POLICY ISSUE
(Notation Vote)

October 4, 1990 SECY-90-341

For: The Commissioners

From: James M. Taylor
Executive Director for Operations

Subject: STAFF STUDY ON SOURCE TERM UPDATE AND DECOUPLING SITING FROM DESIGN

Purpose: To present the conclusions and seek Commission approval of the NRC staff's plan with regard to updated source term information and whether reactor siting should be decoupled from plant design.

Summary: An integrated set of activities involving regulatory implementation of updated source term information in connection with the review of Advanced Light Water Reactors (ALWR) is being recommended. Parallel activities on updating the use of source terms for the design and siting of future plants are proposed. These are 1) in the near term and until such time as decoupling is accomplished, performing plant reviews on a case-by-case basis, with appropriate revisions to current practice incorporated as a part of the design certification rulemaking, and 2) instituting a decoupling of reactor siting and plant design via rulemaking changes to both Parts 50 and 100. A technical update of the TID-14844 source term would also be carried out.

The status and review schedule for future plants has been a major consideration in the staff's

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plans. The review of the Advanced Boiling Water Reactor (ABWR) is currently being conducted on a case-by-case basis, and proposed deviations from the regulations were forwarded to the Commission in SECY-90-016. Commission guidance has been received on these certification issues as provided in the Staff Requirements Memoranda (SRMs) dated May 22 and June 26, 1990, respectively. The staff will provide a paper discussing the advantages and disadvantages of proceeding with generic rulemaking, as requested by the SRM dated May 22, 1990.

The staff proposes to initiate two parallel rulemakings to decouple reactor siting from plant design in two stages. A rulemaking effort to revise reactor site criteria (10 CFR 100) would begin immediately and a proposed rule adding site criteria based on Regulatory Guide 4.7 would be expected to be completed in time to support the review of an early site application in FY 1993. This rulemaking could take the form of a new subpart to 10 CFR 100 that explicitly defines reactor site criteria, which would also prove useful for any site assessment required by Subpart A to 10 CFR 52. In support of this rulemaking, the staff will also carry out a technical update of the TID-14844 source term including revised timing, source term composition and chemistry insights.

A second stage rulemaking would revise Part 100 to delete the dose calculation requirement and revise Part 50 to include a revised source term or plant design requirements based upon revised source term insights. The revised Part 50 would essentially be a severe accident rule covering those aspects of plant design now governed by the dose calculations in Part 100. Those proposed deviations from the regulations addressed in SECY-90-016 and certified by the Commission would be reflected in this rulemaking to the extent practical. This latter rulemaking would also begin immediately, but would require a longer schedule than the site criteria revisions.

The approach outlined above is expected to result in a logical and orderly process for utilizing updated source terms in regulatory guidance. The staff wishes to emphasize, however, that the

schedule will not be allowed to delay the review of any advanced light water reactor (ALWR) application submitted to the staff. Review of such an application would be carried out expeditiously, using available regulatory guidance together with applicable source term insights.

Background: In a Staff Requirements Memorandum (SRM) dated July 31, 1989, the Commission requested that the staff provide a paper on the extent to which the current deterministic source term (TID-14844) could be updated or otherwise improved for future light water reactor designs. In response, the staff transmitted SECY-89-341 which stated that the staff intended to pursue updated source term insights to modify, as appropriate, regulatory guidance for advanced light water reactor plant design aspects such as containment isolation valve closure time, efficacy of fission product cleanup systems and control room habitability.

With regard to siting, the staff noted that it had considered pursuing the development and utilization for siting of a replacement for the TID-14844 release which would make use of the insights obtained by recent research. The staff stated, however, that it also wished to consider an alternate approach, and that it wished to undertake a short-term study to examine the implications of decoupling siting from plant design for future reactors, and to provide its recommendations to the Commission.

In an SRM dated February 13, 1990, the Commission agreed that the staff should perform such a study. The Commission also requested that the staff interact with the Advisory Committee for Reactor Safeguards (ACRS) on this item and, in addition, that the study address:

1. The criteria that would be used in siting decisions, if siting is decoupled from plant designs. Identify and discuss the considerations (e.g., risk, deterministic, policy) of the staff in establishing such criteria and specifically how the criteria were derived.

2. Benefits and disadvantages of risk based siting criteria.

3. Degree of conservatism between options under consideration.

4. Applicability and impact on existing plants.

5. The pros and cons for equating the low population zone to the emergency planning zone.

These items are addressed in Enclosure 1.

The SRM dated May 22, 1990 also requested that the Commission be informed of the results of the technical review of EPRI's source term recommendation. A brief status of this review is also provided in this paper.

Discussion: Decoupling light water reactor (LWR) siting from plant design was suggested by the staff for further study because of the potential benefits which could be realized by such an approach. Specifically, decoupling would replace existing siting dose calculation requirements (which traditionally have affected plant design more than siting) with explicit requirements more directly related to acceptable site characteristics. This would be accomplished by a significant change to 10 CFR 100 and its related guidance documents. A corresponding change to 10 CFR 50 would be required to regulate aspects of plant design now controlled by siting dose calculation requirements.

Decoupling would mean that reactor site requirements would be largely independent of dose calculations and source terms (except perhaps for reactor power level). The site requirements would be expected to remain unchanged from present requirements although they would be stated more explicitly.

Decoupling would also mean that plant engineered safety feature (ESF) design requirements would not be determined by the present design basis accident dose calculations. These design requirements would be based on best engineering judgment, rather than a dose calculation algorithm. The ESF requirements are expected to change; development of new ESF (including containment) criteria is a key element of this effort. Developing these

criteria will result in a severe accident rule-making. The staff believes that such decoupling could potentially be of more benefit than simply updating source term timing and composition because it would explicitly state siting requirements in a regulation and focus more realistically on those plant features which most affect risk.

Site characteristics (e.g., seismic characteristics) would continue to influence design in many ways. A parallel effort is underway to update the seismic requirements of 10 CFR Part 100 and a proposed revision to the Appendix to Part 100 is expected in FY91.

Although this study was initially intended to focus on decoupling, it became clear in the course of the study that an integrated approach to regulatory implementation of updated source term information (including decoupling) was necessary considering the complexity and schedule considerations of changes in this area. Therefore, the scope of this study is somewhat broader than decoupling. The remainder of this section provides a discussion as to why potential changes in staff practice are being considered, including the consequences of current siting practice, and outlines individual phases for improvement. Following the discussion is a section providing the staff's conclusions and proposed future actions.

Why Consider a Change?

The current NRC regulations regarding reactor siting have been in existence since the early 1960's and together with implementing staff guidance have generally served to set the bulk of the requirements and practice for siting, as well as certain accident mitigation features for the present generation of U.S. reactors.

Specifically, present reactors have been sited and designed based on their ability to cope with a group of postulated accidents, the so-called design basis accidents. The ability of the plant to withstand these events, as well as their radiological consequences, must be shown to be

acceptable in order for the plant to receive a license.

Reactor siting also reflects consideration of accidents beyond the design basis. The st tement of considerations (27 FR 3509) published with the issuance of Part 100 noted that accidents beyond the design basis were a factor in the establishment of the population center distance as a siting requirement.

