

   The Commission considers an exclusion area to be an essential feature of a reactor site, and is retaining this requirement for future reactors. However, in keeping with the recommendation of the Siting Policy Task Force to decouple site requirements from reactor design, the proposed rule would eliminate the use of a postulated source term, assumptions regarding mitigation systems and meteorology, and the calculation of radiological consequences to determine the sizes of the exclusion area and low population zone. It would instead require a minimum exclusion area distance of 0.4 miles for reactors.

   The proposed approach of eliminating the use of postulated accident source term and the use of dose calculations in determining the acceptability of a site and replacing these with population criteria and a minimum size of the exclusion area is expected to reduce time and costs associated with obtaining site approval.

2. Nearby Industrial and Transportation Facilities. This area of review is proposed to be incorporated into the regulations for the purpose of site suitability and has been a part of the staff review for many years. The criteria and standards are the same as those currently in staff review guidance documentation (Standard Review Plan, etc.). Hence, the proposed rule involves no substantive changes in this area and merely codifies what has been staff practice for a number of years.

3. Feasibility of Carrying out Protective Actions. The proposed rule

would require that important site factors, such a population distribution, topography, and transportation routes be considered and examined in order to determine whether there are any site characteristics that would pose a significant impediment to the development of an emergency plan.

The cost impact ass(' .ed with this revision is neutral. It is expected to increase .ime and costs for site approval but should significantly reduce time and costs at the OL or COL stage by avoiding licensing delays.

Part 50

The overall cost impact associated with revising the reactor licensing aspects of the regulation are neutral because the source term and dose calculations have always been required under Part 100 for site suitability but will now be required under Part 50 and used in evaluating plant features therefore there is no change in cost.

Seismic Siting and Earthquake Engineering Criteria:

The costs associated with the proposed regulations are subdivided into two categories; the first is associated with the geosciences and site investigations (Appendix B to Part 100), the second is associated with earthquake engineering (Appendix S to Part 50).

Appendix B to Part 100

As substantiated below, the overall cost impact associated with the geosciences and site investigation aspects of the proposed regulation as compared to Appendix A of Part 100 are slightly increased in some areas but reduced overall because of anticipated improvement in the licensing process. Specific examples include:

1. Reduced Licensing Delays. The licensing process will be enhanced because information needed for the staff review can be incorporated in the safety analysis reports at the time of docketing instead of later through staff questions and applicant responses.

2. Probabilistic Analyses. Probabilistic analyses to determine vibratory ground motion, surface tectonic deformation, and seismically induced floods and water waves reflect to some extent what is already current staff practice. In particular, probabilistic hazard analyses have been used to determine the probability of exceeding the Safe Shutdown Earthquake Ground Motion at the plant site. However, the overall use of probabilistic analyses as suggested in Draft Regulatory Guide DG—1015, "Identification and Characterization of Seismic Sources, Deterministic Source Earthquake, and Ground Motion," is new but should not have a significant cost impact. Computer codes to perform the probabilistic analyses are available. An applicant would input the site coordinates and local site effects (current requirement) to obtain the probabilistic hazard data. It is estimated that these analyses can be performed within a few days.

The comparison between the deterministic (current requirement) and probabilistic analyses is new. In cases where it is judged that the deterministic and probabilistic provide equivalent results the process is completed. In cases where the results differ spectra are developed to make additional comparisons. Evaluations associated with these comparisons would be handled on an ad hoc basis. However, as stated above, licensing delays would be reduced because the required data are defined and available to the applicant and staff for evaluation.

As part of the Federal Register notice public comments on specific questions associated with the use of a dual probabilistic and deterministic analyses requirement and the comparison procedure recommended by the staff are requested.

3. Seismic Sources. The new approach towards seismic sources (using seismogenic sources instead of tectonic provinces) and other clarifications of the licensing approach are expected to reduce time and costs required for obtaining site approval.

Appendix S to Part 50

As substantiated below, the overall cost impact associated with the earthquake engineering aspects of the proposed regulation are neutral or reduced. Specific examples include:

1. Reduced OBE Analysis. The response analyses associated with the Operating Basis Earthquake (OBE) may be eliminated if the applicant sets the OBE at one-third of the Safe Shutdown Earthquake Ground Motion (SSE). Selecting an OBE value greater than one-third of the SSE does not increase the analytical effort above current requirements.

2. Control Point Location. Changing the location of the control point (the point at which the vibratory ground motion is applied) from the foundation level to the free-field does not affect costs. The following discussion from Section 2.1.1.4 of NUREG-1233 (pages 13 and 14) is applicable:

> "A number of recent plants were designed to the 1975 Standard Review Plan requirements which specified the free-field motion at the free-surface for soil-structure interaction analysis. During the operating license (OL) review, the implementation of the current position of input motion at the foundation level in the free field resulted in a modification of some structural floor beams of seismic Category I structures at one plant. No hardware changes resulted at other plants. (Note that the staff's investigation was limited to the Safe shutdown systems and structures that housed them, and allowance was made for tested

strength values in some cases.)"

3. Seismic Instrumentation. Although the seismic instrumentation requirements are different, the cost is essentially the same as that currently used in operating plants there are fewer instruments required. The maintenance and calibration costs with the new solid-state seismic instrumentation are less than that associated with the current instrumentation. The processing of instrumentation data will be done at the site, thereby reducing the potential for prolonged plant shutdown while data are being evaluated. In general, the ability to expeditiously assess the effects of the earthquake on the plant will save both staff and licensee resources.

4. Post—earthquake Activities. In preparation of post—earthquake activities it is recommended that the licensee inspect and base—line certain structures, equipment and piping. Base line inspections would differentiate between pre—existing conditions at the nuclear power plant and earthquake related damage. The structures, equipment and piping selected for these inspections are comprised of those routinely examined by plant operators during normal plant walkdowns and inspections. After an earthquake plant operators familiar with the plant would walkdown and visually inspect accessible areas of the plant. Unnecessary plant shutdowns would be avoided since the pre—earthquake condition of equipment and structures (for example, physical appearance, leak rates, vibration levels) would be known. This approach has been submitted to the staff for approval by the Nuclear Management and Resources Council (NUMARC) and is documented in an Electric Power Research Report, EPRI NP—6695, "Guidelines for Nuclear Power Plant Response to an Earthquake." The associated cost impact is minimal and recommended by industry.

IMPACTS

a. Other NRC Programs

None for the non—seismic siting criteria.

Although Appendix A to 10 CFR Part 100 is titled "Seismic and Geologic Siting Criteria for Nuclear Power Plants," it is also referenced in two other Parts of the regulation. They are (1) Part 40, "Domestic Licensing of Source Material," Appendix A, "Criteria Relating to the Operation of Uranium Mills and the Disposition of Tailings or Waste Produced by the Extraction or Concentration of Source Material from Ores Processed Primarily for Their Source Material Content," Section I, Criterion 4(e), and (2) Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste," Paragraphs (a)(2)(b) and (a)(2)(f)(1) of §72.102. The proposed regulation, Appendix B to Part 100, is still applicable only to nuclear power plants. The need to revise Part 72 and Appendix A to Part 40, subject to the implementation of Appendix B to Part 100, should be a separate rulemaking initiative.

b. Other Government Agencies Since the siting and licensing of nuclear power plants is carried out solely by NRC staff, no impact is projected on other government agencies.

c. Constraints

None.

DECISION RATIONALE

Reactor Siting Criteria (non-seismic):

The major considerations that have guided the Commission in this proposed revision to the reactor site criteria are as follows:

1. The criteria will assure a low risk both for individuals as well as for society in general, even in the event of severe, but unlikely reactor accidents. The proposed criteria are consistent with the Commission Safety Goal Policy with respect to the risk of both prompt and latent cancer fatalities. In addition, the Commission has also examined the risks associated with land contamination or property damage in the event of significant releases for long-lived radioactive species, such as cesium. The proposed criteria are expected to result in a low likelihood of any significant offsite contamination of densely populated areas.

2. The criteria will assure that both man-made as well as natural events associated with the site location are identified and used in matching a design with the site.

3. The criteria will assure that a range of protective actions can feasibly be carried out to protect the public in the event of emergency.

The proposed revisions reflect current staff practice.

The revised regulations will not reduce risk, but will improve the description in the regulations of current staff practice in licensing.

Seismic Siting and Earthquake Engineering Criteria:

The recommendations to revise the existing regulation (Appendix A to 10 CFR Part 100) and replace it with the proposed regulations pertaining to the geosciences and site investigations (Appendix B to Part 100), and earthquake engineering (Appendix S to Part 50) are based primarily on qualitative rather than probabilistic (i.e., core damage frequency reduction) arguments. The staff's evaluation augments the regulatory analysis associated with the implementation of Unresolved Safety Issue (USI) A—40, "Seismic Design Criteria" (NUREG—1233). USI A—40 was implemented in August 1989 through the revision of Standard Review Plan Sections 3.7.1, "Seismic Design Parameters," 3.7.2, "Seismic System Analysis," 3.7.3, "Seismic Subsystem Analysis," and 2.5.2, "Vibratory Ground Motion."

The staff's conclusion is that for operating reactor and operating license applicants, the proposed regulations would have little effect on risk. Operating plants have generally been, and will be, seismically upgraded by plant-specific actions such as implementation of the Systematic Evaluation Program (SEP), the implementation of Generic Letter 88—20, Supplement 4, "Individual Plant Examinations of External Events (IPEEE) for Severe Accident Vulnerabilities," the proposed implementation of USI A—46, "Verification of Seismic Adequacy of Equipment in Operating Plants," and NRC Bulletin programs. Therefore, this regulatory action will be applicable only to applicants who apply for an early site permit, design certification, combined license, construction permit or operating license on or after the effective date of the final regulations.

For applicants of early site permits, design certifications, combined licenses, construction permit or operating license, no overall increases in costs are envisioned to implement the proposed regulations. In addition, the proposed regulations will reduce delays in the licensing process because information needed for the staff review can be incorporated in the safety analysis reports at the time of docketing instead of later through staff questions and applicant responses. Therefore, the staff proposed that all new applicants be required to comply with the proposed regulatio s.

Current Regulatory Action

The current regulatory action consists of the following:

1. Revisions to §50.2, §50.8, §50.34, §50.54, and §52.17.

2. Revisions to §100.1, §100.2, §100.3, and §100.8.

3. Add Subpart B §100.20, §100.21, and §100.22.

4. New Appendix B to Part 100, Criteria for the Seismic and Geologic Siting of Nuclear Power Plants After [EFFECTIVE DATE OF THIS REGULATION]

5. New Appendix S to Part 50, Earthquake Engineering Criteria for Nuclear Power Plants

6. New Regulatory Guides:

   a. DG--1015, "Identification and Characterization of Seismic Sources, Deterministic Source Earthquake, and Ground Motion"

   b. DG—1017, "Pre—Earthquake Planning and Immediate Nuclear Power Plant Operator Post--Earthquake Actions"

   c. DG—1018, "Restart of a Nuclear Power Plant Shut Down by a Seismic Event"

7. Revised Regulatory Guide:

   a. Proposed Revision 2 to Regulatory Guide 4.7, "General Site Suitability Criteria for Nuclear Power Stations"

   b. DG—1016, Second Proposed Rev[illegible]on 2 to Regulatory Guide 1.12, "Nuclear Power Plant Instrumentation for Earthquakes"

8. Revised Standard Review Plan Section:

2.5.2, Vibratory Ground Motion

Future Regulatory Action

Several existing regulatory guides will be revised to incorporate editorial changes or maintain the existing design or analysis philosophy . These guides will be issued subsequent to the publication of the final regulations that would implement this proposed action.

The following regulatory guides will be revised to incorporate editorial changes For example, the type of changes contemplated would be to reference new paragraphs in Appendix B to Part 100 or Appendix S to Part 50:

1. 1.57, "Design Limits and Loading Combinations for Metal Primary Containment System Components"

2. 1.59, "Design Basis Floods for Nuclear Power Plants"

3. 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants"

4. 1.83, "Inservice Inspection of Pressurized Water Reactor Steam Generator Tubes"

5. 1.92, "Combining Modal Responses and Spatial Components in Seismic Response Analysis"

6. 1.102, "Flood Protection for Nuclear Power Plants"

7. 1.121, "Bases for Plugging Degraded PWR Steam Generator Tubes"

8. 1.122, "Development of Floor Response Spectra for Seismic Design of Floor-Supported Equipment or Components"

The following regulatory guides will be revised to maintain existing design or analysis philosophy. For example, the types of changes contemplated would be to change OBE to a fraction of the SSE:

1. 1.27, "Ultimate Heat Sink for Nuclear Power Plants"

2. 1.100, "Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants"

3. 1.124, "Service Limits and Loading Combinations for Class 1 Liner-Type Component Supports"

4. 1.130, "Service Limits and Loading Combinations for Class 1 Plate-and-Shell-Type Component Supports"

5. 1.132, "Site Investigations for Foundations of Nuclear Power Plants"

6. 1.138, "Laboratory Investigations of Soils for Engineering Analysis and Design of Nuclear Power Plants"

7. 1.142, "Safety-Related Concrete Structures for Nuclear Power Plants (Other than Reactor Vessels and Containments)"

8. 1.143, "Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants"

During the revision of the regulatory guides cited above, if additional changes are made, the applicable guide(s) will be distributed for public comment. Several regulatory guides will be revised to incorporate editorial changes or, maintain the existing design or analysis philosophy.

IMPLEMENTATION

This regulatory action is applicable only to applicants that apply for an early site permit, design certification, combined license, construction permit or operating license on or after the effective date of the final regulations. However, if the construction permit was issued prior to the effective date of the proposed regulation, the operating license applicant shall comply with the seismic and geologic siting and earthquake engineering criteria in Appendix A to Part 100.

DRAFT ENVIRONMENTAL ASSESSMENT AND FINDING OF NO SIGNIFICANT IMPACT

PROPOSED REVISION OF

10 CFR PART 100

AND

APPENDIX A TO 10 CFR PART 100

DRAFT ENVIRONMENTAL ASSESSMENT AND FINDING OF NO SIGNIFICANT IMPACT PROPOSED REVISION OF 10 CFR PART 100, 10 CFR PART 100 APPENDIX A, AND 10 CFR PART 50

The Nuclear Regulatory Commission is amending its regulations to update the used reactor siting criteria; seismic and geologic siting criteria; and earthquake engineering regulations for nuclear power plants. The non—seismic and seismic areas are discussed separately.

Identification of Proposed Action

Reactor Siting Criteria (non—seismic):

Title 10 CFR Part 100, "Reactor Site Criteria," was originally issued in April 1962. The proposed amendment will apply to applicants who apply for site approval on or after the effective date of the final regulation. Since the revision to the regulation will not be a backfit, the bases for existing nuclear power plants must remain in the same regulation. Therefore, the revised regulation on siting will be designated 10 CFR Part 100, Subpart B.

Criteria not associated with the selection of the site will be relocated into Part 50 consistent with the location in the regulation of other design requirements. Hence, source term and dose calculations will be used for evaluating plant features, and not site suitability.

The proposed rule would eliminate the use of a postulated accident source term and the use of a dose calculation in the determination of acceptability for a nuclear power plant site. It would also eliminate the designation of a low population zone. Instead, it would set a minimum size for the exclusion area and would set population density criteria around proposed nuclear power reactor sites. In addition, criteria regarding the evaluation of man—made hazards and the feasibility of carrying out protective actions in the event of an emergency are to be incorporated.

Seismic Siting and Earthquake Engineering Criteria:

Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants," to 10 CFR Part 100, "Reactor Siting Criteria," was originally issued as a proposed rule on November 25, 1971 (36 FR 22601); published as a final rule on November 13, 1973 (38 FR 31279); and became effective on December 13, 1973. There have been two amendments to 10 CFR Part 100, Appendix A. The first amendment, issued November 27, 1973 (38 FR 32575), corrected the final rule by adding the legend under the diagram. The second amendment resulted from a petition for rule making (PRM 100-1) requesting that an opinion interpreting and clarifying Appendix A with respect to the determination of the Safe Shutdown Earthquake be issued. A notice of filing of the petition was published on May 14, 1975 (40 FR 20983). The substance of the petitioner's proposal was accepted and published as an immediately effective final rule on January 10, 1977 (42 FR 2052).

The proposed amendment will apply to applicants who apply for an early site permit, design certification, combined license, construction permit or operating license on or after [effective date of the revised regulation]. However, if the construction permit was issued prior to [effective date of the regulation], the operating license applicant shall comply with the seismic and geologic siting and earthquake engineering criteria in Appendix A to 10 CFR Part 100. Because the revised criteria presented in the proposed regulation will not be applied to existing plants, the licensing bases for existing nuclear power plants must remain part of the regulations. Therefore, the proposed revised criteria on seismic and geologic siting would be designated as a new Appendix B to 10 CFR Part 100, "Criteria for the Seismic and Geologic Siting of Nuclear Power Plants After [EFFECTIVE DATE OF THIS REGULATION]," and would be added to the existing body of regulations.

Criteria not associated with the selection of the site or establishment of the safe shutdown earthquake ground motion have been placed into Part 50. This action is consistent with the location of other design requirements in Part 50. Hence, earthquake engineering criteria would be located in Appendix S to 10 CFR Part 50, "Earthquake Engineering Criteria for Nuclear Power Plants."

The proposed regulatory action incorporates changes intended to (1) benefit from the experience gained in applying the existing regulation; (2) resolve interpretative questions; (3) provide needed regulatory flexibility to incorporate state-of-the-art improvements in the geosciences and earthquake engineering; (4) simplify the language to a more "plain English" text; and (5) acknowledge various internal staff and industry comments.

Need for the Proposed Action

Reactor Siting Criteria (non-seismic):

Since its initial promulgation in 1962, the Commission has approved more than 75 sites for nuclear power plants, and has had an opportunity to review a number of others. As a result of these reviews, much experience has been gained regarding the site factors that influence risk and their range of acceptability.

Additionally, there has also been an increased awareness and concern regarding the effect of potential nuclear accidents. Although accident considerations have been of key importance in reactor siting from the very beginning, major developments such as the issuance of the Reactor Safety Study (WASH-1400) in 1975, the occurrence of the Three Mile Island accident in 1979, the Chernobyl accident in the Soviet Union in 1986, and the issuance of NUREG-1150, "Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants," in December 1990, have greatly increased awareness, knowledge, and concerns in this area.

The major impetus for the proposed rule is increased interest in new nuclear power generation and the possibility that applicants will request site approval for new nuclear power plants. The Commission believes that, in the event such requests materialize, the criteria for siting power reactors should address directly those site factors important to risk and should reflect the significant experience learned since the regulation was first issued in 1962.

Seismic Siting and Earthquake Engineering Criteria:

The experience gained in the application of the procedures and methods set forth in the current regulation and the rapid advancement in the state-of-the-art of earth sciences have made it necessary to update the 1973 criteria.

Environmental Impacts of the Proposed Action

Reactor Siting Criteria (non—seismic):

Part 100, Subpart B, contains the considerations which will guide the Commission in its evaluation of the suitability of a proposed site for nuclear power plants after the effective date of the final regulation. The revision to Part 50 will contain the engineering considerations which guide the Commission in its evaluation of the suitability of the plant design. The amendment to 10 CFR Part 100 as stated in the proposed rulemaking package reflects current licensing practice and will not change the radiological environmental impact. Further, the Policy Statement on Severe Accidents Regarding Future Design and Existing Plants, published August 8, 1985 (50 FR 32138), affirms the Commission's belief that a new design for a nuclear power plant can be shown to be acceptable for severe accident concerns if the criteria and procedural requirements cited in 50 FR 32138 are met. Stated differently, the proposed regulatory action (10 CFR Part 100, Subpart B) are specifically based on maintaining the present level of risk of radiological releases, thus having zero effect compared to the regulation (10 CFR Part 100, Subpart A) they replace for future siting applications.

Seismic Siting and Earthquake Engineering Criteria:

Proposed Appendix B to Part 100 contains the seismic and geologic considerations which guide the Commission in its evaluation of the suitability of proposed sites for nuclear power plants. Proposed Appendix S to Part 50 contains the earthquake engineering considerations which guide the Commission in its evaluation of the suitability of the plant design bases. The amendment of Appendix A to 10 CFR Part 100 as stated in Appendices B and S reflect current licensing practice in earthquake engineering and enhanced current staff practice in seismic and geologic siting through the use of probabilisitc analyses. Therefore, the radiological environmental impact offsite will not change. Further, the Policy Statement on Severe Reactor Accidents Regarding Future Designs and Existing Plants, published August 8, 1985 (50 FR 32138) affirms the Commission's belief that a new design for a nuclear power plant can be shown to be acceptable for severe accident concerns if the criteria and procedural requirements cited in 50 FR 32138 are met. Stated differently, the proposed regulatory actions (Appendix B to Part 100 and Appendix S to Part 50) are specifically based on maintaining the present level of risk of radiological releases, thus having zero effect compared to the regulation (Appendix A to Part 100) they replace.

Onsite occupational radiation exposure associated with inspection and maintenance will not change. These activities are principally associated with base line inspections of structures, equipment and piping, and maintenance of seismic instrumentation. Base line inspections are needed to differentiate between pre-existing conditions at the nuclear power plant and earthquake related damage. The structures, equipment and piping selected for these inspections are comprised of those routinely examined by plant operators during normal plant walkdowns and inspections. Routine maintenance of seismic instrumentation assures its operability during earthquakes. The location of the seismic instrumentation is similar to that in the existing nuclear power plants. In addition, the proposed regulatory guide pertaining to seismic instrumentation (Second Proposed Revision to Regulatory Guide 1.12, Nuclear Power Plant Instrumentation for Earthquakes) specifically cites occupational radiation exposure as a consideration in selecting the location of the instruments.

The proposed amendments do not affect non-radiological plant effluents and have no other environmental impact. Therefore, the Commission concludes that there are also no significant non-radiological environmental impacts associated with the proposed amendments to the regulations.

Alternatives to the Proposed Action

As required by Section 102(2)(E) of NEPA (42 U.S.C.A. 4332(2)(E)), the staff has considered possible alternatives to the proposed action.

The first alternative considered by the Commission was to avoid initiating a rulemaking proceeding. This is not an acceptable alternative. Although the siting related issues associated with the current generation of nuclear power plants are completed or nearing completion, there is a sense of urgency to initiate the proposed regulatory action in light of the current and future staff review of advanced reactor seismic design criteria. The current regulation has created difficulty for applicants and the staff in terms of inhibiting flexibility in applying basic principles to new situations and the use of evolving methods of analyses in the licensing process. Further, decoupling siting requirements from plant design requirements such that the certified design would not be dependent on site parameters to establish the fission product retention characteristics of the design would benefit the licensing process.

A second alternative considered was the deletion of the existing regulation. This is not an acceptable alternative because these provisions form the licensing bases for many of the operating nuclear power plants and others that are in various stages of obtaining their operating license.

For the seismic siting and earthquake engineering criteria areas, another alternative considered was the replacement of the entire regulation with a regulatory guide. This is not acceptable because a regulatory guide is non-mandatory. The staff believes that there could be an increase in the risk of radiation exposure to the public if the siting and earthquake engineering criteria were non-mandatory.

The approach of establishing the revised requirements in new sections of the regulations while retaining the existing regulation was chosen as the best alternative. The public will benefit from a clearer, more uniform and consistent licensing process subject to fewer interpretations. The NRC staff will benefit from improved regulatory implementation (both technical and legal), fewer interpretive debates, and increased regulatory flexibility. Applicants will derive the same benefits in addition to avoiding licensing delays due to unclear regulatory requirements. The adoption of revised siting and engineering criteria would increase the efficiency of regulatory actions associated with any resurgence of licensing activity.

Alternative Use of Resources

No alternative use of resources was considered.

Agencies and Persons Consulted

Reactor Siting Criteria (non—seismic):

NRC Staff developed the enclosed rulemaking recommendations. No outside agencies or consultants were used in developing this rulemaking package. However, several public meetings were held to inform industry of the staff's efforts in revising the siting criteria.

Seismic Siting and Earthquake Engineering Criteria:

During the development of the proposed regulations and supporting regulatory guides the NRC staff had three public meetings with interested industry groups, principally, the Nuclear Management and Resources Council (NUMARC) and the Electric Power Research Institute (EPRI). The NRC staff also obtained advice from the NRC Advisory Committee on Reactor Safeguards and comments from the U.S. Geological Survey (USGS) staff. As a proposed rule, the regulations will be released for public comment to encourage participation from the public and other organizations in the development of the regulations.

Finding of No Significant Impact

The Commission has determined under the National Environmental Policy Act of 1969, as amended, that the proposed amendments to 10 CFR Parts 50 and 100, relocating dose calculation requirements and specifying siting criteria (population, seismic, and geologic), and earthquake engineering criteria for nuclear power plants, if adopted, would not have a significant effect on the quality of the human environment and that an environmental impact statement is not required.

This determination is based on the following:

1. The proposed amendments to the regulations reflect current practice achieved through the staff's evaluation of applicants safety analysis reports at the time of docketing and applicant's responses to staff initiated questions and the results of research in the earth sciences and seismic engineering.

2. The foregoing environmental assessment.

3. The qualitative, deterministic and probabilistic assessments pertaining to seismic events in NUREG—1070, NUREG—1233, and NUREG—1407.

4. The Policy Statement on Severe Reactor Accidents Regarding Future Designs and Existing Plants, published August 8, 1985 (50 FR 32138) affirming the Commission's belief that a new design for a nuclear power plant can be shown to be acceptable for severe accident concerns if the criteria and procedural requirements cited in 50 FR 32138 are met.

References

NUREG-1070, "NRC Policy on Future Reactor Designs, Decisions on Severe Accident

Issues in Nuclear Power Plant Regulation," July 1985.

NUREG-1233, "Regulatory Analysis for USI A-40, "Seismic Design Criteria" Final Report," September 1989.

NUREG-1407, "Procedural and Submittal Guidance for the Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities, Final Report," Attachment to Appendix D, Value/Impact Analysis for the Implementation of Individual Plant Examination of External Events, June 1991.

NUCLEAR REGULATORY COMMISSION

Documents Containing Reporting or Recordkeeping Requirements: Office of Management and Budget (OMB) Review

AGENCY: U.S. Nuclear Regulatory Commission (NRC)

ACTION: Notice of the Office of Management and Budget review of information collection.

SUMMARY: The Nuclear Regulatory Commission (NRC) has recently submitted to the Office of Management and Budget (OMB) for review the following proposal for the collection of information under the provisions of the Paperwork Reduction Act (44 U.S.C. Chapter 35). There are no new or revised reporting requirements associated with the proposed regulation 10 CFR Part 100, "Reactor Site Criteria," and 10 CFR Part 50, "Domestic Licensing of Production and Utilitzation Facilities."

1. Type of submission new, revision or extension: Revision

2. The title of the information collections:

   Proposed Appendix B, "Criteria for the Seismic and Geologic Siting of Nuclear Power Plants After [EFFECTIVE DATE OF THIS REGULATION]" to 10 CFR Part 100, and Proposed Appendix S, "Earthquake Engineering Criteria for Nuclear Power Plants" to 10 CFR Part 50. (Revision of Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants" to 10 CFR Part 100.)

3. The form number if applicable: Not applicable

4. How often the collection is required:

   As necessary in order for NRC to assess the adequacy of proposed seismic design bases and the design bases for other geological hazards for nuclear power plants constructed and licensed in accordance with 10 CFR Part 50, and the Atomic Energy Act of 1954, as amended (the Act).

5. Who will be required or asked to report: Applicants for a construction permit, operating license, early site permit, design certification, or combined license, for nuclear power plants.

6. An estimate of the number of responses:

   1 annually.

7. An estimate of the number of hours annually needed to complete the requirement or request:

164,500.

8. An indication of whether Section 3504(h), Pub. L. 96-511 applies: Not applicable.

9. Abstract:

Proposed Appendix B to 10 CFR Part 100 contains criteria associated with the selection of the nuclear power plant site and the establishment of the safe shutdown earthquake ground motion. Proposed Appendix S to 10 CFR Part 50 contains earthquake engineering criteria for nuclear power plants. In combination, these appendices will replace the criteria contained in Appendix A to 10 CFR Part 100.

Copies of the submittal may be inspected or obtained for a fee from the NRC Public Document Room, 2120 L Street, NW (Lower Level), Washington, DC.

Comments and questions can be directed by mail to the OMB reviewer:

Ronald Minsk
Office of Information and Regulatory Affairs (3150-0014)
NEOB-3019
Office of Management and Budget
Washington, DC 20503

Comments can also be submitted by telephone at (202) 395-3084.

The NRC Clearance Officer is Brenda Jo Shelton, (301) 492-8132.

Dated at Bethesda, Maryland this day of 1991

For the Nuclear Regulatory Commission

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Gerald F. Cranford, Designated Senior Official
for Information Resources Management

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OMB SUPPORTING STATEMENT FOR

PROPOSED REVISIONS TO 10 CFR PART 100, REACTOR SITING CRITERIA, AND TO 10 CFR PART 50, DOMESTIC LICENSING OF PRODUCTION AND UTILIZATION FACILITIES;

PROPOSED APPENDIX B, CRITERIA FOR THE SEISMIC AND GEOLOGIC SITING OF NUCLEAR POWER PLANTS AFTER [EFFECTIVE DATE], TO 10 CFR PART 100;

AND

PROPOSED APPENDIX S, EARTHQUAKE ENGINEERING CRITERIA FOR NUCLEAR POWER PLANTS, TO 10 CFR PART 50

(REVISION OF APPENDIX A TO 10 CFR PART 100)

Description of the Information Collection

Non-Seismic Siting Criteria:

The proposed change to 10 CFR 50 simply relocates the requirements previously contained in 10 CFR 100 for each applicant to calculate a whole body and a thyroid dose at specified distances. Since these requirements would be used in reactor design rather than siting, it is more appropriately located in 10 CFR 50, thus leaving 10 CFR 100 with site criteria only. The source term and methodology for performing the dose calculations remain unchanged from that stated in 10 CFR 100.

These requirements apply to all future applicants for a power reactor. They are intended to be interim requirements until such time as more specific requirements for future applicants are developed governing containment performance and other fission product cleanup systems.

Seismic Criteria:

Proposed Appendix B, "Criteria for the Seismic and Geologic Siting of Nuclear Power Plants After [EFFECTIVE DATE OF THIS REGULATION]," (Criterion II, IV, and V) to 10 CFR Part 100, "Reactor Site Criteria," requires applicants to provide the types of information that show evidence of the size and frequency of occurrence of earthquakes, tectonic and non-tectonic surface deformation, and seismically induced floods and water waves. Both deterministic and probabilistic analyses of earthquake-related phenomena are required. From these seismic and geologic hazard data, applicants determine earthquake ground motion for the seismic design basis, design bases for seismically induced floods and water waves, the need to design for surface deformation, and other design conditions that may be affected by earthquake ground motion, such as soil and slope stability.

Proposed Appendix S, "Earthquake Engineering Criteria for Nuclear Power Plants," (Criterion II and IV) to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," require applicants to provide the design bases for a nuclear power plant that will ensure that structures, systems, and components important to safety will be able to withstand the natural phenomena specified in General Design Criterion 2 of 10 CFR Part 50, Appendix A and Proposed 10 CFR Part 100, Appendix B without loss of capability to perform their safety functions.

Proposed Appendix B to 10 CFR Part 100 and Proposed Appendix S to 10 CFR Part 50, in combination, are a revision of Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants," to 10 CFR Part 100. The proposed appendices apply to applicants who apply for an early site permit, design certification, or combined license pursuant to 10 CFR Part 52, or a construction permit or operating license pursuant to 10 CFR Part 50 on or after [EFFECTIVE DATE OF THIS REGULATION]. However, if the construction permit was issued prior to [EFFECTIVE DATE OF THIS REGULATION], the operating license applicant shall comply with the seismic and geologic siting and earthquake engineering criteria in Appendix A to 10 CFR Part 100. Appendix A to 10 CFR Part 100 will continue to serve as the criteria for the seismic and geologic siting and earthquake engineering for plants licensed or having received their construction permit before [EFFECTIVE DATE OF THIS REGULATION].

It is anticipated that new plant applications could be submitted within a few years. This is based on the current and projected staff review of advanced reactor seismic design criteria related to the design certification of two evolutionary light water reactor designs (the Advanced Boiling Water Reactor (ABWR) and the System 80+ Pressurized Water Reactor) and the Electric Power Research Institute (EPRI) Advanced Light Water Reactor Requirements Document. Based on NRC staff experience obtained from construction permit and operating license applications relative to Appendix A to 10 CFR Part 100, the review process for a construction permit, operating license, early site permit, design certification, or combined license, as it applies to Proposed Appendix B to 10 CFR Part 100 and Proposed Appendix S to 10 CFR Part 50, is expected to range from one to several years. The NRC staff reviews the Safety Analysis Report for six to twenty four months and, if necessary, generates a request for additional information. The applicant usually responds within 1 to 6 months, depending on the complexity of the issues. The average time is about 3 months. The responses are reviewed and a draft Safety Evaluation Report is written by the NRC staff. This document summarizes conclusions and highlights any outstanding issues. The staff arranges for a meeting and site visit to resolve any open issues. When the open issues have been resolved, the staff writes the final Safety Evaluation Report, which is published and used as a basis for the remainder of the NRC licensing process (the meeting with the Advisory Committee on Reactor Safeguards (ACRS) and hearing, as necessary, before the Atomic Safety and Licensing Board) which usually takes about 1½ years.

A. JUSTIFICATION

1. Need for the Collection of Information

The information required will be needed by the NRC to assess the adequacy of proposed seismic design bases (siting and engineering) and the design bases for other geological hazards for nuclear power plants in support of the agency's mission regarding adequate protection of the health and safety of the public from seismic events. It is submitted to the NRC as part of the application and supporting documentation for a construction permit, operating license, early site permit, design certification, or combined license for a nuclear power plant.

Moreover, Proposed Appendix B to 10 CFR Part 100 and Proposed Appendix S to Part 50, supplemented by the Standard Format, Regulatory Guides and the Standard Review Plan, are used by applicants as general guidance in planning investigations of nuclear power plant sites, and designing nuclear power plant structures, systems, and components important to safety to withstand the effects of natural phenomena, such as earthquakes.

2. Agency Use of Information

The NRC reviews the geological and seismological information to determine the suitability of the proposed site for a nuclear power plant and the suitability of the plant design bases established on the proposed site. A construction permit, early site permit, standard design certification, or combined license cannot be issued until these data have been reviewed and approved by the NRC.

New geological and seismological information that becomes known during the operating life of a plant is also evaluated on the basis of these criteria. The criteria also serve as the basis for ongoing NRC research in the earth sciences.

3. Reduction of Burden Through Information Technology

There are no legal obstacles to reducing the burden associated with this collection through information technology. Moreover, NRC encourages the use of such technology.

4. Effort to Identify Duplication

This information does not duplicate other information being provided to NRC.

5. Effort to Use Similar Information

All pertinent geological and seismological information concerning the nuclear site and region around the site will be used in the analysis of that site, whether it is supplied by the applicant or not. Similarly, any available engineering and design data will be used, as applicable, in the design review of a proposed nuclear power plant whether it is a product of the criteria requirements or not. The availability of geological seismological or engineering data may reduce the applicants efforts related to site investigation or design.

6. Effort to Reduce Small Business Burden

This information collection does not affect small businesses.

7. Consequences of Less Frequent Collection

Less frequent collection of information will result in serious delays in the licensing processes of nuclear power plants or potential additional risks to the health and safety of the public.

8. Circumstances Which Justify Variation From OMB Guidelines

There is no variation from the guidelines.

9. Consultations Outside the NRC

During the development of the proposed regulation the staff had three public meetings with interested industry groups (principally, the Nuclear Management and Resources Council (NUMARC) and the Electric Power Research Institute (EPRI)) related to the seismic and earthquake engineering considerations and six meetings with the same participants related to revision of the non—seismic siting criteria. With respect to the seismic and geological proposed regulations, the NRC staff also obtained comments from the U.S. Geological Survey (USGS) staff during the development of the proposed regulations. As a proposed rule, the regulations will be released for public comment to encourage participation from the public and other organizations in the development of the regulations.

10. Confidentiality of Information

Proprietary information is protected in accordance with the provisions specified in 10 CFR 2 of the NRC's regulations.

11. Justification for Sensitive Questions

These regulations do not require sensitive information.

12. Estimated Annual Cost to the Federal Government

Current NRC staff activities that are applicable to Proposed Appendix S to 10 CFR Part 50 relate to standard design certification. Specifically, the NRC staff is reviewing the design certification of two evolutionary light water reactor designs (the Advanced Boiling Water Reactor (ABWR) and the System 80+ Pressurized Water Reactor) and the Electric Power Research Institute (EPRI) Advanced Light Water Reactor Requirements Document. There are no site-specific construction permit, operating license, early site permit, or combined license application evaluations that relate to Proposed Appendix B to 10 CFR Part 100 or Proposed Appendix S to 10 CFR Part 50 being performed by the NRC staff.

Since activities related to Proposed Appendix B to 10 CFR Part 100 and Proposed Appendix S to 10 CFR Part 50 are limited, the following estimates also include NRC staff experience obtained from construction permit or operating license application evaluations relative to Appendix A to 10 CFR Part 100.

a. Seismic and Geologic Evaluations

Seismic and geologic staff evaluations required for a construction permit, operating license, early site permit, or combined license review can range from about 1,000 hours for a site with uncomplicated geology in a region of low seismicity to as many as 6,000 hours for very complex sites. The estimated average annual effort required to review the seismology and geology of an application is about 2,000 hours or $230,000 ($115 x 2,000 hours).

b. Earthquake Engineering Evaluations

Staff evaluations of nuclear power plant structures, systems, and components, to ensure that they will perform their safety function without loss of capability, average 60,000 hours per plant. The estimated annual staff burden is 12,000 hours per application. The staff review consists of an evaluation of several loads, one of them being the seismic event. Typical loadings that are considered in the design and staff evaluation of the structures, systems, and components include: dead load (equipment or building weight), live load (moveable equipment load), earthquake, thermal effects, and pressure. It is estimated that twenty five percent of the staff evaluation is devoted to seismic-related issues. Therefore, the annual seismic-related portion of the staff review is approximately 3,000 hours (25 percent of 12,000 hours) or $345,000 ($115 x 3,000 hours).

c. Consultants

Consultants and staff from the U.S. Geologic Survey and Department of Energy Laboratories are employed by the NRC on a case-by-case basis to provide advice in activities related to staff reviews performed in accordance with Proposed Appendix B to 10 CFR Part 100 or Proposed Appendix S to 10 CFR Part 50. It is anticipated that an average annual effort for these consultants would not exceed 500 hours or $57,500 ($115 x 500 hours).

