UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

COMMISSIONERS:

William A. Anders, Chairman
Marcus A. Rowden
Edward A. Mason
Victor Gilinsky
Richard T. Kennedy

In the Matter of RULEMAKING HEARING NUMERICAL GUIDES FOR DESIGN OBJECTIVES AND LIMITING CONDITIONS FOR OPERATION TO MEET THE CRITERION "AS LOW AS PRACTICABLE" FOR RADIOACTIVE MATERIAL IN LIGHT-WATER-COOLED NUCLEAR POWER REACTOR EFFLUENTS	Docket No. RM-50-2

OPINION OF THE COMMISSION

CHAPTER I

SUMMARY AND STATEMENT OF CONSIDERATIONS

Background

The Nuclear Regulatory Commission[1/] herewith announces its decision in the rulemaking proceeding concerning numerical guides for design objectives and limiting conditions for operation to meet the criterion "as low as practicable" for radioactive material in light-water-cooled nuclear power reactor effluents.

1/ The licensing and related regulatory functions of the Atomic Energy Commission have been transferred to this Commission. Energy Reorganization Act of 1974, § 201(f), 88 Stat. 1243.

On December 3, 1970, the Atomic Energy Commission published in the Federal Register (35 F. R. 18385), new sections 50.34a and 50.36a in Part 50 of its regulations, specifying design and operating requirements for nuclear power reactors to keep levels of radioactivity in effluents "as low as practicable." The amendments provided qualitative guidance, but not numerical criteria, for determining when design objectives and operations meet the specified requirements. The Commission noted in the Statement of Considerations accompanying the amendments the desirability of developing more definitive guidance. The rule we announce today does that, setting forth criteria which, if met, provide one acceptable method of establishing compliance with the "as low as practicable" requirement of sections 50.34a and 50.36a.

On June 9, 1971, the Atomic Energy Commission published in the Federal Register (36 F. R. 11113) for public comment proposed amendments to 10 CFR Part 50 which would supplement sections 50.34a and 50.36a with a new Appendix I. The Proposed Appendix provided numerical guides for design objectives and technical specification requirements for limiting conditions for operation for light-water-cooled nuclear power reactors.

A subsequent notice, published on November 30, 1971 (36 F. R. 2275), announced a public rulemaking hearing on the proposed amendments. The hearing began on January 20, 1972, before a Hearing Board consisting of Algie A. Wells, Esq., Chairman, Dr. John C. Geyer, and Dr. Walter H. Jordan. The primary participants in the rulemaking hearing included the Commission's Regulatory Staff, a consolidated utility group, the Consolidated National Intervenors, General Electric Company, and the State of Minnesota. In addition, 18 persons or organizations, including the Environmental Protection Agency, made limited appearances.

The hearing was suspended in May of 1972 pending preparation of an Environmental Impact Statement concerning the proposed rulemaking in implementation of the National Environmental Policy Act of 1969. A Draft Environmental Statement was forwarded to the Council on Environmental Quality on January 15, 1973, and circulated for comment to interested Federal agencies and members of the public, including the hearing participants. Notice of public availability of the Statement and an invitation for comment were published in the Federal Register. Comments on the Draft Environmental Statement were received, and a Final Environmental Statement was issued on July 26, 1973. In November 1973, the public

hearing was resumed for consideration of the Environmental Statement. The evidentiary hearing was concluded on December 6, 1973, concluding statements of position were filed, and the entire record was forwarded to the Commission for decision. The proceeding covered some 25 days of hearings, 4172 pages of hearing transcript, and thousands of pages of prepared written direct testimony and exhibits. Oral arguments were heard by the Atomic Energy Commission on June 6, 1974.

As the record developed during this rulemaking shows, there is a general consensus concerning the need to define "as low as practicable" with numerical criteria. The major issues of controversy involved the feasibility of achieving the proposed numerical criteria and the cost of compliance with and the perceived benefits of the criteria. The Nuclear Regulatory Commission has carefully considered the entire record and the views of those who participated in the rulemaking hearing in reaching the decision announced herein.[2/]

It should be emphasized that the Appendix I guides as here adopted by the Commission are not radiation protection standards. The numerical guides of Appendix I which we

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[2/] Some of the parties to this proceeding sent unsolicited letters to individual members of the Commission, expressing views on the subject matter of this rulemaking. These communications, not a part of the hearing record, have been placed in the public document room and served upon all parties in the manner described in 10 CFR 2.780(b), and have not been considered in reaching the decision announced today.

announce today are a quantitative expression of the meaning of the requirement that radioactive material in effluents released to unrestricted areas from light-water-cooled nuclear power reactors be kept "as low as practicable."[3/]

The Commission's radiation protection standards, which are based on recommendations of the Federal Radiation Council (FRC) as approved by the President, are contained in 10 CFR Part 20, "Standards for Protection Against Radiation," and remain unchanged by this Commission decision.[4/] As in the case of parallel recommendations of the National Council on

3/ Under the President's Reorganization Plan No. 3 of 1970, the Environmental Protection Agency (EPA) is responsible for establishing generally applicable environmental radiation standards for the protection of the general environment from radioactive materials. The Nuclear Regulatory Commission is responsible for implementation and enforcement of EPA's generally applicable environmental standards. If the design objectives and operating limits established in this decision should prove to be incompatible with any generally applicable standard hereafter established by EPA, these objectives and limits will be modified as necessary.

4/ The radiation protection guides established by the FRC for individual members of the public are 500 millirems per year to the total body and bone marrow and 1500 millirems per year to the thyroid and bone. The guide for average dose to the population is 5 rems in 30 years to the gonads (an annual average dose of 170 millirems per person averaged over the population). These guides and recommendations apply to exposures from all sources other than medical procedures and natural background.