Underlying the analysis of many of these accidents are certain regulatory assumptions regarding the accidental release of fission products which profoundly affect the design of key plant systems. Certain of these assumptions constitute what is generally referred to as the "source term", that is, the timing, composition, energy and other characteristics needed to analyze the radiological consequences of interest. The most well-known of these is the TID source term, so-called because it was given in the report TID-14844, issued in 1962. The TID report is referenced in a footnote to 10 CFR 100 for further guidance in developing the exclusion area, low population zone and population center distance and is also used elsewhere in 10 CFR 50 in relation to the design of certain plant features such as environmental qualification. Other applications deal with the performance of engineered safety features such as containment spray and filter systems.

Since the issuance of TID-14844, a great deal of information, based upon a wealth of research data, has been accumulated. The source term and other assumptions which make up the prescription used in the siting analysis, while providing a high level of plant mitigation capability, are not consistent with the results of recent research. Use of this prescription in its present form may force plant designers to include design features that may not enhance safety (e.g., valve timing and filter design). Similarly, use of this prescription may cause designers not to focus on certain aspects of plant accidents that should warrant attention (e.g., release of Cesium and potential containment failure under severe accident conditions).

Also contributing to the need for change is the way in which site evaluations have been carried

out. Part 100 refers, via a note at the end of the regulation, to the document TID-14844 as providing a sample calculation that reflects "current siting practices" of the Commission. TID-14844 did not give credit for fission product cleanup systems in dose reduction. As reactor power levels increased shortly after the promulgation of Part 100, reactor designers introduced and developed such cleanup systems to keep site boundary distances from becoming excessively large. It soon became clear that such systems were, in principle, so effective in iodine dose reduction that very small site boundary distances could be found acceptable. But it also became clear that maintenance of containment integrity was pivotal to meeting Part 100 site boundary dose guidelines. In order to avoid revision to the siting regulations, the staff used a conservative methodology which allowed only limited degree of credit for the effectiveness of these systems in order to maintain acceptable site values, but assumed that containment integrity would be maintained under accident conditions. In this fashion, the staff kept exclusion area and LPZ distances roughly the same as those resulting from review of early plants. Stated another way, the staff's conservative methodology resulted in distances roughly reflecting"current (i.e., 1962)" siting practices.

Enclosure 2 provides a description of the NRC's current siting requirements and practice. Application of these requirements and practice over the past 28 years has had consequences in both the areas of siting and plant design which indicate that a change is warranted, as discussed in the following section.

Consequences of Current Practice

The consequences that arise from current practice can be considered to fall into two basic areas as described below:

A. Siting

Although Part 100 requires an exclusion area and a LPZ, it is important to recognize that it does not provide any numerical criteria for site parameters (other than that they must not result in the

calculated dose consequences being exceeded). With regard to the dose calculation method, Part 100 states (via a note at the end) that TID-14844 contains a procedural method and a sample calculation that "result in distances roughly reflecting current siting practices". However, as noted above, after introduction of fission product cleanup systems, the staff implemented conservative assumptions to keep siting distances roughly equivalent to those approved for early plants. Better guidance on actual site criteria that have been found to be acceptable can be found either from an examination of the results of past siting reviews, or by relying upon the guidance given in Regulatory Guide 4.7. Based upon a survey of the 75 U. S. sites where reactors are presently operating or are under construction, the distance to the exclusion area boundary varies from 277 meters to 2130 meters, with a typical value of about 800 meters (0.5 mile). LPZ distances range from 1100 to 11,000 meters with a typical value of about 4800 meters (3 miles). Data for each site is presented in Enclosure 3.

Other aspects arising from current practice should also be noted. These are, first, that the size of the exclusion area and the LPZ is not regulated by Part 100 directly, as noted earlier, but is done so indirectly via the credit for fission product removal that is given for the sprays and filters and by the containment leak rate. Second, Part 100 provides that the population center distance is to be at least one and one-third times the LPZ distance and that a greater distance may be needed where very large cities are concerned but provides no criteria for such case. Although a site <u>within</u> a population center of 25,000 or more persons would not satisfy Part 100, nothing in Part 100 would prohibit a site immediately adjacent to the boundary of such a population center, especially if substantial credit were given for fission product cleanup systems. There are no restrictions in Part 100 on population density other than those associated with the population center distance. Regulatory Guide 4.7 contains population density values for sites which, if exceeded, trigger a review of alternate sites having lower population density. However, Regulatory Guide 4.7 does not limit population density. In fact, it is arguable that, by

requiring consideration of alternative sites where certain population density figures are exceeded, Regulatory Guide 4.7 does no more than what NEPA would require. It is estimated that about half a dozen existing reactor sites have population density values that are in excess of the values listed in Regulatory Guide 4.7. All of these sites were reviewed and approved prior to the issuance of this regulatory guide in 1975. It should be noted that the staff has not received indications of any interest in high population density reactor sites since the Perryman application in 1977.

B. Plant Design

Current practice has also had a significant impact upon plant design. This is because the TID source term, originally intended for siting purposes, has also been applied to many aspects of plant design, as well. Examples of plant design aspects affected by the TID source term include control room habitability, equipment qualification, post-accident sampling systems, and timing of some containment isolation valves. Some aspects of the TID source term are now recognized as inconsistent with the results of recent research. These include such aspects as fission product timing, quantities and types of radionuclides released. As a result, a rigid application of the TID source term may not permit the best engineering solutions for the design of these plant systems, as well as related systems, for future plants.

In addition, current practice assumes that containment integrity is maintained for the duration of the accident, although the containment is assumed to be leaking. Since the containment design basis is the temperature and pressure conditions associated with a loss-of-coolant accident (LOCA), the assumption of containment integrity under severe accident conditions, which could result in a TID-type release into containment, may not be appropriate. Therefore, current practice does not address containment integrity and performance under those conditions (i.e., severe accidents) which would likely result in a TID-type release and which most affect risk. For example, Appendix J concentrates on testing to assure low leak rates for large break LOCA

conditions. While assuring low leak rates for these conditions also tends to provide some assurance of structural integrity, which in turn provides a significant degree of protection against release for a wider range of accidents, it does so only indirectly. Containment integrity requirements more closely linked to containment capability to withstand the effects of severe accidents may provide better regulatory focus on principal safety attributes.

Finally, another aspect of current practice is that the review process, both for staff and utilities, tends to dwell on small changes in containment leak rate or variations in site meteorological dispersion factors which affect the outcome of the dose calculations, but which are secondary for plant safety. A key point in this regard is that the offsite doses will be low over a fairly wide range of containment leak rates or atmospheric dispersion factors provided the containment maintains its integrity and the fission product cleanup systems function.

C. Severe Accidents

As noted above, Part 100 siting evaluations depend on dose consequences from postulated accidents. While TID-14844 is referenced in the regulation as "guidance" for the source term, the regulation does not specify the source term or the postulated accident. Rather, the accident specified is one whose consequences are not exceeded by any accident considered "credible". After the early reviews, it became customary to treat the double ended large break LOCA as the accident assessed for compliance with Part 100. It was fairly common to have issues raised in licensing procedings concerning whether particular sequences should be considered as "maximum credible accidents" or should be considered in NEPA reviews. After TMI-2 and with the advent of probabilistic assessments of more severe events, some recent cases have resulted in complicated litigation over the probabilities and consequences of severe accidents beyond the design basis.