Total annual cost to the Federal Government for activities related to the proposed regulation is estimated to be $632,500 ($115 x 5,500 hours).

13. <u>Estimate of Industry Burden</u>

The estimated seismic and geological revisions burdens are as follows.

a. Seismic and Geologic Evaluations

This estimate is based on the requirement for gathering, analyzing, and synthesizing data. In order for applicants to provide the types of information which show evidence of the size and frequency of occurrence of earthquakes, the last time there was displacement along faults at the site or in the region, or the potential for fault offset during the life of a nuclear power plant, extensive research and analysis must be conducted. This effort involves the analysis of voluminous amounts of drawings, logs, maps, seismic and other geophysical records, and reports. It is estimated that the industry burden will be on the average of 24,000 hours per applicant. The estimated annual burden is 8,000 hours per applicant or $920,000 ($115 x 8,000 hours).

b. Earthquake Engineering Evaluations

This estimate is based on the requirement that nuclear power plant structures, systems and components important to safety are designed to withstand the effects of earthquakes without loss of capability to perform their safety functions. In order for applicants to provide the information which show the functionality of structures, systems and components to vibratory ground motion, suitable analysis, testing or qualification methods are employed.

References 1 and 2 were used to obtain an estimate of seismic-related costs in nuclear power plant design and construction. The incremental cost estimate provided in Table 1 is based on Table 1 of Reference 1, modified as follows: (1) updated to January 1, 1992 costs, (2) increased the Safe Shutdown Earthquake Ground Motion from 0.2g to 0.3g, and (3) increased distribution system and engineering costs.

It is estimated that the industry burden associated with the seismic engineering (staff related costs) of nuclear power plant structures, systems, and components will average $88,850,000 per application. The estimated annual burden per application will average $18,000,000 or approximately 156,500 hours ($115 x 156,500 hours approximately equals $18,000,000). This cost estimate may be reduced due to additional savings associated with standardized plant designs, and reductions in analyses and design associated with the Operating Basis Earthquake as stated in Proposed Appendix S to 10 CFR Part 50.

The total annual burden on industry for activities related to the proposed regulations is estimated to be $18,940,500 ($115 x 164,700 hours).

14. Reasons for Change in Burden

The estimated burden on the NRC staff and industry remains the same. For applicants of a construction permit, operating license, early site permit, design certification, or combined license no significant increases in costs are envisioned to implement the revised regulations. In general, the proposed revisions reflect current staff practice. Specifically, in the area of geologic and seismic siting, the required probabilisitic analyses are new but should not have a significant cost impact. Some probabilistic analyses have been used in recent licensing reviews to determine the probability of exceeding the safe shutdown earthquake ground motion at the plant site. With regard to earthquake engineering, the proposed regulation reflects or possibly reduce current staff practice. In addition, the proposed revisions to the regulations will reduce delays in the licensing process because information needed for the staff review can be incorporated in the safety analysis reports at the time of docketing instead of later through staff questions and applicant responses.

15. Publication for Statistical Use

This information is not collected for statistical purposes.

B. COLLECTION OF INFORMATION EMPLOYING STATISTICAL METHODS

Appendix B of 10 CFR Part 100 allows for the acquisition of statistical data and the use of statistical methods, h[illegible]es not require them.

References

1. NUREG/CR-1508, "Evaluation of the Cost Effects on Nuclear Power Plant Construction Resulting from the Increase in Seismic Design Level," April 1981.

2. Stevenson and Associates, "Differential Design and Construction Cost of a Nuclear Power Plant Safety Related Piping Systems as a Function of Seismic Intensity and Time Period of Construction for New and Operating Plants and Current Simplified Seismic Design Initiatives," Draft, July 1990.

Enclosures:
Table 1, Summary of Incremental Cost Estimate (Seismic vs No Seismic)
Table 2, OMB Supporting Statement

TABLE 1
SUMMARY OF INCREMENTAL COST ESTIMATE

0.3G Safe Shutdown Earthquake Ground Motion vs
No Seismic Design Requirement

ITEM	COST ESTIMATE [1]
Foundations	$ 35,425,000
Structures	3,675,000
Auxiliary Components	16,375,000
NSSS Components	4,425,000
Distribution Systems	114,875,000
Engineering	88,850,000
Turbine Hall	525,000
Total Cost Estimate	$ 264,150,000 [2]

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[1] Based on Table 1 in Reference 1, modified as follows:

a. Updated to January 1, 1992 costs. A factor of 2.2, based on an inflation and escalation rate of 8.0 percent between January 1977 and 1985, and 5.0 percent between January 1985 and 1992 (from Table 7.2 of Reference 2) was used.

b. Increased Safe Shutdown Earthquake Ground Motion from 0.2g to 0.3g. A cost factor of 2, based on Figures 1 and 2 of Reference 1 was used.

c. Increased Distribution System and Engineering costs. In addition to increasing these costs based on Steps a and b, new piping costs, based on Tables 5.10 and 5.11 of Reference 2, were used. (Material and craft costs: $174,882,470 with seismic design and restraints, $67,177,570 without seismic design and restraints. Engineering costs: $63,984,090 with seismic design and restraints, $6,344,920 without seismic design and restraints.)

[2] The total cost estimate does not reflect potential savings associated with the use of a standardized plant designs or reductions in analyses and design associated with the proposed rulemaking. Therefore, the cost estimate may be reduced.

TABLE 2
OMB SUPPORTING STATEMENT

10 CFR Part 100, Appendix B and 10 CFR Part 50, Appendix S
(Revision of 10 CFR Part 100, Appendix A)

TASK	HOURS OR DOLLARS
ESTIMATED AVERAGE ANNUAL BURDEN HOURS PER RESPONSE	164,500
NUMBER OF RESPONDENTS ANNUALLY	1
ESTIMATED TOTAL ANNUAL BURDEN HOURS	164,500
ESTIMATED TOTAL ANNUAL COST TO INDUSTRY	$18,917,500
ESTIMATED TOTAL ANNUAL STAFF HOURS	5,000
ESTIMATED NRC CONSULTANT HOURS	500
ESTIMATED ANNUAL COST TO THE FEDERAL GOVERNMENT (STAFF + CONSULTANT HOURS)	5,500

U.S. NUCLEAR REGULATORY COMMISSION

Proposed Revision 2
March 1992

REGULATORY GUIDE

OFFICE OF NUCLEAR REGULATORY RESEARCH

REGULATORY GUIDE 4.7

GENERAL SITE SUITABILITY
CRITERIA FOR NUCLEAR POWER
STATIONS

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A. INTRODUCTION

The Energy Reorganization Act of 1974 places on the Nuclear Regulatory Commission (NRC) the responsibility for the licensing and regulation of private nuclear facilities from the standpoint of public health and safety. ~~Paragraphs 100.10(b) and (c) of~~ Title 10, CFR Part 100, "Reactor Site Criteria," requires that the population density, use of the site environs including proximity to man-made hazards, and the physical characteristics of the site, including seismology, meteorology, geology, and hydrology, be taken into account in determining the acceptability of a site for a nuclear power reactor. Seismic and geologic site criteria for nuclear power plants are provided in Appendix A and Appendix B to 10 CFR Part 100. Appendix A to 10 CFR Part 50 establishes the minimum requirements for the principal design criteria for water-cooled nuclear power plants; a number of these criteria are directly related to site characteristics as well as to events and conditions outside the nuclear power unit.

The National Environmental Policy Act of 1969 (NEPA) (83 Stat. 852), implemented by Executive Order 11514 Amended by Executive Order 11991 and the Council on Environmental Quality's ~~Guidelines~~ Regulations of ~~August 1, 1973 (38 FR 20550)~~ November 28, 1978 (43 FR 55992) found at 40 CFR Part 1500-1508, requires that all agencies of the Federal Government prepare detailed environmental statements on proposed major Federal actions which can significantly affect the quality of the human environment. A principal objective of NEPA is to require the Federal agency to consider, in its decision-making process, the environmental impacts of each proposed major action and the available alternative actions, including alternative sites.

Part 51, "~~Licensing and Regulatory Policy and Procedures for Environmental Protection~~ Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions," of Title 10, Code of Federal Regulations, sets forth the Nuclear Regulatory Commission's ~~policy and procedures~~ regulations for the preparation and processing of environmental impact statements and related documents pursuant to Section 102(2)(C) of the NEPA.

The limitations on the Commission's authority and responsibility pursuant to the NEPA imposed by the Federal Water Pollution Control Act (86 Stat. 916) are addressed in ~~an Interim~~ Policy Statement published in the Federal Register on ~~January 29, 1973 (38 FR 2679)~~ December 31, 1975 (40 FR 60115).

This guide discusses the major site characteristics related to public health and safety and environmental issues which the NRC staff considers in determining the suitability of sites for ~~light-water-cooled (LWR) and high temperature gas-cooled (HTGR)~~ nuclear power stations.* The guidelines may be used by applicants in identifying suitable candidate sites for nuclear power stations. The decision that a station may be built on a specific candidate site is based on a detailed evaluation of the proposed site-plant combination and a cost-benefit analysis comparing it with alternative site-plant combinations as discussed in Regulatory Guide 4.2. "Preparation of Environmental Reports for Nuclear Power Stations."

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* For the purposes of this guide, nuclear power station refers to the nuclear reactor unit(s), nuclear steam supply, electric generating units, auxiliary systems, including the cooling system and structures such as docks that are located on a given site, and any new electrical transmission towers and lines erected in connection with the facilities.

Chapter 9 of Regulatory Guide 4.2 discusses the selection of a site from among alternative sites. Although it is recognized that planning methods[a] will differ among applicants, Chapter 9 states that the applicant should present its site-plant selection process as the consequence of an analysis of alternatives whose environmental costs and benefits were evaluated and compared and then weighed against those of the proposed facility.

This guide is intended to assist applicants in ~~the initial stage of~~ selecting potential sites for a nuclear power station. Each site that appears to be compatible with the general criteria discussed in this guide will have to be examined in greater detail before it can be considered to be a "candidate" site, i.e., one of the group of sites that are to be considered in selecting a "proposed" or "preferred" site.[b]

This guide ~~should be used only~~ provides general information for use in the initial stages of site selection ~~because~~ up to identification of potential sites. I~~i~~t does not provide detailed guidance on the various relevant factors and ~~format~~ approaches for ranking the relative suitability or desirability of ~~possible~~ candidate sites. This guide provides a general set of safety and environmental criteria which the NRC staff has found to be valuable in assessing candidate sites~~s identification in specific licensing cases~~.

The information needed to evaluate potential sites at this initial stage of site selection is assumed to be limited to that information which may be obtained from published reports, public records, public and private agencies, and individuals knowledgeable about the locality of a potential site. Although in some cases the applicants may have conducted on-the-spot investigations, it is assumed here that these investigations would be limited to reconnaissance-type surveys at this stage in the site selection process.

The safety ~~issues~~ discussed include geologic/seismic, hydrologic, and ~~atmospheric~~ meteorological characteristics of proposed sites: potential effects on ~~the~~ a station from accidents associated with nearby industrial, transportation, and military facilities; and population ~~distribution and~~ densities in the site environs as they relate to protecting the general public from the potential radiation hazards of postulated serious accidents. The environmental issues discussed concern potential impacts from the construction and operation of nuclear power stations on ecological systems, water use, land use, the atmosphere, aesthetics, and socioeconomics.

This guide does not discuss details of the engineering designs required to ensure the compatibility of the nuclear station and the site or the detailed information required for the preparation of the safety analysis and environmental reports. In addition, nuclear power reactor site suitability as it may be affected by the Commission's materials safeguards and plant protection requirements for nuclear power plants is not addressed in this guide.

Guidance concerning the siting of offshore nuclear stations, ~~liquid metal fast breeder reactors (LMFBR),~~ test reactors, and advanced siting concepts such as underground sites and ~~nuclear energy centers~~ sites which include fule cycle facilities is not included in this guide.

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[a] Site selection methodologies that have been used by the nuclear power industry are described in "Nuclear Power Plant Siting, A Generalized Process," Atomic Industrial Forum, August 1974, National Environmental Studies Project, R-1578.

[b] See Chapter 9 of Regulatory Guide 4.2 for a discussion of site selection procedures. The "proposed" site submitted by an applicant for a construction permit is that site of a number of "candidate" sites which the applicant prefers and on which the applicant proposes to construct a nuclear power station.

A significant commitment of time and resources may be required to select a suitable site for a nuclear power station, including safety and environmental considerations, ~~and to develop an acceptable design for that site~~. Site selection involves considerations of public health and safety, engineering and design, economics, institutional requirements, environmental impacts, emergency planning, and other factors. The potential impacts of the construction and operation of nuclear power stations on the physical and biological environment and on social, cultural, and economic features[a] are usually similar to the potential impacts of any major industrial facility, but nuclear power stations are unique in the degree to which potential impacts of the environment on their safety must be considered. The safety requirements are primary determinants of the suitability of a site for nuclear power stations, ~~but~~ however considerations of environmental impacts ~~and public acceptance~~ and of emergency planning around nuclear power stations ~~are~~ also ~~important and~~ need to be evaluated.

In the site selection process, coordination between applicants for nuclear power stations and various Federal, State, and local agencies will be useful in identifying potential problem areas.

Appendices A and B of this guide summarize the important safety-related and environmental considerations for assessing the site suitability of nuclear power stations.

B. DISCUSSION

1. Geology/Seismology

Nuclear power stations must be designed to prevent the loss of safety-related functions. Generally, the most restrictive safety-related site characteristics considered in determining the suitability of a site are surface faulting, potential ground motion and foundation conditions[b] (including liquefaction, subsidence, and landslide potential), and seismically induced floods. Criteria that describe the nature of the investigations required to obtain the geologic and seismic data necessary to determine site suitability are provided by ~~Appendix A, "Seismic and Geologic Criteria for Nuclear Power Plants,"~~ Appendix B, "Criteria for the Seismic and Geological Siting of Nuclear Power Plants after [EFFECTIVE DATE]" to 10 CFR Part 100. Safety-related site characteristics are identified in Section 2.5 of Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants," and Regulatory Guide 1.59, "Design Basis Floods for Nuclear Power Plants." In addition to geologic and seismic evaluation for assessing seismically induced flooding potential, Section 2.4 of Regulatory Guide 1.70 and Regulatory Guide 1.59 describe hydrologic criteria, including coincident flood events that should be considered.

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[a] Biological and physical environment includes geology, geomorphology, surface and groundwater hydrology, climatology, air quality, limnology, water quality, fisheries, wildlife, and vegetation. Social and cultural features include scenic resources, recreation resources, archeological/historical resources, and community resources including land use patterns. From "Development and the Environment: Legal Reforms to Facilitate Industrial Site Selection," final report by the Committee on Environmental Law, American Bar Association, February 1974.

[b] "Classification, Engineering Properties and Field Exploration of Soils, Intact Rock and In Situ Masses," WASH-1301, March of 1974, outlines some of the procedures used to evaluate site foundation properties.

2. ~~Atmospheric Extremes and Dispersion~~ Meteorology

The potential effect of ~~natural atmospheric extremes~~ extreme meteorological conditions (e.g., tornadoes[a], temperature extremes, high winds, and exceptional icing conditions[b]) on the safety-related structures of a nuclear station must be considered. However, the ~~atmospheric~~ extremes that may occur at a site are not normally critical in determining the suitability of a site because safety-related structures, systems, and components can be designed to withstand most ~~atmospheric~~ extremes.

The ~~atmospheric~~ meteorlogical characteristics (including atmospheric stability) at a site need to be ~~are an important~~ consider~~a~~dation in evaluating the dispersion of radioactive effluents both from postulated accidents and from routine releases in gaseous effluents.[c] In addition to meeting the NRC requirements for the dispersion of airborne radioactive material, the station must meet State and Federal requirements of the Clean Air ~~Amendments of 1970 (PL 91-604)~~ Act, as amended (42 U.S.C. §7401 et. seq.). This is unlikely to be an important consideration for nuclear power station siting unless (1) a site is in an area where existing air quality is near or exceeds the limits set under the Clean Air ~~Amendments~~ Act, (2) there is a potential for interaction of the cooling system plume with a plume containing noxious or toxic substances from a nearby facility, or (3) the auxiliary generators are operating.

The atmospheric data necessary for adequate assessment of the potential dispersion of radioactive material from design basis accidents are described in Regulatory Guide 1.23, "Onsite Meteorological Programs." Models and assumptions used for evaluating atmospheric transport and dispersion are provided in Regulatory Guides 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled

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~~[a] Refer to Regulatory Guide 1.76, "Design Basis Tornado for Nuclear Power Plants."~~

~~[b] Refer to Section 2.4.7 of Regulatory Guide 1.70.~~

~~[c] Routine releases of airborne radioactive material must be kept "as low as practicable." (See 10 CFR Part 20, Sec. 20.1(c).) The Commission has published a proposed rule for public comment (40 FR 33029) that substitutes "as low as is reasonably achievable" for the older, less precise term "as low as practicable" where it appears in NRC regulations and regulatory guides.~~

~~Section 50.34a of 10 CFR Part 50 sets forth the requirements for design objectives for equipment to control releases of radioactive material in effluents from nuclear power reactors.~~

~~Section 50.36a further provides that, in order to keep power reactor effluent releases as low as practicable, each license authorizing operation of such a facility will include technical specifications regarding the establishment of effluent control equipment and reporting of actual releases.~~

~~Appendix I to 10 CFR Part 50, promulgated May 5, 1975 (40 FR 19439), provides numerical guidance for design objectives and technical specification requirements for limiting conditions of operation for light-water-cooled nuclear power plants.~~

~~The following regulatory guides are being prepared to assist in application of the numerical guidance in Appendix I.~~

~~1. Calculation of Annual Average Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Implementing Appendix I,~~

~~2. Calculations of Releases of Radioactive Materials in Liquid and Gaseous Effluents from Pressurized Water Reactors (PWRs),~~

~~3. Calculation of Releases of Radioactive Materials in Liquid and Gaseous Effluents from Boiling Water Reactors (BWRs), and~~

~~4. Methods for Estimating Atmospheric Dispersion of Gaseous Effluents from Routine Releases.~~

Reactors," and 1.145, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants." Tthe potential radiological consequences of certain postulated accidents are provided in Regulatory Guides 1.3, "Assumptions Used for Evaluating the potential Radiological Consequences of a Loss-of-Coolant Accident for Boiling Water Reactors;" and 1.4, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss-of-Coolant Accident for Pressurized Water Reactors;." ~~1.5, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Steam Line Break Accident for Boiling Water Reactors;" 1.24, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Pressurized Water Reactor Radioactive Gas Storage Tank Failure;" and 1.25, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Fuel Handling Accident in the Fuel Handling and Storage Facility for Boiling and Pressurized Water Reactors." However, the atmospheric assumptions in the guides may not be appropriate for sites with unusual atmospheric conditions.~~

In the evaluation of potential sites, onsite ~~atmospheric reconnaissance~~ meteorological measurements can determine if the ~~atmospheric~~ meteorological conditions at a site are adequately represented by the available ~~atmospheric~~ meteorological data for the area from measurement systems of similar caliber. Canyons or deep valleys frequently have ~~atmospheric variables~~ meteorological conditions that are substantially different from those ~~variables measured for~~ conditions in the general region. ~~Other t~~Topographical features such as hills, mountain ranges, and lake or ocean shorelines can affect the local ~~atmospheric~~ meteorological conditions at a site and may cause the dispersion characteristics at the site to be less favorable than those in the general area or region. More stringent design or effluent control objectives ~~or a larger exclusion area~~ may be required in such cases.

While it is the concentration of radioactivity in the atmosphere at any distance from the point of release, $\chi(Ci/m^3)$, that must be controlled, the ratio χ/Q, where Q(Ci/sec) is the rate of release of radioactivity from the source, has become a commonly evaluated term because it depends only on ~~atmospheric~~ the meteorlogical variables of wind speed and atmospheric stability and distance from the source.

~~If the atmospheric conditions are unfavorable with respect to dispersion characteristics at a proposed site, the exclusion area may have to be unusually large to satisfy the dose criteria of 10 CFR Part 100.~~ If under assumed unfavorable ~~atmospheric~~ meteorlogical conditions (see Regulatory Guides 1.3, ~~and~~ 1.4, and 1.145) the dispersion of radioactivity released following a design basis accident is ~~insufficient at~~ is poor out to the boundary of the exclusion area (see the following section, "Population Considerations") and to the outer boundary of the low population zone, the ~~site~~ plant design would not satisfy the requirements of 10 CFR Part ~~100~~50.34(a)(1). Thus, the design of the station would be required to include appropriate and adequate compensating engineered safety features. In addition, meteorological conditions are to be determined for use in the environmental report required in 10 CFR Part 51 and for comparison to the meteorological information assured in the Probabilistic Risk Assessment (PRA) for a certified plant design (if such a design is to located at the site) or used in the site specific PRA for a custom plant at the site.

Local fogging and icing can result from plumes discharged into the atmosphere from cooling towers, lakes, canals, or spray ponds, but can generally be acceptably mitigated by station design and operational practices. However, some sites have the potential for severe fogging or icing due to local ~~atmospheric~~ meteorologcial conditions. For example, areas of unusually high moisture content that are protected from large-scale airflow patterns are most likely to experience these conditions. The impacts are generally of greatest potential importance relative to transportation or electrical transmission corridors in the vicinity of a site.

A cooling system designed with special consideration for reducing drift may be required due to the sensitivity of the natural vegetation or the crops in the vicinity of the site to damage from airborne salt particles. The vulnerability of existing industries or other facilities in the vicinity of the site to corrosion by drift from cooling tower or spray system drift should be considered. Not only are the amount, direction, and distance of the drift from the cooling system important, but the salt concentration above the natural background salt deposition at the site is also important in assessing drift effects. None of these considerations are critical in evaluating the suitability of a site, but they could result in special cooling system design requirements or in the need for a larger site to confine the effects of drift within the site boundary. The environmental effects of salt drift are most severe where saline water or water with high mineral content is used for condenser cooling.

Cooling towers may produce cloudlike plumes which vary in size and altitude depending on ~~the atmospheric~~ meteorological conditions of moisture content, wind speed, atmospheric stability and direction. The plumes ~~are often~~ can be a few miles in length before becoming dissipated, but the plumes themselves or their shadows could have aesthetic impacts. Visible plumes emitted from cooling towers in the vicinity of airports could cause a hazard to aviation and in the vicinity of elevated bridges could cause a hazard to vehicular traffic.

3. Population Considerations

A reactor licensee is required by 10 CFR Part 100 to designate an exclusion area and to have authority to determine all activities within that area, including removal of personnel and property. In selecting a site for a nuclear power station, it is necessary to provide for an exclusion area in which the applicant has such authority. ~~The exclusion area must be of such size that doses to individuals at any point on its boundary for 2 hours immediately following the onset of a postulated fission product release are less than certain prescribed values.~~ Transportation corridors, such as highways, railroads, and waterways, are permitted to traverse the exclusion area provided (1) these are not so close to the facility as to interfere with normal operation of the facility and (2) appropriate and effective arrangements are made to control traffic on the highway, railroad, or waterway in the case of emergency to protect the public health and safety.

As set forth in 10 CFR Part 100, ~~a~~ nuclear power station sites should be located in areas with low population density. If the population density of a proposed site a) exceeds 500 people per square mile averaged over any radial distance out to 30 miles or b) is projected to exceed 1000 people per square mile averaged over any radial distance out to 30 miles 40 years after the time of initial site approval or renewal, the applicant should give special attention to alternate sites. ~~must have a low population zone (LPZ) immediately surrounding the exclusion area in which the population is (a) sufficiently limited in number and (b) distributed in such a way that there is a reasonable probability that appropriate measures could be taken in their behalf in the event of a serious accident. A proposed site will also have a "population center distance," defined as the distance from the nuclear reactor to the nearest boundary of a densely populated center containing more than about 25,000 residents. The population center distance must be at least one and one-third times the distance to the outer boundary of the LPZ. However, 10 CFR part 100 requires that the LPZ boundary be sufficiently remote that a release of fission products (calculated as a consequence of a postulated accident) will not result in radiation doses to individuals on the outer boundary of the LPZ greater than certain specified values.~~

~~WASH-1235, "The Site Population Factor, A Technique for Consideration of Population in Site Comparison," October 1974, discusses a methodology that is useful in comparing population distributions at alternative sites.~~

4. Hydrology

4.1 Flooding

Criteria for evaluation of seismically induced floods are provided in ~~Appendix A~~ Appendix B to 10 CFR part 100. Regulatory Guide 1.59 describes an acceptable method of determining the design basis floods for sites along streams or rivers and discusses the phenomena producing comparable design basis floods for coastal, estuary, and Great Lakes sites. The effects of a probable maximum flood (as defined in Regulatory Guide 1.59), seiche, surge, or seismically induced flood such as might be caused by dam failures or tsunami on station safety functions can generally be controlled by engineering design or protection of the safety-related structures, systems, and components which are identified in Regulatory Guide 1.29, "Seismic Design Classification." For some river valleys, flood plains, or areas along coastlines, there may not be sufficient information to make the evaluations needed to satisfy the criteria for seismically induced flooding. In such cases, study of the potential for dam failure, river blockage, or diversion in the river system or distantly and locally generated sea waves may be needed to determine the suitability of a site. In lieu of detailed investigations, Regulatory Guide 1.59 and Section 2.4 of Regulatory Guide 1.70 present acceptable analytical techniques for evaluating seismically induced flooding.

4.2 Water Availability

Nuclear power stations require reliable sources of water for steam condensation, service water, emergency core cooling system, and other functions. In regions where water is in short supply, the recirculation of the hot cooling water through cooling towers, artificial ponds, or impoundments has been practiced.

Essential water requirements for nuclear power plants are that sufficient water be available for cooling during plant operation and normal shutdown, for the ultimate heat sink,[a] and for fire protection. The limitations imposed by existing laws or allocation policies govern the use and consumption of cooling water at potential sites[b] for normal operation. Regulatory Guide 1.27 discusses the safety requirements. Consumptive use of water may necessitate an evaluation of existing and future water uses in the area to ensure adequate water supply during droughts both for station operation and other water users (i.e., nuclear power station requirements versus public water supply). Regulatory agencies should be consulted to avoid potential conflicts.

~~Where required by applicable law, demonstration of a request for certification of the rights to withdraw or consume water and an indication that the request is consistent with appropriate State and regional programs and policies should be provided as part of the application for a construction permit or operating license.~~

The availability of essential water during periods of low flow or low water level is an important initial consideration for identifying potential sites on rivers, small shallow lakes, or along coastlines. Both the frequency and duration of low flow or low level periods should be determined from the historical record and, if the cooling water is to be drawn from impoundments, from projected operating practices.

4.3 Water Quality

Thermal and chemical effluents discharged to navigable streams are governed by the Federal Water Pollution Control Act (FWPCA, PL 92-500), 40 CFR Part 122,

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[a] Regulatory Guide 1.27, "Ultimate Heat Sink for Nuclear Power Plants," provides guidance on water supply for the ultimate heat sink.

[b] To the extent that site selection is dependent on water diversions for consumptive use, allocation of water supply is a function of state statutory and administrative procedures.

A discussion of the establishment of state regulation of water use is provided in "Industrial Developments and the Environment, Legal Reforms to Improve the Decision-Making Process in Industrial Site Selection," Special Committee on Environmental Law of the American Bar Association, August 1973.

40 CFR Part 423, and State water quality standards. The applicant should also determine other regulations that are current at the time sites are under consideration. Section 401(a)(1) of the FWPCA requires, in part, that any applicant for an NRC construction permit or combined license (combined construction permit and operating license) for a nuclear power station provide to the NRC certification from the State that any discharge will comply with applicable effluent limitations and other water pollution control requirements. In the absence of such certification, no construction permit or combined license can be issued by NRC unless the requirement is waived by the State or the State fails to act within a reasonable period of time. A National Pollution Discharge Elimination System (NPDES) permit to discharge effluents to navigable streams pursuant to Section 402 of the FWPCA may be required for a nuclear power station to operate in compliance with the Act, but is not a prerequisite to an NRC construction permit or operating license.

Evaluations of the dispersion and dilution capabilities and potential contamination pathways of the ground water environment under operating and accident conditions with respect to present and future users are required. Potential radiological and nonradiological contaminants of ground water should be evaluated. The suitability of sites for a specific plant design in areas with a complex ground water hydrology or of sites located over aquifers that are or may be used by large populations for domestic or industrial water supplies or for irrigation water can only be determined after reliable assessments have been made of the potential impacts of the reactor plants on the ground water. Accordingly, 10 CFR 100 Subpart B requires that site environmental characteristics, which includes hydrological and meteorological characteristics, be characterized and used in or compared to those characteristics used in the plant PRA and environmental analysis.

Although management of the quality of surface waters is important, water quality per se is not a determining factor in assessing the suitability of a site since adequate design alternatives can generally be developed to meet the requirements of the Federal Water Pollution Control Act and the Commission's regulations implementing NEPA. However, the environmental characteristics or the complexity of the environment at a site and its vicinity may be such that it would be difficult to obtain or develop sufficient information to establish, in a timely manner, that the potential environmental impacts on water quality would be acceptable. Examples of situations that could pose unusual impact assessment or design problems are areas of existing marginal water quality, small bays, estuaries, stratified waters, and sites that would require intake from and discharge to waters of markedly different quality, such as intake of marine water and discharge to an estuary.

The following are examples of potential environmental effects of station construction and operation that must be assessed: physical and chemical environmental alterations in habitats of important species, including plant-induced rapid changes in environmental conditions; changes in normal current direction or velocity of the cooling water source and receiving water; scouring and siltation resulting from construction and cooling water intake and discharge; alterations resulting from dredging and spoil disposal; and interference with shoreline processes.

5. Ecological Systems and Biota

Areas of great importance to the local aquatic ecosystem may present major difficulties in assessing potential impacts on populations of important species or ecological systems. Such areas include those used for breeding (e.g., nesting and spawning), wintering, and feeding, as well as areas where there may be seasonally high concentrations of individuals of important species.* Where the

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* A species, whether animal or plant, is important (for the purpose of this guide) if a specific causal link can be identified between the nuclear power station and the species and if one or more of the following criteria applies:

ecological sensitivity of a site under consideration cannot be established from existing information, more detailed studies, as discussed in Regulatory Guide 4.2., may be necessary. Impacts of station construction* and operation on the biota and ecological systems may be mitigated by design and operational practices if justifiable [illegible]ative to costs and benefits. In general, the important considerations i[illegible] e balancing of costs and benefits are (a) the uniqueness of a habitat or ecol[illegible]al system within the region under consideration and (b) the amount of habitat [illegible] ecological system that would be destroyed or disrupted relative to the total amount of the habitat or ecological system present in the region or the vulnerability of the reproductive capacity of important species populations to the effects of construction and operation of the plant and ancillary facilities.

The alteration of one or more of the existing environmental conditions may render a habitat unsuitable as a breeding or nursery area. In some cases, organisms use identical breeding and nursery areas each year; if the characteristics of the areas are changed, breeding success may be substantially reduced or enhanced. Destruction of part or all of a breeding or nursery area may cause population shifts that result in increased competition for the remaining suitable areas. Such population shifts cannot compensate for the reduced size of the breeding or nursery areas if the remaining suitable area is already occupied by the species. Some species will desert a breeding area because of man's activities in the proximity to the area, even in the absence of physical disturbance of the actual breeding area.

Of special concern relative to site selection are those unique or especially rich feeding areas that might be destroyed, degraded, or made inaccessible to important species by station construction or operation. Evaluation of feeding areas in relation to potential construction or operation impacts includes the following considerations: size of the feeding area onsite in relation to the total feeding area offsite, food density, time of use, location in relation to other habitats, topography relative to access routes, and other factors (including man's activities). Site modification may reduce the quality of feeding areas by destruction of a portion of the food base, destruction of cover, or both.

Construction and operation of nuclear power stations can create barriers to migration, occurring mainly in the aquatic environment. Narrow zones of passage for migratory animals in some rivers and estuaries may be restricted or

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(1) If the species in commercially or recreationally valuable,
(2) If the species is endangered or threatened,
(3) If the species affects the well-being of some important species within criteria (1) or (2) or if it is [illegible]itical to the structure and function of a valuable ecological system or is a biological indicator of radionuclides in the environment.

Endangered and threatened species are defined by PL 93-205, the Endangered Species Act of 1973, as follows: "The term 'endangered species' means any species which is in danger of extinction throughout all or a significant portion of its range other than a species of the Class Insecta determined by the Secretary to constitute a pest whose protection under the provisions of this Act would present an overwhelming and overriding risk to man." "The term 'threatened species' means any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." Lists of endangered and threatened species are published periodically in the Federal Register by the Secretary of the Interior.

* A compilation of construction practices is provided in "General Environmental Guidelines for Evaluating and Reporting the Effects of Nuclear Power Plant Site Preparation, Plant and Transmission Facilities Construction," Atomic Industrial Forum, February 1974.

blocked by station operation. Partial or complete blockage of a zone of passage may result from the discharge of heat or chemicals to receiving water bodies or the construction and placement of power station structures in the water body. Strong-swimming aquatic animals often avoid waters of adverse quality, but larval and immature forms are usually moved and dispersed by water currents. It is therefore important in site selection that the routes and times of movement of the immature stages be considered in relation to potential effects.

A detailed assessment of potential impact on the species population would be required for sites where placement of intake or discharge structures would markedly disrupt normal current patterns in migration paths of important species. The potentials for impingement of organisms on cooling water intake structures and entrainment of organisms through the cooling system are determined by a number of variables including site characteristics, intake structure design, and placement of the structures at the site.

Site characteristics should be considered relative to design and placement of cooling system features and the potential of the cooling system to hold fish in an area longer than the normal period of migration or to entrap resident populations in areas where they would be adversely affected, either directly or indirectly, by limited food supply or adverse temperatures. Canals or areas where cooling waters are discharged may induce fish to remain in an unnaturally warmed habitat. The cessation of station operation during winter can be lethal to these fish because of an abrupt drop in water temperature.

6. Land Use and Aesthetics

Many impacts on land use at the site and in the site neighborhood due to construction and operation of the plant, transmission lines, and transportation corridors can be mitigated by appropriate designs and practices. Aesthetic impacts can be reduced by selecting sites where existing topography and forests can be utilized for screening station structures from nearby scenic, historical, or recreational resources. Restoration of natural vegetation, creative landscaping,[a] and the integration of structures with the environment can mitigate adverse visual impacts.

Preconstruction archeological excavations can usually reduce losses. Short-term salvage archeology may not be sufficient if extensive or valuable archeological sites are found on the potential site for a nuclear station. For areas of archeological concern, the Chief Archeologist of the National Park Service is an information source, as are the State Archeologist and the State Liaison Officer responsible for the National Historic Preservation Act activities for a particular state.

Proposed alternative land use may render a site unsuitable for a nuclear power station. For example, lands specified by a community (1) as planned for other uses or (2) as restricted to compatible uses vis-a-vis other lands may be unsuitable. Therefore, official land use plans developed by governments at any level and by regional agencies should be consulted for possible conflicts with power station siting. A list of Federal agencies that have jurisdiction or expertise in land use planning, regulation, or management has been published by the Council on Environmental Quality.[b]

Another class of impacts involves the preempting of existing land use at the site itself. For example, nuclear power station siting in areas uniquely

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[a] Station protection requirements for nuclear safeguards may influence landscape design and clearing of vegetation.

[b] See U.S. Council on Environmental Quality, ~~"Preparation of Environmental Impact Statements: Guidelines," 38 FR 20549, August 1, 1973~~ "National Environmental Policy Act (NEPA) Implementation Procedures; Appendixes I, II, and III," 49 FR 49750, December 21, 1984.

suited for growing specialty crops may be considered a type of land conversion involving unacceptable economic dislocation.

Sites adjacent to lands devoted to public use may be considered unsuitable. In particular, the use of some sites or transmission lines or transportation corridors close to special areas administered by Federal, State, or local agencies for scenic or recreational use may cause unacceptable impacts regardless of design parameters. Such cases are most apt to arise in areas adjacent to natural-resource oriented areas (e.g., Yellowstone National Park) as opposed to recreation-oriented areas (e.g., Lake Mead National Recreation Area). Some historical and archeological sites may also fall into this category. The acceptability of sites near special areas of public use should be determined by consulting cognizant government agencies.

The following Federal agencies should be consulted for the special areas listed:

a. National Park Service (U.S. Department of the Interior)

National Parks; International ~~Parks;~~ National Memorial Parks; National Battlefields, Battlefield Parks and Battlefield Sites; National Military Parks; Historic Areas and National Historic Sites; National Capital Parks; National Monuments and Cemeteries; National Seashores and Lakeshores; National Rivers and Scenic Riverways; National Recreation Areas; National Scenic Trails and Scientific Reserves; National Parkways

b. National Park Service Preservation Program

National Landmarks Program; Historic American Buildings Survey; National Register of Historic Places; National Historical Landmarks Program; National Park Service Archeological Program

c. Bureau of Sport Fisheries and Wildlife (U.S. Department of Interior)

National Wildlife Refuges

d. Forest Service (U.S. Department of Agriculture)

National Forest Wilderness, Primitive Areas, National Forests.

Individual States and local governments administer parks, recreation areas, and other public use and benefit areas. Information on these areas should be obtained from cognizant State agencies such as State departments of natural resources. (See publications such as the "Conservation Directory 1973: A Listing of Organizations, Agencies and Officials Concerned with Natural Resource Use and Management," published by the National Wildlife Federation for state-by-state references.) The Advisory Council on Historic Preservation or the appropriate State ~~historical society~~ historic preservation officer should be contacted for information on historic areas.

It should be recognized that some areas, as yet undesignated, may be unsuitable for siting because of public interest in future dedication to public scenic, recreational, or cultural use. Relatively rare land types such as sand dunes and wetlands are prime candidates for such future designation. However, the acceptability of sites for nuclear power stations at some future time in these areas will depend on the existing impacts from industrial, commercial, and other developments.

7. Industrial, Military, and Transportation Facilities

Potential accidents at present or projected nearby industrial, military, and transportation facilities may affect the safety of a nuclear power station.* A site should not be selected if, in the event of such an accident, it is not possible to safely shut down a plant at that site or if it is not possible to have nearby facilities alter their mode of operation or incorporate features to reduce to an acceptable level the likelihood and severity of such potential accidents.