The FRC provides no specific radiation protection guides with respect to other organs of the body. The ICRP recommends annual dose limits of 500 millirems to the total body, gonads, and red bone marrow; 3000 millirems to the skin, bone, and thyroid, except 1500 millirems to the thyroid of children up to 16 years of age; and 1500 millirems to other single organs.

Radiation Protection and Measurements (NCRP) and the International Commission on Radiological Protection (ICRP), these FRC standards which have been previously adopted give appropriate consideration to the overall requirements of health protection and the beneficial use of radiation and atomic energy. The Commission believes that the record clearly indicates that any biological effects that might occur at the low levels of these standards have such low probability of occurrence that they would escape detection by present-day methods of observation and measurement.

The Commission fully subscribes to the general principle that, within established radiation protection guides, radiation exposures to the public should be kept "as low as practicable." This precept has been a central one in the field of radiation protection for many years. The term "as low as practicable" is defined in the Commission's regulations [10 CFR 50.34a(a)] to mean "as low as is practicably achievable taking into account the state of technology, and the economics of improvements in relation to the benefits to the public health and safety and in relation to the utilization of atomic energy in the public interest."

We note that during the pendency of this rulemaking the International Commission on Radiological Protection, in ICRP

Publication No. 22, has replaced the phrase "as low as practicable" with "as low as is reasonably achievable" in its recommendation on dose limitation. Its recommendation has also been expanded to identify two specific considerations -- economic and social -- that are to be taken into account in determining a level of exposure that may be considered "as low as is reasonably achievable." Other considerations, such as ethical ones, are not excluded by this wording and may indeed be considered to be included by the adjective "social." The ICRP has clearly stated that the changed terminology does not reflect a change in the objectives of dose limitation, but rather a choice of language which "more closely describes its intentions." See ICRP Publication 22, paragraphs 6, 7, and 20.

We endorse this attempt to make this basic concept of radiation protection more understandable. We are today directing the Commission's Staff to prepare and issue for public comment a proposed rule that substitutes the currently accepted phrasing -- "as low as is reasonably achievable" -- for the older, less precise terminology in the many places throughout our regulations and regulatory guides where it appears. The numerical values of Appendix I quantifying "as low as practicable", will not, of course, be affected by the forthcoming change in terminology.

The principal changes from the proposed amendments published in the Federal Register on June 9, 1971, are as follows:

1. Liquid Effluents

The design objectives in the proposed rule for radioactive material in liquid effluents were based on: (a) an annual release of not more than 5 curies, except tritium, from each reactor, (b) specified concentration limits on tritium and other radioactive materials released to the environment, and (c) a provision for increasing or decreasing the design-objective quantities and concentrations for specific sites subject to keeping annual doses to the total body or any organ of an individual in an unrestricted area to not more than 5 millirems for all reactors on a site. The design objective in Appendix I as adopted limits the total radioactivity released from each light-water-cooled nuclear power reactor to a level that limits the annual dose or dose commitment from liquid effluents from that reactor for any individual in an unrestricted area from all pathways of exposure to not more than 3 millirems to the total body and 10 millirems to any organ.

The adopted design-objective guides contain no numerically specified limits upon quantities of radioactive material

to be released since the record shows that such limits have little if any independent significance. Protection of future users of the near environs of the reactor is provided by the additional requirement that all augments with a favorable cost-benefit balance be included in the radwaste system and by the provision that the estimation of exposure be made with respect to such potential land and water use and food pathways as could actually exist during the term of plant operation.

2. Gaseous Effluents

The principal difference in the design objective in the Appendix adopted by the Commission dealing with external dose from radioactive material in gaseous effluents is the separate treatment of total-body dose and skin dose. The proposed design objective limited both the annual total-body and the annual skin dose from all reactors on a site to 5 millirems, whereas the new design objective incorporates an annual total-body dose limit from gaseous effluents of 5 millirems per light-water reactor and increases the annual dose limit to the skin to not more than 15 millirems per light-water reactor. The design-objective annual dose to the skin has been increased from 5 millirems to 15 millirems on the basis of evidence in

the Final Environmental Statement and the hearing record showing that it is not technically practicable to design and operate a light-water-cooled nuclear power reactor with a limit on the annual skin dose from beta radiation of not more than 5 millirems.[5/] It is noted by way of comparison that an annual dose to the skin of 15 millirems is one-half of one percent of the radiation dose limit for a member of the public recommended by the International Commission on Radiological Protection.

3. Radioactive Iodine and Particulate Matter

The proposed design objective for radioactive iodine and radioactive material in particulate form released in gaseous effluents was expressed as a limit on the average concentrations of radioiodines and radioactive material in particulate form at or beyond the site boundary. The proposed concentration values were designed to limit the annual dose to the thyroid or

5/ The dose rates specified in the rule of 10 millirads per year for gamma radiation and 20 millirads per year for beta radiation are to be based on calculated annual air doses. These calculated annual air doses would normally be considered to meet the objective as limiting doses to individuals in unrestricted areas to not more than 5 millirems to the total body or 15 millirems to the skin. Provisions are made to increase or decrease the annual dose rate if, for a particular site, there are special circumstances where the specified dose rates should be adjusted to limit the exposure of an individual in an unrestricted area to 5 millirems total body exposure or 15 millirems to the skin.

other organs from all reactors on a site to not more than 5 millirems. The design objective in the new Appendix I is expressed as the annual quantity of radioactive iodine and radioactive material released which limits the annual dose or dose commitment to any organ, including the thyroid, of any individual in an unrestricted area from all pathways of exposure to not more than 15 millirems per year per light-water-cooled nuclear power reactor. In determining the annual dose or dose commitment, the applicant or licensee may evaluate the portion due to intake of radioactive material via the food pathways at the locations where the food pathways actually exist. The design-objective annual dose for radioactive iodine has been increased from 5 to 15 millirems on the basis of evidence developed in the hearing which showed that the previous design-objective annual dose of 5 millirems per year for doses to the thyroid from the milk pathway was not practicable.