Source Term Update and Improvement

Several parallel activities for improvement of the regulations and practices in these areas for future plants have been identified by the staff. These are 1) performing plant reviews on a case-by-case basis, with appropriate revisions to current practice incorporated as a part of the design certification rulemaking, and 2) instituting a decoupling of reactor siting and plant design via rulemaking changes to both Parts 50 and 100. These activities are discussed in more detail below.

A. Case-by-case review

In this first activity, siting and licensing for evolutionary LWRs would be done on a case-by-case basis. Any proposed departures from the current regulations would be reviewed by the staff, if justified, presented to the Commission, and, if approved, would be made a part of the design certification rulemaking. This is similar to the process identified by the staff in SECY-90-16 and which is currently being pursued for the evolutionary plants, including the Advanced Boiling Water Reactor (ABWR).

B. Decoupling

In this second activity, reactor siting would be decoupled from ESF design. This will be done in two stages. In stage one, Part 100 will be revised to add site criteria based on present practice and Regulatory Guide 4.7. Part 100 would retain reference to a source term but the referenced source term will be a revision to that given in TID-14844, making use of improved insights in fission product timing, composition, and chemistry. During this stage, Part 50 will remain unchanged. This stage is expected to begin in FY91 and end in FY93 (see Enclosure 4).

In the next stage of decoupling, Part 100 will be revised a second time. The second revision will retain the previously added site criteria but will remove any reference to source terms or dose calculations. The issues previously addressed by the Part 100 dose calculations will be handled by a revision of Part 50. Specifically, ESF design

requirements will be added to Part 50. The ESF requirements will be based on best engineering judgements and will not resort to dose calculations. If the development of these ESF requirements proves intractable, dose criteria and reference to the new source term can be added to Part 50. This rulemaking activity (involved rulemaking changes to Parts 50 and 100) also will begin in FY91, but because of the extensive revision anticipated to be required to Part 50, is expected to require a longer schedule.

It is important to recognize that revisions to Part 50 to incorporate revised source term insights into plant design would essentially be a severe accident rule. This is because it would involve the specification of radiological performance requirements and criteria for a number of plant systems, such as control room habitability, equipment qualification and fission product cleanup systems that are now determined by the postulated appearance of the TID source term within containment. This source term can, of course, arise only as a result of a severe accident involving significant core damage.

As requested by the SRM dated June 15, 1990 (Item 12), any revisions of these rules and guidance will consider the Commission's Safety Goal Policy and the Large Release Guideline.

Decoupling of siting from plant design represents a significant departure from present NRC regulations. This option was first seriously considered by and reported in NUREG-0625 by the Siting Policy Task Force (an internal NRC staff effort which was convened shortly before the Three Mile Island accident to examine siting options for future plants). Staff efforts were initiated for this activity, including the issuance of an Advance Notice of Proposed Rulemaking (ANPR). This effort was subsequently deferred by the Commission in 1981, indicating that it should await further developments on updated source terms and the development of the Safety Goal.

The advantages of this step are that it would provide specific site requirements in the regulations. It would also tend to minimize litigation

over severe accidents although some review and litigation may still be required under NEPA.

Embarking on this effort will involve extensive staff resources because of the significant rulemaking activities required. Even though the anticipated schedule to accomplish this step may not be compatible with the review of the evolutionary ALWRs, it is not expected to delay certification of these designs.

Conclusions: 1. Reactor Siting

The staff concludes that reactor siting could be improved for the evolutionary plants (and possibly for the passive plants), by limiting to some degree the flexibility to use plant design features as a trade-off for site features. This could be accomplished by modifying Part 100 to incorporate those site parameters (exclusion area and LPZ distances, and population density values) considered to be acceptable.

The staff expects that a rulemaking involving Part 100 can be completed in a time period compatible with the schedule for early site reviews. The staff has, however, reviewed sites in the past and concludes that the guidance of Regulatory Guide 4.7 should continue to be used in the selection of acceptable sites until Part 100 can be modified.

2. Plant Design

The TID-14844 source term, originally intended for site evaluation purposes, has been applied to many aspects of plant design. Some aspects of this release into containment are now recognized to be incompatible with present research findings. As a result, a rigid application of the TID source term may not permit the best engineering solutions on some aspects of future plant design.

The staff concludes that improved insights regarding accident source terms, particularly in areas such as fission product timing, fission product composition, quantities and chemistry should be factored into regulatory practice, consistent with the state of knowledge, so as to provide improved guidance for designers of future plants. This could be accomplished either by specifying perfor-

mance requirements for each system (e.g., control room, sprays, filters, etc.) separately, or by providing guidance on the nature of the radiological conditions that plant systems should be expected to accommodate. The staff believes that providing guidance on the nature of the radiological conditions (that is, specifying a new source term) might be accomplished more quickly and offer significant improvements. Maximum benefit, however, would result from addressing ESF engineering requirements directly, without reference to a source term or dose calculation. The staff will pursue, in parallel, a major revision to both Parts 50 and 100 which would eventually replace the dose calculations currently required in Part 100.

Future Staff Actions:

The staff plans the following actions:

1. For future LWRs:

a) The staff will perform plant reviews on a case-by-case basis, with appropriate revisions to source terms and to current practice incorporated as a part of the design certification rulemaking. Applicants will be encouraged to submit sites whose parameters are in agreement with those of Regulatory Guide 4.7. This represents no change in current siting practice.

b) The staff will initiate two rulemakings to decouple reactor siting from plant design (See Enclosure 4). This will be done in two stages. The first stage will focus on a revision of Part 100 to add specific site criteria. In support of this effort, TID-14844 will be revised to reflect improved understanding of accident source terms with some conforming changes to Part 50 and Part 100 included in this effort. Revised site criteria (10 CFR 100) are expected to be available in FY 1993 for review of an early site application.

The second stage will involve further changes to Part 100 and changes to Part 50. Reference to a source term and dose calculations will be removed from Part 100. This will be accompanied by the addition of ESF criteria to Part 50. These ESF criteria will reflect the advances in knowledge acquired since the promulgation of the present

Part 100. The staff's goal is to accomplish this rulemaking prior to completion of review of the passive LWR designs. An Advance Notice of Proposed Rulemaking (ANPR) will be issued in mid-FY1991 explaining the two stage process and soliciting early comment and feedback on the proposal.

2. For existing plants:

The staff plans to make available the results of the updated TID-14844 for voluntary use (for example, licensees may request license amendments in areas such as isolation valve closure time or allowable containment leak rate) by existing plants on a case-by-case basis.

The staff has also begun discussions with industry groups, particularly EPRI, in regard to source term updates and its application to Advanced Light Water Reactors (ALWR).

As requested by the SRM dated May 22, 1990, the following discussion describes the status of the staff's review of EPRI's source term recommendation. For the evolutionary ALWRs, EPRI has proposed that a technical update or modification of the TID-14844 source term should be carried out and implemented without significant rulemaking changes. EPRI has also made proposals regarding the timing and quantities of fission products released as well as the chemical form of the iodine fission products that would be used as a replacement for the TID-14844 source term. Although the staff has not completed its review, it finds considerable technical merit in the EPRI proposal. The staff intends to continue these discussions while evaluating the results of research in this area.