In the event of an accident at a nearby industrial facility such as a chemical plant, refinery, mining and quarrying operation, oil or gas well, or gas and petroleum product storage installation, it is possible that missiles, shock waves, flammable vapor clouds, toxic chemicals, or incendiary fragments may result. These may affect the station itself or the station operators in a way that jeopardizes the safety of the station.

Regulatory Guide 1.78, "Assumptions for Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release," describes assumptions acceptable to the NRC staff for use in assessing the habitability of the control room during and after a postulated external release of hazardous chemicals and describes criteria that are generally acceptable to the staff for the protection of the control room operators.

Nearby military facilities, such as munitions storage areas and ordnance test ranges, may threaten station safety. The acceptability of a site depends on establishing, among other things, that the nuclear power station can be designed so its safety will not be affected by an accident at the military installation. Alternatively, an otherwise unacceptable site may become acceptable if the cognizant military organization agrees to change the installation or mode of operation to reduce the likelihood or severity of potential accidents involving the nuclear station to an acceptable level.

An accident during the transport of hazardous materials (e.g., by air, waterway, railroad, highway, or pipeline) near a nuclear power plant may generate shock waves, missiles, and toxic or corrosive gases which can affect the safe operation of the station. The consequences of the accident will depend the proximity of the transportation facility to the site, the nature and maximum quantity of the hazardous material per shipment, and the layout of the nuclear station. Unless ~~the~~ a station can be designed to operate safely in the event of a postulated accident or an enforceable agreement can be reached to limit the transport of hazardous materials or the transportation link can be relocated, the proposed site may not be acceptable.

Airports are transportation facilities that pose specialized hazards to nearby nuclear power stations. Potential threats to stations from aircraft result from the aircraft itself as a missile and from the secondary effects of a crash, e.g., fire.

8. Socioeconomics

~~Social and economic issues are important determinants of siting policy. It is difficult both to assess the nature of the impacts involved and to determine value schemes for predicting the level or the acceptability of potential impacts.~~

The siting, construction, and operation of a nuclear power station may have significant impacts on the socioeconomic structure of a community and may place severe stresses on the local labor supply, transportation facilities, and community services in general. There may be changes in the tax basis and in community expenditures, and problems may occur in determining equitable levels of compensation for persons relocated as a result of the station siting. It is usually possible to resolve such difficulties by proper coordination with

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* Section 2.2 of Regulatory Guide 1.70 lists these safety considerations.

impacted communities; however, some impacts may be locally unacceptable and too costly to avoid by any reasonable program for their mitigation. Evaluation of the suitability of a site should therefore include consideration of purpose and probable adequacy of socioeconomic impact mitigation plans for such economic impacts on any community where local acceptance problems can be reasonably foreseen.

Certain communities in a site neighborhood may be subject to unusual impacts that would be excessively costly to mitigate. Among such communities are towns that possess notably distinctive cultural character, i.e., towns that have preserved or restored numerous places of historic interest, have specialized in an unusual industry or avocational activity, or have otherwise markedly distinguished themselves from other communities.

9. Noise

Noise levels at nuclear stations occur during both the construction and operation phases and could have unacceptable impacts. Cooling towers, turbines, and transformers contribute to the noise levels during station operation.

C. REGULATORY POSITION

1. Geology/Seismology

Sites that include capable faults, as defined in Appendix A B to 10 CFR Part 100, are not suitable for nuclear power stations. The state of the art has not progressed to the point at which it is possible to design a nuclear power station for surface or near-surface displacement with a sufficiently high level of confidence to ensure that the integrity of the safety-related features of the plant will remain intact.

Sites within about 5 miles of a ~~surface~~ capable ~~fault~~ tectonic source greater than 1000 feet in length are usually not suitable for a nuclear power station. In any case, extensive and detailed geologic and seismic field studies and analyses should be conducted for such a proposed site.

Sites located near geologic structures for which an adequate data base to determine "capability" does not exist at the time of application are likely to be subject to a longer licensing process in view of the need for extensive and detailed geologic and seismic investigations of the site and surrounding region and for the rigorous analyses of the site-plant combination.

Sites with competent bedrock for foundations generally have suitable foundation conditions. In regions where there are few or no such sites, it is prudent to select sites in areas with competent and stable solid soils, such as dense sands and glacial tills. Other materials may also provide satisfactory foundation conditions, but in any case, a detailed geologic and geotechnical investigation will be required to determine static and dynamic engineering properties of the material underlying the site in accordance with ~~Sections IV(a)(4) and V(d) of Appendix A~~ Appendix B to 10 CFR Part 100.

2. ~~Atmospheric Extremes and Dispersion~~ Meteorology

As noted in Section B.2 of this guide, site ~~atmospheric~~ meteorlogical conditions are site suitability characteristics principally with respect to the calculation of radiation doses resulting from the release of fission products as a consequence of a postulated accident. ~~and the establishment of exclusion area boundary, low population zone boundary, and distance to a population center. Accordingly, the regulatory position on atmospheric dispersion of radiological effluents is incorporated into the following section, "Population Considerations."~~ Accordingly, each applicant for initial site approval, renewal, or construction permit must collect meteorological information for at least one year that is representative of the site conditions including wind speed, wind direction, precipitation, and atmospheric stability.

Nonradiological atmospheric considerations such as local fogging and icing, cooling tower drift, cooling tower plume lengths and plume interactions between cooling tower plumes, and plumes from nearby industrial facilities should be considered in evaluating the suitability of potential sites.

3. Population Consideration

Areas of low population density are preferred for nuclear power station sites. High population densities projected for anytime during the lifetime of a station are considered during both the NRC staff review and the public hearing phases of the licensing process. If the population density at the proposed site is not acceptably low, then the applicant will be required to give special attention to alternative sites with lower population densities.

If the offsite population density, including weighted transient population, projected at the time of initial site approval or renewal ~~initial operation of a nuclear power station~~ exceeds 500 persons per square mile averaged over any radial distance out to 30 miles, (cumulative population at a distance divided by the area at that distance), or the projected population density ~~over the lifetime of the facility~~ for 40 years after initial site approval or renewal exceeds 1,000 persons per square mile averaged over any radial distance out to 30 miles, special attention should be given to the consideration of alternative sites with lower population densities.

Transient population should be included for those sites where a significant number of people (other than those just passing through the area) work, reside part-time, or engage in recreational activities and are not permanent residents of the area. The transient population should be taken into account by weighting the transient population according to the fraction of time the transients are in the area.

Based on past experience, the NRC staff has found that a minimum exclusion distance of 0.4 mile, even with unfavorable design basis atmospheric dispersion characteristics, usually provides assurance that engineered safety features can be designed to bring the calculated dose from a postulated accident within the guidelines of 10 CFR Part ~~100~~ 50.34(a)(1). ~~If the minimum exclusion distance is less than 0.4 mile, it may be necessary to place special conditions on the station design (e.g., added engineered safety features) before the requirements of 10 CFR Part 100 are met. Also, based on past experience, the staff has found that a distance of 3 miles to the outer boundary of the low population zone is usually adequate.~~ Subpart B of 10 CFR 100 specifies the exclusion area distance.

4. Hydrology

4.1 Flooding

To evaluate sites located in river valleys, on flood plains, or along coastlines where there is a potential for flooding, the site suitability studies described in Regulatory 1.59, "Design Basis Floods for Nuclear Power Plants," should be made.

4.2 Water Availability

A highly dependable system of water supply sources must be shown to be available under postulated occurrences of natural and site-related accidental phenomena or combinations of such phenomena as discussed in Regulatory Guide 1.59.

To evaluate the suitability of sites, there should be reasonable assurance that permits for consumptive use of water in the quantities needed for a nuclear power plant of the stated approximate capacity and type of cooling system can be obtained by the applicant from the appropriate State, local, or regional bodies.

4.3 Water Quality

The potential impacts of nuclear power stations on water quality are likely to be acceptable if effluent limitations, water quality criteria for receiving waters, and other requirements promulgated pursuant to the Federal Water Pollution Control Act are applicable and satisfied.

The criteria provided in 10 CFR Parts 20 and 5 will be used by the NRC staff for determining permissible concentrations of radioactive materials discharged to surface water or to ground water.*

4.4 Fission Product Retention and Transport

To be able to assess fission product retention and transportation via groundwater, the following information should be determined for the site:

- soil, sediment, and rock characteristics (e.g., volcanic ash, fractured limestone, etc.),
- absorption and retention coefficients for fission product materials,
- ground water velocity, and
- distance to nearest body of surface water.

This information should be used in the environmental report required in 10 CFR Part 51 and compared to the hydrological information used in the PRA for a certified design (if such a design is to be located at the site) or used in the site specific PRA for a custom plant located at the site.

Aquifers that are or may be used by large populations for domestic, municipal, industrial, or irrigation water supplies provide potential pathways for the transport of radioactive material to man in the event of an accident. To evaluate the suitability of proposed sites located over such aquifers, detailed studies of factors identified in Section 2.4.13 of Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants," should be completed.

5. Ecological Systems and Biota

The ecological systems and biota at potential sites and their environs should be sufficiently well known to allow reasonably certain predictions that there would be no unacceptable or unnecessary deleterious impacts on populations of important species or on ecological systems with which they are associated from the construction or operation of a nuclear power station at the site.

When early site inspections and evaluations indicate that critical or exceptionally complex ecological systems will have to be studied in detail to determine the appropriate plant designs, proposals to use such sites should be deferred unless sites with less complex characteristics are not available.

It should be determined whether any important species (as defined in Section B.5 of this guide) inhabit or use the proposed site or its environs; and the relative abundance and distribution of their populations should be considered. Potential adverse impacts on important species should be identified and assessed. The relative abundance of individuals of an important species inhabiting a potential site should be compared to available information in the literature concerning the total estimated local population. Any predicted impacts on the species should be evaluated relative to effects on the local population and the total population of the species. The destruction of, or

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* Appendix I to 10 CFR Part 50 provides numerical guidance for design objectives and technical specification requirements for limiting conditions of operation for light-water-cooled nuclear power stations.

sublethal effects on, a number of individuals which would not adversely affect the reproductive capacity and vitality of a population or the crop of an economically important harvestable population or recreationally important population should generally be acceptable, except in the case of certain endangered species. If there are endangered or threatened species at a site, the potential effects should be evaluated relative to the impact on the local population and the total estimated population over the entire range of the species as noted in the literature.

It should be determined whether there are any important ecological systems at a site or in its environs. If so, determination should be made as to whether the ecological systems are especially vulnerable to change or if they contain important species habitats, such as breeding areas (e.g., nesting and spawning areas), nursery, feeding, resting, and wintering areas, or other areas of seasonally high concentrations of individuals of important species.

The important considerations in the balancing of costs and benefits include the following: the uniqueness of a habitat or ecological system within the region under consideration, the amount of the habitat or ecological system destroyed or disrupted relative to the total amount in the region, and the vulnerability of the reproductive capacity of important species populations to the effects of construction and operation of the station and ancillary facilities.

If sites contain, are adjacent to, or may impact on important ecological systems or habitats that are unique, limited in extent, or necessary to the productivity of populations of important species (e.g., wetlands and estuaries), they cannot be evaluated as to suitability for a nuclear power station until adequate assessments for the reliable prediction of impacts have been completed and the facility design characteristics that would satisfactorily mitigate the potential ecological impacts have been defined. In areas where reliable and sufficient data are not available, the collection and evaluation of appropriate seasonal data may be required.

Migrations of important species and migration routes that pass through the site or its environs should be identified. Generally, the most critical migratory routes relative to nuclear power station siting are those of aquatic species in water bodies associated with the cooling systems. Site conditions that should be identified and evaluated in assessing potential impacts on important aquatic migratory species include (1) narrow zones of passage, (2) migration periods that are coincident with maximum ambient temperatures, (3) potential for major modification of currents by station structures, (4) potential for increased turbidity during construction, and (5) potential for entrapment, entrainment, or impingement by or in the cooling water system, or blocking of migration by facility structures of effluents.

The potential blockage of movements of important terrestrial animal populations due to the use of the site for a nuclear power station and the availability of alternative routes that would provide for maintenance of the species' breeding population should be assessed.

If justifiable relative to costs and benefits, potential impacts of plant construction and operation on the biota and ecological systems can generally be mitigated by adequate engineering design and site planning and by proper construction and operation practice when there is adequate information about the vulnerability of the important species and ecological systems.

A summary of environmental considerations, parameters, and regulatory positions for use in evaluating the suitability of sites for nuclear power stations is provided in Appendix B to this guide. A discussion of ecological systems and habitats, the level of detail that should be addressed the site selection process, and the survey, monitoring, and analytical techniques for assessing impacts on important species and ecological systems will be summarized in subsequent appendices to this guide.

6. Land Use and Aesthetics

Land use plans adopted by Federal, State, regional, or local governmental entities should be examined, and any conflict between these plans and use of a potential site should be resolved by consultation with the appropriate governmental entity.

For potential site on land devoted to specialty crop production where changes in land use might result in market dislocations, a detailed investigation should be provided to demonstrate that potential problems have been identified and resolved.

The potential aesthetic impact of nuclear power stations at sites near natural-resource oriented public use areas is of particular concern, and evaluation of the suitability of such sites is dependent on consideration of specific station design layout. However, existing aesthetic impacts at potential sites should be taken into account as mitigating any requirements for further special design.

7. Industrial, Military, and Transportation Facilities

Potentially hazardous facilities and activities within 5 miles of a proposed site should be identified. If a preliminary evaluation of potential accidents at these facilities indicates that the potential hazards from shock waves and missiles approach or exceed those of the design basis tornado for the region[4] or potential hazards such a flammable vapor clouds, toxic chemicals, or incendiary fragments exist, the suitability of the site should be determined by detailed evaluation of the degree of risk imposed by the potential hazard.

The identification of design basis events resulting from the presence of hazardous materials or activities in the vicinity of a nuclear power station is acceptable if the design basis events include each postulated type of accident for which a realistic estimate of the probability of occurrence of potential exposures in excess of the 10 CFR Part ~~100~~ 50.34(a)(1) guidelines exceeds approximately 10^{-7} per year. Because of the difficulty of assigning precise numerical values to the probability of occurrence of the types of potential hazards generally considered in determining the acceptability of sites for nuclear stations, judgment must be used as to the acceptability of the overall risk presented by an event.

In view of the low probability events under consideration, the probability of occurrence of the initiating events leading to potential consequences in excess of 10 CFR Part ~~100~~ 50.34(a)(1) exposure guidelines should be based on assumptions that are as realistic as is practicable. In addition, because of the low probability events under consideration, valid statistical data are often not available to permit accurate quantitative calculation of probabilities. Accordingly, a conservative calculation showing that the probability of occurrence of potential exposures in excess of the 10 CFR Part ~~100~~ 50.34(a)(1) guidelines is approximately 10^{-6} per year is acceptable if, when combined reasonable qualitative arguments, with the realistic probability can be shown to be lower.

The effects of design basis events have been appropriately considered if analyses of the effects of those accidents on the safety-related features of ~~the~~ a proposed nuclear station have been performed and appropriate measures (e.g., hardening fire protection) to mitigate the consequences of such events have been taken.

To evaluate the suitability of sites in detail for potential accidents involving hazardous materials and activities at nearby industrial, military, and transportation facilities, the studies described in Section 2.2 of Regulatory Guide 1.70 should be made.

8. Socioeconomics

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4 The design basis tornado is described in Regulatory Guide 1.76, "Design Basis Tornado for Nuclear Power Plants."

The NRC staff considers that an evaluation of the suitability of nuclear power station sites near distinctive communities should demonstrate that the construction and operation of the nuclear station, including transmission and transportation corridors, and potential problems relating to community services, such as schools, police and fire protection, water and sewage, and health facilities, will not adversely affect the distinctive character of the community. A preliminary investigation should be made to identify and analyze problems that may arise due to the proximity of a distinctive community to a proposed site.

9. Noise

Noise levels at proposed sites must comply with applicable Federal, State, and local noise regulations.

10. Emergency Planning

As a minimum, each applicant for site approval should provide a description of the area within a 10 mile radius of the plume exposure EPZ, including:

- o population distribution (current and projected for the next 40 years),
- o residential, industrial, public, and commercial facilities and structures,
- o transportation routes, including any egress limitations, and
- o topography.

In addition, the applicant shall provide a description of any contacts, evaluations by and assessments with local, State, and Federal government agencies with emergency planning responsibilities. An evaluation of the above information with respect to its impact on the development of an emergency plant that can assure adequate protective measures for the populace should be provided.

D. IMPLEMENTATION

~~The purpose of this section is to provide information to applicants and licensees regarding the NRC staff's plans for using this regulatory guide.~~

~~Since this guide reflects current NRC staff practice with regard to the implementation of existing regulations concerning site suitability,~~ This guide discusses the major site characteristics related to public health and safety and environmental issues which the NRC staff considers in determining the suitability of sites for nuclear power stations. Accordingly, it can be used ~~immediately~~ after [EFFECTIVE DATE OF THIS REGULATION] ~~to indicate~~ as a general list of considerations that should be addressed early in the ~~initial stage of the~~ site selection process to identify potential sites for nuclear power stations.

APPENDIX A

SAFETY-RELATED SITE CONSIDERATIONS FOR ASSESSING SITE SUITABILITY FOR NUCLEAR POWER STATIONS

This appendix provides a checklist of safety-related site characteristics, relevant regulations and regulatory guides, and regulatory experience and positions for assessing site suitability for nuclear power stations.

Considerations	Relevant Regulations and Regulatory Guides	Regulatory Experience and Position
A.1 Geology/Seismology		
Geologic and seismic characteristics of a site, such as surface faulting, ground motion, and foundation conditions (including liquefaction, subsidence, and landslide potential), may affect the safety of a nuclear power station.	10 CFR Part 100, Appendix ~~A~~ **B**, "**Criteria for the** Seismic and Geologic Siting ~~Criteria for~~ **of** Nuclear Power Plants **after [EFFECTIVE DATE]**." Regulatory Guide 1.70, ~~Chapter 2~~ (identifies safety-related site characteristics). Regulatory Guide 1.29 (discusses plant safety features which should be controlled by engineering design).	Sites that include capable faults are not suitable for a nuclear power station. Sites within about 5 miles of a ~~surface~~ capable ~~fault~~ **tectonic source** (greater than 1000 feet in length) are generally not suitable for a nuclear power station. Sites should be selected in areas for which an adequate geologic data base exists to determine "capability." Delay in licensing can result from a need for extensive geologic and seismic investigations. Conservative design of safety-related structures will be required when geologic, seismic, and foundation information is questionable. Sites with competent bedrock generally have suitable foundation conditions. If bedrock sites are not available, it is prudent to select sites in areas known to have a low subsidence and liquefaction potential. Investigations will be required to determine the static and dynamic engineering properties of the material underlying the site as stated in 10 CFR Part 100, ~~Sec. IV(a)(4) and Sec. V(d) of Appendix A~~ **Appendix B**.

Considerations	Relevant Regulations and Regulatory Guides	Regulatory Experience and Position

A.2 ~~Atmospheric Dispersion~~ Meteorology

The ~~atmospheric~~ meteorological conditions at a site should provide ~~sufficient~~ good dispersion of radioactive materials released during a postulated accident to reduce the radiation exposures of individuals at the exclusion area and low population zone boundaries to the values prescribed in 10 CFR Part ~~100~~ 50.34.

10 CFR Part ~~100, "Reactor Site Criteria."~~ 50, "Domestic Licensing of Production and Utilization Facilities."

Regulatory Guide 1.23, "Onsite Meteorological Programs."

Regulatory Guide 1.3 "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Boiling Water Reactors."

Regulatory Guide 1.4, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Pressurized Water Reactors."

Regulatory Guide 1.5, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Steam Line Break Accident for Boiling Water Reactors."

Regulatory Guide 1.24, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Pressurized Water Reactor Radioactive Gas Storage Tank Failure."

Regulatory Guide 1.25, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Fuel Handling Accident in the Fuel Handling and Storage Facility for Boiling and Pressurized Water Reactors."

Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants LWR Edition."

Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light—Water—Cooled Reactors."

Regulatory Guide 1.145, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants."

Unfavorable safety-related design basis atmospheric dispersion characteristics can be compensated for by ~~an adequate exclusion distance and~~ engineered safety features. ~~Accordingly, the regulatory position on atmospheric dispersion of radiological effluents is incorporated into the section "Population Considerations" (see A.3 of this appendix).~~

Considerations	Relevant Regulations and Regulatory Guides	Regulatory Experience and Position

A.3 Population Considerations

In the event of a serious accident at a nuclear power station, effective action must be taken to minimize exposure of individuals outside the station to any radioactive materials which may be released during the accident. To ensure that exposure to populations will be minimized in the event of an accident, the nuclear power station should not be located in a densely populated area.

10 CFR Part 100, "Reactor Site Criteria," requires the following:

- An "exclusion area" surrounding the reactor in which the reactor licensee has the authority to determine all activities, including exclusion or removal of personnel and property;

- 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities."

- ~~A "low population zone" (LPZ) which immediately surrounds the exclusion area in which the population number and distribution is such that "there is a reasonable probability that appropriate measures could be taken in their behalf in the event of a serious accident;";~~

- ~~At any point on the exclusion area boundary and on the outer boundary of the LPZ the exposure of individuals to a postulated release of fission products (as a consequence of an accident) be less than certain prescribed values.~~

- ~~That the "population center distance," defined as the distance from the nuclear reactor to the nearest boundary of a densely populated center having more than 25,000 residents, be at least one and one third the distance from the reactor to the outer boundary of the LPZ.~~

Regulatory Guides 1.3, 1.4, 1.5, 1.24, ~~and~~ 1.25, 1.70, 1.111, and 1.145 give calculational methods (see A.2 of this appendix.)

If the offsite population density, including weighted transient population, projected at the time of initial ~~operation of a nuclear power station~~ site approval and renewal exceeds 500 persons per square mile averaged over any radial distance out to 30 miles (cumulative population at a distance divided by the area at that distance), or the projected population density ~~over the life-time of the facility~~ for 40 years after site approval exceeds 1,000 persons per square mile averaged over any radial distance out to 30 miles, special attention should be given to the consideration of alternative sites with the lower population densities.

Transient population should be included for those sites where a significant number of people (other than those just passing through the area) work, reside part-time, or engage in recreational activities, and are not permanent residents of the area. The transient population should be taken into account by weighing the transient population according to the fraction of time the transients are in the area.

Based on past experience the NRC staff has found that a minimum exclusion distance of 0.4 mile,* even with the most unfavorable design basis atmospheric dispersion characteristics, provides assurance that engineered safety features can be added that will bring the calculated doses from a postulated accident within the guidelines of 10 CFR Part 50.34. ~~100. If the minimum exclusion distance is less than 0.4 mile, it may be necessary to place special conditions on station design (e.g., added engineered safety features) before the site can be considered acceptable. Also based on past experience, the NRC staff has found that a distance of 3 miles to the outer boundary of the LPZ is usually adequate.*~~

*The guidelines ~~numbers~~ values for the exclusion area ~~and LPZ are~~ is based on historical siting experience of light-water-cooled reactors. ~~In certain instances different dimensions have been established for high temperature gas cooled reactors.~~

Considerations	Relevant Regulations and Regulatory Guides	Regulatory Experience and Position
A.4 Hydrology		
A.4.1 Flooding		
Precipitation, wind, or seismically induced flooding (e.g., resulting from dam failure, from river blockage or diversion, or from distantly and locally generated sea waves) can affect the safety of a nuclear power station.	10 CFR Part 100, Appendix ~~A~~ **B**, "**Criteria for the** Seismic and Geologic Siting ~~Criteria for~~ **of** Nuclear Power Plants **after [EFFECTIVE DATE]**." Regulatory Guide 1.59, "Design Basis Floods for Nuclear Power Plants." Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants," (Section 2.4). 10 CFR Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants;" Criterion 2, "Design Bases for Protection Against Natural Phenomena."	To evaluate sites located in river valleys, on flood plains, or along coastlines where there is a potential for flooding, the studies described in Regulatory Guide 1.59 should be made.
A.4.2 Water Supply		
A safety-related water supply is required for normal or emergency shutdown and cooldown.	10 CFR Part 100, Appendix ~~A~~ **B**, "**Criteria for the**Seismic and Geologic Siting ~~Criteria for~~ **of** Nuclear Power Plants **after [EFFECTIVE DATE]**." Regulatory Guide 1.59, "Design Basis Floods for Nuclear Power Plants." Regulatory Guide 1.27, "Ultimate Heat Sink for Nuclear Power Plants."	A highly dependable system of water supply sources should be shown to be available under postulated occurrences of natural phenomena and site-related accidental phenomena or combinations of such phenomena as discussed in Regulatory Guide 1.59. To evaluate the suitability of a site, there must be a reasonable assurance that permits for water use and for water consumption in the quantities needed for a nuclear power plant of the stated approximate capacity and type of cooling system can be obtained by the applicant from the appropriate State, local, or regional bodies.
A.4.3 Water Quality		
Contamination of ground water and surface water by radioactive materials discharged from nuclear stations could cause public health hazards	10 CFR Part 20, "Standards For Protection Against Radiation." 10 CFR Part 50, "Licensing of Production and Utilization Facilities."	The criteria provided in 10 CFR Parts 20 and 50 will be used by the NRC staff for determining permissible concentrations of radionuclides discharged to surface water and ground water.

Considerations	Relevant Regulations and Regulatory Guides	Regulatory Experience and Position
A.5 Industrial, Military and Transportation Facilities Near the Site. Accidents at present or projected nearby industrial, military, and transportation facilities may affect the safety of the nuclear power station.	10 CFR Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants," Criterion 4, "Environmental and Missile Design Bases." Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports," Section 2.2 (lists types of facilities and potential accidents). Regulatory Guide 1.78, "Assumptions for Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release."	Potentially hazardous facilities and activities within 5 miles of a proposed site must be identified. If a preliminary evaluation of potential accidents of these facilities indicates that the potential hazards from shock waves and missiles approach or exceed those of the design basis tornado for the region (the design basis tornado is described in Regulatory Guide 1.76), or potential hazards such as flammable vapor clouds, toxic chemicals, or incendiary fragments exist, the suitability of the site should be determined by detailed evaluation of the potential hazard. The identification of design basis events resulting from the presence of nearby hazardous materials or activities in the vicinity of a nuclear power station is acceptable if the design basis events include each postulated type of accident for which a realistic estimate of the probability of occurrence of potential exposures in excess of 10 CFR Part ~~100~~ 50.34 guidelines exceeds approximately 10^{-7} per year. To evaluate the suitability of sites in detail for potential accident situations involving hazardous materials and activities from nearby industrial, military, and transportation facilities, the studies described in Section 2.2 of Regulatory Guide 1.70 should be made.

APPENDIX B

ENVIRONMENTAL CONSIDERATIONS FOR ASSESSING SITE SUITABILITY FOR NUCLEAR POWER STATIONS

This appendix summarizes environmental considerations related to site characteristics that should be addressed in the early site selection process. The relative importance of the different factors to be considered varies with the region or State in which the potential sites are located.

Site Selection processes can be facilitated by establishing limits for various parameters based on the best judgment of specialists knowledgeable of the region under consideration. For example, limits can be chosen for the fraction of water that can be diverted in certain situations without adversely affecting the local populations of important species. Although simplistic because important factors such as the distribution of important species in the water body are not taken into account, such limits can be useful in a screening process for site selection.

A discussion of performance characteristics of light-water-cooled reactor stations which may affect the environment is given in WASH-1355, "Nuclear Power Facility Performance Characteristics for Making Environmental Impact Assessments," December 1974.

Considerations	Parameters	Regulatory Position
B.1 Preservation of Important Habitats Important habitats are those that are essential to maintaining the reproductive capacity and vitality of important species populations* or the harvestable crop of economically or recreationally important species. Such habitats include breeding areas (e.g., nesting and spawning areas), nursery, feeding, resting, and wintering areas or other areas of seasonally high concentrations of individuals of important species. The construction and operation of nuclear power stations (including new transmission lines and access corridors constructed in conjunction with the station) can result in the destruction or alteration of habitats of important species leading to changes in the abundance of a species or in the species composition of a community.	The proportion of an important habitat that would be destroyed or significantly altered in relation to the total habitat within the region in which the proposed site is to be located is a useful parameter for estimating potential impacts of the construction or operation of a nuclear power station. The value of the proportion varies among species and among habitats. The region considered in determining proportions is the normal geographic range of the specific population in question. If endangered or threatened species occur at a site, the potential effects of the construction and operation of a nuclear power station should be evaluated relative to the potential impact on the local population and the total estimated population over the entire range of species. See also Chapter 2 of Regulatory Guide 4.2, "Preparation of Environmental Reports for Nuclear Power Stations."	In general, a detailed justification should be provided when the destruction or significant alteration of more than a few percent of important habitat types is proposed. The reproductive capacity of populations of important species and the harvestable crop of economically or recreationally important populations must be maintained unless justification for proposed or probable changes can be provided.

*As defined for this guide in Section B.

B.2 Migratory Routes of Important Species

Seasonal or daily migrations are essential to maintaining the reproductive capacity of some important species populations.

Disruption of migratory patterns can result from partial or complete blockage of migratory routes by structures, discharge plumes, environmental alterations, or man's activities (e.g., transportation or transmission corridor clearing and site preparation).

The width or cross-sectional area of a water body at a proposed site relative to the general width or cross-sectional area in the portion of the water used by migrating species should be estimated.

Suggested minimum zones of passage range from 1/3 to 3/4 of the width or cross-sectional areas of narrow water bodies.[a,b]

Some species migrate in central, deeper areas while others use marginal, shallow areas. Rivers, streams, and estuaries are seldom homogeneous in their lateral dimension with respect to depth, current velocity, and habitat type. Thus, the use of width or cross-sectional area criteria for determining adequate zones of passage should be combined with a knowledge of important species and their migratory requirements.

Narrow reaches of water bodies should be avoided as sites for locating intake or discharge structures.

A zone of passage that will permit normal movement of important species populations and maintenance of the harvestable crop of economically important populations should be provided.

[a] Water Quality Criteria, 1972, National Academy of Sciences - National Academy of Engineering, Washington, D.C., 1972.
[b] Handbook of Environmental Control, Volume III: Water Supply and Treatment, R.G. Bond and C.P. Straub (Editors), CRS Press, Cleveland, Ohio, 1973.

Considerations	Parameters	Regulatory Position
B.3 Entrainment and Impingement of Aquatic Organisms		
Plankton, including eggs, larvae, and juvenile fish, can be killed or injured by entrainment through power station cooling systems or in discharge plumes. The reproductive capacity of important species populations may be impaired by lethal stresses or by sublethal stresses that affect reproduction of individuals or result in increased predation on the affected species population. Fish and other aquatic organisms can be killed or injured by impingement on cooling water intake screens[a] or by entrainment in discharge plumes.	The depth of the water body at the point of intake relative to the general depth of the water body in the vicinity of the site. The proportion of water withdrawn relative to the net new available water at the site is an indirect measure of the destruction of plankton which in turn is indicative of possible effects on populations of important species. It has been suggested that the fraction of available new water that can be diverted is in the range of 10% to 20% of flow.[b,c] The simplistic parameter (proportion of water withdrawal) is suitable for use in a screening process or site selection. However, other factors such as distribution of important species should be considered and in all cases the advice of experts on the local fisheries should be consulted to ensure that proposed withdrawals will not be excessive.	The site should have characteristics that allow placement of intake structures where the relative abundance of important species is small and where low approach velocities can be attained. (Deep regions are generally less productive than shallow areas. It is not implied that benthic intakes are necessary.) Important habitats (see B.1) should be avoided as locations for intake structures.

[a] Approach velocity and screen-face velocity are design criteria that may affect the impingement of larger organisms, principally fish, on intake screens. Acceptable approach and screen-face velocities are based on fish swim speeds which will vary with the species, site and season.

[b] The Water's Edge: Critical Problems of the Coastal Zone, B.H. Ketchum (Editor), MIT Press, Cambridge, Mass., 1972.

[c] Engineering for Resolution of the Energy-Environment Dilemma, National Academy of Engineering, Washington, D.C. 1972.

Considerations	Parameters	Regulatory Position
B.4 Entrapment of Aquatic Organisms		
Cooling water intake and discharge system features, such as canals and thermal plumes, can attract and entrap organisms, principally fish. The resulting concentration of important fish species near the station site can result in higher mortalities from station-related causes, such as impingement, cold shock, or gas bubble disease, than would otherwise occur. Entrapment can also interrupt normal migratory patterns.	Site characteristics that will accommodate design features that mitigate or prevent entrapment.	Sites where the construction of intake or discharge canals would be necessary should be avoided unless the site and important species characteristics are such that entry of important species to the canal can be prevented or limited by screening.
B.5 Water Quality		
Effluents discharged from nuclear power plants are governed under the authority of the Federal Water Pollution Control Act (FWPCA)--(PL 92-500) **as implemented in 40 CFR Parts 122-125 and 422**.	Applicable EPA-approved State water quality standards. ~~For States without EPA-approved water quality standards, the water quality criteria* listed in *Water Quality Criteria, 1972*, will be used for evaluation.~~	Pursuant to Section 401(a)(1) of the FWPCA, certification from the State that any discharge will comply with applicable effluent limitations and other water pollution control requirements is necessary before the NRC can issue a construction permit unless the requirement is waived by the State or the State fails to act within a reasonable length of time. Issuance of a permit pursuant to Section 402 of the Act is not a prerequisite to an NRC license or permit. Where station construction or operation has the potential to degrade water quality to the possible detriment of other users, more detailed analyses and evaluation of water quality may be necessary.

~~*Water Quality Criteria, 1972, National Academy of Sciences–National Academy of Engineering, Washington, D.C. 1972.~~

Considerations	Parameters	Regulatory Position
B.6 Water Availability		
The consumptive use of water for cooling, potable, and service water may be restricted by statute, may be inconsistent with water use planning, or may lead to an unacceptable impact to the water resource.	Applicable Federal, State, and local statutory requirements. Compatability with water use plan of cognizant water resource planning agency. In the absence of a water use plan, the effect on other water users is evaluated considering flow or volume reduction and the resultant ability of all users to obtain adequate supply and to meet applicable water quality standards (see B.5, Water Quality).	Water use and consumption must comply with statutory requirements and be compatible with water use plans of cognizant water resources planning agencies. Consumptive use of surface and ground water should be restricted such that the supply of other users is not impaired and that applicable surface water quality standards could be met, assuming normal station operational discharges and extreme low flow conditions defined by generally accepted engineering practices. For multipurpose impounded lakes and reservoirs, consumptive use should be restricted such that the magnitude and frequency of drawdown will not result in unacceptable damage to important habitats (see B.1, Preservation of Important Habitats) or be inconsistent with the management goals for the water body.
B.7 Established Public Amenity Areas		
Areas or properties dedicated by Federal, State, or local governments to historic, scenic, recreational, or cultural purposes are generally prohibited areas for siting power stations. Siting nuclear power stations in the vicinity of established public amenity areas could result in the loss or deterioration of important public amenities.	Proximity to historic properties or public amenity area. Viewability (see B.10, Visual Amenities).	Siting in the vicinity of designated public amenity areas will generally require extensive evaluation and justification. The evaluation of the suitability of sites in the vicinity of historic properties or public amenity areas is dependent on consideration of a specific plant design and station layout in relation to potential impacts on the public amenity area. Possible effects on historic properties must be reviewed according to 36 CFR Part 800, "Protection of Historic Properties," whichimplements the Natural Historic Preservation Act of 1966, as amended.
B.8 Prospective Designated Amenity Areas		
Areas containing important resources for historic, scenic, recreational, or cultural use may not currently be designated as such by public agencies but may involve a net loss to the public if converted to power generation. These areas may include locally rare land types, such as sand dunes, wetlands, or coastal cliffs.	Comparison of possible amenity areas in number and extent with other similar areas available on a local, regional, or national basis, as appropriate.	Public amenity areas that are distinctive, unique, or rare in a region should be avoided as sites for nuclear power stations.

Considerations	Parameters	Regulatory Position
B.9 Public Planning		
Land use for a nuclear power station should be compatible with established land use or zoning plans of governmental entities.	Officially adopted land use plans.	Land use plans adopted by Federal, State, regional, or local government entities must be examined, and any conflict between these plans and use of a proposed site must be resolved by consultation with the appropriate governmental entity.
B.10 Visual Amenities		
The presence of power station structures may introduce adverse visual impacts to residential, recreational, historic, scenic, or cultural areas or other areas with significant dependence on desirable viewing characteristics.	The solid angle subtended by station structures at critical viewing points.	The visual intrusion of nuclear power station structures as viewed from nearby residential, recreational, scenic, or cultural areas should be controlled by selecting sites where existing topography and forests can be utilized for screening station structures from those areas in which visual impacts would otherwise be unacceptable.
B.11 Local Fogging and Icing		
Water and water vapor released to the atmosphere from recirculating cooling systems can lead to ground fog and ice resulting in transportation hazards and damage to electric transmission systems.	Increase in number of hours of fogging or icing caused by operation of the station.	The hazards on transportation routes from fog or ice that result from station operation should be evaluated. The evaluation should include estimates of frequency of occurrance of station-induced fogging and icing and their impact on transportation, electrical transmission, and other activities and functions.
B.12 Cooling Tower Drift		
Concentrations of chemicals, dissolved solids, and suspended solids in cooling tower drift could affect terrestrial biota and result in unacceptable damage to vegetation and other resources.	The percent drift loss from recirculating condenser cooling water, particle size distribution, salt deposition rate, local atmospheric conditions, and loss of sensitive terrestrial biota affected by salt deposition from cooling tower drift.	The potential loss of important terrestrial species and other resources should be considered.
B.13 Cooling Tower Plume Lengths		
Natural draft cooling towers produce cloud-like plumes which vary in size and altitude depending on the atmospheric conditions. The plumes are usually a few miles in length before becoming dissipated, although plume lengths of 20 to 30 miles have been reported from cooling towers. Visible plumes emitted from cooling towers could cause a hazard to commercial and military aviation in the vicinity of commercial and military airports. The plumes themselves or their shadows could have aesthetic impacts.	The number of hours per year the plume is visible as a function of direction and distance from the cooling towers.	The visibility of cooling tower plumes as a function of direction and distance from cooling towers should be considered. The evaluation should include estimates of frequency of occurrence for plumes as well as potential hazards to aviation in the vicinity of commercial and military airports.