4. Cost-Benefit Requirements

In addition to the numerical design-objective guides described in paragraphs 1, 2, and 3 above, our decision requires that the applicant include in the radwaste systems all items of reasonably demonstrated technology

that, when added to the system sequentially and in order of diminishing cost-benefit return, can with a favorable cost-benefit ratio effect reduction in dose to the population reasonably expected to be within 50 miles of the reactor. The definition of as low as practicable (10 CFR 50.34a(a)) includes consideration of "...the economics of improvements in relation to the benefits to the public health and safety...." We find support in the record for the application of a cost-benefit analysis as a part of the process for determination of the radwaste systems to be used. Such a cost-benefit analysis requires that both the costs of and the benefits from reduction in dose levels to the population be expressed in commensurate units, and it seems sound that these commensurate units be units of money. Accordingly, to accomplish the cost-benefit balancing, it is necessary that the worth of the decrease of a man-rem and man-thyroid-rem or some essentially equivalent quantities in dose to the population be assigned monetary values.

The record, in our view, does not provide an adequate basis to choose a specific dollar value for the worth of decreasing the population dose by a man-rem or a man-thyroid-rem. Published values for the worth of a man-rem were shown in the record to range from about

$10 to $980. No similar values for worth of a man-thyroid-rem are presented. One of the hearing participants chose $1000 per man-rem and $333 per man-thyroid-rem. This choice for worth of a man-rem simply reflected a value slightly more conservative than the highest previously published value and implied no independent assessment of the worth of either entity. We, therefore, recognize that there is no consensus in this record or otherwise regarding proper value for worth of a man-rem and even less information upon which to base the choice of a proper value for worth of a man-thyroid-rem.

Moreover, we also recognize that selection of such values is difficult since it involves, in addition to actuarial considerations that are commonly reduced to financial terms, aesthetic, moral, and human values that are difficult to quantify. At the same time we believe that meaningful cost-benefit balances are an essential part of the considerations of the as low as practicable concept for control of insult to the population from radioactive effluents, and for that matter, from other pollutants.

We propose, therefore, at the earliest practicable date to conduct a rulemaking hearing to establish appropriate monetary values for the worth of reduction of radiation doses to the population. We are aware that the National Academy of Sciences - National Research Council Advisory Committee on Biological Effects of Ionizing Radiation is currently studying and developing methodologies for benefit-risk-cost analysis for activities involving radiation exposure. It is possible that information on monetary values for the worth of reduction of radiation dose, as well as useful methodology, may be provided by this study. When such appropriate values (or some other equivalent quantified, and as yet unspecified, criteria) are available, we shall consider them for incorporation in Appendix I.

Meanwhile, and purely as an interim measure, we believe that we can accept the conservative value of $1000 per total-body man-rem for these cost-benefit evaluations. Since we realize that the ultimately accepted value may well prove to be less than this, we should leave it open to demonstration in individual cases that a lower figure should be used if the applicant chooses to and can make that demonstration. It is also clear to us that

arguments can be made that the worth of reduction in thyroid dosage should have a smaller value than that for a total-body man-rem. Since the record can offer no clear guidance in this regard, we have accepted, purely as an interim measure, $1000 per man-thyroid-rem as the value to be used in the cost-benefit evaluations. This figure is subject to individual case demonstration of a lower value, as indicated above, since it may well be that the ultimately accepted value will be lower.

In summary, we have decided that, pending completion of the further rulemaking to establish better values (or suitable equivalent criteria), the cost-benefit balances required by section II, paragraph D of Appendix I, shall be accomplished using the value of $1000 per total-body man-rem and $1000 per man-thyroid-rem, or such lesser values as may be demonstrated by the applicant to be suitable in a particular case.

We intend that radwaste augments necessary to satisfy the limits (of section II, paragraphs A, B, and C of Appendix I) on maximum dosages to individuals will be required in all cases. Additional radwaste augments

will be required when, and only when, it can be shown that, where each is added sequentially and in order of diminishing cost-benefit return, the sum of its annualized cost of installation, its annual operating cost, and a reasonable allowance for its maintenance is less than the annual worth of the decreases in total-body man-rem and in man-thyroid-rem which the augment can achieve for the population within 50 miles of the reactor.

5. Per Site vs. Per Reactor

From the foregoing it is clear that the Commission's policy is to minimize the radiation exposure of human beings from the effluents of light-water-cooled nuclear power reactors. We have chosen to express the design objectives on a per light-water-cooled nuclear power reactor basis rather than on a site basis, as was originally proposed. While no site limits are being adopted, it is expected that the dose commitment from multi light-water-cooled reactor sites should be less than the product of the number of reactors proposed for a site and the per-reactor design-objective guides because there are economies of scale due to the use of common radwaste systems for multi-reactor sites which are capable of reducing exposures. Moreover, we note that the matter of overall environmental impact of

nuclear sites is a topic to be specifically addressed in the energy-center study mandated by the Energy Reorganization Act of 1974.