In the SRM dated February 13, 1990 the staff was also directed to "propose changes to regulatory positions as soon as possible for both current and advanced reactor designs in those areas where the NRC has a sufficient technical basis from available research results (e.g., fission product timing)." A paper discussing potential impacts of source term timing on NRC regulatory positions (SECY-90-307) has been transmitted to the Commission.

The staff also notes that resources have been budgeted in the Five-Year Plan to perform the technical update of TID-14844 and the decoupling rulemakings. However, some adjustment of these resources may be necessary to accomplish the two decoupling rulemakings in parallel. These adjustments will be reflected in the next update of the Five-Year Plan.

Coordination: The Office of the General Counsel has reviewed this paper and has no legal objection to it. The Advisory Committee on Reactor Safeguards (ACRS) has been briefed regarding the contents of this paper and has provided a letter (Enclosure 5) on the staff proposal.

Recommendation:

That the Commission approve the staff's plans to implement updated source term knowledge including rulemaking for the decoupling of plant design from site characteristics.

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Enclosures:
1. Responses to SRM of February 13, 1990
2. Current Siting Requirements & Practices
3. Data for Existing U.S. Reactor Sites
4. Schedule for Source Term Activities
5. ACRS Letter of June 13, 1990

Commissioners' comments or consent should be provided directly to the Office of the Secretary by COB Friday, October 19, 1990.

Commission Staff Office comments, if any, should be submitted to the Commissioners NLT Friday, October 12, 1990, with an information copy to the Office of the Secretary. If the paper is of such a nature that it requires additional time for analytical review and comment, the Commissioners and the Secretariat should be apprised of when comments may be expected.

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ENCLOSURE 1

Responses to Staff Requirements Memorandum (SRM) dated February 13,1990

The staff requirements memorandum (SRM) dated Feb. 13, 1990 requested that the report on decoupling siting requirements from plant design should address the following:

1. The criteria that would be used in siting decisions, if siting is decoupled from plant designs. Identify and discuss the considerations (e.g., risk, deterministic, policy) of the staff in establishing such criteria and specifically how the criteria were developed.

2. Benefits and disadvantages of risk based siting criteria.

3. Degree of conservatism between options under consideration.

4. Applicability and impact on existing plants.

5. The pros and cons for equating the low population zone to the emergency planning zone.

These items are provided below, in question and answer format.

Question 1: The criteria that would be used in siting decisions, if siting is decoupled from plant designs. Identify and discuss the considerations (e.g., risk, deterministic, policy) of the staff in establishing such criteria and specifically how the criteria were derived.

Response: Decoupling will not result in significant changes in reactor siting criteria. (The principal objective of this effort is to change the basis for evaluating certain Engineered Safety Feature (ESF) designs.) Guidance would continue to be that given in Regulatory Guide 4.7 "General Site Suitability Criteria for Nuclear Power Stations", Revision 1, November 1975. 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 reactor sites, and was

intended to assist applicants in the initial stage of selecting potential sites for a nuclear power station.

With regard to population considerations, this guide states that a minimum exclusion area distance of 0.4 miles 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 100. The guide also states that, 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.

With regard to population density in the site vicinity, the guide states that 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 criteria with regard to minimum exclusion area and low population zone outer radius distances arose from the deterministic consequence calculations that are mandated by 10 CFR 100. It was based upon the judgment and experience of the staff that plants equipped with the normal complement of accident mitigation features (low leakage containment plus fission product cleanup systems such as sprays or filters) would be very likely to meet the guideline doses of 10 CFR 100, given these site parameters.

The population density guidelines given in Regulatory Guide 4.7 were developed in order to provide a reasonable separation distance between nuclear power stations and large population centers while maintaining a good availability of potential sites for nuclear power plants, even in the Northeastern United States.

The staff considers these siting criteria to be consistent with most existing U.S. reactor sites. Based upon a survey of the 75 U.S. sites where reactors are presently operating

or are under construction, the distance to the exclusion area boundary varies from 277 meters to 2130 meters, with a typical value of about 800 meters (0.5 mile). Low population zone distances range from 1100 to 11,000 meters with a typical value of about 4800 meters (3 miles). It is estimated that about half a dozen existing reactor sites have population density values that are in excess of the values given in Regulatory Guide 4.7. All of these were reviewed and approved prior to the issuance of Regulatory Guide 4.7 in 1975.

Question 2: Benefits and disadvantages of risk based siting criteria.

Response: The staff understands the Commission request for a discussion of this subject to be one of contrasting risk based siting criteria with the presently used deterministic criteria contained in Part 100 (the use of PRA-based source terms for purposes other than siting has been discussed in SECY-90-173). The following discussion focuses primarily on the use of risk-based criteria that 1) could be used to determine the acceptability of a proposed site for licensing purposes, 2) can be expressed quantitatively and 3) would replace present siting criteria. A closely related subject, design criteria for events of natural or man-made origin associated with a proposed site that can adversely affect the safe operation of a plant is not discussed. These are typically called external events. For many of these (but not seismic), the staff already uses a probabilistic approach that deals with risk in the sense of risk of damage to the plant that may have consequences of offsite releases. The staff has also dealt with the operational and severe accident risks in approximately 30 plant-specific Environmental Statements and expects to do so more broadly as part of ongoing efforts to develop a Generic Environmental Statement in support of Part 51 requirements for licensing renewal. Finally, the discussion is related to the licensing options now available in 10 CFR Part 52.

Risk based siting criteria implies a formulation as a risk statement in probabilistic terms, like the quantitative health objectives in the Commission's Safety Goal Policy Statement. Setting the numerical value of a criterion is judgmental and also involves a selection among possible consequence measures, e.g., radiation exposure or dose, or

health effects, and a selection of measures associated with risks to individuals or for risks to population groups. If a single measure were selected as a siting criterion, a perceived benefit might be the sense of equity created by requiring plants and sites to present the same public risk, regardless of the nature or size of the plant and the characteristics of the site. An example would be a frequency criterion for a radiation dose to an individual to be equal to or less than a specified value at a specified distance from the reactor. Another would be a population dose equal to or less than a specified value for the population in a specified region. Alternatively, two or more consequence measures could be selected, in which case it is likely that only one would be controlling at some sites, whereas another might be controlling at other sites. The potential benefit would then be the tangible recognition that the criteria selected deal with the reality that some consequence measures are conceptually more important for some sites than others, e.g., in contrasting sites with very different population density characteristics.

A process or analysis method is necessary to determine whether or not a proposed site is in compliance with a given siting criterion. For risk based siting criteria the only analysis method available would appear to be a Level Three probabilistic risk analysis (PRA). A possible benefit of this would be the opportunity that a PRA presents in principle to be realistic, unbiased, and based on the facts of the case. However, it would most likely be a very resource intensive process. Further, existing Commission guidance is not to use safety goals and PRA results for individual plant licensing purposes.