Considerations	Parameters	Regulatory Position
B.14 Plume Interaction		
Water vapor from cooling tower plumes may interact with industrial emissions from nearby facilities to form noxious or toxic substances which could cause adverse public health impacts, or result in unacceptable levels of damage to biota, structures, or other resources.	The degree to which impacts may occur will vary depending on the distance between the nuclear and fossil-fueled sites, the hours per year of plume interaction, the type and concentration of chemical reaction products, the area of chemical fallout, and the local atmospheric conditions.	The hazards to public health, structures, and other resources from potential plume interaction between cooling tower plumes and plumes from fossil-fueled sites and industrial emissions from nearby facilities should be considered.
B.15 Noise		
Undesirable noise levels at nuclear power stations could occur during both the construction and operation phases and have unacceptable impacts near the plant.	Applicable Federal, State, and local noise regulations.	Noise levels at proposed sites must comply with statutory requirements.
B.16 Economic Impact of Preemptive Land Use		
Nuclear power stations can preempt large areas, especially when large cooling lakes are constructed. The land requirement is likely to be an important issue when a proposed site is on productive land (e.g., agricultural land) that is locally limited in availability and is important to the local economy, or which may be needed to meet foreseeable national demands for agricultural products.	The level of local economic dislocation, such as loss of income, jobs, and production, caused by preemptive use of productive land and its effect on meeting foreseeable national demands for agriculture products.	If a preliminary evaluation of net local economic impact of the use of productive land for a nuclear power station indicates a potential for large economic dislocation, the NRC staff will require a detailed evaluation of the potential impact and justification for the use of the site based on a cost-effectiveness comparison of alternative station designs and site-station combinations. To complete its evaluation, the staff will also need information on whether and to what extent the land use affects national requirements for agricultural products.

10 CFR PART 100, APPENDIX B

COMPARATIVE TEXT

Appendix B to Part 100 -- CRITERIA FOR THE SEISMIC AND GEOLOGIC SITING ~~CRITERIA FOR~~ OF NUCLEAR POWER PLANTS AFTER [EFFECTIVE DATE]

GENERAL INFORMATION

This appendix applies to applicants who apply for an early site permit or combined license pursuant to Part 52 of this chapter, or a construction permit or operating license pursuant to Part 50 of this chapter on or after [EFFECTIVE DATE OF THIS REGULATION]. However, if the construction permit was issued prior to [EFFECTIVE DATE OF THIS REGULATION], the operating license applicant shall comply with the seismic and geologic siting criteria in Appendix A to Part 100 of this chapter.

This appendix and Appendix S to Part 50 of this chapter provide the seismic, geologic, and earthquake engineering criteria for nuclear power plants constructed pursuant to applications applied for on or after the effective date of this regulation.

I. PURPOSE

General Design Criterion 2 of Appendix A to Part 50 of this chapter requires that nuclear power plant structures, systems, and components important to safety be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions. It is the purpose of these criteria to set forth the principal seismic and geologic considerations which guide the Commission in its evaluation of the suitability of proposed sites for nuclear power plants and the suitability of the plant design bases established in consideration of the seismic and geologic characteristics of the proposed sites.[1]

These criteria are based on the ~~limited~~ current geophysical, ~~and~~ geological, and seismological information ~~available to date~~ concerning faults and earthquake occurrences and effects. They will be revised as necessary

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[1] Considerations presented in this regulation are general. Acceptable methods and additional discussion are provided in regulatory guides and standard review plan sections.

when more complete information becomes available.

II. SCOPE

These criteria, which apply to nuclear power plants, describe the nature of the investigations required to obtain the geologic and seismic data necessary to determine site suitability and 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. ~~They describe procedures for determining the quantitative vibratory ground motion design basis at a site due to earthquakes and describe information needed to determine whether and to what extent a nuclear power plant need be designed to withstand the effects of surface faulting. Other g~~Geologic and seismic factors required to be taken into account in the siting and design of nuclear power plants are identified.

The investigations described in this appendix are within the scope of investigations permitted by § 50.10(c)(1) of this chapter.

Each applicant for a construction permit, operating license, early site permit, or combined license shall investigate all seismic and geologic factors that may affect the design and operation of the proposed nuclear power plant irrespective of whether such factors are explicitly included in these criteria. Both deterministic and probabilistic evaluations shall be conducted to determine site suitability and seismic design requirements for the site. Additional investigations ~~and/~~or more conservative determinations than those included in these criteria may be required for sites located in areas ~~having~~ with complex geology, recent tectonic deformation, or in areas of high seismicity. If an applicant believes that the particular ~~seismology~~ seismic and ~~geology~~ geologic characteristics of a site indicate that some of these criteria, or portions thereof, need not be satisfied, the specific sections of these criteria should be identified in the license application, and supporting data to ~~justify~~ clearly justify such departures ~~should~~ shall be presented. The Director, Office of Nuclear Reactor Regulation must approve such deviations.

~~These criteria do not address investigations of volcanic phenomena required for sites located in areas of volcanic activity. Investigations of the volcanic aspects of such sites will be determined on a case by case basis.~~

III. DEFINITIONS

As used in these criteria:

(a) The "magnitude" of an earthquake is a measure of the size of an earthquake and is related to the energy released in the form of seismic waves. "Magnitude" means the numerical value on a standardized scale such as, but not limited to, Moment Magnitude, Surface Wave Magnitude, Body Wave Magnitude, or Richter Magnitude scales.

~~(b) The "intensity" of an earthquake is a measure of its effects on man, on man built structures, and on the earth's surface at a particular location. "Intensity" means the numerical value on the Modified Mercalli scale.~~

(b) A deterministic source earthquake (DSE) is the largest earthquake that can reasonably be expected to occur in a given seismic source in the current tectonic regime, and is used in a deterministic analysis. It is generally based on the maximum historical earthquake associated with that seismic source, unless recent geological evidence warrants a larger earthquake, or where the rate of occurrence of earthquakes indicates the likelihood of larger than the largest historical event.

(c) The "Safe Shutdown Earthquake Ground Motion (SSE)"[2] ~~135~~ is ~~that earthquake which is based upon an evaluation of the maximum earthquake potential considering the regional and local geology and seismology and specific characteristics of local subsurface material. It is that earthquake which produces~~ the ~~maximum~~ vibratory ground motion for which certain structures, systems, and components ~~are~~ shall be 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 in a safe shutdown condition, or~~

~~(3) The capability to prevent or mitigate the consequences of accidents which could result in potential offsite exposures comparable to the guideline exposures of this part.~~

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[2] ~~The "Safe Shutdown Earthquake" defines that earthquake which has commonly been referred to as the "Design Basis Earthquake."~~

~~(d) The "Operating Basis Earthquake" is that earthquake which, considering the regional and local geology and seismology and specific characteristics of local subsurface material, could reasonably be expected to affect the plant site during the operating life of the plant; it is that earthquake which produces the vibratory ground motion for which those features of the nuclear power plant necessary for continued operation without undue risk to the health and safety of the public are designed to remain functional.~~

(~~e~~d) A ~~"~~fault~~"~~ is a tectonic structure along which differential slippage of the adjacent earth materials has occurred parallel to the fracture plane. ~~It is distinct from other types of ground disruptions such as landslides, fissures, and craters.~~ A fault may have gouge or breccia between its two walls and includes any associated monoclinal flexure or other similar geologic structural feature.

(~~f~~e) ~~"~~Surface faulting~~"~~ is differential ground displacement at or near the surface caused directly by fault movement and is distinct from nontectonic types of ground disruptions, such as landslides, fissures, and craters.

(f) Surface deformation is distortion of soils or rocks at or near the ground surface by the processes of folding, faulting, compression, or extension as a result of various earth forces. Tectonic surface deformation is associated with earthquake processes.

(g) A seismic source is a general term referring to both seismogenic sources and capable tectonic sources.

(h) A seismogenic source is a portion of the earth that has uniform earthquake potential (same deterministic source earthquake and frequency of recurrence) distinct from the surrounding area. A seismogenic source will not cause surface displacements. Seismogenic sources cover a wide range of possibilities from a well-defined tectonic structure to simply a large region of diffuse seismicity (seismotectonic province) thought to be characterized by the same earthquake recurrence model. A seismogenic source is also characterized by its involvement in the current tectonic regime as reflected in the Quaternary (approximately the last 2 million years) geologic history.

(~~g~~i) A ~~"~~capable ~~fault~~ tectonic source~~"~~ is a tectonic structure that can generate both earthquakes and tectonic surface deformation such as faulting or folding at or near the surface in the present seismotectonic regime. It is characterized by at least one ~~a fault which has exhibited one or more~~ of the following characteristics:~~-~~

~~(1) Movement at or near the ground surface at least once within the~~

~~past 35,000 years or movement of a recurring nature within the past 500,000 years.~~

(1) The presence of surface or near surface deformation of landforms or geologic deposits of recurring nature within the last approximately 500,000 years or at least once in the last approximately 50,000 years.

~~(2) Macro seismicity instrumentally determined with records of sufficient precision to demonstrate a direct relationship with the fault.~~

(2) A reasonable association with one or more large earthquakes or sustained earthquake activity that are usually accompanied by significant surface deformation.–

~~(3) A structural relationship to a capable fault according to characteristics (1) or (2) of this paragraph such that movement on one could be reasonably expected to be accompanied by movement on the other.~~

(3) A structural association with a capable tectonic source having characteristics in (1) of this paragraph such that movement on one could be reasonably expected to be accompanied by movement on the other.

In some cases, the geologic evidence of past activity at or near the ground surface along a particular ~~fault~~ capable tectonic source may be obscured at a particular site. This might occur, for example, at a site having a deep overburden. For these cases, evidence may exist elsewhere along the ~~fault~~ structure from which an evaluation of its characteristics in the vicinity of the site can be reasonably based. Such evidence shall be used in determining whether the ~~fault~~ structure is a capable ~~fault~~ tectonic source within this definition.

Notwithstanding the foregoing paragraphs III(~~g~~i) (1), (2) and (3), structural association of a ~~fault~~ structure with geologic structural features ~~which~~ that are geologically old (at least pre-Quaternary) such as many of those found in the Eastern region of the United States shall, in the absence of conflicting evidence, demonstrate that the ~~fault~~ structure is not a capable ~~fault~~ tectonic source within this definition.

~~(h) A "tectonic province" is a region of the North American continent characterized by a relative consistency of the geologic structural features contained therein.~~

~~(i) A "tectonic structure" is a large scale dislocation or distortion within the earth's crust. Its extent is measured in miles.~~

~~(j) A "zone requiring detailed faulting investigation" is a zone within which a nuclear power reactor may not be located unless a detailed~~

~~investigation of the regional and local geologic and seismic characteristics of the site demonstrates that the need to design for surface faulting has been properly determined.~~

~~(k) The "control width" of a fault is the maximum width of the zone containing mapped fault traces, including all faults which can be reasonably inferred to have experienced differential movement during Quaternary times and which join or can reasonably be inferred to join the main fault trace, measured within 10 miles along the fault's trend in both directions from the point of nearest approach to the site. (See Figure 1 of this appendix.)~~

(~~l~~j) A ~~"~~response spectrum~~"~~ is a plot of the maximum responses (acceleration, velocity, or displacement) of a family of idealized single-degree-of-freedom ~~damped~~ oscillators ~~against~~ as a function of the natural frequencies ~~(or periods)~~ of the oscillators for a given damping value. The response spectrum is calculated for ~~to~~ a specified vibratory motion input at the~~ir~~ oscillators supports.

(k) Combined license or early site permit, as defined in Part 52 of this chapter.

IV. REQUIRED INVESTIGATIONS

The geological, ~~seismic~~ seismological, and engineering characteristics of a site and its environs shall be investigated in sufficient scope and detail ~~to provide reasonable assurance that they are sufficiently well understood~~ to permit an adequate evaluation of the proposed site, ~~and~~ to provide sufficient information to support ~~the~~ both probabilistic and deterministic determinations required by these criteria, and to permit adequate engineering solutions to actual or potential geologic and seismic effects at the proposed site. The size of the region to be investigated and the type of data pertinent to the investigations shall be determined by the nature of the region surrounding the proposed site. The investigations shall be carried out by a review of the pertinent literature and field investigations ~~and shall include the steps outlined~~ as identified in paragraphs (a) through (~~c~~e) of this section.

(a) ~~Required Investigation for~~ Vibratory Ground Motion.

The purpose of these investigations ~~required by this paragraph~~ is to obtain information needed to ~~describe the vibratory ground motion produced by~~ assess the Safe Shutdown Earthquake ground motion. The seismic sources (capable tectonic sources and seismogenic sources) in the site region shall be identified and evaluated. The deterministic source earthquakes shall be evaluated for each seismic source. ~~All of the steps in paragraphs (a)(5) through (a)(8) of this section need not be carried out if the Safe Shutdown Earthquake can be clearly established by investigations and determinations of a lesser scope. The investigations required by this paragraph provide an adequate basis for selection of an Operating Basis Earthquake. The investigations shall include the following:~~

~~(1) Determination of the lithologic, stratigraphic, hydrologic, and structural geologic conditions of the site and the region surrounding the site, including its geologic history;~~

~~(2) Identification and evaluation of tectonic structures underlying the site and the region surrounding the site, whether buried or expressed at the surface. The evaluation should consider the possible effects caused by man's activities such as withdrawal of fluid from or addition of fluid to the subsurface, extraction of minerals, or the loading effects of dams or reservoirs;~~

~~(3) Evaluation of 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;~~

~~(4) Determination of the static and dynamic engineering properties of the materials underlying the site. Included should be properties needed to determine the behavior of the underlying material during earthquakes and the characteristics of the underlying material in transmitting earthquake induced motions to the foundations of the plant, such as seismic wave velocities, density, water content, porosity, and strength;~~

~~(5) Listing of all historically reported earthquakes which have affected or which 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 maximum ground acceleration of at least one tenth the acceleration of gravity (0.1g) at the foundations of the proposed nuclear power plant structures, the acceleration or intensity and duration of ground shaking at these foundations shall 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. The comparative characteristics of the material underlying the epicentral location or region of highest intensity and of the material underlying the site in transmitting earthquake vibratory motion shall be considered;

(6) Correlation of epicenters or locations of highest intensity of historically reported earthquakes, where possible, with tectonic structures any part of which is located within 200 miles of the site. Epicenters or locations of highest intensity which cannot be reasonably correlated with tectonic structures shall be identified with tectonic provinces any part of which is located within 200 miles of the site;

(7) For faults, any part of which is within 200 miles[3] of the site and which may be of significance in establishing the Safe Shutdown Earthquake, determination of whether these faults are to be considered as capable faults.[4]-[5] This determination is required in order to permit appropriate consideration of the geologic history of such faults in establishing the Safe Shutdown Earthquake. For guidance in determining which faults may be of significance in determining the Safe Shutdown Earthquake, Table 1 of this appendix presents the minimum length of fault to be considered versus distance from site. Capable faults of lesser length than those indicated in Table 1 and faults which are not capable faults need not be considered in determining the Safe Shutdown Earthquake, except where unusual circumstances indicate such consideration is appropriate;

TABLE 1

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[3] If the Safe Shutdown Earthquake can be associated with a fault closer than 200 miles to the site, the procedures of paragraphs (a)(7) and (a)(8) of this section need not be carried out for successively more remote faults.

[4] In the absence of absolute dating, evidence of recency of movement may be obtained by applying relative dating technique to ruptured, offset, warped or otherwise structurally disturbed surface or near surface materials or geomorphic features.

[5] The applicant shall evaluate whether or not a fault is a capable fault with respect to the characteristics outlined in paragraphs III(g)(1), (2), and (3) by conducting a reasonable investigation using suitable geologic and geophysical techniques.

	~~Minimum[1] length~~
~~Distance from the site (miles):~~	
~~0 to 20~~	~~1~~
~~Greater than 20 to 50~~	~~5~~
~~Greater than 50 to 100~~	~~10~~
~~Greater than 100 to 150~~	~~20~~
~~Greater than 150 to 200~~	~~40~~

1 Minimum length of fault (miles) which shall be considered in establishing Safe Shutdown Earthquake.

~~(8) For capable faults, any part of which is within 200 miles[3] of the site and which may be of significance in establishing the Safe Shutdown Earthquake, determination of:~~

~~(i) The length of the fault;~~

~~(ii) The relationship of the fault to regional tectonic structures; and~~

~~(iii) The nature, amount, and geologic history of displacements along the fault, including particularly the estimated amount of the maximum Quaternary displacement related to any one earthquake along the fault.~~

(b) ~~Required Investigation for~~ Tectonic Surface Deformation~~Faulting~~.

The purpose of these investigations ~~required by this paragraph~~ is to assess the potential for tectonic surface deformation near the site and, if any, to what extent the nuclear power plant needs to be designed for these occurrences. ~~obtain information to determine whether and to what extent the nuclear power plant need be designed for surface faulting. If the design basis for surface faulting can be clearly established by investigations of a lesser scope, not all of the steps in paragraphs (b)(4) through (b)(7) of this section need be carried out. The investigations shall include the following:~~

~~(1) Determination of the lithologic, stratigraphic, hydrologic, and structural geologic conditions of the site and the area surrounding the site, including its geologic history;~~

~~(2) Evaluation of tectonic structures underlying the site, whether buried or expressed at the surface, with regard to their potential for causing~~

surface displacement at or near the site. The evaluation shall consider the possible effects caused by man's activities such as withdrawal of fluid from or addition of fluid to the subsurface, extraction of minerals, or the loading effects of dams or reservoirs;

(3) Determination of geologic evidence of fault offset at or near the ground surface at or near the site;

(4) For faults greater than 1000 feet long, any part of which is within 5 miles[6] of the site, determination of whether these faults are tobe considered as capable faults;[7,8]

(5) Listing of all historically reported earthquakes which can reasonably be associated with capable faults greater than 1000 feet long, any part of which is within 5 miles[6] of 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 region of highest intensity;

(6) Correlation of epicenters or locations of highest intensity of historically reported earthquakes with capable faults greater than 1000 feet long, any part of which is located within 5 miles[6] of the site;

(7) For capable faults greater than 1000 feet long, any part of which is within 5 miles[6] of the site, determination of:

(i) The length of the fault;

(ii) The relationship of the fault to regional tectonic structures;

(iii) The nature, amount, and geologic history of displacements along the fault, including particularly the estimated amount of the maximum Quaternary displacement related to any one earthquake along the fault; and

(iv) The outer limits of the fault established by mapping Quaternary

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[6] If the design basis for surface faulting can be determined from a fault closer than 5 miles to the site, the procedures of paragraphs (b)(4) through (b)(7) of this section need not be carried out for successively more remote faults.

[7] In the absence of absolute dating, evidence of recency of movement may be obtained by applying relative dating techniques to ruptured, offset, warped or otherwise structurally disturbed surface of near-surface materials or geomorphic features.

[8] The applicant shall evaluate whether or not a fault is a capable fault with respect to the characteristics outlined in paragraphs III(g)(1), (2), and (3) by conducting a reasonable investigation using suitable geological and geophysical techniques.

~~fault traces for 10 miles along its trend in both directions from the point of its nearest approach to the site.~~

(c) **Non-Tectonic Deformation.**

The purpose of these investigations is to assess the potential for surface deformations not directly attributable to tectonics such as those associated with subsidence or collapse as in karst terrane, glacially induced offsets, and growth faulting. Paragraph IV(b) concerns investigations required for tectonic surface deformation that can occur coseismically. Nontectonic phenomena can represent significant surface displacement hazards to a site, but can in many cases be monitored, controlled, or mitigated by engineering, or it can be demonstrated that conditions that were the cause of the displacements no longer exist. Geological and geophysical investigations shall be carried out to identify and define nontectonic deformation features and, where possible, distinguish them from tectonic surface displacements. If such distinction is not possible, the questionable features shall be treated as tectonic deformation.

(~~c~~d) ~~Required Investigation for~~ Seismically Induced Floods and Water Waves.

The purpose of these investigations is to assess the potential for nearby and distant tsunamis and other waves that could affect coastal sites. Included in this assessment is the determination of the potential for slides of earth material that could generate waves. Information regarding distant and locally generated waves or tsunamis that have affected the site, and available evidence of runup and drawdown associated with these events, shall be analyzed. Local features of coastal or undersea topography which could modify wave runup or drawdown must be considered. For sites located near lakes or rivers, analyses shall include the potential for seismically induced floods or water waves, as, for example, from the failure during an earthquake of a dam upstream or from slides of earth or debris into a nearby lake. ~~(1) For coastal sites, the investigations shall include the determination of:~~

~~(i) Information regarding distantly and locally generated waves or tsunami which have affected or could have affected the site. Available evidence regarding the runup and drawdown associated with historic tsunami in the same coastal region as the site shall also be included;~~

~~(ii) Local features of coastal topography which might tend to modify tsunami runup or drawdown. Appropriate available evidence regarding historic local modifications in tsunami runup or drawdown at coastal locations having~~

topography similar to that of the site shall also be obtained; and

(iii) Appropriate geologic and seismic evidence to provide information for establishing the design basis for seismically induced floods or water waves from a local offshore earthquake, from local offshore effects of an onshore earthquake, or from coastal subsidence. This evidence shall be determined, to the extent practical, by a procedure similar to that required in paragraphs (a) and (b) of this section. The probable slip characteristics of offshore faults shall also be considered as well as the potential for offshore slides in submarine material.

(2) For sites located near lakes and rivers, investigations similar to those required in paragraph (c)(1) of this section shall be carried out, as appropriate, to determine the potential for the nuclear power plant to be exposed to seismically induced floods and water waves as, for example, from the failure during an earthquake of an upstream dam or from slides of earth or debris into a nearby lake.

(8) **Volcanic Activity**.

The purpose of these investigations is to assess the potential volcanic hazards that would adverse the site.

V. SEISMIC AND GEOLOGIC DESIGN BASES

(a) Determination of Design Basis for Vibratory Ground Motion.

The design of each nuclear power plant shall take into account the potential effects of vibratory ground motion caused by earthquakes. The design basis for the maximum vibratory ground motion and the expected vibratory ground motion should be determined through evaluation of the seismology, geology, and the seismic and geologic history of the site and the surrounding region. The most severe earthquakes associated with tectonic structures or tectonic provinces in the region surrounding the site should be identified, considering those historically reported earthquakes that can be associated with these structures or provinces and other relevant factors. If faults in the region surrounding the site are capable faults, the most severe earthquakes associated with these faults should be determined by also considering their geologic history. The vibratory ground motion at the site should be then determined by assuming that the epicenters or locations of highest intensity of the earthquakes are situated at the point on the tectonic structures or tectonic provinces nearest to the site. The earthquake which

~~could cause the maximum vibratory ground motion at the site should be designated the Safe Shutdown Earthquake. The specific procedures for determining the design basis for vibratory ground motion are given in the following paragraphs.~~

(a) **Determination of Deterministic Source Earthquakes.**

For each seismogenic and capable tectonic source identified in Paragraph IV(a), the deterministic source earthquake shall be evaluated. As a minimum, the deterministic source earthquake shall be the largest historical earthquake in each source. The uncertainty in determining the deterministic source earthquakes shall be accounted for in the probabilistic analysis.

~~(1) Determination of Safe Shutdown Earthquake. The Safe Shutdown Earthquake shall be identified through evaluation of seismic and geologic information developed pursuant to the requirements of paragraph IV(a), as follows:~~

~~(i) The historic earthquakes of greatest magnitude or intensity which have been correlated with tectonic structures pursuant to the requirements of paragraph (a)(6) of section IV shall be determined. In addition, for capable faults, the information required by paragraph (a)(8) of section IV shall be taken into account in determining the earthquakes of greatest magnitude related to the faults. The magnitude or intensity of earthquakes based on geologic evidence may be larger than that of the maximum earthquakes historically recorded. The accelerations at the site shall be determined assuming that the epicenters of the earthquakes of greatest magnitude or the locations of highest intensity related to the tectonic structures are situated at the point on the structures closest to the site;~~

~~(ii) Where epicenters or locations of highest intensity of historically reported earthquakes cannot be reasonably related to tectonic structures but are identified pursuant to the requirements of paragraph (a)(6) of section IV with tectonic provinces in which the site is located, the accelerations at the site shall be determined assuming that these earthquakes occur at the site;~~

~~(iii) Where epicenters or locations of the highest intensity of historically reported earthquakes cannot be reasonably related to tectonic structures but are identified pursuant to the requirements of paragraph (a)(6) of section IV with tectonic provinces in which the site is not located, the accelerations at the site shall be determined assuming that the epicenters or locations of highest intensity of these earthquakes are at the closest point to the site on the boundary of the tectonic province;~~

(iv) The earthquake producing the maximum vibratory acceleration at the site, as determined from paragraph (a)(1)(i) through (iii) of this section shall be designated the Safe Shutdown Earthquake for vibratory ground motion, except as noted in paragraph (a)(1)(v) of this section. The characteristics of the Safe Shutdown Earthquake shall be derived from more than one earthquake determined from paragraph (a)(1)(i) through (iii) of this section, where necessary to assure that the maximum vibratory acceleration at the site throughout the frequency range of interest is included. In the case where a causative fault is near the site, the effect of proximity of an earthquake on the spectral characteristics of the Safe Shutdown Earthquake shall be taken into account. The procedures in paragraphs (a)(1)(i) through (a)(1)(iii) of this section shall be applied in a conservative manner. The determinations carried out in accordance with paragraphs (a)(1)(ii) and (a)(1)(iii) shall assure that the safe shutdown earthquake intensity is, as a minimum, equal to the maximum historic earthquake intensity experienced within the tectonic province in which the site is located. In the event that geological and seismological data warrant, the Safe Shutdown Earthquake shall be larger than that derived by use of the procedures set forth in section IV and V of the appendix. The maximum vibratory accelerations of the Safe Shutdown Earthquake at each of the various foundation locations of the nuclear power plant structures at a given site shall be determined taking into account the characteristics of the underlying soil material in transmitting the earthquake induced motions, obtained pursuant to paragraphs (a)(1), (3), and (4) of section IV. The Safe Shutdown Earthquake shall be defined by response spectra corresponding to the maximum vibratory accelerations as outlined in paragraph (a) of section VI; and

(v) Where the maximum vibratory accelerations of the Safe Shutdown Earthquake at the foundations of the nuclear power plant structures are determined to be less than one tenth the acceleration of gravity (0.1 g) as a result of the steps required in paragraphs (a)(1)(i) through (iv) of this section, it shall be assumed that the maximum vibratory accelerations of the Safe Shutdown Earthquake at these foundations are at least 0.1 g.

(2) Determination of Operating Basis Earthquake. The Operating Basis Earthquake shall be specified by the applicant after considering the seismology and geology of the region surrounding the site. If vibratory ground motion exceeding that of the Operating Basis Earthquake occurs, shutdown of the nuclear power plant will be required. Prior to resuming operations, the

~~licensee will be required to demonstrate to the Commission that no functional damage has occurred to those features necessary for continued operation without undue risk to the health and safety of the public.~~

~~The maximum vibratory ground acceleration of the Operating Basis Earthquake shall be at least one half the maximum vibratory ground acceleration of the Safe Shutdown Earthquake.~~

(b) **Determination of the Ground Motion at the Site.**

The ground motion at the site shall be estimated from all earthquakes, including the deterministic source earthquake associated with each source which could potentially affect the site using both probabilistic and deterministic approaches. In the deterministic approach, the deterministic source earthquake associated with each source shall be assumed to occur at the part of the source which is closest to the site. Appropriate models, including local site conditions, shall be used to account for uncertainty in estimating the ground motion for the site. The uncertainty in the ground motion shall be accounted for. The ground motion is defined by both horizontal and vertical free-field ground motion response spectra at the free ground surface or hypothetical rock outcrop, as appropriate.

(c) **Determination of Safe Shutdown Earthquake Ground Motion.**

The Safe Shutdown Earthquake Ground Motion is characterized by response spectra. These spectra are developed from or compared to the ground motions determined in Paragraph V(b). Deterministic and probabilistic seismic hazard analyses shall be used to assess the adequacy of the Safe Shutdown Earthquake Ground Motion. The probability of exceeding the Safe Shutdown Earthquake Ground Motion is considered acceptably low if it is less than the median probability computed from the current [EFFECTIVE DATE OF THE REGULATION] population of nuclear power plants.

As a minimum, the horizontal Safe Shutdown Earthquake Ground Motion at the foundation level of the structures shall be an appropriate response spectrum with a peak ground acceleration of at least 0.1g.

(~~b~~d) **Determination of Need To Design for Surface Tectonic and Non-Tectonic Deformations ~~Faulting~~.**

Sufficient geological, seismological, and geophysical data shall be provided to clearly establish that surface deformation need not be taken into account in the design of a nuclear power plant. When surface deformation is likely, an assessment of the extent and nature of surface deformations must be characterized.

In order to determine whether a nuclear power plant is required to be designed to withstand the effects of surface faulting, the location of the nuclear power plant with respect to capable faults shall be considered. The area over which each of these faults has caused surface faulting in the past is identified by mapping its fault traces in the vicinity of the site. The 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 because, for example, traces may be obscured along portions of the fault. The maximum width of the mapped fault traces, called the control width, is then determined from this map. Because surface faulting has sometimes occurred beyond the limit of mapped fault traces or where fault traces have not been previously recognized, the control width of the fault is increased by a factor which is dependent upon the largest potential earthquake related to the fault. This larger width delineates a zone, called the zone requiring detailed faulting investigation, in which the possibility of surface faulting is to be determined. The following paragraphs outline the specific procedures for determining the zone requiring detailed faulting investigation for a capable fault.

(1) Determination of Zone Requiring Detailed Faulting Investigation. The zone requiring detailed faulting investigation for a capable fault which was investigated pursuant to the requirement of paragraph (b)(7) of section IV shall be determined through use of the following table:

Table 2 — Determination of Zone Requiring Detailed Faulting Investigation

Magnitude of earthquake	Width of zone requiring detailed faulting investigation (See fig. 1)
Less than 5.5	1 x control width.
5.5 – 6.4	2 x control width.
6.5 – 7.5	3 x control width.
Greater than 7.5	4 x control width.

~~The largest magnitude earthquake related to the fault shall be used in Table 2. This earthquake shall be determined from the information developed pursuant to the requirements of paragraph (b) of Section IV for the fault, taking into account the information required by paragraph (b)(7) of section IV. The control width used in Table 2 is determined by mapping the outer limits of the fault traces from information developed pursuant to paragraph (b)(7)(iv) of section IV. The control width shall be used in Table 2 unless the characteristics of the fault are obscured for a significant portion of the 10 miles on either side of the point of nearest approach to the nuclear power plant. In this event, the use in Table 2 of the width of mapped fault traces more than 10 miles from the point of nearest approach to the nuclear power plant may be appropriate.~~

~~The zone requiring detailed faulting investigation, as determined from Table 2, shall be used for the fault except where:~~

~~(i) The zone requiring detailed faulting investigation from Table 2 is less than one half mile in width. In this case the zone shall be at least one half mile in width; or~~

~~(ii) Definitive evidence concerning the regional and local characteristics of the fault justifies use of a different value. For example, thrust or bedding plane faults may require an increase in width of the zone to account for the projected dip of the fault plane; or~~

~~(iii) More detailed three dimensional information, such as that obtained from precise investigative techniques, may justify the use of a narrower zone. Possible examples of such techniques are the use of accurate records from closely spaced drill holes or from closely spaced, high resolution offshore geophysical surveys.~~

~~In delineating the zone requiring detailed faulting investigation for a fault, the center of the zone shall coincide with the center of the fault at the point of nearest approach of the fault to the nuclear power plant as illustrated in Figure 1.~~

(~~e~~e) Determination of Design Bases for Seismically Induced Floods and Water Waves.

The size of seismically induced floods and water waves ~~which~~ that could affect a site from either locally or distantly generated seismic activity shall be determined, taking into consideration the results of the investigation required by paragraph (~~c~~d) of section IV. ~~Local topographic characteristics which might tend to modify the possible runup and drawdown at~~

~~the site shall be considered. Adverse tide conditions shall also be taken into account in determining the effect of the floods and waves on the site. The characteristics of the earthquake to be used in evaluating the offshore effects of local earthquakes shall be determined by a procedure similar to that used to determine the characteristics of the Safe Shutdown Earthquake in paragraph V(a).~~

(~~d~~f) Determination of Other Design Conditions. –

(1) Soil Stability. Vibratory ground ~~motion associated with the Safe Shutdown Earthquake~~ motions determined in Paragraph V(b) can cause soil instability ~~due to~~ from ground disruption such as fissuring, lateral spreads, differential ~~consolidation~~ settlement, and liquefaction, ~~and cratering~~ which is not directly related to surface faulting. ~~The following~~ Geological features ~~which~~ that could affect the foundations of the proposed nuclear power plant structures shall be evaluated, taking into account the information concerning the physical properties of materials underlying the site ~~developed pursuant to paragraphs (a)(1), (3), and (4) of section IV~~ and the effects of the ~~Safe Shutdown Earthquake:~~ vibratory ground motion determined in Paragraph V(b).

~~(i) Areas of actual or potential surface or subsurface subsidence, uplift, or collapse resulting from:~~

~~(a) Natural features such as tectonic depressions and cavernous or karst terrains, particularly those underlain by calcareous or other soluble deposits;~~

~~(b) Man's activities such as withdrawal of fluid from or addition of fluid to the subsurface, extraction of minerals, or the loading effects of dams or reservoirs; and~~

~~(c) Regional deformation.~~

~~(ii) Deformational zones such as shears, joints, fractures, folds, or combinations of these features.~~

~~(iii) Zones of alteration or irregular weathering profiles and zones of structural weakness composed of crushed or disturbed materials.~~

~~(iv) Unrelieved residual stresses in bedrock.~~

~~(v) Rocks or soils that might be unstable because of their mineralogy, lack of consolidation, water content, or potentially undesirable response to seismic or other events. Seismic response characteristics to be considered shall include liquefaction, thixotropy, differential consolidation, cratering, and fissuring.~~

(2) Slope stability. Stability of all slopes, both natural and

artificial, the failure of which could adversely affect the nuclear power plant, shall be considered. An assessment shall be made of the potential effects of erosion or deposition and of combinations of erosion or deposition with seismic activity, taking into account information concerning the physical ~~property~~ properties of the materials underlying the site ~~developed pursuant to paragraph (a)(1), (3), and (4) of section IV~~ and the effects of the ~~Safe Shutdown Earthquake~~ vibratory ground **motion determined** in Paragraph V(b).

(3) Cooling water supply. Assurance of **an** adequate cooling water supply for emergency and long-term shutdown decay heat removal shall be considered in the design of the nuclear power plant, taking ~~in to~~ into account information concerning the physical properties of the materials underlying the site, ~~developed pursuant to paragraphs (a)(1), (3), and (4) of section IV and~~ the effects of the Safe Shutdown Earthquake **Ground Motion**, and the design basis for **tectonic and nontectonic** surface **deformation** ~~faulting~~. Consideration of river blockage or diversion or other failures ~~which~~ that may block the flow of cooling water, coastal uplift or subsidence, ~~or~~ tsunami runup and drawdown, and failure of dams and intake structures shall be included in the evaluation, where appropriate.

(4) Distant structures. Those structures ~~which~~ that are not located in the immediate vicinity of the site but ~~which~~ are safety-related shall be designed to withstand the effect of the Safe Shutdown Earthquake Ground Motion. ~~and the~~ The design basis for surface faulting **shall be** determined on a basis comparable ~~basis~~ to that of the nuclear power plant, taking into account the material underlying the structures and the different location with respect to that of the site.

VI. APPLICATION TO ENGINEERING DESIGN

~~(a) Vibratory ground motion~~

~~(1) Safe Shutdown Earthquake. The vibratory ground motion produced by the Safe Shutdown Earthquake shall be defined by response spectra corresponding to the maximum vibratory accelerations at the elevations of the foundations of the nuclear power plant structures determine pursuant to paragraph (a)(1) of section V. The response spectra shall relate the response of the foundations of the nuclear power plant structures to the vibratory ground motion, considering such foundations to be single degree of freedom damped oscillators and neglecting soil structure interaction effects. In view~~

~~of the limited data available on vibratory ground motions of strong earthquakes, it usually will be appropriate that the response spectra be smoothed design spectra developed from a series of response spectra related to the vibratory motions caused by more than one earthquake.~~

~~The nuclear power plant shall be designed so that, if the Safe Shutdown Earthquake occurs, certain structures, systems, and components will remain functional. These structures, systems, and components are those necessary to assure (i) the integrity of the reactor coolant pressure boundary, (ii) the capability to shut down the reactor and maintain it in a safe condition, or (iii) the capability to prevent or mitigate the consequences of accidents which could result in potential offsite exposures comparable to the guideline exposures of this part. In addition to seismic loads, including aftershocks, applicable concurrent functional and accident induced loads shall be taken into account in the design of these safety related structures, systems, and components. The design of the nuclear power plant shall also take into account the possible effects of the Safe Shutdown Earthquake on the facility foundations by ground disruption, such as fissuring, differential consolidation, cratering, liquefaction, and landsliding, as required in paragraph (d) of section V.~~

~~The engineering method used to insure that the required safety functions are maintained during and after the vibratory ground motion associated with the Safe Shutdown Earthquake shall involve the use of either a suitable dynamic analysis or a suitable qualification test to demonstrate that structures, systems and components can withstand the seismic and other concurrent loads, except where it can be demonstrated that the use of an equivalent static load method provides adequate conservatism.~~

~~The analysis or test shall take into account soil structure interaction effects and the expected duration of vibratory motion. It is permissible to design for strain limits in excess of yield strain in some of these safety related structures, systems, and components during the Safe Shutdown Earthquake and under the postulated concurrent conditions, provided that the necessary safety functions are maintained.~~

~~(2) Operating Basis Earthquake. The Operating Basis Earthquake shall be defined by response spectra. All structures, systems, and components of the nuclear power plant necessary for continued operation without undue risk to the health and safety of the public shall be designed to remain functional and within applicable stress and deformation limits when subjected to the effects~~

of the vibratory motion of the Operating Basis Earthquake in combination with normal operating loads. The engineering method used to insure that these structures, systems, and components are capable of withstanding the effects of the Operating Basis Earthquake shall involve the use of either a suitable dynamic analysis or a suitable qualification test to demonstrate that the structures, systems and components can withstand the seismic and other concurrent loads, except where it can be demonstrated that the use of an equivalent static load method provides adequate conservatism. The analysis or test shall take into account soil structure interaction effects and the expected duration of vibratory motion.