6. Licensee and Commission Action

Revisions have been made in the guides for limiting conditions for operation with respect to when appropriate action must be taken to reduce release rates of radioactive material. The proposed action levels provided that, if rates of release of quantities and concentrations in effluents actually experienced over any calendar quarter indicate that annual rates of release were likely to exceed 2 times the design objectives, the licensee should take corrective action. If such annual rates were likely to exceed a range of 4 to 8 times the design objectives, the Commission would take appropriate action to ensure that the release rates were reduced.

The provisions adopted require the licensee to initiate action if the average dose rate offsite during any calendar quarter from materials discharged to the atmosphere exceeds 10 millirems whole body per year or 30 millirems to the skin and any organ per year, or if the average dose rate offsite during any calendar

quarter from liquid effluents exceeds 6 millirems whole body per year or 20 millirems to the skin and any organ per year.

Existing Commission regulations (10 CFR 50.36a) have recognized the need for licensees to be permitted flexibility of operation compatible with considerations of health and safety to ensure that the public is provided a dependable source of power even under unusual operating conditions that may temporarily result in releases higher than the numerical guides for design objectives. Some flexibility of operation is believed to be essential and warranted in view of the restrictive nature of the Appendix I guides and the fact that, even with this flexibility, it can be ensured that the average population exposure will still be a small fraction of doses from natural background radiation. The Commission notes, however, that, in using this operational flexibility under temporary or short-term unusual operating conditions, the licensee must continue to exert his best efforts to keep levels of radioactive material in effluents within the numerical guides for design objectives.

In order to provide assurance that releases of radioactive materials are known, the Commission has expanded the surveillance and monitoring program beyond current requirements for licensees to report on the quantities of the principal radionuclides released to unrestricted areas. It is expected that this expanded monitoring program will be used by licensees as a basis for initiating prompt and effective corrective action towards ensuring that the actual offsite exposures per reactor are compatible with the design objectives as adopted.

These guides will continue to provide operating flexibility and at the same time ensure a positive system of control by a graded scale of action first by the licensee and second by the Commission, if the need arises, to reduce the release of radioactive material should the rates of release actually experienced substantially exceed the design objectives.

7. Implementation

The proposed Appendix I was silent on the method for implementation of the numerical guides. The Commission believes, however, that Appendix I should guide the

Commission Staff and other interested persons in the use of appropriate calculational procedures for applying the numerical guides for design objectives. Consequently, the provision adopted states that compliance with the guides on design objectives shall be demonstrated by calculational procedures based on models and data that will not substantially underestimate the actual exposure of an individual through appropriate pathways, all uncertainties being considered together.

Quantitative measurement of radioactive materials released in effluents from licensed light-water-cooled nuclear power reactors is required by 10 CFR 50.36a. This requirement is made more specific by Appendix I and reflects the desirability of the use of the best available experimental data as well as calculational models in order to achieve increased accuracy and realism. Strong incentives already exist for improving the calculational models used in establishing design objectives in view of the economic penalty associated with needless overdesign for conservatism. Actual measurements and surveillance programs can provide data for improving these models. It is recognized, however, that measurements of environmental exposures and quantities of radioactive materials

in the environs are complicated by the very low concentrations that are encountered, compared to background, and by the fact that there are a number of variables in both time and space that affect concentration. Thus, the correlation of the best measurements with the best calculations is tedious and difficult. However, since calculational procedures must be employed in implementing the design-objective guides of Appendix I, the Commission has adopted an implementation policy that encourages the improvement of calculation models and the use of the best data available.

The foregoing "Summary and Statement of Considerations" has briefly summarized the technical context of the issues presented and outlined the changes made in Appendix I from the form in which it was originally proposed. The text of Appendix I as adopted follows in Chapter II of this Opinion. The three following chapters of text set forth the record bases for the changes in greatly expanded detail. These supplemental explanatory chapters (III through V), because of their length, will not be published in the Federal Register with the text of Appendix I and the Summary and Statement of Considerations, but will be published in the

April issue of Nuclear Regulatory Commission Issuances.[6/] Single copies of this volume may be purchased at a cost of $4.00 from the USERDA Technical Information Center, P.O. Box 62, Oak Ridge, Tennessee, 37830. Copies of the complete Opinion are also available for inspection and copying in the Commission's Public Document Room, 1717 H Street, N.W., Washington, D.C. 20555.

6/ Copies of the complete five-chapter Opinion of the Commission have been filed with the original document submitted for publication in the Federal Register, and may be examined by members of the public at the Offices of the Federal Register.

CHAPTER II

APPENDIX I

Pursuant to the Atomic Energy Act of 1954, as amended, and Sections 552 and 553 of Title 5 of the United States Code, the following amendments to Title 10, Chapter 1, Code of Federal Regulations, Part 50, are published as a document subject to codification to be effective on June 4, 1975.

1. Section 50.34a of 10 CFR Part 50 is amended by adding the following sentence to the end of paragraph (a):

(a) * * * The guides set out in Appendix I provide numerical guidance on design objectives for light-water-cooled nuclear power reactors to meet the requirement that radioactive material in effluents released to unrestricted areas be kept as low as practicable. These numerical guides for design objectives and limiting conditions for operation are not to be construed as radiation protection standards.

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2. Section 50.36a of 10 CFR Part 50 is amended by adding the following sentence at the end of paragraph (b):

(b) * * * The guides set out in Appendix I provide numerical guidance on limiting conditions for operation for light-water-cooled nuclear power reactors to meet the requirement that radioactive materials in effluents released to unrestricted areas be kept as low as practicable.