With respect to the applicability of risk based siting criteria to the Part 52 categories of Early Site Permits and Certified Designs, not all of the "facts of the case" would appear to be present. Early Site Permits contemplate no specific design and require no PRA. Hypothetical "bounding site characteristics" can be used to fill out a Level III PRA that might be thought of as bounding the risk and a showing that the risk criteria are met. Even in this case, however, many portions of a PRA on a design, as distinct from a plant that can be walked down to observe firsthand such things as piping and valve configurations, are not verifiable. Although the combined CP and OL licensing option in Part 52

would bring together the available facts about both the design and the site, the use of risk based siting criteria here, in the absence of either an Early Site Permit or Certified Design, or both, would still suffer from the lack of verification that can lend credibility to a PRA.

In summary, the staff does not recommend the use of risk based siting criteria for the reasons given above.

On the other hand, it is possible to set or reset deterministic criteria in the light of a background of risk analyses performed for a sufficient sample size of plants and sites. For example, for each such available PRA it might be useful to amplify the existing results to estimate the probabilities of exceeding the dose guideline values as given in 10 CFR Part 100. The values obtained might be useful in estimating the range of individual risk of exposure that appears to be implied by the current siting criteria and could, in principle, serve as a basis for a decision that they either continue to be acceptable, or might be changed to some other value(s). The benefit of this could be improved understanding of the risk significance of the siting crit· ia.

Question 3: Degree of conservatism between options under consideration.

Response: As noted in response to question 1, the staff is proposing siting criteria that are consistent with all but a few present reactor sites. The staff considers that these criteria provide a high degree of safety to members of the public and society in the event of an emergency and assures adequate protection of the nuclear plant from potential offsite external hazards. At the same time, these criteria permit the availability of a large pool of potential sites in every region of the nation.

Question 4: Applicability and impact on existing plants.

Response: Criteria being proposed for siting future nuclear power plants would not be applicable to existing plants. Since these proposed siting criteria are generally consistent with those for existing plants, the staff sees no need to review existing plants in this regard, and concludes that the proposed criteria will have no impact on existing plants.

Application for existing plants of revised source term criteria that impacts plant design would be evaluated on a case-by-case basis.

Question 5: The pros and cons for equating the low population zone to the emergency planning zone.

Response: The low population zone (LPZ) is the area immediately beyond the exclusion area, and is required for every reactor site by 10 CFR 100. Although the distance is not fixed, a typical distance to the outer radius of the LPZ is about 3 miles. Before the Three Mile Island accident, the LPZ represented the region where emergency planning was required.

The plume exposure emergency planning zone (EPZ) is the region around every nuclear power plant where emergency planning is currently required by 10 CFR 50.47 and 10 CFR 50 Appendix E. The plume exposure EPZ is required to have a radius of about 10 miles. The size of the plume exposure emergency planning zone was based upon the insights of NUREG-0396, and reflected the considerations of the complete spectrum of accidents, including those beyond the design basis. Another fundamental consideration for establishing the size of the plume exposure EPZ was that "detailed planning within 10 miles would provide a substantial base for expansion of response efforts in the event that this proved necessary." (NUREG-0654/FEMA REP-1, Rev. 1 at page 12). If the EPZ was reduced to the LPZ size the planning base might be too small to provide adequate assurance that protective actions beyond the LPZ could be carried out if needed.

The way offsite doses would be expected to vary with distance, assuming various offsite protective actions, was calculated in NUREG-1150 (June 1989) using the Zion plant as an example. Figures 13.5 and 13.6 (Attached) show the results for early and late containment failure, respectively. As can be seen, there could be a significant probability of exceeding a 50-rem[1] whole body dose within a few miles for

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[1]200-rem and 50-rem whole body doses were used to allow comparisons with earlier studies (e.g., NUREG-0396) and because they serve as surrogates for the early fatality and

this plant, even for late containment failure if no protective action is taken. However, this probability diminishes rapidly with distance from the reactor for both early and late containment failure.

In conclusion, the size of the 10 mile EPZ was determined using the methodologies available in 1980. Today there exists more sophisticated techniques and computer models based upon recent research that tend to indicate that radiation doses and consequences would generally be lower at a given distance than previously predicted. However, there are significant uncertainties associated with these analyses. Furthermore, protective actions for the public are typically planned at the levels of the EPA Protective Action Guides (PAGs) (1 to 5 rem whole body and 5 to 25 rem thyroid), in contrast to the 50 rem and 200 rem levels where early health effects would be noted. Some severe accident scenarios could exceed the PAG levels at distances of 10 miles and beyond. Overall, the staff believes that an overriding argument for maintaining the present EPZ size is to provide assurance that an adequate planning base is maintained.

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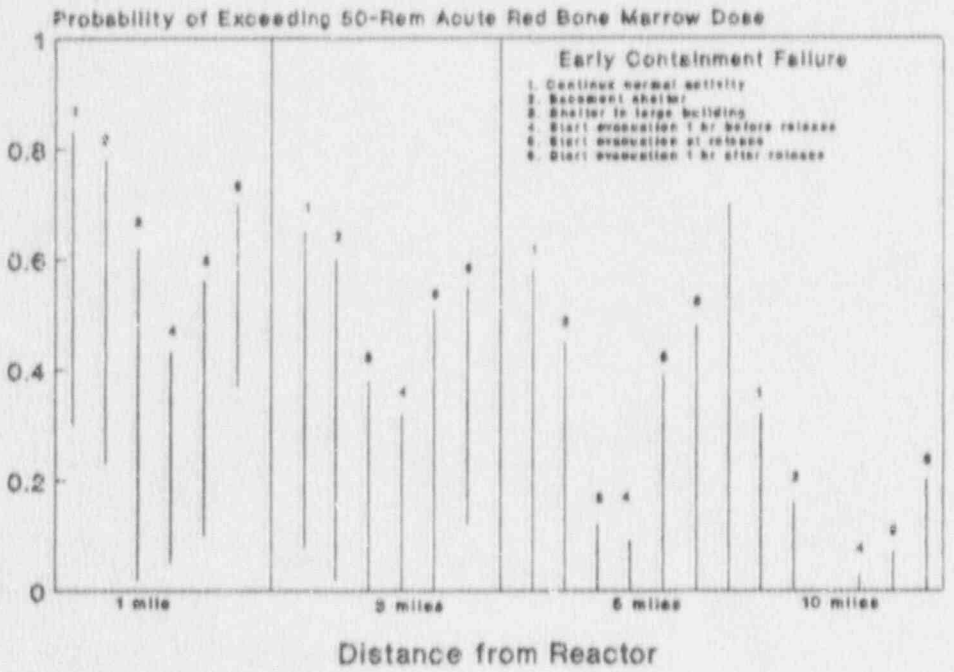
injury thresholds, respectively.