(3) Required Seismic instrumentation. Suitable instrumentation shall be provided so that the seismic response of nuclear power plant features important to safety can be determined promptly to permit comparison of such response with that used as the design basis. Such a comparison is needed to decide whether the plant can continue to be operated safely and to permit such timely action as may be appropriate.

These criteria do not address the need for instrumentation that would automatically shut down a nuclear power plant when an earthquake occurs which exceeds a predetermined intensity. The need for such instrumentation is under consideration.

(b) Surface Faulting.

(1) If the nuclear power plant is to be located within the zone requiring detailed faulting investigation, a detailed investigation of the regional and local geologic and seismic characteristics of the site shall be carried out to determine the need to take into account surface faulting in the design of the nuclear power plant. Where it is determined that surface faulting need not be taken into account, sufficient data to clearly justify the determination shall be presented in the license application.

(2) Where it is determined that surface faulting must be taken into account, the applicant shall, in establishing the design basis for surface faulting on a site take into account evidence concerning the regional and local geologic and seismic characteristics of the site and from any other relevant data.

(3) The design basis for surface faulting shall be taken into account in the design of the nuclear power plant by, providing reasonable assurance that in the event of such displacement during faulting, certain structures, systems, and components will remain functional. These structures, systems, and

components are those neccessary to assure (i) the integrity of the reactor coolant pressure boundary, (ii) the capability to shut down the reactor and maintain it in a safe shutdown condition, or (iii) the capability to prevent or mitigate the consequences of accidents which could result in potential offsite exposures comparable to the guideline exposures of this part. In addition to seismic loads, including aftershocks, applicable concurrent functional and accident induced loads shall be taken into account in the design of such safety features. The design provisions shall be based on an assumption that the design basis for surface faulting can occur in any direction and azimuth and under any part of the nuclear power plant unless evidence indicates this assumption is not appropriate, and shall take into account the estimated rate at which the surface faulting may occur.

(c) Seismically Induced Floods and Water Waves and Other Design Conditions.

The design basis for seismically induced floods and water waves from either locally or distantly generated seismic activity and other design conditions determined pursuant to paragraphs (c) and (d) of section V, shall be taken into account in the design of the nuclear power plant so as to prevent undue risk to the health and safety of the public.

Pursuant to the seismic and geologic design basis requirements of paragraphs V(a) through (f), applications to engineering design are contained in Appendix S to Part 50 of this chapter for the following areas:

(a) Vibratory ground motion.

(1) Safe Shutdown Earthquake Ground Motion.

(2) Operating Basis Earthquake.

(3) Required Plant Shutdown.

(4) Required Seismic Instrumentation.

(b) Surface Tectonic Deformation.

(c) Seismically Induced Floods and Water Waves and Other Design Conditions.

Figure 1 Diagrammatic Illustration of Delineation of Width of Zone Requiring Detailed Faulting Investigations For Specific Nuclear Power Plant Location.

~~(Sec. 201, Pub. L. 93 - 438, 88 Stat. 1243 (42 U.S.C. 5841))~~
~~[38 FR 31281, Nov. 13, 1973, as amended at 38 FR 32575, Nov. 27, 1973; 42 FR 2052, Jan. 10, 1977]~~

10 CFR PART 50, APPENDIX S

COMPARATIVE TEXT

Appendix S To Part 50 - EARTHQUAKE ENGINEERING CRITERIA FOR NUCLEAR POWER PLANTS

GENERAL INFORMATION

This appendix applies to applicants who apply for a design certification or combined license pursuant to Part 52 of this chapter, or a construction permit or operating license pursuant to Part 50 of this chapter on or after [EFFECTIVE DATE OF THIS REGULATION]. However, if the construction permit was issued prior to [EFFECTIVE DATE OF THIS REGULATION], the operating license applicant shall comply with the earthquake engineering criteria in Section VI of Appendix A to Part 100 of this chapter.

2nd ¶ removed

I. INTRODUCTION

Each applicant for a construction permit, operating license, design certification, or combined license is required by §50.34(a)(12), §50.34(b)(10), and General Design Criterion 2 of Appendix A to this Part to design nuclear power plant structures, systems, and components important to safety to withstand the effects of natural phenomena, such as earthquakes, without loss of capability to perform their safety functions. Also, a condition of all operating licenses for nuclear power plants, as specified in §50.54(ee), is plant shutdown if the criteria in Paragraph IV(a)(3) of this appendix are exceeded.

These criteria implement General Design Criterion 2 insofar as it requires structures, systems, and components important to safety to withstand the effects of earthquakes.

II. SCOPE

The evaluations described in this appendix are within the scope of investigations permitted by §50.10(c)(1) of this chapter.

III. DEFINITIONS

As used in these criteria:

(a) The "Safe Shutdown Earthquake Ground Motion (SSE)" is ~~that earthquake which is based upon an evaluation of the maximum earthquake potential considering the regional and local geology and seismology and specific characteristics of local subsurface material. It is that earthquake which produces~~ the ~~maximum~~ vibratory ground motion for which certain structures, systems, and components ~~are~~ shall be 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 in a safe shutdown condition, or~~

~~(3) The capability to prevent or mitigate the consequences of accidents which could result in potential offsite exposures comparable to the guideline exposures of this part.~~

(b) The structures, systems, and components required to withstand the effects of the Safe Shutdown Earthquake Ground Motion or surface deformation 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 in a safe shutdown condition, or

(3) The capability to prevent or mitigate the consequences of accidents which could result in potential offsite exposures comparable to the guideline exposures of §50.34(a)(1) of this chapter.

(c) The "Operating Basis Earthquake Ground Motion (OBE)" is ~~that earthquake which, considering the regional and local geology and seismology and specific characteristics of local subsurface material, could reasonably be expected to affect the plant site during the operating life of the plant; it is that earthquake which produces~~ the vibratory ground motion for which those features of the nuclear power plant necessary for continued operation without undue risk to the health and safety of the public ~~are designed to~~ will remain functional. The value of the Operating Basis Earthquake Ground Motion is lower than the Safe Shutdown Earthquake Ground Motion and is set by the applicant.

(d) A "response spectrum" is a plot of the maximum responses (acceleration, velocity, or displacement) of a family of idealized single-degree-of-freedom ~~damped~~ oscillators ~~against~~ as a function of the natural frequencies ~~(or periods)~~ of the oscillators for a given damping value. The response spectrum is calculated for ~~to~~ a specified vibratory motion input at the~~ir~~ oscillators supports.

(e) Surface deformation is distortion of soils or rocks at or near ground surface by the processes of folding, faulting, compression, or extension as a result of various earth forces. Tectonic surface deformation is associated with earthquake processes.

(f) Combined license or design certification, as defined in Part 52 of this chapter.

IV. APPLICATION TO ENGINEERING DESIGN

The following are pursuant to the seismic and geologic design basis requirements of paragraphs V(a) through (f) of Appendix B to Part 100 of this chapter:

(a) **~~Vibration~~ Vibratory Ground Motion**

(1) **Safe Shutdown Earthquake Ground Motion**. The ~~vibratory ground motion produced by the~~ Safe Shutdown Earthquake Ground Motion shall be ~~defined~~ characterized by ~~derived from a~~ free-field ground motion response spectra at the free ground surface or hypothetical rock outcrop, as appropriate. ~~corresponding to the maximum vibratory accelerations at the elevations of the foundations of the nuclear power plant structures determine pursuant to paragraph (a)(1) of section V. The response spectra shall relate the response of the foundations of the nuclear power plant structures to the vibratory ground motion, considering such foundations to be single degree of freedom damped oscillators and neglecting soil structure interaction effects.~~ In view of the limited data available on vibratory ground motions of strong earthquakes, it usually will be appropriate that the design response spectra be smoothed ~~design~~ spectra developed from ~~a series~~ an ensemble of response spectra related to the vibratory motions caused by more than one earthquake. As a minimum, the horizontal Safe Shutdown Earthquake Ground Motion at the foundation level of the structures shall be an appropriate response spectrum with a peak ground acceleration of at least 0.1g.

The nuclear power plant shall be designed so that, if the Safe Shutdown Earthquake Ground Motion occurs, certain structures, systems, and components will remain functional and within applicable stress and deformation limits. ~~These structures, systems, and components are those necessary to assure (i)~~

~~the integrity of the reactor coolant pressure boundary, (ii) the capability to shut down the reactor and maintain it in a safe condition, or (iii) the capability to prevent or mitigate the consequences of accidents which could result in potential offsite exposures comparable to the guideline exposures of this part.~~ In addition to seismic loads,~~ including aftershocks,~~ applicable concurrent normal operating, functional, and accident-induced loads shall be taken into account in the design of these safety-related structures, systems, a components. The design of the nuclear power plant shall also take into account the possible effects of the Safe Shutdown Earthquake Ground Motion on the facility foundations by ground disruption, such as fissuring, lateral spreads, differential ~~consolidation~~ settlement, ~~cratering,~~ liquefaction, and landsliding, as required in ~~paragraph (d) of Section V.~~ Paragraph V(f) of Appendix B to Part 100 of this chapter.

The ~~engineering method used to insure that the~~ required safety functions of structures, systems, and components shall be ~~are maintained~~ assured during and after the vibratory ground motion associated with the Safe Shutdown Earthquake Ground Motion through ~~shall involve the use of either a suitable dynamic analysis~~ design, testing, or ~~a suitable~~ qualification ~~test~~ methods. ~~to demonstrate that structures, systems and components can withstand the seismic and other concurrent loads, except where it can be demonstrated that the use of an equivalent static load method provides adequate conservatism .~~

The ~~analysis or test~~ evaluation shall take into account soil-structure interaction effects and the expected duration of vibratory motion. It is permissible to design for strain limits in excess of yield strain in some of these safety-related structures, systems, and components during the Safe Shutdown Earthquake Ground Motion and under the postulated concurrent ~~conditions~~ loads, provided ~~that~~ the necessary safety functions are maintained.

(2) **Operating Basis Earthquake Ground Motion**.

(i) ~~The Operating Basis Earthquake shall be defined by response spectra.~~ When subjected to the effects of the Operating Basis Earthquake Ground Motion in combination with normal operating loads, ~~All~~ all structures, systems, and components of the nuclear power plant necessary for continued operation without undue risk to the health and safety of the public shall ~~be designed to~~ remain functional and within applicable stress and deformation limits. ~~when subjected to the effects of the vibratory motion of the Operating Basis Earthquake in combination with normal operating loads. The engineering method used to insure that these structures, systems, and components are capable of~~

~~withstanding the effects of the Operating Basis Earthquake shall involve the use of either a suitable dynamic analysis or a suitable qualification test to demonstrate that the structures, systems and components can withstand the seismic and other concurrent loads, except where it can be demonstrated that the use of an equivalent static load method provides adequate conservatism. The analysis or test shall take into account soil structure interaction effects and the expected duration of vibratory motion.~~

(ii) The Operating Basis Earthquake Ground Motion shall be characterized by response spectra. The value of the Operating Basis Earthquake Ground Motion shall be set to one of the following choices:

(A) One-third of the Safe Shutdown Earthquake Ground Motion. The requirements associated with this Operating Basis Earthquake Ground Motion in (i) can be satisfied without the applicant performing explicit response or design analyses, or

(B) A value greater than one-third of the Safe Shutdown Earthquake Ground Motion. Analysis and design shall be performed to demonstrate that the requirements associated with this Operating Basis Earthquake Ground Motion in (i) are satisfied. The design shall take into account soil-structure interaction effects and the expected duration of vibratory ground motion.

(3) **Required Plant Shutdown.**[1] If vibratory ground motion exceeding that of the Operating Basis Earthquake Ground Motion or significant plant damage occurs, the licensee must shutdown ~~of~~ the nuclear power plant ~~will be required~~. Prior to resuming operations, the licensee ~~will be required to~~ shall demonstrate to the Commission that no functional damage has occurred to those features necessary for continued operation without undue risk to the health and safety of the public.

(4) **Required Seismic Instrumentation**. Suitable instrumentation shall be provided so that the seismic response of nuclear power plant features important to safety can be ~~determined~~ evaluated promptly after an earthquake. ~~to permit comparison of such response with that used as the design basis. Such a comparison is needed to decide whether the plant can continue to be operated safely and to permit such timely action as may be appropriate.~~

~~These criteria do not address the need for instrumentation that would~~

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1 Guidance is being developed in Draft Regulatory Guide DG-1017, "Pre-Earthquake Planning and Immediate Nuclear Power Plant Operator Post-Earthquake Actions."

~~automatically shut down a nuclear power plant when an earthquake occurs which exceeds a predetermined intensity. The need for such instrumentation is under consideration.~~

(b) Surface ~~Faulting~~ Deformation.

~~(1) If the nuclear power plant is to be located within the zone requiring detailed faulting investigation, a detailed investigation of the regional and local geologic and seismic characteristics of the site shall be carried out to determine the need to take into account surface faulting in the design of the nuclear power plant. Where it is determined that surface faulting need not be taken into account, sufficient data to clearly justify the determination shall be presented in the license application.~~

~~(2) Where it is determined that surface faulting must be taken into account, the applicant shall, in establishing the design basis for surface faulting on a site take into account evidence concerning the regional and local geologic and seismic characteristics of the site and from any other relevant data.~~

~~(3)~~The ~~design basis~~ potential for surface ~~faulting~~ deformation shall be taken into account in the design of the nuclear power plant by providing reasonable assurance that in the event of such ~~displacement during faulting~~ deformation certain structures, systems, and components will remain functional. ~~These structures, systems, and components are those necessary to assure (i) the integrity of the reactor coolant pressure boundary, (ii) the capability to shut down the reactor and maintain it in a safe shutdown condition, or (iii) the capability to prevent or mitigate the consequences of accidents which could result in potential offsite exposures comparable to the guideline exposures of this part.~~ In addition to surface deformation induced loads, the design of such safety features shall take into account seismic loads, including aftershocks, and applicable concurrent functional and accident-induced loads. ~~shall be taken into account in the design of such safety features.~~ The design provisions ~~shall be based on an assumption that the design basis~~ for surface ~~faulting~~ deformation ~~can occur~~ shall be based on its postulated occurrence in any direction and azimuth and under any part of the nuclear power plant, unless evidence indicates this assumption is not appropriate, and shall take into account the estimated rate at which the surface ~~faulting~~ deformation may occur.

(c) Seismically Induced Floods and Water Waves and Other Design Conditions. ~~The design basis for s~~Seismically induced floods and water waves from either locally or distantly generated seismic activity and other design conditions determined pursuant to ~~paragraphs (c) and (d) of section V,~~ Paragraphs V(e) and (f) of Appendix B to Part 100 of this chapter shall be taken into account in the design of the nuclear power plant so as to prevent undue risk to the health and safety of the public.

DRAFT REGULATORY GUIDE DG-1015

SEISMIC SOURCES

SPECIFIC ISSUES FOR COMMENTS

The proposed guide, DG1015, outlines, for the first time, concepts and procedures to be used in conjunction with the probabilistic/deterministic seismic hazard analyses. Rationale for the approach is discussed in Section V.B.3 of the supplementary information of the accompanying federal register notice to this rule-making action.

The staff is currently performing confirmatory studies to evaluate and refine these proposed procedures. A limited study has been completed demonstrating the feasibility of procedures and the validity of the concepts. However, the staff would like to solicit comments on the concepts outlined in the proposed guide at this time. To facilitate the review, results of the application of the proposed procedure to four test sites are published separately (Letter report from D. Bernreuter of LLNL to A. Murphy of NRC).

There are some divergent views on the role probabilistic seismic hazard analysis should play in the licensing arena. Within the staff it appears that there is a general consensus that the revised seismic and geological siting criteria should allow considerations for a probabilistic hazard analysis. There is also a general belief that the probabilistic analysis should be calibrated against the past practices for siting and licensing the current generation of nuclear power plants. There is a general consensus that ground motions should be calculated using deterministic methods once the controlling earthquakes are determined. With regards to the role of the probabilistic analysis, views range from an advocacy of a predominantly probabilistic analysis to the probabilistic/deterministic dual approach proposed here to a predominantly deterministic approach as used currently. Given these divergent views, the staff would like to invite comments regarding the use of probabilistic seismic hazard analysis and balance between the deterministic and probabilistic analyses. This and other associated issues are itemized below. (As the detailed technical studies are completed some of the staff positions may be confirmed, but specific comments would be helpful at this time.)

1. Should both deterministic and probabilistic approaches be used in siting nuclear power plants? If both are used how should they be combined or weighted, i.e., should one control over the other?

2. If the dual probabilistic/deterministic approach as proposed in this draft guide is to be used, is the proposed procedure in Appendix C adequate to determine controlling earthquakes from a probabilistic analysis?

3. In determining the controlling earthquakes should the median values of the seismic hazard analysis be used to the exclusion of other statistical measures such as mean or 85th percentile?

   (The staff has selected probability of exceedance levels associated with the median hazard analysis estimates as they provide more stable estimates of controlling earthquakes.)

4. Should the median target level of 1E-4 for LLNL or 3E-5 for EPRI be raised or lowered, i.e., should the next generation of NPPs have design levels

for seismic events approximately equal to, greater than, or less than the current NPPs?

(The NRC has made a policy statement that stated the current NPPs are at the appropriate level of safety.)

5. For the probabilistic analysis, should and how many controlling earthquakes be generated to cover the frequency band of concern for NPPs?

   (For the four trial plants used to develop the criteria presented in this regulatory guide, the average of results for the 5 Hz and 10 Hz spectral velocities was used to establish the probability of exceedance level. Controlling earthquakes were evaluated for this frequency band, for the average of 1 and 2.5 Hz spectral responses, and for peak ground acceleration.)

DRAFT REGULATORY GUIDE DG-1015

IDENTIFICATION AND CHARACTERIZATION OF SEISMIC SOURCES, DETERMINISTIC SOURCE EARTHQUAKES AND GROUND MOTION

A. INTRODUCTION

Paragraph IV (a, b and c) of proposed Appendix B, "Criteria for the Seismic and Geologic Siting of Nuclear Power Plants after [Effective Date]," to 10 CFR Part 100, "Reactor Site Criteria," requires investigations to assess the proposed site for: (a) vibratory ground motion, (b) tectonic surface deformation and (c) non-tectonic deformation. Paragraph V(a through d) of Proposed Appendix B to 10 CFR Part 100 requires the determination of: (a) deterministic source earthquakes, (b) site ground motions, (c) safe shutdown earthquake ground motion and (d) the need to design for surface tectonic and non-tectonic deformations.

The purpose of this guide is to provide general guidance on acceptable procedures to (1) identify and characterize seismic sources, (2) determine deterministic source earthquakes (DSEs) and controlling earthquakes (CEs), and (3) compare the seismic hazard level to that at operating plants. These procedures are required by Appendix B to 10 CFR Part 100.

Any information collection activities mentioned in this regulatory guide are contained as requirements in the proposed amendments to 10 CFR Part 50 that would provide the regulatory basis for this guide. The proposed amendments have been submitted to the Office of Management and Budget for clearance that may be appropriate under the Paperwork Reduction Act. Such clearance, if obtained, would also apply to any information collection activities mentioned in this guide.

B. DISCUSSION

Appendix B requires consideration of both probabilistic and deterministic approaches to obtain site geologic and seismologic characteristics. The approach required by Appendix A to 10 CFR Part 100 for determining the safe shutdown earthquake ground motion is deterministic and, thus, does not explicitly incorporate uncertainties about the seismic hazard into the ground motion determination. Current probabilistic seismic hazard analyses rely heavily on expert opinion and their results are driven by the tails of the probability distributions, and, thus, need to be benchmarked by simpler deterministic analysis. Therefore the role of the probabilistic analysis is to ensure that the uncertainties have been included in the assessment of the seismic hazard and the role of the deterministic analysis is to ensure that the resultant design provides protection against a scenario based on historical seismicity and recent geological history.

Before providing specific guidance, the following synopsis of the development of the Safe Shutdown Earthquake Ground Motion (SSE) is presented. The development of the SSE follows two required, parallel paths. The first path is referred to in Figure 1 as Deterministic Analysis (DA) and the second path as Probabilistic

Analysis (PA). The initial step in the process is to obtain the site and region specific geological, seismological, and geophysical data. Branching from the first step to DA, the seismic sources around the site are identified and the deterministic source earthquake (DSE) for each source is determined. Ground motion is calculated using DSEs and the ground motion guidance provided in Standard Review Plan (SRP) Section 2.5.2. The controlling earthquakes for this path are determined as illustrated in Figure 2. The initial step along PA is to conduct an Electric Power Research Institute (EPRI) or a Lawrence Livermore National Laboratory (LLNL) seismic hazard assessment of the site (EPRI-NP-63950 and NUREG/CR-5250) for eastern U.S. sites. The results of this assessment are compared to the collected assessments of the currently operating plants as described in Appendix B of this guide. The site seismic hazard assessments are deaggregated as described in Appendix C of this guide to obtain the controlling earthquakes for PA. Ground motion based on the controlling earthquakes from PA are also calculated using the guidance in SRP 2.5.2. The ground motions from the DA and PA controlling earthquakes are compared to the SSE ground motion or are used to develop the SSE.

1. Identification and Characterization of Seismic Sources

"Seismic source" is a general term referring to both seismogenic sources and capable tectonic sources. A "seismogenic source" is a portion of the earth which is considered to have uniform seismicity (same DSE and frequency of recurrence). A seismogenic source would not cause surface displacement. Seismogenic sources cover a wide range of possibilities from a well-defined tectonic structure to simply a large region of diffuse seismicity (seismotectonic province). A "capable tectonic source" is a tectonic structure which can generate both earthquakes and deformation such as faulting or folding at or near the surface in the present tectonic regime. Appendix A contains definitions of these and other terms used in this regulatory guide.

Investigations of the site and region around the site are necessary to identify seismic sources and determine their potential for generating earthquakes and causing surface deformation. Identification and characterization of seismic sources is based on regional and site geological and geophysical data, historical and instrumental seismicity data, the regional stress field, and geologic evidence for prehistoric earthquakes. The bases for the identification of the seismic sources should be documented. Appendix D describes investigation procedures that may be used in identifying and defining seismic sources.

The following is a general list of characteristics to be determined for a seismic source:

a. Source zone geometry (location and extent, both surface and subsurface).

b. Description of Quaternary (last 2 million years) displacements (sense of slip on the fault, fault length and width, age of displacements, estimated displacement per event, estimated magnitude per offset, rupture length and area, and displacement history or uplift rates of seismogenic folds).

c. Historical and instrumental seismicity associated with each source.

d. Evidence of paleoseismicity.

e. Relationship of the fault to other potential seismic sources in the region.

f. Deterministic Source Earthquake. (Details for the determination of the DSEs are provided in section 2.)

g. Recurrence model (frequency of earthquake occurrence versus magnitude).

h. Effects of human activities such as withdrawal of fluid from or addition of fluid to the subsurface, extraction of minerals, or the effects of dams or reservoirs.

i. Volcanism. Volcanic hazard is not addressed in this regulatory guide. It will be considered on a case by case basis in regions where this hazard exists.

j. Other factors that can contribute to characterization of seismic sources such as strike and dip of tectonic structures, orientations of regional and tectonic stresses, fault segmentation (both along strike and down-dip), etc.

The level of detail for investigations around the site is governed by the Quaternary tectonic regime and the geological complexity of the site and region. Regional investigations such as geological reconnaissances and literature reviews should be conducted within a radius of 320 km (200 miles) of the site to identify seismic sources. Geological, seismological, and geophysical investigations should be carried out within a radius of 40 km (25 miles) to identify and characterize the seismic and surface deformation potential of capable tectonic sources and the seismic potential of seismogenic sources, or demonstrate that such structures are not present. Detailed geological, geotechnical, seismological, and geophysical investigations should be conducted within a radius of 8 km (5 miles) of the site to determine the potential for tectonic deformation at or near the ground surface in the site vicinity. Sites that are located such that there are capable and/or seismogenic structures within a radius of 40 km (25 miles) will require more extensive geologic and seismic investigations and analyses (similar to those within a 8 km (5 mile) radius). The areas of investigations may be asymmetrical and larger than specified above in areas near capable tectonic sources, high seismicity, or complex geology.

For the site and the area surrounding the site, the lithologic, stratigraphic, hydrologic and structural geologic conditions will need to be determined. The investigations should include the determination of the static and dynamic engineering properties of the materials underlying the site and an evaluation of physical evidence concerning the behavior during prior earthquakes of the surficial materials and the substrata underlying the site. The properties needed to determine the behavior of the underlying material during earthquakes and the characteristics of the underlying material in transmitting earthquake ground motions to the foundations of the plant (such as seismic wave velocities, density, water content, porosity, elastic modulii, and strength) should be determined. Geological, seismological and geophysical investigations are described in Appendix D to this guide and geotechnical investigations are described in Regulatory Guide 1.132.

Where it is determined that surface deformation need not be taken into account, sufficient data to clearly justify the determination should be presented. Because engineering solutions cannot always be demonstrated for the effects of permanent ground displacement phenomena, it is prudent to avoid a site when there is potential for surface deformation.

Eastern United States

The area east of the Rocky Mountains within the North American Plate and well away from the active plate margins is described as the "stable continental region" (SCR). In the SCR characterization of seismic sources is more problematic than in the active plate margin region because there is generally no clear association between seismicity and known tectonic structures. The observed geologic structures were generated in response to tectonic forces that no longer exist and bear little correlation with current tectonic forces. Thus, a greater amount of judgment must be used than for active plate margin regions, and it is important to account for this uncertainty by the use of alternative models.

Based on current knowledge, seismic sources in the SCR are generally relatively large areas, or seismotectonic provinces. The identification of seismic sources in the SCR should consider hypotheses presently accepted for the occurrence of earthquakes in the SCR (for example, the reactivation of favorably oriented zones of weakness or the local amplification and release of stresses concentrated around a geologic structure).

Western United States

For the active plate margin region, where earthquakes can often be correlated with tectonic structures, those structures should be assessed for their seismic and surface deformation potential. In the western U.S., at least three types of sources exist: (1) faults that are known at the surface, (2) buried (blind) sources and, (3) subduction zone sources, such as exist in the Pacific Northwest. The nature of surface faults can be determined by conventional surface and near surface investigation techniques to determine strike, geometry, sense of displacements, length of rupture, Quaternary history, etc.

Buried (blind) faults are often accompanied by coseismic surficial deformation such as folding, uplift or subsidence. The surface expression of blind faulting can be detected by the mapping of uplifted or down-dropped geomorphological features or stratigraphy, survey leveling and geodetic methods. The nature of the structure at depth can often be determined by core borings and geophysical techniques.

Subduction zones are seismic sources in the Pacific Northwest and Alaska. The seismic sources associated with subduction zones are the interface between the subducting and overriding lithospheric plates and intraslab sources in the interior of the downgoing oceanic slab. The characterization of subduction zone seismic sources should include consideration of the following: geometry of the subducting plate, rupture segmentation of subduction zones, geometry of historical ruptures, constraints on the up-dip and down-dip extent of rupture, and comparisons with other subduction zones worldwide.

NUREG-XXXX provides a list of references that may be useful in characterizing seismic sources.

2. Deterministic Source Earthquakes (DSEs)

DSEs are the largest earthquakes that can reasonably be expected to occur in a given seismic source in the current tectonic regime. Deterministic source earthquakes are characterized by their magnitudes and, as a minimum, will be the largest historical earthquake associated with each source. A larger earthquake is warranted in cases where specific geological evidence is available, e.g., paleoliquefaction evidence of larger prehistoric earthquakes or where the rate of occurrence of earthquakes indicates the likelihood of larger than the largest historical event.

Eastern United States

In the SCR there is a short record of the historical seismicity and considerable uncertainty about the underlying causes of earthquakes. Because of this uncertainty, it is necessary to use considerable judgment and a variety of approaches to establish the DSEs. In addition to the maximum historical earthquake, the determination of the DSE earthquake for each identified seismogenic source is based on the pattern and rate of seismic activity, the Quaternary (2-million years and younger) development and characteristics of the source, the current stress regime and how it aligns with the known tectonic structures in the source, and paleoseismic data.

Western United States

In the Western U.S., earthquakes can often be associated with tectonic structures. For faults, the magnitude of an earthquake is related to the characteristics of the estimated rupture such as the length or the amount of fault displacement. The following empirical correlations can be used to estimate DSE's from fault behavioral data and also to predict the amount of displacement that might be expected for a given magnitude.

a. Surface rupture length versus magnitude (Slemmons, 1977, 1982; Bonilla and others, 1984; and Wesnousky, 1988).

b. Subsurface rupture length versus magnitude (Wells and others, 1989).

c. Rupture area versus magnitude (Wyss, 1979).

d. Maximum and average displacement versus magnitude (Wells and Coppersmith, in review).

In the Pacific Northwest and Alaska, DSE's must be assessed for subduction zone seismic sources. Worldwide observations indicate that the largest earthquakes are associated with the plate interface, although intraslab earthquakes (e.g., the 1949 Puget Sound earthquake) can also be large. DSEs for subduction zone sources can be based on estimates of the expected dimensions of rupture or analogies to other subduction zones worldwide.

NUREG-XXXX contains a list of references, some of which may be useful in developing maximum earthquakes using deterministic methodologies.

3. Probabilistic Seismic Hazard Analysis

A probabilistic seismic hazard analysis (PSHA) should be carried out for the site. A PSHA allows the use of multi-valued models to estimate the likelihood of earthquake ground motions occurring at a site. The PSHA systematically takes into account uncertainties which exist in various parameters (such as seismic sources, maximum earthquakes, and ground motion attenuation). Alternate hypotheses are considered in a quantitative fashion. The PSHA can be used to determine the effects of varying significant parameters, identify significant sources in terms of magnitude and distance, and provide hazard estimates for use in seismic probabilistic risk assessments.

The results of a PSHA are specifically used to derive controlling earthquakes as discussed in Section 4 below and Appendix C. It can also be used to estimate the probability of exceeding the SSE and demonstrate that the probability of exceeding the SSE design ground motion at the site compares favorably with that for the currently operating nuclear power plants. (The procedure for this demonstration is described in Appendix B.)

Either the Lawrence Livermore National Laboratory (LLNL) (NUREG/CR-5250) or Electric Power Research Institute (EPRI) (EPRI-NP-6395-D) seismic hazard analyses, including associated data bases, should be used for plant sites in the SCR. However, alternative seismic hazard analyses may be used with proper justification. For the PSHA, the use of the seismic sources identified in the LLNL and EPRI studies are considered acceptable except in regions of the SCR with high activity rates, e.g., near New Madrid and Charleston. In these cases, either describe additional site specific seismic sources or show that the regional seismic sources in the LLNL and EPRI probabilistic studies adequately model the tectonics in the vicinity of the site.

Probabilistic methodologies similar to the LLNL and EPRI seismic hazard studies have not been performed for the western U.S. For western U.S. sites, a site specific PSHA must be performed and documented in such detail that a thorough review can be carried out by the NRC staff (PG&E, 1988; NUREG-0675; WPPSS, 1988).

4. Controlling Earthquakes

Controlling earthquakes are those earthquakes that have the greatest effect on the ground motion at the nuclear power plant site. There may be several controlling earthquakes for a site, e.g., a moderate, near earthquake may control the high frequency portion of the ground motion spectrum and a large, distant earthquake may control the low frequency portion of the spectrum. See Figure 2.

In the Deterministic Analysis (Figure 1.), the controlling earthquakes are determined via the following procedure.

a. For each seismic source, place the DSE at the closest approach of that source to the site. For the seismic source in which the site is located, the DSE should be considered to occur at about 15 km from the site.

b. Determine the DSEs that produce the largest ground motions at the site. Ground motions at the site from DSEs are estimated using the procedures described in Standard Review Plan Section 2.5.2 (Vibratory Ground Motion). The earthquakes producing the largest ground motions at the site are the controlling earthquakes.

In the Probabilistic Analysis (Figure 1), the controlling earthquakes are determined via the following procedure.

a. Perform a probabilistic seismic hazard analysis for the site. The analysis will develop uniform hazard spectra at several probabilities of exceedance.

b. Deaggregate the probabilistic seismic hazard results to identify controlling earthquakes; their description includes magnitude and distance from the site (Appendix C). This deaggregation should be done at the probability of exceedance level discussed in Appendix B.

The controlling earthquakes thus derived from the deterministic and probabilistic analyses can be compared at this stage to determine if the controlling earthquakes from these two approaches are similar and also to determine if the controlling earthquake(s) which will dominate the ground motion estimates at the site is (are) easily identifiable. If the dominant controlling earthquake(s) can be identified, the ground motions are determined only for this identified controlling earthquake(s). If the controlling earthquakes from the two approaches are dissimilar, then ground motion estimates are made for various controlling earthquakes and compared to derive the final ground motion estimates for use in establishing the SSE ground motion or comparing it with the SSE ground motion.

C. REGULATORY POSITION

1. During the site selection phase, preferred sites are those where there is a minimum likelihood of surface or near surface deformation or the occurrence of earthquakes on faults in the site vicinity (within a radius of 8 km (5 miles)). Because of the uncertainties and difficulties in mitigating the effects of permanent ground displacement phenomena such as surface faulting or folding, fault creep, subsidence or collapse, the NRC staff considers it prudent to select an alternate site when the potential for permanent ground displacement exists at the site.

2. Regional investigations such as geological reconnaissances and literature reviews should be conducted within a radius of 320 km (200 miles) of the site to identify seismic sources.

3. Geological, sei[illegible]gical, and geophysical investigation should be carried out within a ra[illegible]s of 40 km (25 miles) to identify and characterize the seismic potential of capable tectonic and seismogenic sources or demonstrate that such structures are not present.

4. Detailed geological, geotechnical, seismological, and geophysical investigations should be conducted within a radius of 8 km (5 miles) of the site to determine the potential for tectonic deformation at or near the ground surface in the site vicinity. Geological, seismological and geophysical investigations are described in Appendix D and geotechnical investigations are described in Regulatory Guide 1.132.

5. Sites that are located such that there are capable and/or seismogenic faults within a radius of 40 km (25 miles) will require more extensive geologic and seismic investigations and analyses (similar to those within a 8 km (5 mile) radius). The area of investigation may be asymmetrical and extend beyond 40 km (25 miles).

6. Seismic sources should be identified and characterized using the information developed by the investigations. Alternative seismic sources should be developed to incorporate a range of interpretations and the bases for the identification of these sources should be documented. Source zone geometry should be defined for each seismic source. For faults, the type of slip, length of rupture, amount of displacement per maximum event, and area of the rupture surface should be determined.

7. Deterministic Source Earthquakes, which are the best judgment of the maximum earthquake that can reasonably be expected to occur in a given seismic source should be defined for each seismic source.

8. Perform a probabilistic seismic hazard analysis (PSHA) for the site to estimate the probability of exceeding the SSE. Either the LLNL or EPRI probabilistic seismic hazard analyses with associated data bases should be used for plants in the eastern United States. For western plants, a site-specific probabilistic seismic hazard study should be performed. Use the PSHA to identify sources in terms of magnitude and distance that contribute significantly to the seismic hazard at the site.

9. Determine the Ces that produce the largest ground motions at the site. Ground motions at the site from CE's are estimated using the procedures described in Section 4 of this guide and Standard Review Plan Section 2.5.2 (Vibratory Ground Motion).

D. IMPLEMENTATION

The purpose of this section is to provide guidance to applicants and licensees regarding the NRC staff's plans for using this regulatory guide.

This draft guide has been released to encourage public participation in its development. Except in those cases in which the applicant proposes an acceptable alternative method for complying with the specified portions of the Commission's regulations, the method to be described in the active guide reflecting public comments will be used in the evaluation of applications for a construction permit, operating license, early site permit, or combined license submitted after the implementation date to be specified in the active guide. This guide would not be used in the evaluation of an application for an operating license submitted after the implementation date to be specified in the active guide if the construction permit was issued prior to that date.

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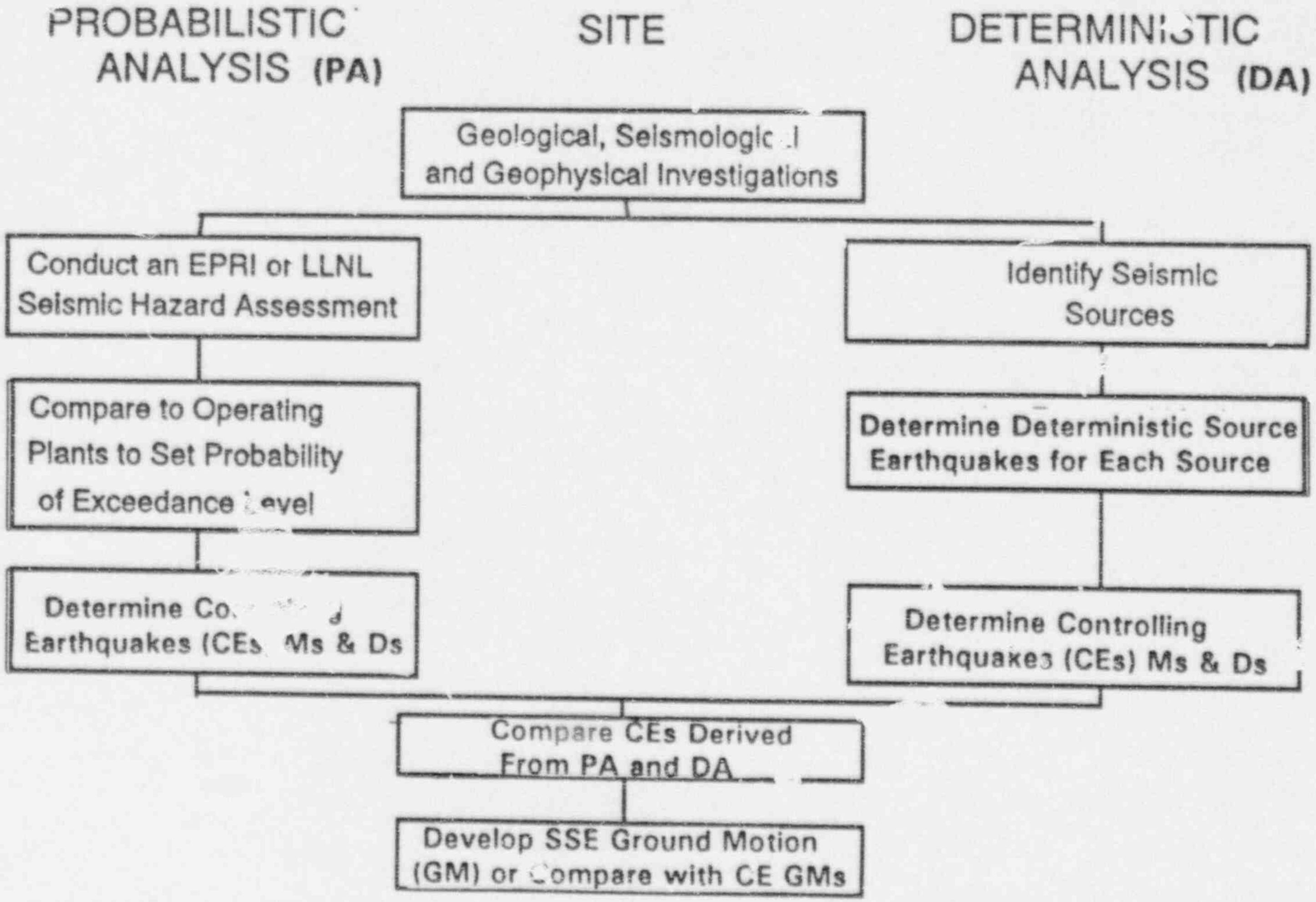

Figure 1. Flow chart for determination of the SSE in the eastern U.S.