3. A new Appendix I is added to 10 CFR Part 50 to read as follows:

APPENDIX I - NUMERICAL GUIDES FOR DESIGN OBJECTIVES AND LIMITING CONDITIONS FOR OPERATION TO MEET THE CRITERION "AS LOW AS PRACTICABLE" FOR RADIOACTIVE MATERIAL IN LIGHT-WATER-COOLED NUCLEAR POWER REACTOR EFFLUENTS.

SECTION I. INTRODUCTION

Section 50.34a provides that an application for a permit to construct a nuclear power reactor shall include a description of the preliminary design of equipment to be installed to maintain control over radioactive materials in gaseous and liquid effluents produced during normal reactor operations, including expected operational occurrences. In the case of an

application filed on or after January 2, 1971, the application must also identify the design objectives, and the means to be employed, for keeping levels of radioactive material in effluents to unrestricted areas as low as practicable.

Section 50.36a contains provisions designed to assure that releases of radioactive material from nuclear power reactors to unrestricted areas during normal reactor operations, including expected operational occurrences, are kept as low as practicable.

This Appendix provides numerical guides for design objectives and limiting conditions for operation to assist applicants for, and holders of, licenses for light-water-cooled nuclear power reactors in meeting the requirements of Sections 50.34a and 50.36a that radioactive material in effluents released from these facilities to unrestricted areas be kept as low as practicable. Design objectives and limiting conditions for operation conforming to the guidelines of this Appendix shall be deemed a conclusive showing of compliance with the "as low as practicable" requirements of 10 CFR sections 50.34a and 50.36a. Design objectives and limiting conditions for operation

differing from the guidelines may also be used, subject to a case-by-case showing of a sufficient basis for the findings of "as low as practicable" required by sections 50.34a and 50.36a. The guides presented in this Appendix are appropriate only for light-water-cooled nuclear power reactors and not for other types of nuclear facilities.

SECTION II. GUIDES ON DESIGN OBJECTIVES FOR LIGHT-WATER-COOLED NUCLEAR POWER REACTORS LICENSED UNDER 10 CFR PART 50

The guides on design objectives set forth in this section may be used by an applicant for a permit to construct a light-water-cooled nuclear power reactor as guidance in meeting the requirements of 50.34a(a). The applicant shall provide reasonable assurance that the following design objectives will be met.

A. The calculated annual total quantity of all radioactive material above background[1/] to be released from each light-water-cooled nuclear power reactor to unrestricted

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1/ Here and elsewhere in this Appendix background means radioactive materials in the environment and in the effluents from light-water-cooled power reactors not generated in, or attributable to, the reactors of which specific account is required in determining design objectives.

areas will not result in an estimated annual dose or dose commitment from liquid effluents for any individual in an unrestricted area from all pathways of exposure in excess of 3 millirems to the total body or 10 millirems to any organ.

B.1. The calculated annual total quantity of all radioactive material above background to be released from each light-water-cooled nuclear power reactor to the atmosphere will not result in an estimated annual air dose from gaseous effluents at any location near ground level which could be occupied by individuals in unrestricted areas in excess of 10 millirads for gamma radiation or 20 millirads for beta radiation.

2. Notwithstanding the guidance of paragraph B.1:

(a) The Commission may specify, as guidance on design objectives, a lower quantity of radioactive material above background to be released to the atmosphere if it appears that the use of the design objectives in paragraph B.1 is likely to result in an estimated annual external dose from gaseous effluents to any individual in an unrestricted area in excess of 5 millirems to the total body; and

(b) Design objectives based upon a higher quantity of radioactive material above background to be released to the atmosphere than the quantity specified in paragraph B.1 will be deemed to meet the requirements for keeping levels of radioactive material in gaseous effluents as low as practicable if the applicant provides reasonable assurance that the proposed higher quantity will not result in an estimated annual external dose from gaseous effluents to any individual in unrestricted areas in excess of 5 millirems to the total body or 15 millirems to the skin.

C. The calculated annual total quantity of all radioactive iodine and radioactive material in particulate form above background to be released from each light-water-cooled nuclear power reactor in effluents to the atmosphere will not result in an estimated annual dose or dose commitment from such radioactive iodine and radioactive material in particulate form for any individual in an unrestricted area from all pathways of exposure in excess of 15 millirems to any organ.

D. In addition to the provisions of paragraphs A, B, and C above, the applicant shall include in the radwaste system all items of reasonably demonstrated technology

that, when added to the system sequentially and in order of diminishing cost-benefit return, can for a favorable cost-benefit ratio effect reductions in dose to the population reasonably expected to be within 50 miles of the reactor. As an interim measure and until establishment and adoption of better values (or other appropriate criteria), the values $1000 per total body man-rem and $1000 per man-thyroid-rem (or such lesser values as may be demonstrated to be suitable in a particular case) shall be used in this cost-benefit analysis.

SECTION III. IMPLEMENTATION

A.1. Conformity with the guides on design objectives of Section II shall be demonstrated by calculational procedures based upon models and data such that the actual exposure of an individual through appropriate pathways is unlikely to be substantially underestimated, all uncertainties being considered together. Account shall be taken of the cumulative effect of all sources and pathways within the plant contributing to the particular type of effluent being considered. For determination of design objectives in accordance with the guides of Section II, the estimation of exposure shall be made with respect to such potential

land and water usage and food pathways as could actually exist during the term of plant operation, provided that, if the requirements of paragraph B of Section III are fulfilled, the applicant shall be deemed to have complied with the requirements of paragraph C of Section II with respect to radioactive iodine if estimations of exposure are made on the basis of such food pathways and individual receptors as actually exist at the time the plant is licensed.