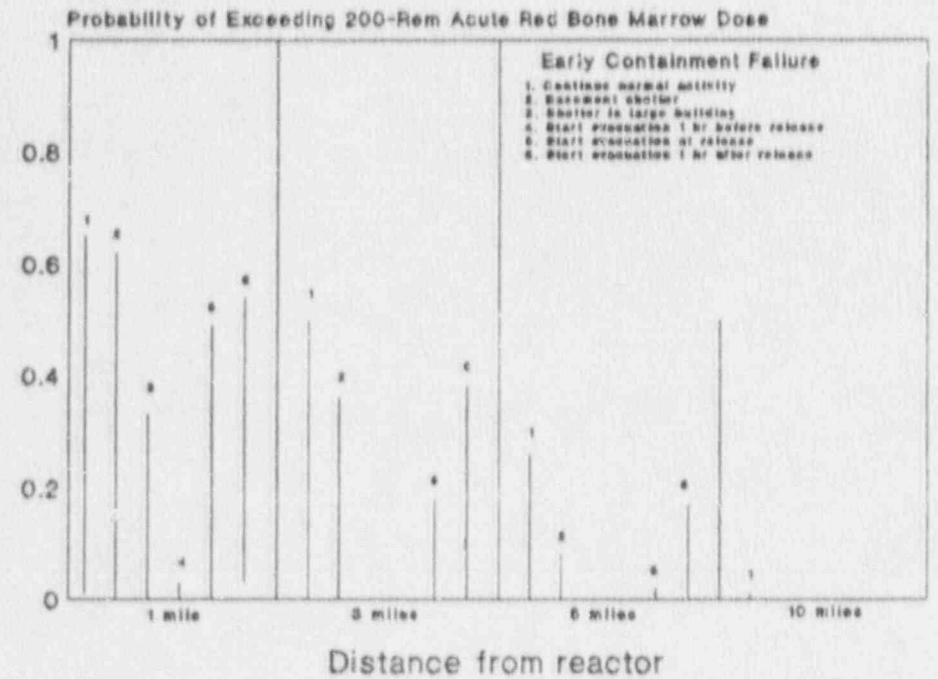
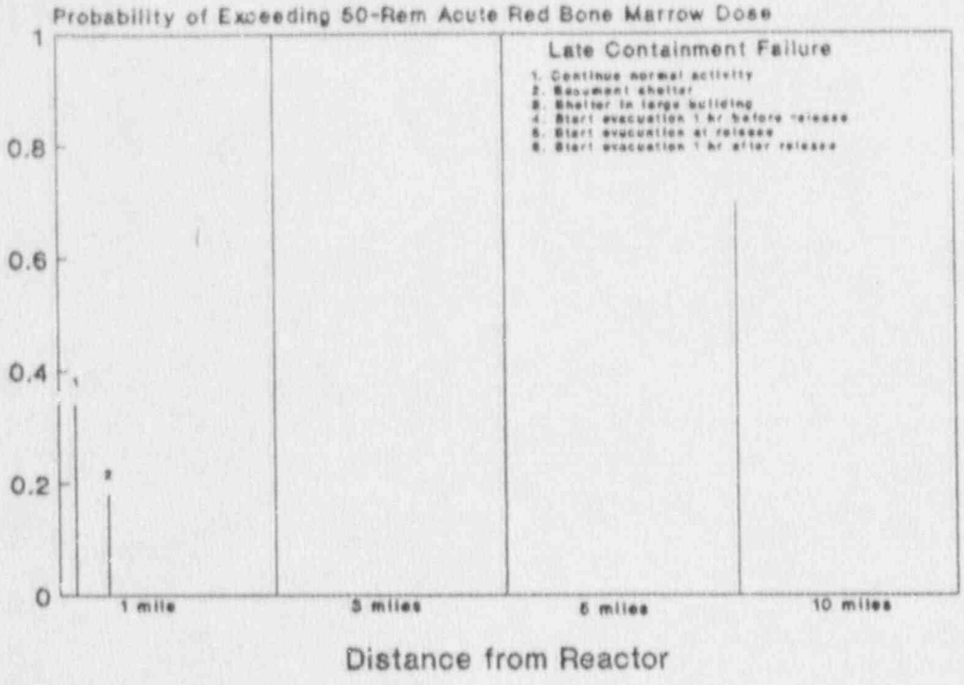


Figure 13.5 Relative effectiveness of emergency response actions assuming early containment failure with high and low source terms.



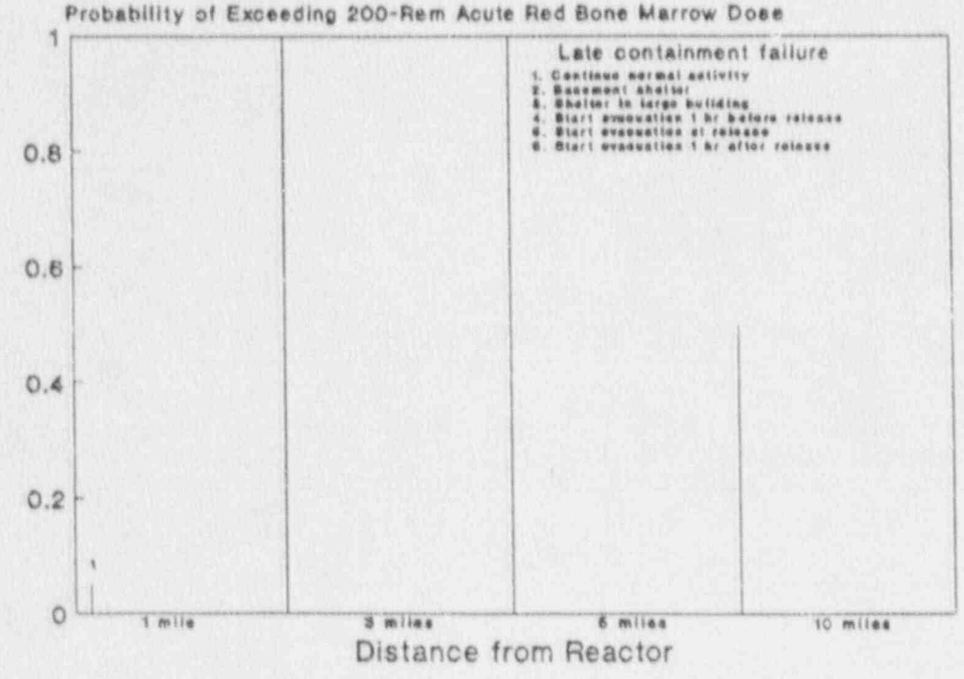


Figure 13.6 Relative effectiveness of emergency response actions assuming late containment failure with high and low source terms.

ENCLOSURE 2

Current Siting Requirements and Practice

A. Siting Regulations

The NRC's regulations with regard to reactor siting are provided in 10 CFR 100, promulgated in 1962. 10 CFR 100 requires that every reactor site provide an exclusion area and a low population zone (LPZ) around the reactor site. The exclusion area is defined as the immediate area around the reactor. This area must be under the control of the applicant, usually by ownership. Residence by members of the public within the exclusion area is prohibited, but the exclusion area may be traversed by transportation routes such as a road, railway or waterway provided these are not so close as to interfere with normal operations and provided the applicant has made suitable arrangements to control such traffic in the event of an emergency.

The immediate area outside the exclusion area is known as the low population zone (LPZ). This area is not required to be under the control of the applicant and, although the regulation does not provide a numerical value, is one where low density residential areas are permitted. 10 CFR 100 also requires that the nearest densely populated center of about 25,000 or more residents must be located no closer than one and one-third times the outer radius of the LPZ.