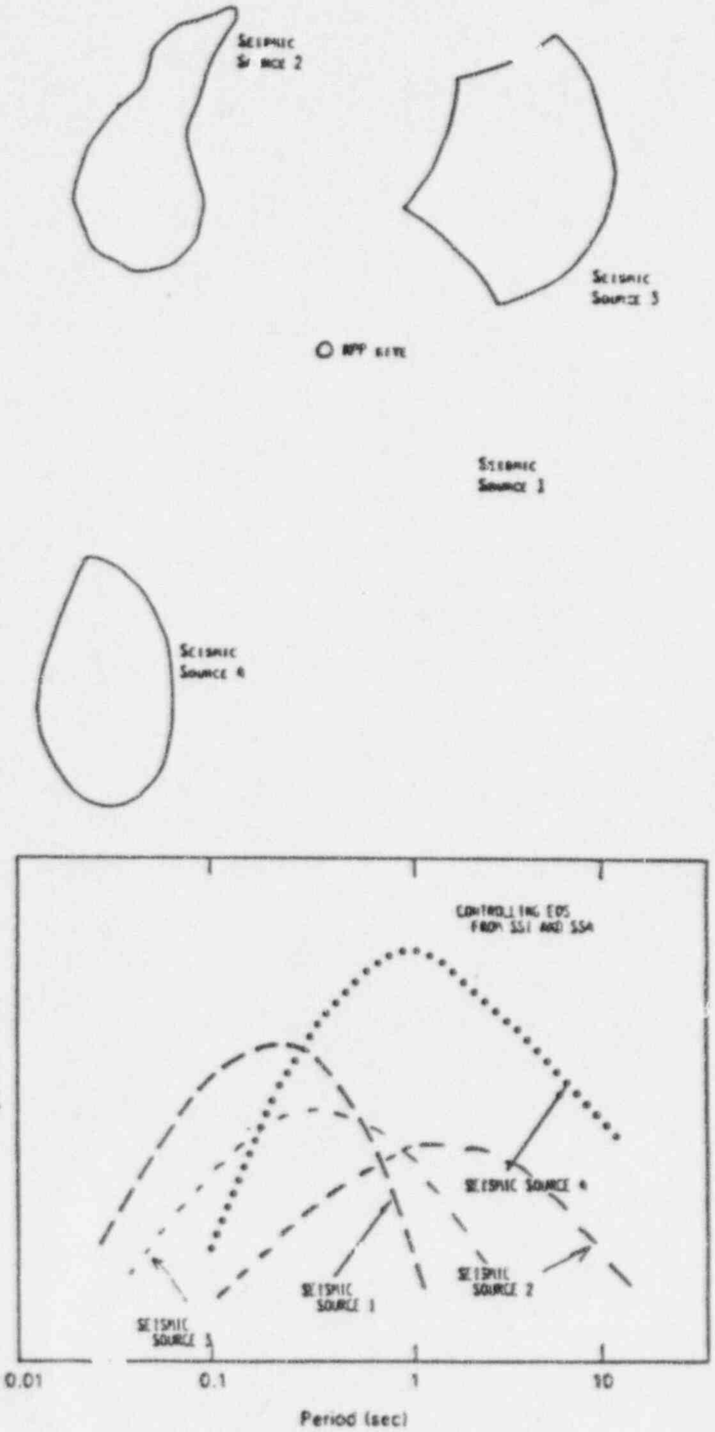

Figure 2. Schematic representation of the determination of the controlling earthquakes for the deterministic analysis path.

Definitions

Seismic Source

A "seismic source" is a general term referring to both seismogenic sources and capable tectonic sources.

Seismogenic Source

A "seismogenic source" is a portion of the earth that has uniform earthquake potential (same expected maximum earthquake and frequency of recurrence) distinct from the surrounding area. A seismogenic source will not cause surface displacement. Seismogenic sources cover a wide range of possibilities from a well-defined tectonic structure to simply a large region of diffuse seismicity (seismotectonic province) thought to be characterized by the same earthquake recurrence model. A seismogenic source is also characterized by its involvement in the current tectonic regime as reflected in the Quaternary (approximately the last 2 million years).

Capable Tectonic Source

A "capable tectonic source" is a tectonic structure which can generate both earthquakes and tectonic surface deformation such as faulting or folding at or near the surface in the present seismotectonic regime. It is characterized by at least one of the following characteristics:

a. Presence of surface or near surface deformation of landforms or geologic deposits of a recurring nature within the last approximately 500,000 years or at least once in the last approximately 50,000 years.

b. A reasonable association with one or more large earthquakes or sustained earthquake activity which are usually accompanied by significant surface deformation.

c. A structural association with a capable tectonic source having characteristics (a) of this paragraph such that movement on one could be reasonably expected to be accompanied by movement on the other.

In some cases, the geologic evidence of past activity at or near the ground surface along a particular capable tectonic source may be obscured at a particular site. This might occur, for example, at a site having a deep overburden. For these cases, evidence may exist elsewhere along the structure from which an evaluation of its characteristics in the vicinity of the site can be reasonably based. Such evidence shall be used in determining whether the structure is a capable tectonic source within this definition.

Notwithstanding the foregoing paragraphs, structural association of a structure with geologic structural features which are geologically old (at least pre-Quaternary) such as many of those found in the eastern region of the United States shall, in the absence of conflicting evidence, demonstrate that the structure is not a capable tectonic source within this definition.

Deterministic Source Earthquake (DSE)

A DSE is the largest earthquake that can reasonably be expected to occur in a given seismic source in the current tectonic regime, and is used in a deterministic analysis. It is generally based on the maximum historical earthquake associated with that seismic source, unless recent geological evidence warrants a larger earthquake, or where the rate of occurrence of earthquakes indicates the likelihood of larger than the largest historical event.

Controlling Earthquakes (CE)

Controlling Earthquakes are the earthquakes which produce the largest ground motions estimated at the site. There may be several Ces for a site.

Stable Continental Region

A "stable continental region" (SCR) is comprised of continental crust, including continental shelves, slopes and attenuated continental crust and excludes active plate boundaries and zones of currently active tectonics directly influenced by plate margin processes. It exhibits no significant deformation associated with the major Mesozoic-to-Cenozoic (last 240 million years) orogenic belts. It excludes major zones of Neogene (last 25 million years) rifting, volcanism or suturing.

Safe Shutdown Earthquake

The Safe Shutdown Earthquake Ground Motion is the vibratory ground motion for which certain structures, systems, and components shall be designed to remain functional.

Intensity

The intensity of an earthquake is a measure of its effects on humans, human-built structures, and on the earth's surface at a particular location. Intensity is described by a numerical value on the Modified Mercalli scale.

Tectonic Structure

A tectonic structure is a large-scale dislocation or distortion usually within the earth's crust. Its extent is on the order of miles.

Magnitude

An earthquake magnitude is a measure of the strength of an earthquake as determined by seismographic observations.

Nontectonic Deformation

Nontectonic deformation is distortion of surface or near surface soils or rocks that is not directly attributable to tectonic activity. Such deformation includes features associated with subsidence, karst terrane, glaciation or deglaciation, and growth faulting.

Appendix B to Regulatory Guide DG - 1015

Probabilistic Comparison of Safe Shutdown Earthquake to Operating Plants

B.1 Introduction

This appendix outlines a procedure to calculate the probability of exceeding the Safe Shutdown Earthquake Ground Motion (SSE). This procedure can be used (1) to compare the calculated probability of exceeding the SSE to those for the currently operating plants as required by Appendix B to 10 CFR Part 100; and (2) to establish controlling earthquakes in the probabilistic hazard analysis as discussed in Appendix C to this regulatory guide. Uniform hazard spectra (spectra that have a uniform probability of exceedance over the frequency range of interest) should be calculated to estimate the probability of exceeding the SSE design response spectrum.

B.2 Procedure

The following procedure is one acceptable approach to assure that the probability of exceeding the SSE compares favorably with that for the currently operating nuclear power plants as of [date].

B.2.1 Eastern U.S. Sites.

There are two state-of-the-art approaches (EPRI NP-6395-D, 1989 and NUREG/CR-5250, 1989) currently available to calculate the probabilistic seismic hazard for sites east of the Rocky mountains (Eastern U.S.). These approaches, however, produce different hazard estimates for a given site. Therefore, the staff is recommending the following interim procedure until the differences between the two hazard methods are resolved. This procedure relies on relative measures to assure that the annual probability of exceeding the SSE is comparable to that of operating plants. The procedure is based on studies conducted for the Eastern Seismicity Issue and the IPEEE program (NUREG-1407, 1990). Either the LLNL or EPRI methodology can be used to carry out the following calculations, with the appropriate set of limits associated with each method. If any analysis other than the LLNL or EPRI methods is used in the eastern U.S., probabilities of exceeding the SSE would need to be developed for all operating plant sites in addition to the site under consideration in order to make the appropriate comparison.

Step 1. Calculate Uniform Hazard Response Spectra (UHRS) with various return periods. Figure B.1 shows a sample set of median UHRS for various return periods. The UHRS should be developed at the same location as the location of the SSE (i.e. either at the free ground surface or at a hypothetical rock outcrop).

Step 2. Calculate composite annual probabilities of exceeding the SSE and compare those probabilities with operating plants using median hazard estimates. (Although the median estimates are used for the purpose of the carrying out the procedure outlined in this appendix, the hazard analysis should be performed with consideration of uncertainties to develop complete insights.) The procedure is illustrated in Figure B.2.

(a) Estimate the annual probabilities of exceeding the SSE spectrum at two discrete frequencies (5 and 10 Hz) using the UHRS.

(b) Calculate the composite annual probability using the following formula:

Composite Probability = 1/2(a1) + 1/2(a2)

where a1 and a2 represent annual probabilities of exceeding SSE spectral ordinates at 5 and 10 Hz, respectively.

<u>Example</u>: From Figure B.2, for a median UHRS derived using the LLNL methodology, at points a1 and a2 corresponding to 5 and 10 Hz:

Composite Probability = 1/2(4E-5) + 1/2(8E-5)
= 6E-5.

(c) Figure B.3 shows the distribution of median probabilities of exceeding SSEs for op[illegible]ing Eastern U.S. plants using LLNL hazard estimates. T[illegible]s figure also indicates a limit; approximately 50% of the currently operating plants have a probability of exceeding the SSE ground motion below this limit. (Limits [illegible]r both the current EPRI and LLNL seismic hazard studies are listed in Table B.1.) The SSE is adequate when the probability of exceeding the SSE compares favorably to the limits shown in these figures.

<u>Table B.1</u>

Method	Probability of Exceedance Limits for Median Hazard Estimates
LLNL	1E-4
EPRI	3E-5

For the hypothetical exampl[illegible] the calculated probability of exceedance of 6E-5 is less than the limit of 1E-4 and thus the probability of exceeding the SSE compares favorably with that of operating plants.

Figures B.4 presents the same information resulting from the use of the EPRI UHRS estimates. This limit should be used when the EPRI method is used to calculate the probability of exceeding the SSE.

B.2.2 Western U.S. Sites

For the Western U.S. (WUS) sites, a probabilistic data base, such as that compiled in the LLNL and EPRI studies, is not available. To date no procedure exists, similar to that described above, to compare the probability of exceeding the SSE to other sites in the WUS. In addition, the probabilistic hazard at a site in the WUS may be governed by clearly identifiable seismic sources, such as faults (or folds) observed at the surface, which have better defined seismicity characteristics. Therefore, for WUS sites, a site-specific analysis should be developed using suitable methodologies to estimate the probability of exceeding the SSE and to identify significant contributors to the hazard (e.g., NUREG-0675, 1991).

REFERENCES

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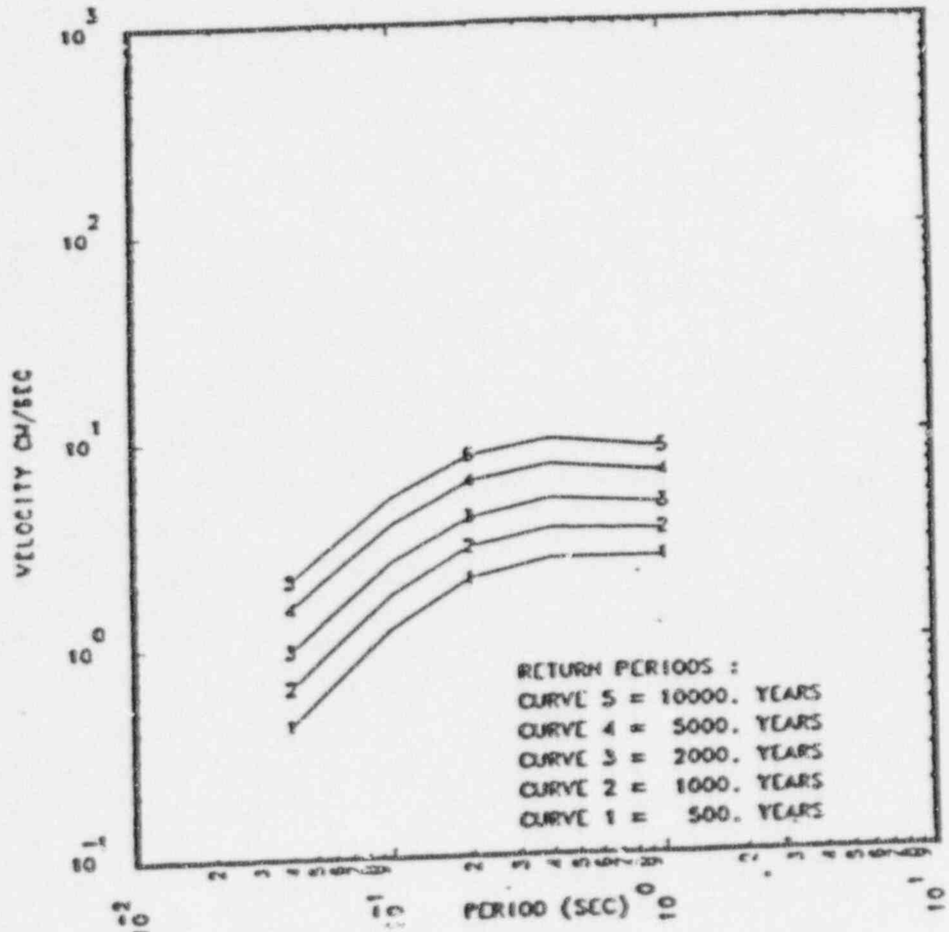

Fig. B.1 Median Uniform Hazard Response Spectra

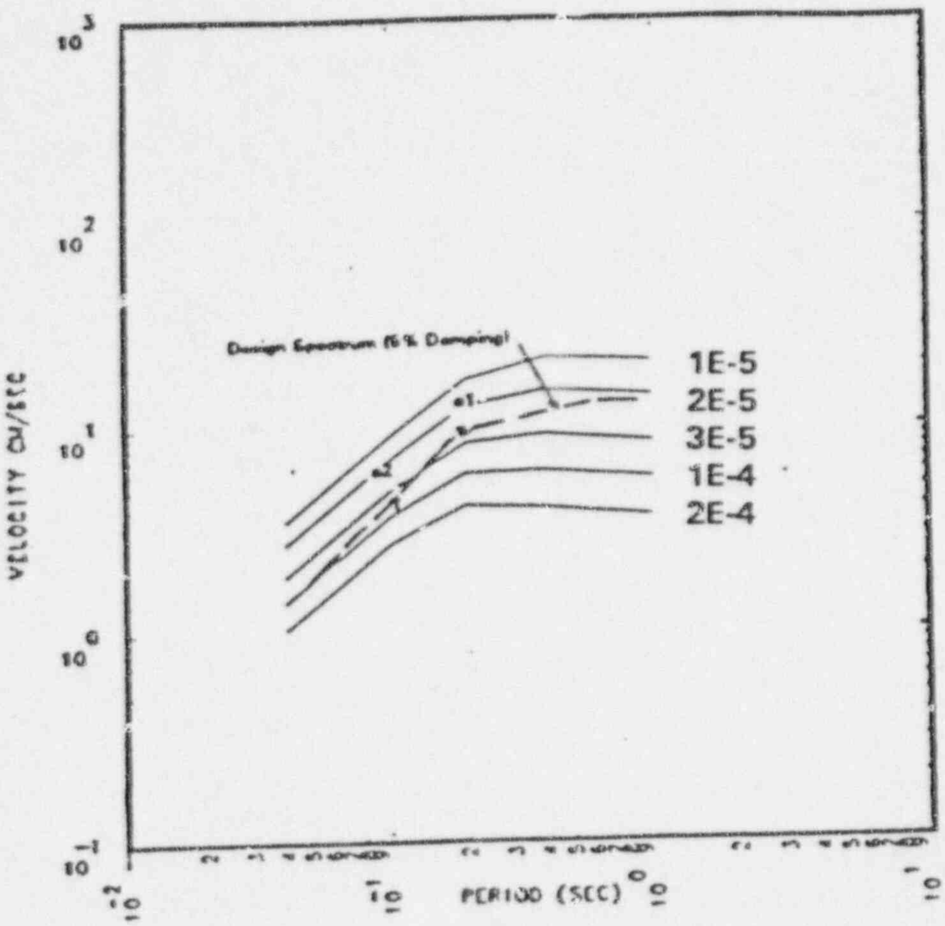

Figure B.2 Procedure to Compute Probability of Exceeding Design Basis

Comp. Prob. = 1/2(a1) + 1/2(a2)

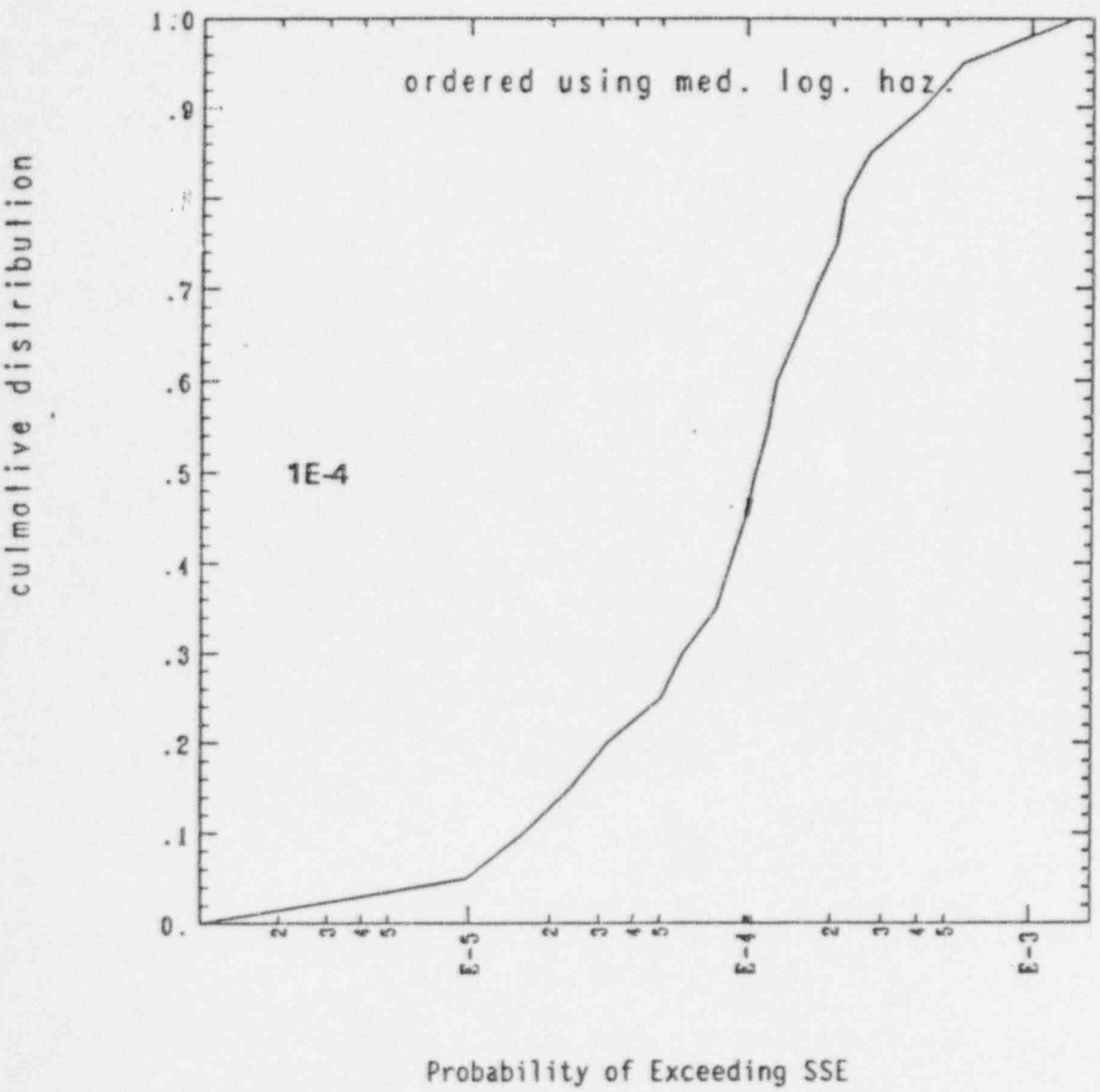

Figure B.3 Probability of Exceeding SSE Using Median LLNL Hazard Estimates

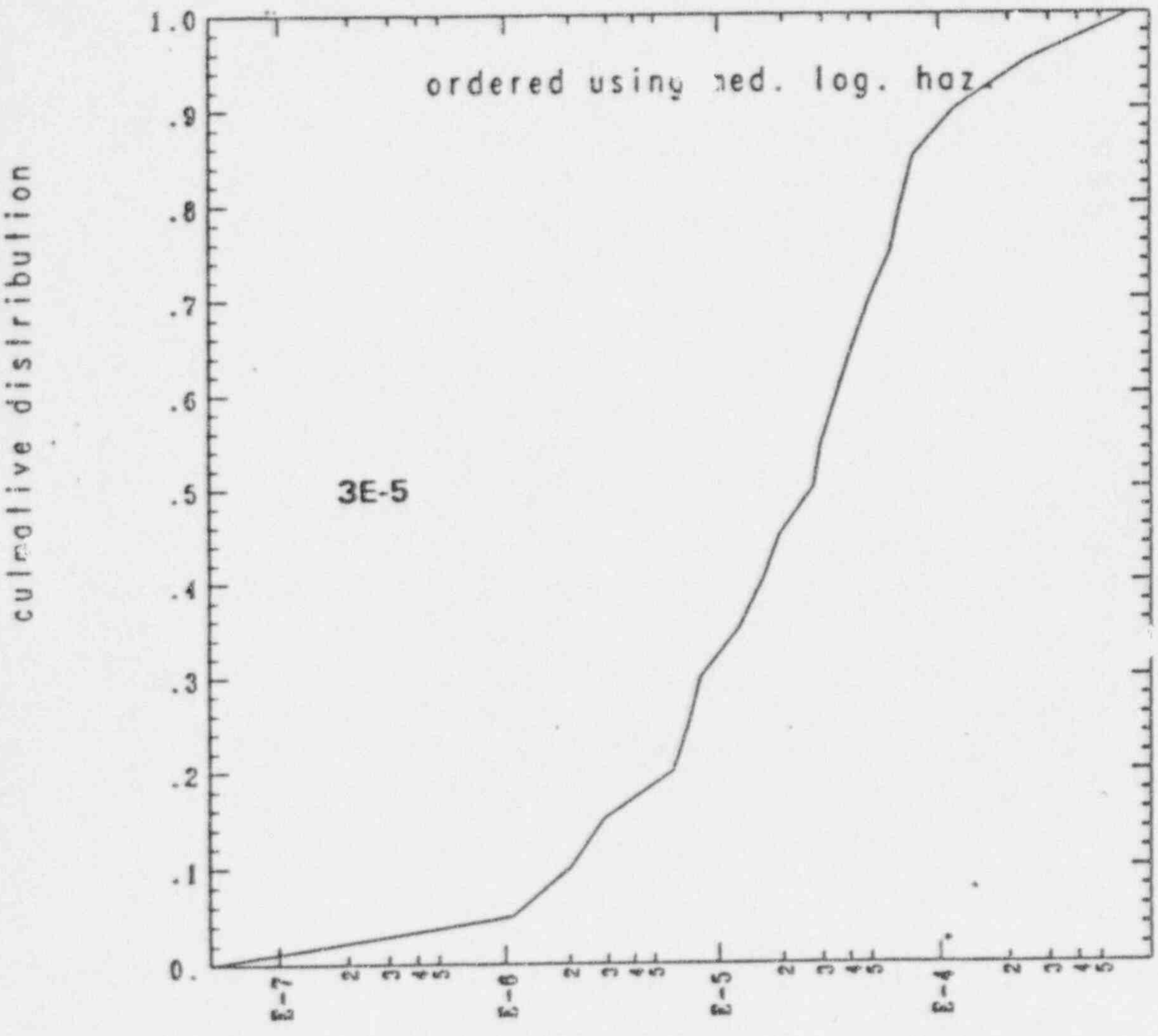

Figure B.4 Probability of Exceeding SSE Using-Median EPRI Hazard Estimates

Appendix C to Regulatory Guide DG-1015

Determination of Controlling Earthquakes from the Probabilistic Analysis

C.1 Introduction

This appendix outlines a procedure to determine controlling earthquake(s) from the probabilistic hazards analysis for a site. The ground motions from these controlling earthquakes should be determined following the procedures outlined in Section 2.5.2 of the Standard Review Plan. Controlling earthquakes should be determined for the median seismic hazard limit used to satisfy the requirement discussed in Section C.2 below and Appendix B of this Regulatory Guide to demonstrate that the probability of exceeding the safe shutdown earthquake ground motion (SSE) compares favorably with that of the currently operating nuclear power plants.

C.2 Procedure

The following procedure is one acceptable approach to determine controlling earthquakes from an probabilistic hazards analysis.

C.2.1 Eastern U. S. Sites

As discussed in Appendix B of this Regulatory Guide there are two approaches (NUREG/CR-5250, 1989 and EPRI NP-6395-D, 1989) currently available to calculate probabilistic seismic hazards for sites east of the Rocky mountains (Eastern U.S.). Either of these methods can be used to carry out the following calculations, with the appropriate set of limits associated with each method.

Step 1. Perform the site-specific hazard analysis using the LLNL or EPRI method and associated data. From this analysis, compute median hazard curves for the average of the 5 and 10 Hz spectral velocities, S_{v5-10}. That is a curve showing probability of exceeding various levels of the average of the 5 and 10 Hz spectral velocity.

Step 2. Using the appropriate probability of exceedance level, P_ε, (e.g., for the median S_{v5-10} hazard curve derived from the LLNL method, P_ε is 1E-4 according to Figure B.3(c) and Table B.1 of Appendix B), enter the hazard curve of step 1 at P_ε to determine the corresponding spectral velocity.

Step 3. Deaggregate the median of the average of the 5 and 10 Hz hazard curves as a function of magnitude and distance by calculating the contribution to the hazard for all of the earthquakes in a selected set of magnitude and distance bins, to determine the relative contribution to the hazard, H_{md}, for each bin centered at Magnitude m and Distance d. H_{md}, is the probability of exceeding $S_v(P_\varepsilon)$

computed for a bin at magnitude m and distance d.

Step 4. Compute the magnitude of the controlling earthquake for the median estimate using the contributions H_{md} computed in Step 3.

$$\bar{M} = \sum_m \sum_d m H_{md} / \sum_m \sum_d H_{md}$$

The distance of the controlling earthquake from the site is determined from

$$\bar{D} = \sum_m \sum_d d H_{md} / \sum_m \sum_d H_{md}$$

Step 5. Using the same P_E and steps 1 through 4 as above, also determine controlling earthquakes for median spectral response for the average of the 1 and 2.5 Hz spectral responses, and for the median estimates of the peak ground acceleration.

Step 6. The ground motion corresponding to the controlling earthquake is determined as outlined in Section 2.5.2 of the Standard Review Plan.

C.2.2 Western U. S. Sites

For the Western U. S. Sites, a probabilistic data base, such as compiled in the LLNL or EPRI studies, is not available. In a region of active tectonics there is less uncertainty about the significant contributors to the seismic hazard and the controlling earthquakes can generally be defined deterministically. For regions of lower, less active tectonics, an analysis similar to the one outlined above in Steps 1-4 can be performed. Step 1 would be omitted and the S_v level used would correspond to the value selected for the SSE.

C.3 Example for Eastern U. S. Site

To illustrate the application of the above procedure, calculations are performed for an eastern U. S. site using the LLNL methodology given in NUREG/CR-5250.

Step 2

Table C.1 gives the probability of exceeding various levels of the average of the 5 and 10 Hz spectral velocity hazard curves from the LLNL study.

<u>Table C.1</u>

Average of 5 and 10 Hz S_v Curves for the Site

Spectral Velocity (S_v-cm/s)	Probability of Exceedance (Median)
2	2.6E-3
5	3.7E-4
10	5.8E-5

Entering Table C.1 with the probability of exceedance (P_E) values given in Table B.1, and by interpolating, the corresponding value for $S_v(P_E)$ is as given in Table C.2.

<u>Table C.2</u>

	Median
$S_v(P_E)$~cm/s	8

Step 3

For this example, to deaggregate the hazard and determine the H_{md}, it is first necessary to compute the contribution to the average hazard for the 5 and 10 Hz spectral velocities for the matrix of magnitudes and distance bins such as given in Table C.3.

Table C.3

Magnitudes and Distance Bins Used in Example

Distance Range of Bin (km)	Magnitude Range of Bin					
	5 - 5.5	5.5 - 6	6 - 6.5	6.5 - 7	7 - 7.5	>7.5
0-25						
25-50						
50-100						
100-150						
150-200						
>200						

For each bin a complete hazard analysis is performed to give the contribution to the hazard from all earthquakes within the bin, e.g., all earthquakes with magnitudes 6 to 6.5 and distance 25 to 50 km from the site. The results for this bin are given in Table C.4.

Table C.4

Contribution to the Hazard From All Earthquakes in the Range of $6 \leq M \leq 6.5$ and distances $25 \leq d \leq 50$ to the average of the 5 and 10 Hz spectral velocity

Spectral Velocity, S_v	Median Probability of Exceedance
5	1.4E-5
10	3.1E-6
12.5	1.1E-6

The value of H_{md} (Probability of exceeding $S_v(P_E)$) for this bin is obtained by entering Table C.4 with the $S_v(P_E)$ values given in Table C.2 and computing H_{md} by interpolation. The values for H_{md} for this bin are given in Table C.5.

Table C.5

Value for H_{md} for the bin $6 \leq m \leq 6.5$ and $25 \leq d \leq 50$ for the Example Site

	Median
H_{md}	5.0E-6

Table C.6 gives the complete matrix of the H_{md} values for the example site.

Table C.6

H_{md} Values for All Bins Based on the Median Hazard (Note: If $H_{md} \leq$ 1.E-10, it is listed as 0)

Distance Range Bin	Magnitude Range of Bin					
	5 - 5.5	5.5 - 6	6 - 6.5	6.5 - 7	7 -7.5	>7.5
0-25	2.0E-5	1.1E-5	2.4E-6	0	0	0
25-50	6.2E-6	8.9E-6	5.0E-6	6.5E-9	0	0
50-100	6.0E-7	2.3E-6	6.8E-6	8.4E-7	0	0
100-150	1.6E-9	1.6E-7	1.5E-6	2.8E-6	0	0
150-200	0	1.1E-9	2.1E-8	4.6E-7	0	0
>200	0	0	0	6.0E-9	0	0

Step 4

To compute $\bar{M}$, $\bar{D}$ for the example site, the values of H_{md} given in Table C.6 are used with m and d values corresponding to the midpoint of the magnitude of the bin (5.25, 5.75, 6.25, 6.75, 7.25, 7.75) and centroid of the ring area (16.7, 38.9, 77.8, 126, 176 and somewhat arbitrarily 300km).

Thus for the example site, the controlling earthquakes, in $\bar{M}$, $\bar{D}$ values are given in Table C.7.

Table C.7

Magnitude and Distance of Controlling Earthquake From the LLNL Probabilistic Analysis

	Based on Median Hazard Estimate
$\bar{M}$	5.8
$\bar{D}$	32

C.4 Examples for Western U. S. Sites

Since a general approach for the western U.S. sites is not available, two specific cases illustrating determination of controlling earthquakes are discussed below.

C.4.1 - Diablo Canyon

The Diablo Canyon site is located on the California coast. A logic-tree approach has been used to assign weights to variables associated with faults near the site and determine maximum magnitude distributions (NUREG-0675, Supplement 34). The logic tree approach was also part of the probabilistic seismic hazard analysis. The result was that the Hosgri fault zone was the most significant source. The controlling earthquake for the Diablo Canyon site is a magnitude 7.2 event on the Hosgri fault zone at the closest distance of this fault zone to the site (4.5 km). The controlling earthquake magnitude is larger than the maximum historical earthquake (the 1927 magnitude 7.0 Lompoc earthquake) which may have occurred on a structure related to the Hosgri.

C.4.2 - WNP-3

The WNP-3 site is located in western Washington and lies above the Cascadia subduction zone. The staff considered four controlling earthquakes for the site (January 4, 1991 letter from Mendonca to Mazur):

a. The applicant proposed that a maximum random earthquake in the crust near the site is magnitude 5-1/2 to 6. This earthquake is based on the largest historical earthquakes in the Coastal Plain seismotectonic province (about magnitude 5) and the resolution of geological studies in the site region.

b. The maximum earthquake associated with the Olympia Lineament 35 km northeast of the site is a magnitude 7.5 based on estimated maximum rupture length.

c. The maximum magnitude earthquake for the intraslab subduction zone source is about magnitude 7-1/2 based on the maximum historical event associated with the Cascadia subduction zone intraslab source (the 1949 magnitude 7.1 Puget Sound earthquake) and comparisons with intraslab sources in other subduction zones worldwide.

d. The interface subduction zone source is capable of great (larger than magnitude 8) earthquakes. This maximum magnitude is still under review in light of ongoing geological studies. At this time the staff considers the maximum magnitude to be 8-1/4 based on arguments about the likely dimensions of rupture and comparisons with other subduction zones with slow convergence rates.

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Electric Power Research Institute Report NP-6395-D, "Probabilistic Seismic Hazard Evaluations at Nuclear Power Plant Sites in the Central and Eastern United States: Resolution of the Charleston Earthquake Issue," 1989.

NUREG/CR-5250, "Seismic Hazard Characterization of 69 Nuclear Plant Sites East of the Rocky Mountains," 1989.

Letter from Marvin Mendonca, NRC to D.W. Mazur, Washington Public Power Supply System, "NRC Review of Seismic Report for WNP-3," January 4, 1991.

NUREG-0675, Supplement No. 34, "Safety Evaluation Report related to the operation of Diablo Canyon Nuclear Power Plant, Units 1 and 2," 1991.

Appendix D to Regulatory Guide DG-1015
Geological, Seismological and Geophysical Investigations to Characterize Seismic Sources

D.1 Introduction

Seismic sources define areas where future earthquakes are likely to occur. Geological and seismological investigations provide the information needed to characterize source parameters, including the size and geometry of the seismic sources, earthquake recurrence models, and deterministic source earthquakes (DSE). The amount of data available about earthquakes and their causative sources varies substantially between the western U.S. and the stable continental region (SCR) and also from region to region within these broad areas. In active tectonic regions the focus will be on the identification of both capable tectonic sources and seismogenic sources and the methods described in section D2 can be applied. In the SCR east of the Rocky Mountains, seismogenic sources play a significant role because of the difficulty in unequivocally correlating earthquake activity with known tectonic structures.

In the SCR a number of significant tectonic structures exist which have been suggested as potential seismogenic sources (i.g. New Madrid fault zone, Nemaha Ridge, Meers fault, Ramapo fault zone, Clarendon-Linden fault). There is no clear procedure to follow to characterize the DSE magnitude associated with such possible seismogenic sources; therefore, it is most likely that the determination of the seismogenic nature of the source will be inferred rather than demonstrated by strong correlations with seismicity and/or geologic data. Furthermore, it is not known what relations exist between observed tectonic structures in a given seismogenic source and the current earthquake activity loosely correlated with that source. Generally, the observed tectonic structure resulted from ancient tectonic forces that are no longer present, and thus the structural extent may not be a very meaningful indicator of the size of future earthquakes in the source. Careful analysis of the historical record and the results of regional and site studies and judgment play key roles. If, on the other hand, such strong correlations and/or data exist between seismicity and seismic sources, then approaches used for active tectonic regions can be applied.

The following is a general list of characteristics to be determined for a seismic source:

a. Source zone geometry (location and extent, both surface and subsurface).

b. Description of Quaternary (last 2 million years) displacements (sense of slip on the fault, fault length and width, age of displacements, estimated displacements per event, estimated magnitudes per offset, rupture length and area, and displacement history or uplift rates of seismogenic folds).

c. Historical and instrumental seismicity associated with each source.

d. Paleoseismicity.

e. Relationship of the fault to other potential seismic sources in the region.

f. Deterministic Source Earthquake.

g. Recurrence model (frequency of earthquake occurrence versus magnitude).

h. Effects of human activities such as w[illegible]awal of fluid from or addition of fluid to the subsurface, extraction [illegible]inerals, or the effects of dams or reservoirs.

i. Volcanism. Volcanic hazard is not addressed in this regulatory guide. It will be considered on a case by case basis in regions where this hazard exists.

j. Other factors that can contribute to characterization of seismic sources such as strike and dip of tectonic structures, orientations of regional and tectonic stresses, fault segmentation (both along strike and downdip), etc.