2. The characteristics attributed to a hypothetical receptor for the purpose of estimating internal dose commitment shall take into account reasonable deviations of individual habits from the average. The applicant may take account of any real phenomenon or factors actually affecting the estimate of radiation exposure, including the characteristics of the plant, modes of discharge of radioactive materials, physical processes tending to attenuate the quantity of radioactive material to which an individual would be exposed, and the effects of averaging exposures over times during which determining factors may fluctuate.

B. If the applicant determines design objectives with respect to radioactive iodine on the basis of existing conditions and if potential changes in land and water

usage and food pathways could result in exposures in excess of the guideline values of paragraph C of Section II, the applicant shall provide reasonable assurance that a monitoring and surveillance program will be performed to determine:

1 the quantities of radioactive iodine actually released to the atmosphere and deposited relative to those estimated in the determination of design objectives;

2 whether changes in land and water usage and food pathways which would result in individual exposures greater than originally estimated have occurred; and

3 the content of radioactive iodine and foods involved in the changes, if and when they occur.

SECTION IV. GUIDES ON TECHNICAL SPECIFICATIONS FOR LIMITING CONDITIONS FOR OPERATION FOR LIGHT-WATER-COOLED NUCLEAR POWER REACTORS LICENSED UNDER 10 CFR PART 50

The guides on limiting conditions for operation for light-water-cooled nuclear power reactors set forth below may be used by an applicant for a license to operate a light-water-cooled

nuclear power reactor as guidance in developing technical specifications under section 50.36a(a) to keep levels of radioactive materials in effluents to unrestricted areas as low as practicable.

Section 50.36a(b) provides that licensees shall be guided by certain considerations in establishing and implementing operating procedures specified in technical specifications that take into account the need for operating flexibility and at the same time assure that the licensee will exert his best effort to keep levels of radioactive material in effluents as low as practicable. The guidance set forth below provides additional and more specific guidance to licensees in this respect.

Through the use of the guides set forth in this Section it is expected that the annual releases of radioactive material in effluents from light-water-cooled nuclear power reactors can generally be maintained within the levels set forth as numerical guides for design objectives in Section II.

At the same time, the licensee is permitted the flexibility of operation, compatible with considerations of health and safety, to assure that the public is provided a dependable

source of power even under unusual operating conditions which may temporarily result in releases higher than such numerical guides for design objectives but still within levels that assure that the average population exposure is equivalent to small fractions of doses from natural background radiation. It is expected that in using this operational flexibility under unusual operating conditions, the licensee will exert his best efforts to keep levels of radioactive material in effluents within the numerical guides for design objectives.

A. If the quantity of radioactive material actually released in effluents to unrestricted areas from a light-water-cooled nuclear power reactor during any calendar quarter is such that the resulting radiation exposure, calculated on the same basis as the respective design objective exposure, would exceed one-half the design objective annual exposure derived pursuant to Sections II and III, the licensee shall:[2/]

2/ Section 50.36a(2) requires the licensee to submit certain reports to the Commission with regard to the quantities of the principal radionuclides released to unrestricted areas. It also provides that, on the basis of such reports and any additional information the Commission may obtain from the licensee and others, the Commission may from time to time require the licensee to take such action as the Commission deems appropriate.

1. Make an investigation to identify the causes for such release rates;
2. Define and initiate a program of corrective action; and
3. Report these actions to the Commission within 30 days from the end of the quarter during which the release occurred.

B. The licensee shall establish an appropriate surveillance and monitoring program to:

1. Provide data on quantities of radioactive material released in liquid and gaseous effluents to assure that the provisions of paragraph A of this section are met;
2. Provide data on measurable levels of radiation and radioactive materials in the environment to evaluate the relationship between quantities of radioactive material released in effluents and resultant radiation doses to individuals from principal pathways of exposure; and
3. Identify changes in the use of unrestricted areas (e.g., for agricultural purposes) to permit modifications in monitoring programs

for evaluating doses to individuals from principal pathways of exposure.

C. If the data developed in the surveillance and monitoring program described in paragraph B of this section and in paragraph B of Section III or from other monitoring programs show that the relationship between the quantities of radioactive material released in liquid and gaseous effluents and the dose to individuals in unrestricted areas is significantly different from that assumed in the calculations used to determine design objectives pursuant to Sections II and III, the Commission may modify the quantities in the technical specifications defining the limiting conditions for operation in a license authorizing operation of a light-water-cooled nuclear power reactor.

SECTION V. EFFECTIVE DATES

A. The guides for limiting conditions for operation set forth in this Appendix shall be applicable in any case in which an application was filed on or after January 2, 1971, for a permit to construct a light-water-cooled nuclear power reactor.

B. For each light-water-cooled nuclear power reactor constructed pursuant to a permit for which application was filed prior to January 2, 1971, the holder of the permit or a license authorizing operation of the reactor shall, within a period of twelve months from June 4, 1975, file with the Commission:

1. such information as is necessary to evaluate the means employed for keeping levels of radioactivity in effluents to unrestricted areas as low as practicable, including all such information as is required by section 50.34a(b) & (c) not already contained in his application; and
2. plans and proposed technical specifications developed for the purpose of keeping releases of radioactive materials to unrestricted areas during normal reactor operations, including expected operational occurrences, as low as practicable.

CHAPTER III

GUIDES ON DESIGN OBJECTIVES

Section 50.34a of 10 CFR Part 50 contains provisions to ensure that releases of radioactive material from nuclear power reactors to unrestricted areas during normal reactor operations, including expected operational occurrences, are kept as low as practicable. The Appendix I that we adopt provides specific guidance to licensees in this respect.