Part 100 also assumes the existence of a low-leakage containment throughout the duration of the accident. Although TID-14844 indicates that the containment leak rate is 0.1 percent per day, the regulation does not require this value and plants have been licensed with a variety of leak rates. The regulation indicates that the site evaluation is to be performed using the expected demonstrable leak rate of the containment.

In order to evaluate a site and plant combination, Part 100 requires that a fission product release into the containment is to be postulated and that the radiological consequences for individuals at two locations (at the exclusion area boundary and at the LPZ outer radius) are to be evaluated. With regard to the fission product release into containment, Footnote 1 to Part 100 indicates that it should be "based upon a major accident", and notes furthermore that such accidents "have generally been assumed to result in substantial meltdown of the core with subsequent release of appreciable quantities of fission products."

Finally, Part 100 requires that the calculated doses must not exceed the values given in the regulation (25 rem to the whole body or 300 rem to the thyroid gland) for a period of two hours

and for the entire period of the cloud's passage, for individuals located at the nearest exclusion area boundary and at the outer radius of the LPZ, respectively.

B. Current Siting Practice

Current siting practice and engineered safety features (ESF) design includes a number of assumptions regarding fission product release, plant performance and dose calculation methodology that, although not specified in the regulation, are employed in assessing compliance with Part 100 and other requirements. These are generally given in Regulatory Guides and the Standard Review Plan (SRP). Many of these assumptions and models play key roles in implementing the regulation, so that a discussion of key practices is essential to a complete understanding of current reactor siting.

The fission product release into containment is derived from the 1962 report "Calculation of Distance Factors for Power and Test Reactor Sites", TID-14844, by J.J. DiNunno, et. al. This report is referenced in Part 100 and was published at the same time. At the present time the fission product release used by the staff for site evaluation is given in Regulatory Guides 1.3 and 1.4 for Boiling Water and Pressurized Water reactors, respectively. These specify a release into containment of a) 100 percent of the noble gas inventory of the core, and b) 50 percent of the iodine fission product inventory of the core (half of which is assumed to deposit on interior surfaces very quickly). In addition, Regulatory Guides 1.3 and 1.4 specify that the fission products are to be assumed to be instantaneously available for release from the containment, and that the chemical form of the iodine fission products are assumed to be 91 percent elemental, 5 percent particulate, and 4 percent organic iodine.

In evaluating the site and engineered safety features, the containment is assumed to maintain its integrity for the duration of the accident and is assumed to leak at the maximum leak rate that is to be incorporated into the Technical Specifications. Furthermore, for PWRs, the containment leak rate stays at its maximum value for a 24 hour period following the accident, after which its leak rate is assumed to be half that value for the remainder of the accident duration (taken as 30 days). For BWRs, the containment is assumed to leak at its maximum leak rate for the entire duration of the accident.

Fission product cleanup systems are given credit for reduction of iodine concentrations in containment or for removal prior to release to the environment. However, such credit is evaluated conservatively (i.e., a realistic evaluation would indicate a greater reduction or removal of iodine than credited), to account for uncertainties.

Doses to hypothetical individuals at the exclusion area boundary and at the LPZ outer radius are also calculated using conservative assumptions, in that individuals are assumed to be on the plume centerline for the duration of the accident, no protective actions are assumed to be taken, and the atmospheric dispersion factors utilized represent highly unfavorable meteorological conditions that would result in higher doses no more than about 5 percent of the time for the actual site conditions.

Regulatory Guide 4.7, "General Site Suitability Criteria for Nuclear Power Stations", is also applied. This guide provides guidance on a minimum exclusion area distance (0.4 miles), minimum LPZ outer radius (3 miles), and population density in the vicinity of the site. With regard to population density, the Guide states that, 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, special attention should be given to the consideration of alternative sites with lower population densities.

Finally, it must also be noted that reactor siting is determined by other safety as well as environmental considerations, in addition to the exclusion area, LPZ and population density. These include such diverse conditions as seismic characteristics, nearby industrial and military facilities, potential for flooding, and the availability of a suitable ultimate heat sink. Consideration of these as well as other site characteristics is given in Regulatory Guide 4.7.

ENCLOSURE 3

EXISTING U.S. REACTOR SITES

REACTOR SITE	EXCLUSION AREA BOUNDARY DISTANCE (METERS)	LOW POPULATION ZONE (LPZ) OUTER RADIUS (METERS)	POP. CENTER DISTANCE (MILES)
1. Arkansas	1046	4024	4
2. Beaver Valley	610	5795	5
3. Bellefonte	914	3219	4
4. Big Rock Pt	817	6439	45
5. Braidwood	457	1810	20
6. Browns Ferry	1219	3219	10
7. Brunswick	914	3219	16
8. Byron	460	4827	17
9. Callaway	1100	4023	25
10. Calvert Cliffs	1150	3219	45
11. Catawba	762	6097	5.1
12. Clinton	975	4025	22
13. Comanche Pk.	1400	6440	40
14. Cook	610	3219	8
15. Cooper	746	1609	60
16. Crystal River	1340	8047	55
17. Davis Besse	634	3219	20
18. Diablo Canyon	800	9656	12
19. Dresden	671	8000	14
20. Duane Arnold	440	9659	8