D.2. <u>Investigations to Characterize Seismic Sources</u>

a. <u>General</u>

Investigations of the site and region around the site are necessary to identify both seismogenic sources and capable tectonic sources and determine their potential for generating earthquakes and for causing surface deformation. Where it is determined that surface deformation need not be taken into account, sufficient data to clearly justify the determination should be presented in the license application or early site review.

In the siting of nuclear power plants, engineering solutions are generally available to mitigate the potential vibratory effect of earthquakes through design. However, such solutions cannot always be demonstrated as being adequate for mitigation of the effects of permanent ground displacement phenomena such as surface faulting or folding, subsidence, ground collapse or fault creep. For this reason, it is prudent to select an alternative site when the potential for permanent ground displacement exists at the site (IAEA, 1991). In most of the eastern U.S. tectonic structures at seismogenic depths, as determined from earthquake hypocenters, apparently bear no relationship to geologic structures exposed at the ground surface. Young faults either do not extend to the ground surface or there is insufficient geologic material of the appropriate age available to date the faults. Seismogenic faults are not always exposed at ground surface in the western U.S. as demonstrated by the buried (blind) reverse sources of the 1983 Coalinga, 1988 Whittier Narrows and 1989 Loma Prieta earthquakes. These factors emphasize the need to not only conduct thorough investigations at the ground surface but also to identify structures at seismogenic depths.

The level of detail for investigations should be governed by the current and late Quaternary tectonic regime and the geological complexity of the site and region. Whenever faults or other structures are encountered at a site (i[illegible]uding in the SCR) either in outcrop or excavations, it is necessary to per[illegible]y of the investigations described below to demonstrate whether or not they are capable tectonic sources.

Regional investigations should extend to a distance of 320 km (200 miles) from the site and data presented at a scale of 1:500,000 or smaller. Investigations of greater detail should be conducted to a distance of 40 km (25 miles) from the site and the data presented at a scale of 1:50,000 or smaller. Detailed investigations should be carried out within a radius of 8 km (5 miles) from the site and data presented at a scale of 1:5000 or smaller. Data from investigations within the site area (approximately 1 km^2) should be presented at a scale of 1:500 or smaller. The areas of investigations may be asymmetrical and larger than those described above in regions of late Quaternary activity or historical seismic activity (felt or instrumentally recorded data) or where a site is located near a capable tectonic source such as a fault zone.

Regional and site information needed to assess the integrity of the site with respect to potential ground motions and surface deformation caused by capable tectonic sources include determination of: (1) the lithologic, stratigraphic, geomorphic, hydrologic, geotechnical and structural geologic characteristics of the site and the area surrounding the site, including its geologic history; (2) geologic evidence of fault offset or other distortion such as folding at or near ground surface at or near the site; and (3) determination of whether or not any faults or other tectonic structures any part of which are within a radius of 8 km (5 miles) are capable tectonic sources. This information will be used to evaluate tectonic structures underlying the site, whether buried or expressed at the surface, with regard to their potential for generating earthquakes and for causing surface deformation at or near the site. The evaluation should consider the possible effects caused by human activities such as withdrawal of fluid from or addition of fluid to the subsurface, extraction of minerals, or the loading effects of dams or reservoirs.

b. Reconnaissance Investigations, Literature Review and Other Sources of Preliminary Information

Site and regional investigations can be planned based on field reconnaissances data from previous investigations and reviews of available documents. Possible sources of information may include universities, consulting firms and government agencies. A detailed list of possible sources of information is given in Regulatory Guide 1.132.

c. Detailed Investigations to Characterize Seismic Sources

The following methods are suggested but they are not all-inclusive and investigations should not be limited to them. Some procedures will not be applicable to every site and situations will occur requiring investigations which are not included in the following discussion. It is anticipated that new technologies will be available in the future that will be applicable to these investigations.

Surface exploration needed to assess neotectonic conditions of the geology of the area around the site is dependent on the site location and may be carried out with the use of any appropriate combination of geological, geophysical, seismological and geotechnical engineering techniques.

(1) Geological interpretations of aerial photographs and other remote-sensing imagery, as appropriate for the particular site conditions, to assist in identifying rock outcrops, faults and other tectonic features, fracture traces, geologic contacts, lineaments, soil conditions, and evidence of landslides or soil liquefaction.

(2) Mapping of topographic, geologic, geomorphic and hydrologic features at scales and contour intervals suitable for analysis, stratigraphy (particularly Quaternary), surface tectonic structures such as fault zones, and Quaternary geomorphic features. For offshore sites, coastal sites, or sites located near lakes or rivers this includes topography, geomorphology (particularly mapping marine and fluvial terraces), bathymetry, geophysics (such as seismic reflection), and hydrographic surveys to the extent needed for evaluation.

(3) Identification and evaluation of vertical crustal movements by: (a) geodetic land surveying to identify and measure short term crustal movements (Reilinger and others, 1984; Mark and others, 1981) and (b) geological analyses such as analysis of regional dissection and degradation patterns, marine and lacustrine terraces and shorelines, fluvial adjustments such as changes in stream longitudinal profiles or terraces and other long term changes such as elevation changes across lava flows, etc. (Rockwell and others, 1984)

(4) Analysis of offset, displaced or anomalous landforms such as displaced stream channels or changes in stream profiles or the upstream migration of knickpoints (Sieh, 1984; Sieh and Jahns, 1984; Sieh and others, 1989; Weldon and Sieh, 1985; Swan and others, 1980; PG&E, 1988), abrupt changes in fluvial deposits or terraces, changes in paleochannels across a fault (Swan and others, 1980), or uplifted, downdropped or laterally displaced marine terraces (PG&E, 1988).

(5) Analysis of Quaternary sedimentary deposits within or near tectonic zones such as fault zones and including: (a) fault related or fault controlled deposits including sag ponds, graben fill deposits, and colluvial wedges formed by the erosion of a fault paleoscarp, and (b) non-fault related, but offset deposits including alluvial fans, debris cones, fluvial terrace and lake shoreline deposits.

(6) Identification and analysis of deformation features caused by vibratory ground motions including seismically induced liquefaction features (sand boils, explosion craters, lateral spreads, settlement, soil flows), mud volcanoes, landslides, rockfalls, deformed lake deposits or soil horizons, shear zones, cracks or fissures (Obermeier and others, 1985; Amick and others, 1990).

(7) Estimation of the ages of fault displacements by analysis of the morphology of topographic fault scarps associated with or produced by surface rupture. Fault scarp morphology is useful in estimating age of

last displacement, approximate size of the earthquake, recurrence intervals, slip rate and the nature of the causative fault at depth (Wallace, 1977, 1980, 1981; Crone and Harding, 1984).

(8) Listing of all historically reported earthquakes which can reasonably be associated with seismic sources any part of which is within a radius of 320 km (200 miles) of the site, including date of occurrence and the following measured or estimated data: highest intensity, magnitude, epicenter, depth, focal mechanism, stress drop, etc. Historical seismicity includes both historically reported and instrumentally recorded data. For pre-instrumentally recorded data, intensity should be converted to magnitude, the procedure used to convert it to magnitude should be clearly documented, and epicenters should be determined based on intensity contours. Methods to convert intensity values to magnitudes in the central and eastern U.S. are described in Nuttli (1979), Street and Turcotte (1975), and Street and Lacroix (1979).

(9) Seismic monitoring in the site area should be established as soon as possible after site selection.

Subsurface investigations that should be accomplished in the site area or within the region to identify and define seismogenic sources and capable tectonic sources may include:

(1) Geophysical investigations such as air or ground magnetic and gravity surveys, seismic reflection and seismic refraction surveys, borehole geophysics, and ground penetrating radar.

(2) Core borings to map subsurface geology and obtain samples for testing such as age dating.

(3) Excavating and logging trenches across geological features as part of the neotectonic investigation and to obtain samples for age dating those features.

At some sites, deep soil, bodies of water, or other material may obscure geologic evidence of past activity along a tectonic structure. In such cases the analysis of evidence elsewhere along the structure can be used to evaluate its characteristics in the vicinity of the site (PG&E, 1988; NUREG-0675, 1991).

An important part of the geologic investigations to identify and define potential seismic sources is the age-dating of geologic materials. The following techniques are useful in dating Quaternary deposits:

(1) Radiometric Dating Methods

(a) Carbon 14 for dating organic materials (upper limit ranges from 30,000 up to 100,000 years) (Callender, 1989).
(b) Potassium argon for dating volcanic rocks ranging in age from about 50,000 to 10 million years (Callender, 1989).
(c) Uranium series uses the relative properties of various decay products of ^{238}U or ^{235}U. Ages range from 10,000 to 350,000

(Callender, 1989). $^{235}U/^{238}U$ can yield between 40,000 and 1,000,000 years (Muhs and Szabo, 1982)

(d) Fission track uses minerals such as zircon and apatite, with fissionable uranium in volcanic rocks. Although some interpretation is required in counting tracks, the technique has no inherent age range limitations if suitable materials are available (Callender, 1989).

(e) Thermoluminescence (TL) is best used for stratigraphic correlation and determining relative ages rather than absolute ages. The maximum age is 10 million years (Callender, 1989).

(f) Electron spin resonance (ESR) is used to date quartz that formed in fault gouge during the fault event (Ikeya and others, 1982).

(2) Other Quantitative Numerical Methods

(a) Paleomagnetic dating requires material containing magnetic-susceptible minerals with sufficient stratigraphic and time ranges to provide several reversals. An independent time datum for correlation with the polarity time scale is required (Callender, 1989).

(b) Thicknesses of weathering rind development on the margins of clasts, such as caused by obsidian hydration, can be used to estimate the age of deposits (Coleman and Pierce, 1981).

(c) Cation-ratio dating of desert varnish on rock surfaces by chemical analysis (Dorn, 1983).

(d) Tephrochronology, which is the identification and correlation of undated and dated volcanic ashes by geochemical and petrographic analyses (Sheets and Grayson, 1979; Self and Sparks, 1981).

(e) Amino-acid racemization uses organic material and is based on time-dependent diagenetic conversion of one form of amino-acid polymer structure to another (Bada and Helfman, 1975; Bada and Protsch, 1973).

(f) Lichenometry is used to estimate ages from sizes of lichens growing on gravel or boulders (such as glacial deposits) (Locke and others, 1979).

(g) Soil profile development is used to determine age based on measured amounts of accumulated pedogenic materials (Machette, 1978).

(h) Dendrochronology is used to determine the ages of trees that were affected by a tectonic event or other phenomena such as landsliding or flooding (Page, 1970; Sieh, 1978; Atwater and Yamaguchi, 1991).

(3) Relative Age Dating Methods

(a) Relative degree of soil profile development of B and C horizons can provide at least an order of magnitude estimate of the ages of buried soils or relict surface soils on surficial deposits (Callender, 1989; Machette, 1982). For B horizons the diagnostic characteristics include: thickness, depth, amount, texture, type of clay, soil structure and color, and amount of Fe oxides or Fe-Al-organic accumulation (Callender, 1989). For C horizons the important diagnostic characteristics are thickness, depth, stage of development and amount of pedogenic carbonate and other soluble salts (Macfadden and Tinsley, 1982; Hardin, 1982). Other references for this subject include Matti and others, 1982; Pearthree and Calvo, 1982; Pearthree and others, 1983; Keller and others, 1984, and Chadwick and others, 1984.

(b) Relative degree of weathering of surface and subsurface clasts in sedimentary deposits such as glacial moraines is useful but requires independent means of age calibration (Callender, 1989).

In the SCR it may not be possible to demonstrate, in an absolute manner, the age of last activity of a tectonic structure. In such cases the NRC staff will accept association of such structures with geologic structural features or tectonic processes which are geologically old (at least pre-Quaternary) as an age indicator in the absence of conflicting evidence.

These investigative procedures should also be applied, where possible, to characterize offshore structures (faults or fault zones, and also folds, uplift or subsidence related to faulting at depth) for coastal sites or those sites located adjacent to landlocked bodies of water. Investigations of offshore structures will rely heavily on seismicity, geophysics and bathymetry rather than conventional geologic mapping methods which can be used effectively onshore. However, it is often useful to investigate similar features onshore to learn more about the significant offshore features.

d. <u>Distinction Between Tectonic and Nontectonic Deformation</u>

Nontectonic deformation like tectonic deformation can pose a substantial hazard to nuclear power plants but there are likely to be differences in the approaches used to resolve the issues raised by the two types of phenomena. Therefore, non-tectonic deformation should be distinguished from tectonic deformation at a site. In past nuclear power plant licensing activities, surface displacements caused by phenomena other than tectonic phenomena have been confused with tectonically induced faulting. Such features include faults on which the last displacement was induced by glaciation or deglaciation, collapse structures, such as found in karst terrain, and growth faulting, such as occurs in the Gulf Coastal Plain or in other deep soil regions subject to extensive subsurface fluid withdrawal.

Glacially induced faults generally do not represent a deep seated seismic or fault displacement hazard because the conditions that created them are no longer present. However, residual stresses from Pleistocene glaciation may still be present in glaciated regions although they are of less concern than active tectonically induced stresses. These features should be investigated with respect to their relationship to current in-situ stresses.

The nature of faults related to collapse features can usually be defined through geotechnical investigations and can either be avoided, or if feasible, adequate engineering fixes can be provided.

Large, naturally occurring growth faults as found in the coastal plain of Texas and Louisiana can pose a surface displacement hazard even though offset m[illegible] likely occurs at a much less rapid rate than that of tectonic faults. They are not regarded as having the capacity to generate damaging earthquakes, can often be identified and avoided in siting, and their displacements can be monitored. Some growth faults and antithetic faults related to growth faults are not easily identified; therefore, investigations described above with respect to capable tectonic faults and fault zones should be applied in regions where growth faults are known to be present. Local human-induced growth faults can be monitored and controlled or avoided.

If questionable features cannot be demonstrated to be of non-tectonic origin they should be treated as tectonic deformation.

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REGULATORY ANALYSIS

A separate regulatory analysis was not prepared for this regulatory guide. The draft regulatory analysis "Proposed Revision of 10 CFR Part 100 and 10 CFR Part 50," provides the regulatory basis for this guide and examines the costs and benefits of the rule as implemented by the guide. A copy of the draft regulatory analysis is available for inspection and copying for a fee at the NRC Public Document Room, 2120 L Street NW. (Lower Level), Washington, DC, as Enclosure 2 to Secy 92-???. Single copies of the draft regulatory analysis are available from Mr. Leonard Soffer, Office of Nuclear Regulatory Research, Mail Stop NL/S-324, U.S. Nuclear Regulatory Commission, Washington, DC 20555, telephone (301) 492-3916 or Dr. Andrew J. Murphy, Office of Nuclear Regulatory Research, Mail Stop NL/S-217A, U.S. Nuclear Regulatory Commission, Washington, DC 20555, telephone (301) 492-3860.

DRAFT STANDARD REVIEW PLAN SECTION 2.5.2

PROPOSED REVISION 3

2.5.2 VIBRATORY GROUND MOTION

REVIEW RESPONSIBILITIES

Primary - Structural and Geosciences Branch (ESGB)

Secondary - None

AREAS OF REVIEW

The Structural and Geosciences Branch review covers the seismological and geological investigations carried out to ~~establish~~ **evaluate** ~~the acceleration for~~ the safe shutdown earthquake (SSE) ~~and the operating basis earthquake (OBE)~~ for the site. ~~The safe shutdown earthquake is that earthquake that is based upon an evaluation of the maximum earthquake potential considering the regional and local geology and seismology and specific characteristics of local subsurface material. It is that earthquake that produces the maximum vibratory ground motion for which safety-related structures, systems, and components are designed to remain functional. The operating basis earthquake is that earthquake that, considering the regional and local geology, seismology, and specific characteristics of local subsurface material, could reasonably be expected to affect the plant site during the operating life of the plant; it is that earthquake that produces the vibratory ground motion for which those features of the nuclear power plant necessary for continued operation without undue risk to the health and safety of the public are designed to remain functional.~~ **The SSE represents the potential for earthquake ground motion at the site and is the vibratory ground motion for which all safety related structures, systems and components are designed to ensure public safety. The SSE is based upon a detailed evaluation of the earthquake potential, taking into account regional and local geology, seismicity, and specific characteristics of local subsurface material. It is defined as the free-field ground response spectra at the plant site and is described by horizontal and vertical response spectra corresponding to the expected ground motion at the free-field ground surface or a hypothetical rock outcrop.**

Seismological and geological investigations are described in Regulatory Guide DG1015, Identification and Characterization of Seismic Sources. These investigations describe the seismicity of the site region and correlation of earthquake activity with seismic sources. Seismic sources are identified and characterized, including the Deterministic Source Earthquake (DSE) associated with each seismic source. All seismic sources, any part of which is

within 320 km (200 miles) of the site, must be identified. Sources at larger distances which are capable of earthquakes large enough to affect the site must also be identified. Seismic sources can be capable tectonic sources or seismogenic sources; a seismotectonic province is a type of seismogenic source.

The principal regulation used by the staff in determining the scope and adequacy of the submitted seismologic and geologic information and attendant procedures and analyses is ~~Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants."~~ **Appendix B, "Criteria for the Seismic and Geologic Siting of Nuclear Power Plants after [effective date]" to 10 CFR Part 100 (Ref. 1).** Additional guidance (regulations, regulatory guides, and reports) is provided to the staff through References 2 through 8.

Specific areas of review include seismicity (Subsection 2.5.2.1), geologic and tectonic characteristics of the site and region (Subsection 2.5.2.2), correlation of earthquake activity with geologic structure or tectonic provinces (Subsection 2.5.2.3), maximum earthquake potential (Subsection 2.5.2.4), seismic wave transmission characteristics of the site (Subsection 2.5.2.5), **and** safe shutdown earthquake (Subsection 2.5.2.6)~~, and operating basis earthquake (Subsection 2.5.2.7)~~. **Both deterministic and probabilistic evaluations are used to assess the SSE.**

The geotechnical engineering aspects of the site and the models and methods employed in the analysis of soil and foundation response to the ground motion environment are reviewed under SRP Section 2.5.4. The results of the geosciences review are used in SRP Sections 3.7.1 and 3.7.2.

II. ACCEPTANCE CRITERIA

The applicable regulations (Refs. 1, 2, and 3) and regulatory guides (Refs. 4, 5, and 6) and basic acceptance criteria pertinent to the areas of this section of the Standard Review Plan are:

1. 10 CFR Part 100, ~~Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants."~~ **Appendix B, "Criteria for the Seismic and Geologic Siting of Nuclear Power Plants after [effective date]."** These criteria describe the kinds of geologic and seismic information needed to determine site suitability and identify geologic and seismic factors required to be taken into account in the siting and design of nuclear power plants (Ref. 1).

2. 10 CFR Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants"; General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena." This criterion requires that safety-related portions of the structures, systems, and components important to safety shall

be designed to withstand the effects of earthquakes, tsunami, and seiche without loss of capability to perform their safety functions (Ref. 2).

3. 10 CFR Part 100, "Reactor Site Criteria." This part describes criteria that guide the evaluation of the suitability of proposed sites for nuclear power and testing reactors (Ref. 3).

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 under anticipated loading conditions including earthquake. It provides general guidance and recommendations for developing site-specific investigation programs as well as specific guidance for conducting subsurface investigations, including the spacing and depth of borings as well as sampling intervals (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 which the NRC staff considers in determining the suitability of sites for nuclear power stations (Ref. 5).

6. Regulatory Guide 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants." ~~This guide gives one method acceptable to the NRC staff for defining the response spectra corresponding to the expected maximum ground acceleration (Ref. 6). See also~~ **For design purposes smoothed response spectra are generally used - for example, a standard spectral shape which has been used in the past is Regulatory Guide 1.60 (Ref. 6). These smoothed spectra are still acceptable when an appropriate peak acceleration is used as the high frequency asymptote and the smoothed spectra compare favorable with site specific response spectra derived from the deterministic and probabilistic procedures discussed** in Subsection 2.5.2.6.

The primary required investigations are described in 10 CFR Part 100, Section IV(a) of Appendix ~~A~~ **B**(Ref. 1) **and regulatory guide DG1015**. The acceptable procedures for ~~determining~~ assessing the seismic design bases are given in Section V(a), **(b), and (c).** ~~and Section VI(a) of the appendix.~~ The seismic design bases are predicated on a reasonable, conservative determination of the SSE ~~and the OBE~~. As defined in Section**s** ~~III~~ **IV and V** of 10 CFR Part 100, Appendix ~~A~~ **B**(Ref. 1), the SSE ~~and OBE are~~ **is** based on consideration of the regional and local geology and seismology and on the characteristics of the subsurface materials at the site and ~~are~~ **is** described in terms of the vibratory ground motion ~~that they~~

~~would produce~~ at the site. No comprehensive definitive rules can be promulgated regarding the investigations needed to establish the seismic design bases; the requirements vary from site to site.

2.5.2.1 Seismicity. In meeting the requirement of Reference 1, this subsection is accepted when the complete historical record of earthquakes in the region is listed and when all available parameters are given for each earthquake in the historical record. The listing should include all earthquakes having Modified Mercalli Intensity (MMI) greater than or equal to IV or magnitude greater than or equal to 3.0 that have been reported ~~in all tectonic provinces~~ **for all seismic sources**, any parts of which are within **320 km** (200 miles) of the site. A regional-scale map should be presented showing all listed earthquake epicenters and should be supplemented by a larger-scale map showing earthquake epicenters of all known events within **80 km** (50 miles) of the site. The following information concerning each earthquake is required whenever it is available: epicenter coordinates, depth of focus, origin time, highest intensity, magnitude, seismic moment, source mechanism, source dimensions, distance from the site, and any strong-motion recordings (references from which the information was obtained should be identified). All magnitude designations such as m_b, M_L, M_s, M_w, etc., should be identified. In addition, any reported earthquake-induced geologic failure, such as liquefaction, landsliding, landspreading, and lurching should be described completely, including the level of strong motion that induced failure and the physical properties of the materials. The completeness of the earthquake history of the region is determined by comparison to published sources of information (e.g., Refs. 9 through 13). When conflicting descriptions of individual earthquakes are found in the published references, the staff should determine which is appropriate for licensing decisions.

2.5.2.2 Geologic and Tectonic Characteristics of Site and Region. In meeting the requirements of References 1, 2, and 3, this subsection is accepted when all ~~geologic structures within the region and tectonic activity~~ **seismic sources** that are significant in determining the earthquake potential of the region are identified, or when an adequate investigation has been carried out to provide reasonable assurance that all significant ~~tectonic structures~~ **seismic sources** have been identified. Information presented in Section 2.5.1 of the applicant's safety analysis report (SAR) and information from other sources (e.g., Refs. 9 and 14 through 18) dealing with the current tectonic regime should be developed into a coherent, well-documented discussion to be used as the basis characterizing the earthquake-generating potential of **seismogenic sources and capable tectonic sources** ~~the identified geologic structures~~. Specifically, each ~~tectonic province~~ **seismic source**, any part of which is within **320 km** (200 miles) of the site, must be identified. The staff interprets **seismo**tectonic provinces to be regions of uniform ~~earthquake potential (seismotectonic~~

~~provinces)~~ **seismicity (same DSE and frequency of recurrence) distinct from the seismicity of the surrounding area.** The proposed **seismo**tectonic provinces may be based on seismicity studies, differences in geologic history, differences in the current tectonic regime, etc. The staff considers that the most important factors for the determination of **seismo**tectonic provinces include both (1) development and characteristics of the current tectonic regime of the region that is most likely reflected ~~in the neotectonics (Post-Miocene or about 5~~ **in the Quaternary (approximately the last 2 million** years and younger geologic history) and (2) the pattern and level of historical seismicity. Those characteristics of geologic structure, tectonic history, present and past stress regimes, and seismicity that distinguish the various **seismo**tectonic provinces and the particular areas within those provinces where historical earthquakes have occurred should be described. Alternative regional tectonic models derived from available literature sources, including previous SARs and NRC staff Safety Evaluation Reports (SERs), should be discussed. The model that best conforms to the observed data is accepted. In addition, in those areas where there are capable ~~faults~~ **tectonic sources**, the results of the additional investigative requirements described in ~~10 CFR Part 100, Appendix A, Section IV(a)(8) (Ref. 1),~~ **SRP Section 2.5.1** must be presented. The discussion should be augmented by a regional-scale map showing the ~~tectonic provinces~~ **seismic sources**, earthquake epicenters, locations of geologic structures and other features that characterize the **seismotectonic** provinces, and the locations of any capable ~~faults~~ **tectonic sources.**

<u>2.5.2.3 Correlation of Earthquake Activity with ~~Geologic Structure~~ **Seismogenic Sources, Capable Tectonic Sources** or **Seismo**Tectonic Provinces</u>. In meeting the requirements of Reference 1, acceptance of this subsection is based on the development of the relationship between the history of earthquake activity and the ~~geologic structures or seismotectonic provinces~~ **seismic sources** of a region. The applicant's presentation is accepted when the earthquakes discussed in Subsection 2.5.2.1 of the SAR are shown to be associated with either ~~geologic structure or tectonic province~~ **capable tectonic sources or seismogenic sources**. Whenever an earthquake hypocenter or concentration of earthquake hypocenters can be reasonably correlated with geologic structures, the rationale for the association should be developed considering the characteristics of the geologic structure (including geologic and geophysical data, seismicity, and the tectonic history) and the regional tectonic model. The discussion should include identification of the methods used to locate the earthquake hypocenters, an estimate of their accuracy, and a detailed account that compares and contrasts the geologic structure involved in the earthquake activity with other areas within the **seismo**tectonic province. Particular attention should be given to determining the capability of faults with which instrumentally located earthquake

hypocenters are associated.

The presentation should be augmented by regional maps, all of the same scale, showing the ~~tectonic provinces~~ **seismic sources**, the earthquake epicenters, and the locations of geologic structures and measurements used to define provinces. Acceptance of the proposed ~~tectonic provinces~~ **seismic sources** is based on the staff's independent review of the geologic and seismic information.

2.5.2.4 Maximum Earthquake Potential **and Controlling Earthquake (CE)**. In meeting the requirements of Reference 1, this subsection is accepted when the vibratory ground motion due to the ~~maximum credible earthquake~~ **DSE** associated with each ~~geologic structure or the maximum historic earthquake associated with each tectonic province~~ **seismic source** has been assessed and when the earthquake**(s)** that would produce the ~~maximum~~ **most severe** vibratory ground motion at the site has been determined. The ~~maximum credible earthquake~~ **DSE** is the largest earthquake that can reasonably be expected to occur on a ~~geologic structure~~ **given seismic source** in the current tectonic regime. **Considerable judgement is involved in estimating the magnitude of the DSE. Suggested procedures for estimating the DSE are given in Regulatory Guide DG1015.** ~~Geologic or seismological evidence may warrant a maximum earthquake larger than the maximum historic earthquake.~~ Earthquakes associated with each ~~geologic structure or tectonic province~~ **seismic source** must be identified. Where an earthquake is associated with geologic structure, the ~~maximum credible earthquake~~ **DSE** that could occur on that structure should be evaluated, taking into account significant factors, for example, the type of the faulting, fault length, fault slip rate, rupture length, rupture area, moment, and earthquake history (e.g., Refs. 19 through 22).

In order to determine the ~~maximum credible earthquake~~ **DSE** that could occur on those faults that are shown or assumed to be capable **tectonic sources**, the staff accepts conservative values based on historic experience in the region and specific considerations of the earthquake history and geologic history of movement on the faults. Where the earthquakes are associated with a **seismo**tectonic province, the largest historic earthquake within the province should be identified. Isoseismal maps should also be presented for the most significant earthquakes. The ground motion at the site should be evaluated assuming appropriate seismic energy transmission effects and assuming that the ~~maximum earthquake~~ **DSE** associated with each ~~geologic structure or with each tectonic province~~ **seismic source** occurs at the point of closest approach of the structure or province to the site. (Further description is provided in Subsection 2.5.2.6.)

The earthquake(s) that would produce the most severe vibratory ground motion at the site should be defined. If different potential earthquakes would produce the most severe ground motion in different frequency bands, these earthquakes should be specified. The description of the potential earthquake(s) is to include the maximum intensity or magnitude and the distance from the assumed location of the potential earthquake(s) to the site. **For the seismotectonic province surrounding the site, the DSE is assumed to occur within 25 km of the site.** The staff independently evaluates the site ground motion produced by the ~~largest earthquake~~ **DSE** associated with each ~~geologic structure or tectonic province~~ **seismic source. Controlling earthquakes (CE) are those earthquakes that have the greatest effect on the ground motion at the nuclear power plant site.** Acceptance of the description of the ~~potential~~ **controlling** earthquake(s) that would produce the largest ground motion at the site is based on the staff's independent analysis.

<u>2.5.2.5 Seismic Wave Transmission Characteristics of the Site</u>. In meeting the requirements of Reference 1, this subsection is accepted when the seismic wave transmission characteristics (amplification or deamplification) of the materials overlying bedrock at the site are described as a function of the significant frequencies. The following material properties should be determined for each stratum under the site: seismic compressional and shear wave velocities, bulk densities, soil index properties and classification, shear modulus and damping variations with strain level, and water table elevation and its variation. In each case, methods used to determine the properties should be described in Subsection 2.5.4 of the SAR and cross-referenced in this subsection. For the ~~maximum earthquake~~ **controlling earthquake**, determined in Subsection 2.5.2.4, the free-field ground motion (including significant frequencies) must be determined, and an analysis should be performed to determine the site effects on different seismic wave types in the significant frequency bands. If appropriate, the analysis should consider the effects of site conditions and material property variations upon wave propagation and frequency content.

The free-field ground motion (also referred to as control motion) should be defined to be on a ground surface and should be based on data obtained in the free field. Two cases are identified depending on the soil characteristics at the site and subject to availability of appropriate recorded ground-motion data. When data are available, for example, for relatively uniform sites of soil or rock with smooth variation of properties with depth, the control point (location at which the control motion is applied) should be specified on the soil surface at the top of the finished grade. The free-field ground motion or control motion should be consistent with the properties of the soil profile. For sites composed of one or more thin soil layers overlying a competent material, or in case of insufficient recorded ground-motion data, the control point is specified on an outcrop or a hypothetical outcrop at a location on the top of the competent material. The control motion specified should be consistent with the properties of the competent material.

Where vertically propagating shear waves may produce the maximum ground motion, a one-dimensional equivalent-linear analysis (e.g., Ref. 23 or 24) or nonlinear analysis (e.g., Refs. 25, 26, and 27) may be appropriate and is reviewed in conjunction with geotechnical and structural engineering. Where horizontally propagating shear waves, compressional waves, or surface waves may produce the maximum ground motion, other methods of analysis (e.g., Refs. 28 and 29) may be more appropriate. However, since some of the variables are not well defined and the techniques are still in the developmental stage, no generally agreed-upon procedures can be promulgated at this time. Hence, the staff must use discretion in reviewing any method of analysis. To insure appropriateness, site response characteristics determined from analytical procedures should be compared with historical and instrumental earthquake data, when available.

<u>2.5.2.6 Safe Shutdown Earthquake</u>. In meeting the requirements of Reference 1, this subsection is accepted when the vibratory ground motion specified for the SSE is described in terms of the free-field response spectrum and is at least as conservative as that which would result at the site from the ~~maximum earthquake~~ **CEs** (determined in Subsection 2.5.2.4) considering the site transmission effects (determined in Subsection 2.5.2.5). If several different ~~maximum potential earthquakes~~ **CEs** produce the largest ground motions in different frequency bands (as noted in Subsection 2.5.2.4), the vibratory ground motion specified for the SSE must be as conservative in each frequency band as that for each earthquake.

The staff reviews the free-field response spectra of engineering significance (at appropriate damping values). Ground motion may vary for different foundation conditions at the site. When the site effects are significant, this review is made in conjunction with the review of the design response spectra in Section 3.7.1 to ensure consistency with the free-field motion. The staff normally evaluates response spectra on a case-by-case basis. The staff considers compliance with the following conditions acceptable in the evaluation of the SSE. In all these procedures, the proposed free-field response spectra shall be considered acceptable if they equal or exceed the estimated 84th percentile ground-motion spectra from the ~~maximum or controlling earthquake~~ **CE** described in Subsection 2.5.2.4.

The following steps summarize the staff review of the SSE.

1. Both horizontal and vertical component site-specific response spectra should be developed statistically from response spectra of recorded strong motion records that are selected to have similar source, propagation path, and recording site properties as the controlling earthquake(s). It must be ensured that the recorded motions represent free-field

conditions and are free of or corrected for any soil-structure interaction effects that may be present because of locations and/or housing of recording instruments. Important source properties include magnitude and, if possible, fault type, and tectonic environment. Propagation path properties include distance, depth, and attenuation. Relevant site properties include shear velocity profile and other factors that affect the amplitude of waves at different frequencies. A sufficiently large number of site-specific time histories and/or response spectra should be used to obtain an adequately broadband spectrum to encompass the uncertainties in these parameters. An 84th percentile response spectrum for the records should be presented for each damping value of interest and compared to the SSE free-field and design response spectrum (e.g., Refs. 30, 31, 32, and 33). The staff considers direct estimates of spectral ordinates preferable to scaling of spectra to peak accelerations. In the Eastern United States, relatively little information is available on magnitudes for the larger historic earthquakes; hence, it may be appropriate to rely on intensity observations (descriptions of earthquake effects) to estimate magnitudes of historic events (e.g., Refs. 34 and 35). If the data for site-specific response spectra were not obtained under geologic conditions similar to those at the site, corrections for site effects should be included in the development of the site-specific spectra.

2. Where a large enough ensemble of strong-motion records is not available, response spectra may be approximated by scaling that ensemble of strong-motion data that represent the best estimate of source, propagation path, and site properties (e.g., Ref. 36). Sensitivity studies should show the effects of scaling.

3. If strong-motion records are not available, site-specific peak ground acceleration, velocity, and displacement (if necessary) should be determined for appropriate magnitude, distance, and foundation conditions. Then response spectra may be determined by scaling the acceleration, velocity, and displacement values by appropriate amplification factors (e.g., Ref. 37). Where only estimates of peak ground acceleration are available, it is acceptable to select a peak acceleration and use this peak acceleration as the high frequency asymptote to standardized response spectra such as described in Regulatory Guide 1.60 (Ref. 6) for both the horizontal and vertical components of motion with the appropriate amplification factors. For each controlling earthquake, the peak ground motions should be determined using current relations between acceleration, velocity, and, if necessary, displacement, earthquake size (magnitude or intensity), and source distance. Peak ground motion should be

determined from state-of-the-art relationships. Relationships between magnitude and ground motion are found, for example, in References 38, 39, 40, and 41 and relationships between ground motion and intensity are found, for example, in References 41, 42, and 43. Due to the limited data for high intensities greater than Modified Mercalli Intensity (MMI) VIII, the available empirical relationships between intensity and peak ground motion may not be suitable for determining the appropriate reference acceleration for seismic design.

4. Response spectra developed by theoretical-empirical modeling of ground motion may be used to supplement site-specific spectra if the input parameters and the appropriateness of the model are thoroughly documented (e.g., Refs. 19, 44, 45 ~~and~~ 46**, and 53**). Modeling is particularly useful for sites near capable ~~faults~~ **tectonic sources or for deeper structures** that may experience ground motion that is different in terms of frequency content and wave type from ground motion caused by more distant earthquakes.

5. Probabilistic estimates of seismic hazard should be calculated (e.g., Refs. 41 and 47) and the underlying assumptions and associated uncertainties should be documented to assist in the staff's overall deterministic approach. The probabilistic studies should highlight which seismic sources are significant to the site. ~~Uniform hazard spectra (spectra that have a uniform probability of exceedance over the frequency range of interest) showing uncertainty should be calculated for 0.01, 0.001, and 0.0001 annual probabilities of exceedance at the site.~~ The probability of exceeding the SSE response spectra should also be estimated and comparison of results made with other probabilistic studies. **Suggested procedures are contained in DG1015.**

The time duration and number of cycles of strong ground motion is required for analysis of site foundation liquefaction potential and for design of many plant components. The adequacy of the time history for structural analysis is reviewed under SRP Section 3.7.1. The time history is reviewed in this SRP section to confirm that it is compatible with the seismological and geological conditions in the site vicinity and with the accepted SSE model. At present, models for deterministically computing the time history of strong ground motion from a given source-site configuration may be limited. It is therefore acceptable to use an ensemble of ground-motion time histories from earthquakes with similar size, site-source characteristics, and spectral characteristics or results of a statistical analysis of such an ensemble. Total duration of the motion is acceptable when it is as conservative as values determined using current studies such as References 48, 49, 50, and 51.

~~2.5.2.7 Operating Basis Earthquake. In meeting the requirements of Reference 1, this subsection is acceptable when the vibratory ground motion for the OBE is described and the response spectrum (at appropriate damping values) at the site specified. Probability calculations (e.g., Refs. 41, 47, and 52) should be used to estimate the probability of exceeding the OBE during the operating life of the plant. The maximum vibratory ground motion of the OBE should be at least one-half the maximum vibratory ground motion of the SSE unless a lower OBE can be justified on the basis of probability calculations. It has been staff practice to accept the OBE if the return period is on the order of hundreds of years (e.g., Ref. 31).~~

III. REVIEW PROCEDURES

Upon receiving the applicant's SAR, an acceptance review is conducted to determine compliance with the investigative requirements of 10 CFR Part 100, Appendix ~~A~~ **B** (Ref. 1). The reviewer also identifies any site-specific problems, the resolution of which could result in extended delays in completing the review.

After SAR acceptance and docketing, those areas are identified where additional information is required to determine the earthquake hazard. These are transmitted to the applicant as draft requests for additional information.

A site visit may be conducted during which the reviewer inspects the geologic conditions at the site and region around the site as shown in outcrops, borings, geophysical data, trenches, and those geologic conditions exposed during construction if the review is for an operating license. The reviewer also discusses the questions with the applicant and his consultants so that it is clearly understood what additional information is required by the staff to continue the review. Following the site visit, a revised set of requests for additional information, including any additional questions that may have been developed during the site visit, is formally transmitted to the applicant.

The reviewer evaluates the applicant's response to the questions, prepares requests for additional clarifying information, and formulates positions that may agree or disagree with those of the applicant. These are formally transmitted to the applicant.