A. The Rule

Section II of Appendix I defines design objectives for effluents from light-water-cooled power reactors. When used by an applicant for a permit to construct a light-water-cooled power reactor, these guides assure compliance with the requirements of section 50.34a of 10 CFR Part 50. Four guides provide this assurance: limits are set upon radiation doses or dose commitments to individuals in unrestricted areas from radioactive materials (1) in liquid effluents, (2) in gaseous effluents, and (3) as radioiodine and particulate emissions and (4) a requirement is imposed that the radwaste systems include all items of reasonably demonstrated technology that for a favorable cost-benefit ratio can effect a reduction in the radiation dose to the general population.

The total quantity of all radioactive material above background to be released each year from each light-water-cooled nuclear power reactor to unrestricted areas shall not result in an estimated annual dose or dose commitment from liquid effluents for any individual in unrestricted areas in excess of 3 millirems to the total body or 10 millirems to any organ.

The calculated quantity of all radioactive material above background to be released to the atmosphere annually from each light-water-cooled nuclear reactor shall not result in an estimated annual air dose from gaseous effluents in excess of 10 millirads for gamma radiation and 20 millirads for beta radiation at any location near ground level which could be occupied by individuals in unrestricted areas.

The Commission may specify a smaller quantity of radioactive material to be released to the atmosphere if such smaller quantity appears necessary to prevent an annual external total-body dose from gaseous effluents in excess of 5 millirems to any individual in an unrestricted area. Conversely, if the applicant can provide reasonable assurance that a larger quantity of emitted radioactivity will not result in an estimated annual external dose from gaseous effluents to any individual in unrestricted areas in excess of 5 millirems to

the total body or 15 millirems to the skin, such larger quantity of emitted radioactivity may be deemed to meet the requirements of "as low as practicable."

The calculated annual total quantity of all radioactive iodine and radioactive material in particulate form above background to be released to the atmosphere from each light-water-cooled nuclear power reactor in effluents to the atmosphere shall not result in an estimated annual dose or dose commitment from such radioactive iodine and radioactive material in particulate form from all pathways of exposure for any individual in unrestricted areas in excess of 15 millirems to any organ. As described in more detail in Chapter V, that portion of the dose or dose commitment due to intake of radioactive material through food pathways may be evaluated at the locations where the food pathways actually exist.

In addition to these limits on liquid, gaseous, and radioiodine and particulate effluents, the radwaste system of each light-water-cooled nuclear power reactor shall include all equipment items of reasonably demonstrated technology which can for a favorable cost-benefit ratio effect a reduction in dose to the population reasonably expected to be within 50 miles of the reactor. As an interim measure and until establishment and adoption of better values (or other appropriate criteria), the

values $1000 per total body man-rem and $1000 per man-thyroid-rem (or such lesser values as may be demonstrated to be suitable in a particular case) shall be accepted for use in this cost-benefit analysis.

We believe these requirements ensure that radiation doses to near neighbors of light-water-cooled nuclear reactors will be limited to a small fraction of the doses permitted by the Federal Radiation Protection Guides and will be well within the variation in natural background radiation levels. At the same time, radiation doses to members of the population at large will be held to very low values.

B. The Considerations

Adoption of these design objectives for effluents from light-water-cooled nuclear power reactors required that we make decisions on a variety of questions that, as the hearing record shows, were contested strongly by the several hearing participants. We describe these contesting views, discuss our assessment of the record, and report our resolution under individual headings below.

1. Shall Quantity and Concentration Limits Be Included in Addition to Dose Limits?

The hearing record shows an almost complete consensus that the basic purpose of the design-objective values is the

limitation of radiation-dose levels to off-site members of the public. However, in early stages of the hearing, the Regulatory Staff contended that these dose levels should be limited by placing limits on the quantities and concentrations of radioactive materials in effluents from light-water-cooled nuclear power plants.[1,2]

The Regulatory Staff modified this position during the course of the hearing. The version of Appendix I presented in the Staff's concluding statement[3] did not specify concentration limits on tritium and other radioactive materials released to the environment, but it did include, in addition to limitations on doses to any individual in an unrestricted area, limits on the quantity of radioactive material (except tritium and dissolved gases) in liquid effluents and on the quantity of iodine that could be released.

The Regulatory Staff's final position, i.e., that quantity limits, in addition to dose limits, should be required, was intended to remove the possibility that future land-use patterns in the neighborhood of reactor sites might be prejudiced. The Staff argued that dose limits alone could permit releases of excessive quantities of radionuclides at sites where the environs were unpopulated at the time the reactor

1/ Regulatory Staff, Exhibit 1, Tab. 1, pp. 13-19.
2/ Tr., pp. 25-26.
3/ Regulatory Staff, Concluding Statement of Position, Feb. 20, 1974.

was built; such releases might preclude future use of these environs.[4,5]

The General Electric Company (GE) argued throughout the hearing[6-9] that specification of quantities (and concentrations) of radioactive materials released in effluents is unnecessary in view of the primacy of the dose limitation. They insisted that such quantity limits protect no public interest and provide no significant saving of calculational effort in demonstrating compliance with dose limits.[7] And they argued[9] that quantity limits on radioactive materials in liquid effluents would jeopardize the advantages that a dose formulation alone would provide, namely, an "as low as practicable" (ALAP) regulation that encourages the applicant's choice of a favorable site.