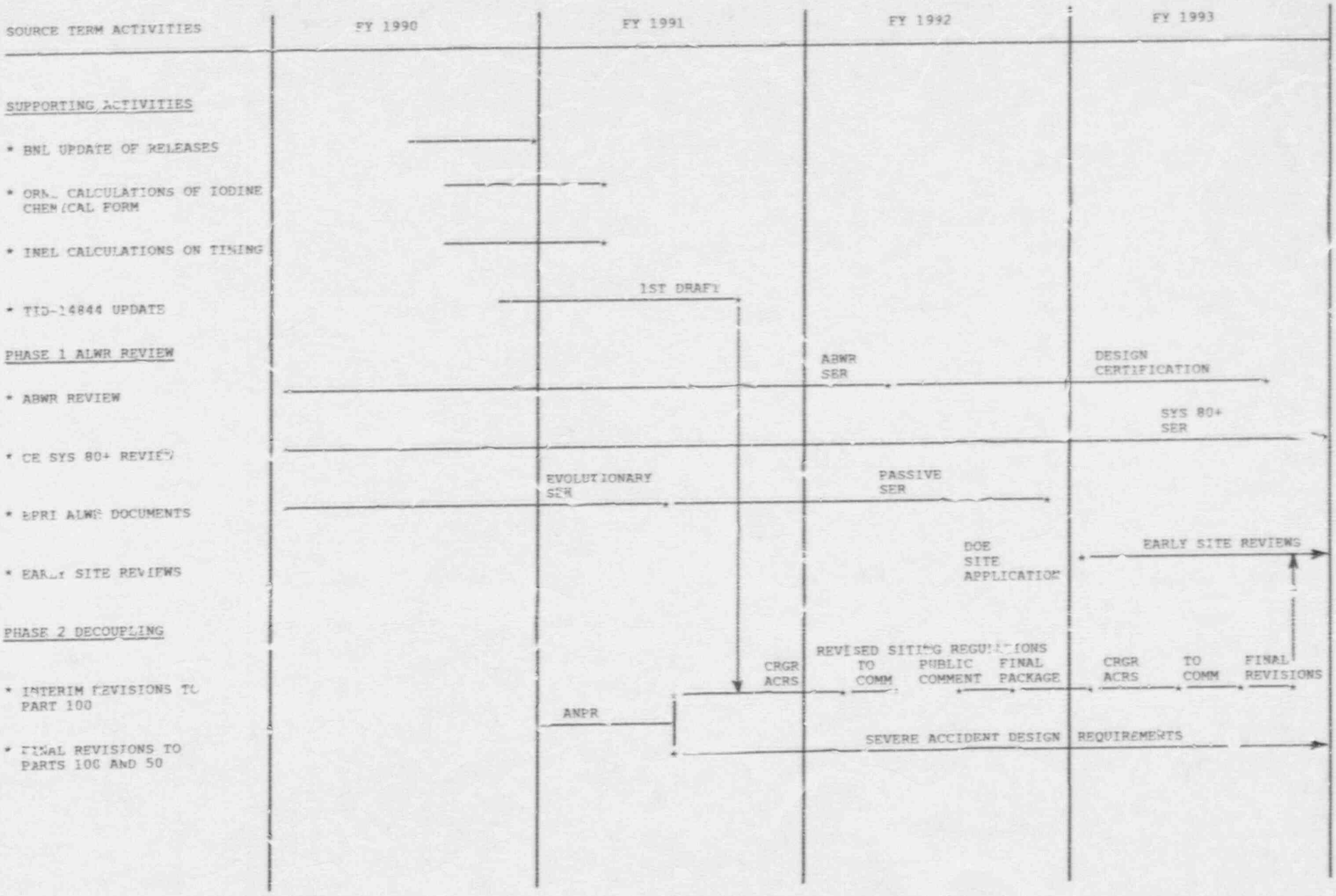
	EAB	LPZ	PCD
21. Farley	1260	3219	16.5
22. Fermi	915	4828	6
23. Fitzpatrick	975	5470	7
24. Ft. Calhoun	375	4827	10
25. Ft. St. Vrain	590	4827	14
26. Ginna	457	4827	16
27. Grand Gulf	752	3219	25
28. Haddam Neck	530	11,263	9.5
29. Hatch	1250	7250	48
30. Hope Creek	792	8045	18
31. Indian Pt.	330	1100	0.87
32. Kewaunee	1200	4827	17.5
33. LaSalle	515	6400	5
34. Limerick	700	2043	1.7
35. Maine Yankee	610	9654	26
36. McGuire	762	8850	11
37. Millstone	503	3700	3.2
38. Monticello	488	1609	22
39. Nine Mile Pt.	1555	6115	7
40. North Anna	1350	9656	24
41. Oconee	1609	9654	21
42. Oyster Creek	402	3219	8
43. Palisades	671	4827	20
44. Palo Verde	900	6437	34

	EAB	LPZ	PCD
45. Peach Bottom	820	7300	18
46. Perry	915	6437	6.3
47. Pilgrim	441	2414	2.5
48. Pt. Beach	1207	9012	8
49. Prairie Is.	715	2414	26
50. Quad Cities	380	4827	7
51.Rancho Seco	640	8000	17
52. River Bend	914	4023	24
53. Robinson	425	7242	25
54. St. Lucie	1554	8049	8
55. Salem	1165	8047	18
56. San Onofre	800	4827	17
57. Seabrook	914	2413	4
58. Sequoyah	585	4827	16
59. Shearon Harris	2133	4827	12
60. So. Texas	1430	4827	26
61. Summer	1630	4827	26
62. Surry	560	4827	4.5
63. Susquehanna	567	4800	12
64. Three Mile Is.	610	3219	12
65. Trojan	662	4023	6
66. Turkey Pt.	1269	8047	15
67. Vt. Yankee	277	8047	30
68. Vogtle	1098	3219	26

	EAB	LPZ	PCD
69. WPPSS1	1950	6440	8
70. WPPSS-2	1950	4827	12
71. Waterford	915	3219	13
72. Watts Bar	1200	4827	40
73. Wolf Creek	1200	4023	28
74. Yankee Rowe	945	3219	25
75. Zion	415	1600	6

ENCLOSURE 4

SCHEDULE FOR SOURCE TERM ACTIVITIES



UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, D. C. 20555

ENCLOSURE 5

June 13, 1990

The Honorable Kenneth M. Carr
Chairman
U S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Chairman Carr:

SUBJECT: DRAFT STUDY ON SOURCE TERM UPDATE AND DECOUPLING SITING FROM DESIGN

During the second meeting of the Advisory Committee on Reactor Safeguards, June 7-9, 1990, we reviewed the NRC staff's Draft Study Source Term Update and Decoupling Siting from Design. This matter was also discussed during our 361st meeting, May 10-11, 1990. During this review, we had the benefit of discussions with representatives of the NRC staff. We also had the benefit of the document referenced.

At present, siting issues, including the definitions of the Exclusion Area (EA) and Low Population Zone (LPZ), are governed by 10 CFR Part 100, Reactor Site Criteria, which sets limits on the exposure of an exposed individual in the event of certain hypothetical accidents. The necessary calculations require assumptions about the amount of radioactivity released to the containment in those accidents, the so-called source term.

It is customary to use for the latter an old AEC report, Technical Information Document 14844, dated March 23, 1962. It has been recognized for about ten years that that report grossly overestimates radioactive releases in a typical accident, and misrepresents their forms. Consequently there has been in this period a leisurely effort to "update the source term."

The staff soon recognized that the effects due to possible reduction of the source term, and reduced probability of an accident, could combine with the requirements of 10 CFR Part 100 to make possible the licensing of plants with uncomfortably close boundaries, perhaps even in a metropolitan area. To avoid this, the staff proposed that the siting question be decoupled from the source term upgrade, so that the customary sizes of the EA and LPZ could be preserved, as encapsulated in Regulatory Guide 4.7, General Site Suitability Criteria for Nuclear Power Stations. This is a matter of preserving the answer, in the face of creeping safety improvements, by rephrasing the question.

In the end, the staff considered a number of options, including a revision of 10 CFR Part 100 through rulemaking, and concluded that they were all so difficult that one ought to proceed by first updating the source term to accommodate current technical understanding. Then the tentative proposed solution to the siting problem is to "encourage" conformance to Regulatory Guide 4.7, in effect substituting a regulatory guide for rulemaking.

We support (as we always have) the effort to adjust the source term to reflect current knowledge. Since it appeared at our meeting that the staff is not itself entirely clear about its position on siting, we cannot yet provide definitive advice on that aspect of the problem. Perhaps, since no one is now proposing other than remote siting of nuclear power plants in the United States, the question is moot.

Sincerely,

Carlyle Michelson

Carlyle Michelson
Chairman

Reference:
Draft Commission Paper from James M. Taylor, Executive Director for Operations, Subject: Staff Study on Source Term Update and Decoupling Siting from Design (Predecisional), transmitted by memorandum dated May 25, 1990 from Warren Minners, Office of Nuclear Regulatory Research, for Raymond F. Fraley, ACRS