The safety analysis report and amendments responding to the requests for additional information are reviewed to determine that the information presented by the applicant is acceptable according to the criteria described in Section II (Acceptance Criteria) above. Based on information supplied by the applicant, obtained from site visits or from staff consultants or literature sources, the reviewer independently identifies **and evaluates** the relevant ~~seismotectonic provinces~~ **seismogenic sources and capable tectonic**

sources, evaluates the capability of faults in the region, and determines the earthquake potential for each ~~province and each capable fault or tectonic structure~~ **seismogenic source or capable tectonic source** using procedures noted in Section II (Acceptance Criteria) above. The reviewer evaluates the vibratory ground motion that the ~~potential earthquakes~~ **controlling earthquakes** could produce at the site and ~~defines~~ **compares that ground motion to** the safe shutdown earthquake~~ and operating basis earthquake~~.

IV. EVALUATION FINDINGS

If the evaluation by the staff, on completion of the review of the geologic and seismologic aspects of the plant site, confirms that the applicant has met the requirements or guidance of applicable portions of References 1 through 6, the conclusion in the SER states that the information provided and investigations performed support the applicant's conclusions regarding the seismic integrity of the subject nuclear power plant site. In addition to the conclusion, this section of the SER includes (1) ~~definitions~~ **an evaluation** of ~~tectonic provinces~~ **seismogenic sources and capable tectonic sources**; (2) evaluations of the capability of geologic structures in the region; (3) ~~determinations~~ **evaluation** of the ~~SSE earthquake(s)~~ **DSEs** and free-field response spectra based on evaluation of the ~~potential~~ **controlling** earthquakes; **and** (4) time history of strong ground motion~~, and (5) determinations of the OBE free-field response spectra~~. Staff reservations about any significant deficiency presented in the applicant's SAR are stated in sufficient detail to make clear the precise nature of the concern. The above evaluation determinations or redeterminations are made by the staff during both the construction permit (CP) and operating license (OL) phases of review.

OL applications are reviewed for any new information developed subsequent to the CP safety evaluation report (SER). The review will also determine whether the CP recommendations have been implemented.

A typical OL-stage summary finding for this section of the SER follows:

> In our review of the seismologic aspects of the plant site we have considered pertinent information gathered since our initial seismologic review which was made in conjunction with the issuance of the Construction Permit. This new information includes data gained from both site and near-site investigations as well as from a review of recently published literature.
>
> As a result of our recent review of the seismologic information, we have determined that our earlier conclusion regarding the safety of the plant from a seismolog

standpoint remains valid. These conclusions can be summarized as follows:

1. Seismologic information provided by the applicant and required by Appendix ~~A~~ **B** to 10 CFR Part 100 provides an adequate basis to establish that no ~~capable faults~~ **seismic sources** exist in the plant site area which would cause earthquakes to be centered there.

2. The response spectrum proposed for the safe shutdown earthquake is the appropriate free-field response spectrum in conformance with Appendix ~~A~~ **B** to 10 CFR Part 100.

The new information reviewed for the proposed nuclear power plant is discussed in Safety Evaluation Report Section 2.5.2.

The staff concludes that the site is acceptable from a seismologic standpoint and meets the requirements of (1) 10 CFR Part 50, Appendix A (General Design Criterion 2), (2) 10 CFR Part 100, and (3) 10 CFR Part 100, Appendix ~~A~~ **B**. This conclusion is based on the following:

1. The applicant has met the requirements of:

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

   b. 10 CFR Part 100 (Reactor Site Criteria) with respect to the identification of geologic and seismic information used in determining the suitability of the site.

   c. 10 CFR Part 100, ~~Appendix A (Seismic and Geologic Siting Criteria for Nuclear Power Plants)~~ **Appendix B (Criteria for the Seismic and Geologic Siting of Nuclear Power Plants after [effective Date])** with respect to obtaining the geologic and seismic information necessary to determine (1) site suitability and (2) the appropriate design of the plant. Guidance for complying with this regulation is contained in Regulatory Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants," Regulatory Guide 4.7, "General Site Suitability for Nuclear Power Stations," and Regulatory Guide 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants."

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/licensee proposes an acceptable alternative method for complying with specific portions of the Commission's regulations, the methods 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 and NUREGs (Refs. 4 through 8).

The provisions of this SRP section apply to reviews of construction permit (CP), operating license (OL), preliminary design approval (PDA), final design approval (FDA), and combined license (CP/OL) applications docketed after the date of issuance of this SRP section.

VI. REFERENCES

1. 10 CFR Part 100, ~~Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants."~~ **Appendix B, "Criteria for the Seismic and Geologic Siting of Nuclear Power Plants After [Effective Date]."**

2. 10 CFR Part 50, Appendix A, General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena."

3. 10 CFR Part 100, "Reactor Site Criteria."

4. Regulatory Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants."

5. Regulatory Guide 4.7, "General Site Suitability Criteria for Nuclear Power Stations."

6. Regulatory Guide 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants."

7. Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants."

8. NUREG-0625, "Report of Siting Policy Task Force" (1979).

9. NUREG/CR-1577, "An Approach to Seismic Zonation for Siting Nuclear Electric Power Generating Facilities in the Eastern United States," prepared by Rondout Associates, Inc., for the U.S. Nuclear Regulatory Commission. Authored by N. Barstow, K. Brill, O. Nuttli, and P. Pomeroy (1981).

10. C. W. Stover et al., 1979-1981, Seismicity Maps of the States of the U.S., Geological Survey Miscellaneous Field Studies Maps.

11. "Earthquake History of the United States," Publication 41-1, National Oceanic and Atmospheric Administration, U.S. Department of Commerce (1982).

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13. P. W. Basham, D. H. Weichert, and M. J. Berry, "Regional Assessment of Seismic Risk in Eastern Canada," Bulletin Seismological Society of America, Vol. 65, pp. 1567-1602 (1979).

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17. M. L. Sbar and L. R. Sykes, "Contemporary Compressive Stress and Seismicity in Eastern North America: An Example of Intra-Plate Tectonics," Bulletin Geological Society of America, Vol. 84 (1973).

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19. NUREG-0712, "Safety Evaluation Report (Geology and Seismology) Related to the Operation of San Onofre Nuclear Generating Station, Units 2 and 3" (1980).

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DRAFT REGULATORY GUIDE DG-1016

SEISMIC INSTRUMENTATION

DRAFT REGULATORY GUIDE DG-1016

SECOND PROPOSED REVISION 2 TO REGULATORY GUIDE 1.12

NUCLEAR POWER PLANT INSTRUMENTATION FOR EARTHQUAKES

A. INTRODUCTION

In 10 CFR Part 20, "Standards for Protection Against Radiation," licensees are required to make every reasonable effort to maintain radiation exposures as low as is reasonably achievable. Paragraph (c) of §50.36, "Technical Specifications," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," requires the technical specifications of a facility to include surveillance requirements to ensure that the necessary quality of systems and components is maintained, that facility operation will be within safety limits, and that the limiting conditions of operation will be met. Paragraph IV(a)(4) of Proposed Appendix S, "Earthquake Engineering Criteria for Nuclear Power Plants," to 10 CFR Part 50 would require that suitable instrumentation be provided so that the seismic response of nuclear power plant features important to safety can be evaluated promptly. Paragraph IV(a)(3) of Proposed Appendix S to 10 CFR Part 50 would require shutdown of the nuclear power plant if vibratory ground motion exceeding that of the Operating Basis Earthquake (OBE) ground motion occurs.[1]

This guide is being developed to describe seismic instrumentation acceptable to the NRC staff for satisfying the requirements of Parts 20 and 50 and the Proposed Appendix S to Part 50.

Any information collection activities mentioned in this draft regulatory guide are contained as requirements in the proposed amendments to 10 CFR Part 50 that would provide the regulatory basis for this guide. The proposed amendments have been submitted to the Office of Management and Budget for clearance that may be appropriate under the Paperwork Reduction Act. Such

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[1] Guidance is being developed in Draft Regulatory Guide DG-1017, "Pre-Earthquake Planning and Immediate Nuclear Power Plant Operator Post-Earthquake Actions," to provide plant shutdown criteria.

clearance, if obtained, would also apply to any information collection activities mentioned in this guide.

B. DISCUSSION

When an earthquake occurs, it is important to assess immediately the effects of the earthquake at the nuclear power plant. State-of-the-art solid-state digital time-history accelerographs installed at appropriate locations will provide data on the frequency, amplitude, and phase relationship of the seismic response of the free-field, containment structure, and other Category I structures. The instrumentation should be located so that a comparison and evaluation of such response may be made with the design basis and so that occupational radiation exposures are maintained as low as reasonably achievable (ALARA).

Free-field instrumentation data would be used to determine if the OBE ground motion has been exceeded (see Draft Regulatory Guide DG-1017, "Pre-Earthquake Planning and Immediate Nuclear Power Plant Operator Post-Earthquake Actions"). Foundation-level instrumentation would provide data on the actual seism input to the containment and other buildings and would quantify differences between the vibratory ground motion at the free-field and foundation-level. Instrumentation is not located on equipment, piping, or supports since experience has shown that data obtained at these locations are obscured by vibratory motion associated with normal plant operation.

The guidance being developed in Draft Regulatory Guide DG-1017 is based on the assumption that the nuclear power plant has operable seismic instrumentation, including the equipment and software required to process the data within four hours after an earthquake. This is necessary because the decision to shut down the plant will be made in part, by comparing the recorded data against OBE exceedance criteria. The decision to shut down the plant is also based on the results of the operator walkdown inspections which take place within eight hours of the event.

It may not be necessary that identical nuclear power units on a given site each be provided with seismic instrumentation if essentially the same seismic response at each of the units is expected from a given earthquake.

An evaluation of seismic instrumentation operational experience noted that instruments have been out of service during plant shutdown and sometimes during plant operation. The instrumentation system should be operable at all times. If the seismic instrumentation is inoperable, the guidelines being developed in Appendix B to Draft Regulatory Guide DG-1017 should be used to determine if the Operating Basis Earthquake ground motion has been exceeded.

Information pertaining to instrumentation characteristics, installation, activation, remote indication, and maintenance is provided in this guide to ensure (1) that the data provided are comparable with the data used in the design of the nuclear power plant, (2) that exceedance of the Operating Basis Earthquake can be determined, and (3) that the equipment will perform as required.

Appendix A to this guide provides definitions to be used with this guidance.

C. REGULATORY POSITION

The type, locations, operability, characteristics, installation, actuation, remote indication, and maintenance of seismic instrumentation described below are acceptable to the NRC staff for satisfying the requirements in 10 CFR 20.1(c), 10 CFR 50.36(c), and Paragraph IV(a)(4) of Proposed Appendix S to 10 CFR 50 for ensuring the safety of nuclear power plants.

1. Seismic Instrumentation Type and Location

1.1 State-of-the-art solid-state digital instrumentation that will enable the quick processing of data at the plant site should be used.

1.2 A triaxial time-history accelerograph should be provided at each of the following locations:

1. Free-field.

2. Containment foundation.

3. Two elevations (excluding the foundation) on a structure internal to the containment.

4. Two independent Category I structure foundations (for instance, the diesel generator building and the auxiliary building) where the response is different from that of the containment structure.

5. An elevation (excluding the foundation) on each of the independent Category I structures selected in 4 above.

6. If seismic isolators are used, instrumentation should be placed on both the rigid and isolated portions of the structures at approximately the same elevations.

1.3 The specific locations for instrumentation should be determined by the nuclear plant designer to obtain the most pertinent information consistent with maintaining occupational radiation exposures ALARA for the location, installation, and maintenance of seismic instrumentation. In general:

1. A design review of location, installation, and maintenance of proposed instrumentation for maintaining exposures ALARA should be performed by the facility in the planning stage in accordance with Regulatory Guide 8.8, "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will Be As Low As Is Reasonably Achievable."

2. Instrumentation should be placed in a location with as low a dose rate as is practical, consistent with other requirements.

3. Instruments should be selected to require minimal

maintenance and in-service inspection, and minimal time and numbers of personnel to conduct installation and maintenance.

2. Instrumentation at Multi-Unit Si

Instrumentation in addition to that installed for a single unit will not be required if essentially the same seismic response is expect d at the other units based on the seismic analysis used in the seismic design of the plant. However, if there are separate control rooms, annunciation should be provided to both control rooms as specified in Regulatory Position 7.

3. Seismic Instrumentation Operability

The seismic instrumentation should operate during all modes of plant operation, including periods of plant shutdown. The maintenance and repair procedures should provide for keeping the maximum number of instruments in service during plant opera on and shutdown.

4. Instrumentation Characteristics

4.1 The design should include provisions for in-service testing. The instruments should be capable of periodic channel checks during normal plant operation.

4.2 The instruments should have the capability for in-place functional testing.

4.3 The instrumentation on the foundation and at elevations within the same building or structure should be interconnected for common starting and common timing, and the instrumentation should contain provisions for an external remote alarm to indicate actuation.

4.4 The instrumentation should have the ability to record the 5 seconds prior to seismic trigger actuation. It should operate continuously during the period in which the earthquake exceeds the seismic trigger threshold and for a minimum of 5 seconds beyond the last seismic trigger signal. The instrumentation should be capable of a minimum of 25 minutes of continuous recording

4.5 Acceleration Sensor(s).

1. The dynamic range should be 1000:1 zero to peak, for example, 0.001g to 1.0g.

2. The frequency range should be 0.0 Hz to 33.0 Hz, or an equivalent demonstrated to be adequate by computational techniques applied to the resultant accelerogram.

4.6 Recorder.

1. The sample rate should be at least 200 samples per second.

2. The bandwidth should be at least from 0.20 Hz to 50 Hz.

3. The dynamic range should be 1000:1.

4.7 Seismic Trigger.

The actuating level should be adjustable for a minimum of 0.005g to 0.02g.

5. Instrumentation Installation

5.1 The instrumentation should be designed and installed so that the vibratory transmissibility over the amplified region of the design spectral frequency range is essentially unity, that is, the mounting is rigid.

5.2 The instrumentation should be oriented so that the horizontal axes are parallel to the orthogonal horizontal axes assumed in the seismic analysis.

5.3 Protection against accidental impacts should be provided.

6. Instrumentation Actuation

6.1 Both vertical and horizontal input vibratory ground motion should actuate the same time-history accelerograph. One or more seismic triggers may be used to accomplish this.

6.2 Spurious triggering should be avoided.

6.3 The seismic trigger mechanisms of the time-history accelerograph should be set for a threshold ground acceleration of not more than 0.02g.

7. Remote Indication

Activation of the free-field or any foundation-level time-history accelerograph should be annunciated in the control room. If there are two or more control rooms at the site, annunciation should be provided to each control room.

8. Maintenance

8.1 The purpose of the maintenance program is to ensure that the equipment will perform as required. As stated in Regulatory Position 3, the maintenance and repair procedures should provide for keeping the maximum number of instruments in service during plant operation and shutdown.

8.2 Systems are to be given channel checks every two weeks for the first three months of service after startup. Failures of devices normally occur during initial operation. After the initial three-month period and three consecutive successful checks, monthly channel check are sufficient. The monthly channel check is to include checking the batteries. The channel functional test should be performed every 6 months. Channel calibration should be performed during refueling.

D. IMPLEMENTATION

The purpose of this section is to provide guidance to applicants and licensees regarding the NRC staff's plans for using this regulatory guide.

This proposed revision has been released to encourage public participation in its development. Except in those cases in which the applicant proposes an acceptable alternative method for complying with the specified portions of the Commission's regulations, the method to be described in the active guide reflecting public comments will be used in the evaluation of applications for a construction permit, operating license, combined license, or design certification submitted after the implementation date to be specified in the active guide. This guide would not be used in the evaluation of an application for an operating license submitted after the implementation date to be specified in the active guide if the construction permit was issued prior to that date.

APPENDIX A
DEFINITIONS

<u>Acceleration Sensor</u>. An instrument capable of sensing absolute acceleration and transmitting the data to a recorder.

<u>Channel Calibration</u> (Primary Calibration). The determination and adjustment, if required, of an instrument, sensor, or system such that it responds within a specific range and accuracy to an acceleration, velocity, or displacement input, as applicable, traceable to the National Institute of Standards and Technology (NIST), or an acceptable physical constant.

<u>Channel Check</u>. The qualitative verification of the functional status of the instrument sensor. This check is an "in-situ" test and may be the same as a channel functional test.

<u>Channel Functional Test</u> (Secondary Calibration). The determination without adjustment that an instrument, sensor, or system responds to a known input, not necessarily traced to the National Institute of Standards and Technology (NIST), of such character that it will verify the instrument, sensor, or system is functioning in a manner that can be calibrated.

<u>Containment</u> - See Primary Containment and Secondary Containment.

<u>Operating Basis Earthquake Ground Motion</u> (OBE). The vibratory ground motion for which those features of the nuclear power plant necessary for continued operation without undue risk to the health and safety of the public will remain functional. The value of the Operating Basis Earthquake Ground Motion is set by the applicant.

<u>Primary Containment</u>. The principal structure of a unit that acts as the barrier, after the fuel cladding and reactor pressure boundary, to control the release of radioactive material. It includes (1) the containment structure and its access openings, penetrations, and appurtenances, (2) the valves, pipes, closed systems, and other components used to isolate of the containment atmosphere from the environment, and (3) those systems or portions of systems that, by their system functions, extend the containment structure boundary

(e.g., the connecting steam and feedwater piping) and provide effective isolation.

Recorder. An instrument capable of simultaneously recording the data versus time from acceleration sensor(s).

Secondary Containment. The structure surrounding the primary containment that acts as a further barrier to control the release of radioactive material.

Seismic Isolator. A device (for instance, laminated elastomer and steel) installed between the structure and its foundation to reduce the acceleration of the isolated structure, and the attached equipment and components.

Seismic Trigger. A device that starts the time-history accelerograph.

Time-History Accelerograph. An instrument capable of measuring and permanently recording the absolute acceleration versus time. The components of the time-history accelerograph (acceleration sensor, recorder, seismic trigger) may be assembled in a self-contained unit or be separately located.

Triaxial. Describes the function of an instrument or group of instruments in three mutually orthogonal directions, one of which is vertical.

REGULATORY ANALYSIS

A separate regulatory analysis was not prepared for this regulatory guide. The draft regulatory analysis, "Proposed Revision of 10 CFR Part 100 and 10 CFR Part 50," provides the regulatory basis for this guide and examines the costs and benefits of the rule as implemented by the guide. A copy of the draft regulatory analysis is available for inspection and copying for a fee at the NRC Public Document Room, 2120 L Street NW. (Lower Level), Washington, DC, as Enclosure 2 to Secy 92-???. Single copies of the draft regulatory analysis are available from Mr. Leonard Soffer, Office of Nuclear Regulatory Research, Mail Stop NL/S-324, U.S. Nuclear Regulatory Commission, Washington, DC 20555, telephone (301) 492-3916 or Dr. Andrew J. Murphy, Office of Nuclear Regulatory Research, Mail Stop NL/S-217A, U.S. Nuclear Regulatory Commission, Washington, DC 20555, telephone (301) 492-3860.

DRAFT REGULATORY GUIDE DG-1017

PLANT SHUTDOWN

DRAFT REGULATORY GUIDE DG-1017

PRE-EARTHQUAKE PLANNING AND IMMEDIATE NUCLEAR POWER PLANT OPERATOR POST-EARTHQUAKE ACTIONS

A. INTRODUCTION

Paragraph IV(a)(4) of Proposed Appendix S, "Earthquake Engineering Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," would require that suitable instrumentation[1] be provided so that the seismic response of nuclear power plant features important to safety can be evaluated promptly. Paragraph IV(a)(3) of Proposed Appendix S to 10 CFR Part 50 would require shutdown of the nuclear power plant if vibratory ground motion exceeding that of the Operating Basis Earthquake Ground Motion or significant plant damage occurs. Proposed Paragraph 50.54(ee) to 10 CFR 50 would require licensees of nuclear power plants that have adopted the earthquake engineering criteria in Proposed Appendix S to 10 CFR 50 to shut down the plant if the criteria in Paragraph IV(a)(3) of Proposed Appendix S are exceeded.

This guide is being developed to provide guidance acceptable to the NRC staff for a timely evaluation after an earthquake of the recorded instrumentation data and for determining whether plant shutdown would be required by the proposed amendments to 10 CFR Part 50.

Any information collection activities mentioned in this draft regulatory guide are contained as requirements in the proposed amendments to 10 CFR Part 50 that would provide the regulatory basis for this guide. The proposed amendments have been submitted to the Office of Management and Budget for clearance that may be appropriate under the Paperwork Reduction Act. Such clearance, if obtained, would also apply to any information collection

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[1] Guidance is being developed in Draft Regulatory Guide DG-1016, Second Proposed Revision 2 to Regulatory Guide 1.12, "Nuclear Power Plant Instrumentation for Earthquakes," to describe seismic instrumentation acceptable to the NRC staff.

activities mentioned in this guide.

B. DISCUSSION

When an earthquake occurs, ground motion data are recorded by the seismic instrumentation.[1] These data are used to make an early determination of the degree of severity of the seismic event. The data from the seismic instrumentation, coupled with information obtained from a plant walkdown, are used to make the initial determination of whether the plant should be shut down, if it has not already been shut down by operational perturbations resulting from the seismic event. If on the basis of these initial evaluations (instrumentation data and walkdown) it is concluded that the plant shutdown criteria have not been exceeded, it is presumed that the plant will not be shut down. Guidance is being developed on post shutdown inspections and plant restart; see Draft Regulatory Guide DG-1018, "Restart of a Nuclear Power Plant Shut Down by a Seismic Event."

The Electric Power Research Institute has developed guidelines that will enable licensees to quickly identify and assess earthquake effects on nuclear power plants. These guidelines are in EPRI NP-5930, "A Criterion for Determining Exceedance of the Operating Basis Earthquake," July 1988, EPRI NP-6695, "Guidelines for Nuclear Plant Response to an Earthquake," December 1989, and EPRI TR-100082, "Standardization of Cumulative Absolute Velocity," December 1991.[2]

This guide is based on the assumption that the nuclear power plant has operable seismic instrumentation. If the seismic instrumentation is inoperable, the guidelines being developed in Appendix A to this guide would be used to determine whether the Operating Basis Earthquake Ground Motion has been exceeded.

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[2] Copies may be obtained from the Research Reports Center (RRC), Box 50490, Palo Alto, California 94303.

Shutdown of the nuclear power plant would be required if the vibratory ground motion experienced exceeds that of the Operating Basis Earthquake (OBE) ground motion. Two criteria for determining exceedance of the OBE are provided in EPRI NP-5930: a threshold response spectrum ordinate criterion and a cumulative absolute velocity criterion (CAV). A procedure to standardize the calculation of the CAV is provided in EPRI TR-100082. In addition, a spectral velocity threshold has also been recommended by EPRI since some structures have fundamental frequencies below the range specified in EPRI NP-5930. The staff now recommends 1.0 to 2.0 Hz for the range of the spectral velocity limit since some structures have fundamental frequencies below 1.5 Hz. The former range was 1.5 to 2.0 Hz.

Decisions on continued operation will be made by the staff in conjunction with the licensee on a case-by-case basis consistent with applicable regulations. Therefore, the staff does not endorse the philosophy discussed in EPRI NP-6695, Section 4.3.4 (first paragraph, last sentence), pertaining to plant shutdown considerations following an earthquake based on the need for continued power generation in the region.

Appendix B to this guide provides definitions to be used with this guidance.

C. REGULATORY POSITION

1. Base-line Data

1.1 Information Related to Seismic Instrumentation

A file containing information on all the seismic instrumentation should be kept at the plant. The file should include:

1. Information on each instrument type such as make, model, and serial number; manufacturers' data sheet; list of special features or options; performance characteristics; examples of typical instrumentation readings and interpretations; operations and maintenance manuals; repair procedures

(manufacturers' recommendations for repairing common problems); and a list of any special requirements, e.g., maintenance, operational, installation.

2. Plan views and vertical sections showing the locations of each seismic instrument and the orientation of the instrument axis with respect to a plant reference axis.

3. A complete service history of each seismic instrument. The service history should include information such as dates of servicing, description of completed work, and calibration records and data (where applicable).

4. The response spectrum and cumulative absolute velocity (see Regulatory Position 4). These data should be obtained after the initial installation and each servicing of the free-field instrumentation using a suitable earthquake time history (e.g., the October 1987 Whittier, California earthquake) or manufacture's calibration standard.

1.2 Planning for Post Earthquake Inspections

The selection of equipment and structures for inspections and the content of the base line inspections as described in Sections 5.3.1 and 5.3.2.1 of EPRI NP-6695, "Guidelines for Nuclear Plant Response to an Earthquake," are acceptable to the NRC staff for satisfying the requirements in Paragraph IV(a)(3) of Proposed Appendix S to 10 CFR Part 50 for ensuring the safety of nuclear power plants.

2. <u>Immediate Postearthquake Actions</u>

The guidelines for immediate postearthquake actions specified in Sections 4.3.1 and 4.3.2 (including Section 5.3.2.1 and items 7 and 8 of Table 5-1) of EPRI NP-6695 are acceptable to the NRC staff for satisfying the requirements indicated in Paragraph IV(a)(3) of Proposed Appendix S to 10 CFR Part 50.

3. Evaluation of Ground Motion Records

3.1 Data Identification

A record collection log should be maintained at the plant, and all data should be identifiable and traceable with respect to:

1. The date and time of collection,

2. The make, model, serial number, location, and orientation of the instrument (sensor) from which the record was collected.

3.2 Data Collection

1. Only personnel trained in the operation of the instrument should collect the data.

2. Procedures for removing and storing records from each seismic instrument should be preplanned and performed in accordance with established procedures.

3. Extreme caution should be exercised to prevent accidental damage to the recording media and instruments during data collection and subsequent handling.

4. As data are collected and the instrumentation is inspected, notes should be made regarding the condition of the instrument and its installation, for example, instrument flooded, mounting surface tilted, whether fallen objects might have struck the instrument or the instrument mounting surface.

5. For validation of the collected data, a reference signal (see Regulatory Position 1.1(4)) should be added to the record without affecting the previously recorded data.

6. If the instrument operation appears to have been normal, the instrument should remain in service without readjustment or

change that would defeat attempts to obtain postevent calibration.

3.3 Record Evaluation

Records should be analyzed according to the manufacturer's specifications and the results of the analysis should be evaluated. Any record anomalies, invalid data, and nonpertinent signals should be noted, with any known causes.

4. <u>Determining OBE Exceedance</u>

The evaluation to determine if the OBE was exceeded should be performed using data obtained from the three components of the free-field ground motion (i.e., two horizontal and one vertical). The evaluation may be performed on uncorrected earthquake records. It was found in a study of uncorrected versus corrected earthquake records (EPRI NP-5930) that the use of uncorrected records is conservative. The evaluation should consist of a check of the response spectrum, cumulative absolute velocity limit, and the operability of the instrumentation.

4.1 Response Spectrum Check

The OBE response spectrum is exceeded if any one of the three components (two horizontal and one vertical) of the 5 percent damped free-field ground motion response spectra is larger than:

1. The corresponding design response spectral acceleration (OBE spectra if used, otherwise 1/3 of the Safe Shutdown Earthquake (SSE) spectra) or 0.2g, whichever is greater, for frequencies between 2 to 10 Hz, or

2. The corresponding design response spectral velocity (OBE spectra if used, otherwise 1/3 of the SSE spectra) or a spectral velocity of 6 inches per second, whichever is greater, for frequencies between 1 to 2 Hz.

4.2 Cumulative Absolute Velocity (CAV) Limit

The CAV should be calculated as follows: For each component of the free-field ground motion, (1) the absolute acceleration (g units) time-history is segmented into 1-second intervals, (2) each 1-second interval that has at least 1 exceedance of 0.025g is integrated over time, (3) all the integrated values are summed together to arrive at the CAV. Additional guidance on how to determine the CAV is provided in EPRI TR-100082.

The CAV Limit is exceeded if any CAV calculation is greater than 0.16 g-second.

4.3 Instrument Operability Check

After an earthquake at the plant site, the response spectrum and CAV should be obtained using the calibration standard (see Regulatory Position 1.1(4)) to demonstrate that the system was functioning properly.

5. Criteria for Plant Shutdown

If the OBE vibratory ground motion is exceeded or significant plant damage occurs, the plant must be shut down.

5.1 OBE Exceedance. If the response spectrum check and the CAV limit, performed in accordance with Regulatory Position 4.1 and 4.2, were exceeded, the OBE was exceeded and plant shutdown is required. If either limit does not exceed the criterion, the earthquake motion did not exceed the OBE. The determination of whether or not the OBE has been exceeded should be performed even if the plant automatically trips off-line as a result of the earthquake, or

5.2 Damage. The plant should shutdown if the walkdown inspections, performed in accordance with Regulatory Position 2 (Section 4.3.2 of EPRI NP-6695), discover damage.

6 Pre-Shutdown Inspections

The pre-shutdown inspections described in Section 4.3.4 of EPRI NP-6695, "Guidelines for Nuclear Plant Response to an Earthquake," are acceptable to the NRC staff for satisfying the requirements indicated in Paragraph IV(a)(3) of Proposed Appendix S to 10 CFR 50 for ensuring the safety of nuclear power plants subject to the following:

6.1 Delete the last sentence in the first paragraph of Section 4.3.4.

6.2 The following paragraph in Section 4.3.4 is repeated to emphasize that the plant should shut down in an orderly manner.

> "Prior to initiating plant shutdown following an earthquake, visual inspections and control board checks of safe shutdown systems should be performed by plant operations personnel, and the availability of off-site and emergency power sources should be determined. The purpose of these inspections is to determine the effect of the earthquake on essential safe shutdown equipment which is not normally in use during power operation so that any resets or repairs required as a result of the earthquake can be performed, or alternate equipment can be readied, prior to initiating shutdown activities. In order to ascertain possible fuel and reactor internal damage, the following checks should be made, if possible, before plant shutdown is initiated .... "

If the OBE was not exceeded and the walkdown inspection indicates no damage to the nuclear power plant, shutdown of the plant is not required. The plant may continue to operate (or restart following a post-trip review, if it tripped off-line due to the earthquake).

D. IMPLEMENTATION

The purpose of this section is to provide guidance to applicants and licensees regarding the NRC staff's plans for using this regulatory guide.

This draft guide has been released to encourage public participation in its development. Except in those cases in which the applicant proposes an acceptable alternative method for complying with the specified portions of the Commission's regulations, the method to be described in the active guide reflecting public comments will be used in the evaluation of applications for a construction permit, operating license, combined license, or design certification submitted after the implementation date to be specified in the active guide. This guide would not be used in the evaluation of an application for an operating license submitted after the implementation date to be specified in the active guide if the construction permit was issued prior to that date.

APPENDIX A

INTERIM OPERATING BASIS EARTHQUAKE EXCEEDANCE GUIDELINES

Draft Regulatory Guide DG-1017 is based on the assumption that the nuclear power plant has operable seismic instrumentation. If the seismic instrumentation is inoperable, the following should be used to determine whether the Operating Basis Earthquake Ground Motion (OBE) has been exceeded:

1. For plants at which instrumentally determined data are available only at the foundation level, the Cumulative Absolute Velocity (CAV) Limit (see Regulatory Position 4.2 of this guide) is not applicable, and a determination of OBE exceedance is based on the response spectrum check described in Regulatory Position 4.1 of this regulatory guide. A comparison is made between the foundation level design response spectra and data obtained from the foundation level instruments. If the response spectrum check at any foundation is exceeded, the OBE is exceeded and shutdown is warranted.

2. For plants at which no instrumental data are available, the OBE will be considered to have been exceeded and shutdown to be warranted if one of the following applies:

    1. The earthquake resulted in Modified Mercalli Intensity (MMI) VI or greater within 5 km of the plant,

    2. The earthquake was felt within the plant and was of magnitude 6.0 or greater, or

    3. The earthquake was of magnitude 5.0 or greater, and occurred within 200 km of the plant.

3. A postearthquake plant walkdown should be conducted (see Regulatory Position 2 of this guide).

4. If plant shutdown is warranted under the above guidelines, the plant

should be shut down in an orderly manner (see Regulatory Position 6 of this guide).

Note:

The U.S. Geological Survey, National Earthquake Information Center, determinations of epicentral location, magnitude, and intensity will usually take precedence over other estimates; however, regional and local determinations will be used if they are considered to be more accurate. Also, higher quality damage reports or a lack of damage reports from the nuclear power plant site or its immediate vicinity will take precedence over more distant reports.

APPENDIX B
DEFINITIONS

Design Response Spectra. Response spectra used to design Seismic Category I structures, systems, and components.

Operating Basis Earthquake Ground Motion (OBE). The vibratory ground motion for which those features of the nuclear power plant necessary for continued operation without undue risk to the health and safety of the public will remain functional. The value of the Operating Basis Earthquake Ground Motion is set by the applicant.

Spectral Acceleration. The acceleration response of a linear oscillator with prescribed frequency and damping.

Spectral Velocity. The velocity response of a linear oscillator with prescribed frequency and damping.

REGULATORY ANALYSIS

A separate regulatory analysis was not prepared for this regulatory guide. The draft regulatory analysis, "Proposed Revision of 10 CFR Part 100 and 10 CFR Part 50," provides the regulatory basis for this guide and examines the costs and benefits of the rule as implemented by the guide. A copy of the draft regulatory analysis is available for inspection and copying for a fee at the NRC Public Document Room, 2120 L Street NW. (Lower Level), Washington, DC, as Enclosure 2 to Secy 92-???. Single copies of the draft regulatory analysis are available from Mr. Leonard Soffer, Office of Nuclear Regulatory Research, Mail Stop NL/S-324, U.S. Nuclear Regulatory Commission, Washington, DC 20555, telephone (301) 492-3916 or Dr. Andrew J. Murphy, Office of Nuclear Regulatory Research, Mail Stop NL/S-217A, U.S. Nuclear Regulatory Commission, Washington, DC 20555, telephone (301) 492-3860.

DRAFT REGULATORY GUIDE DG-1018

PLANT RESTART

DRAFT REGULATORY GUIDE DG-1018

RESTART OF A NUCLEAR POWER PLANT SHUT DOWN

BY A SEISMIC EVENT

A. INTRODUCTION

Paragraph IV(a)(3) of Proposed Appendix S, "Earthquake Engineering Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," would require shutdown of the nuclear power plant if vibratory ground motion exceeding that of the Operating Basis Earthquake Ground Motion occurs.[1] Prior to resuming operations, the licensee must demonstrate to the Commission that no functional damage has occurred to those features necessary for continued operation without undue risk to the health and safety of the public

This guide is being developed to provide guidelines that are acceptable to the NRC staff for performing inspections and tests of nuclear power plant equipment and structures prior to restart of a plant that has been shut down by a seismic event.

Any information collection activities mentioned in this draft regulatory guide are contained as requirements in the proposed amendments to 10 CFR Part 50 that would provide the regulatory basis for this guide. The proposed amendments have been submitted to the Office of Management and Budget for clearance that may be appropriate under the Paperwork Reduction Act. Such clearance, if obtained, would also apply to any information collection activities mentioned in this guide.

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[1] Guidance is being developed in Draft Regulatory Guide DG-1017, "Pre-Earthquake Planning and Immediate Nuclear Power Plant Operator Post-Earthquake Actions," to provide plant shutdown criteria.

B. DISCUSSION

Data from seismic instrumentation[2] and a walkdown of the nuclear power plant are used to make the initial determination of whether the plant should be shut down after an earthquake, if the plant has not already shut down from operational perturbations resulting from the seismic event.[1]

The Electric Power Research Institute has developed guidelines that will enable licensees to quickly identify and assess earthquake effects on nuclear power plants, EPRI NP-6695, "Guidelines for Nuclear Plant Response to an Earthquake,"[3] December 1989. This regulatory guide addresses sections of EPRI NP-6695 that relate to post-shutdown inspection and tests, inspection criteria, inspection personnel, documentation, and long-term evaluations.

C. REGULATORY POSITION

After a plant has been shut down by an earthquake, the guidelines for inspections and tests of nuclear power plant equipment and structures that are specified in Sections 5.3.2 (including Tables 2-1, 2-2, and 5-1), 5.3.3 (including Table 5-1), 5.3.4, 5.3.5, and the long-term evaluations that are specified in Section 5.3 (all sections and subsections) of EPRI NP-6695 would be acceptable to the NRC staff for satisfying the requirements in Paragraph IV(a)(3) of Proposed Appendix S to 10 CFR 50.

Coincident with the long-term evaluations, the plant should be restored to its current licensing basis. Exceptions to this must be approved by the Director, Office of Nuclear Reactor Regulation.

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[2] Guidance is being developed in Draft Regulatory Guide DG-1016, Second Proposed Revision 2 to Regulatory Guide 1.12, "Nuclear Power Plant Instrumentation for Earthquakes," that will describe seismic instrumentation acceptable to the NRC staff.

[3] Copies may be obtained from the Research Reports Center (RRC), Box 50490, Palo Alto, California 94303.

D. IMPLEMENTATION

The purpose of this section is to provide guidance to applicants and licensees regarding the NRC staff's plans for using this regulatory guide.

This draft guide has been released to encourage public participation in its development. Except in those cases in which the applicant proposes an acceptable alternative method for complying with the specified portions of the Commission's regulations, the method to be described in the active guide reflecting public comments will be used in the evaluation of applications for a construction permit, operating license, combined license, or design certification submitted after the implementation date to be specified in the active guide. This guide would not be used in the evaluation of an application for an operating license submitted after the implementation date to be specified in the active guide if the construction permit was issued prior to that date.

REGULATORY ANALYSIS

A separate regulatory analysis was not prepared for this regulatory guide. The draft regulatory analysis, "Proposed Revision of 10 CFR Part 100 and 10 CFR Part 50," provides the regulatory basis for this guide and examines the costs and benefits of the rule as implemented by the guide. A copy of the draft regulatory analysis is available for inspection and copying for a fee at the NRC Public Document Room, 2120 L Street NW. (Lower Level), Washington, DC, as Enclosure 2 to Secy 92-???. Single copies of the draft regulatory analysis are available from Mr. Leonard Soffer, Office of Nuclear Regulatory Research, Mail Stop NL/S-324, U.S. Nuclear Regulatory Commission, Washington, DC 20555, telephone (301) 492-3916 or Dr. Andrew J. Murphy, Office of Nuclear Regulatory Research, Mail Stop NL/S-217A, U.S. Nuclear Regulatory Commission, Washington, DC 20555, telephone (301) 492-3860.