The Consolidated Utility Group (CU) also argued[10,11] consistently that quantity and concentration limits be omitted from Appendix I. They took the position[10] that, though dose should be the primary basis for numerical guidance on ALAP, they had no quarrel with the principle that quantity

4/ Ibid., pp. 50-53.
5/ Tr., pp. 343-344.
6/ General Electric, Exhibit 1, Mar. 17, 1972, pp. 7-13.
7/ Tr., pp. 1435-36.
8/ General Electric, Closing Statement, Jan. 21, 1974, p. 13.
9/ General Electric, Reply, Mar. 14, 1974, pp. 43-48.
10/ Consolidated Utility Group, Statement of Position, Jan. 19, 1974, pp. 51-52.
11/ Consolidated Utility Group, Reply, Mar. 7, 1974, p. 17.

limits on releases from specific plants might be needed. They insisted,[10] however, that such quantity limits should not be incorporated in the rule and thereby be standardized for all light-water-cooled nuclear power plants without regard to the environmental factors and potential pathways associated with a particular site. Instead, they strongly endorsed inclusion in the technical specifications of operating licenses of individual quantity limits set for each plant so as to achieve the basic objectives of Appendix I on the basis of actual site conditions and actual exposure pathways.

Both GE[12] and CU[13] argued strongly against the Regulatory Staff's proposed limit[9] of 1 curie of iodine-131 per reactor. Both argued that the proposal had no foundation in the record and that it was based solely on the belief that without such a quantity limit licensees would build and operate reactors which did not use readily available technology and which would, consequently, release large quantities of radioiodine at sites where no milk pathways exist within miles of the reactor. Both CU and GE insisted that such an eventuality was not a realistic one.

12/ General Electric, Reply, Mar. 17, 1974, p. 46.
13/ Consolidated Utility Group, Reply, Mar. 7, 1974, p. 13.

The propriety of dose limits rather than quantity limits was strongly supported by Lauriston Taylor,[14,15] on behalf of the National Council on Radiation Protection, by Merril Eisenbud,[16] who made a limited appearance on behalf of the Atomic Industrial Forum, and by R. M. Hartman,[17] who made a limited appearance on behalf of Ebasco Services, Incorporated. Dr. Edward P. Radford,[18] who testified on behalf of the Consolidated National Intervenors, also endorsed this position. In addition, limited participant Andrew P. Hull[19] testified to his belief that the specification of release and concentration limits, over and above an overall exposure limit, is unwarranted and in many cases would lead to significant expenditures for protection against nonexistent or completely inconsequential risks.

The State of Minnesota, on the other hand, consistently argued[20-22] that quantities and concentrations of emitted radioactive material should be minimized. Although it is clear that Minnesota's objective is the protection of individuals, and especially those individuals near nuclear

14/ Tr., pp. 1737-38.
15/ Tr., pp. 2055-56.
16/ Tr., p. 88.
17/ Tr., pp. 109-116.
18/ National Intervenors, Exhibit 3, p. 2.
19/ Andrew P. Hull (Limited Participant), Final Statement of Position, Feb. 11, 1974, p. 4.
20/ Tr., pp. 1778-79.
21/ State of Minnesota, Final Statement of Position, Feb. 1, 1974.
22/ Oral Argument, Tr., pp. 159-160.

facilities, the language recommended in its final statement[23] suggests that Minnesota would give primary attention to quantities and concentrations of radioactive materials released.

The overriding purpose of Appendix I is to establish limits on radiation doses to people. Whether additional limits on quantities of emitted radioactive materials should be included is a more complex question.

We agree that the Regulatory Staff was correct in recommending removal of concentration limits for radioactive materials in liquid effluents from its proposed Appendix I. Since, however, many of the very low doses of Appendix I are not in themselves subject to accurate measurement, the quantities and concentrations of the radioactive materials must be measured at the point of discharge, and doses must be inferred by calculations from these measurements. This fact affords a basis for an argument for inclusion in Appendix I of limits on such quantities.

23/ State of Minnesota, Final Statement of Position, Feb. 1, 1974, pp. 21-22.

Not all the arguments against inclusion of such limits are persuasive. We are not impressed, for example, by the GE[7] claim that guides containing quantity limits will lead to substantial misunderstanding and confusion regarding compliance with effluent-emission criteria.

We do find persuasive, however, the arguments advanced by GE[9] and CU[10] that the imposition of quantity limits in addition to dose limits could jeopardize the advantages that dose limitations alone would provide and might preclude a regulation which is fitted to the particular characteristics of individual plants and sites and which encourages the applicant's choice of a favorable site. It is clear that the Regulatory Staff recognized some validity in this argument when it indicated[1] that the specified quantities and concentrations are substantially more conservative than would be required to meet the dose-limiting criteria for many sites.

We have, accordingly, adopted an Appendix I that specifies neither quantity nor concentration limits for the effluents from light-water-cooled nuclear power plants. As recommended by CU,[10] it seems reasonable to us that limits on quantities of emitted radioactive materials compatible with dose limits and the characteristics of specific sites might be incorporated in the technical specifications of the individual plant operating license.

Though we do not include quantity limits in Appendix I, we do agree with the Regulatory Staff argument[3/] that it is inadequate to base parameters on uses of the environment only at the time the reactor is designed and constructed. We certainly wish to ensure that the rule cannot result in approval of designs of radwaste systems that do not use the rudimentary, readily available technology to reduce releases. The record does not warrant the inference that the nuclear industry has any intention of doing this, and we note that both GE[12/] and CU[13/] declare that no such actions will be taken. We consider it plain, however, that our public responsibilities cannot be satisfied by an Appendix I that depends for its efficacy upon the continuing good intentions of those subject to regulation.

Sections III and IV of Appendix I require that the applicant determine whether changes in land and water use and in food pathways occur during the reactor lifetime so as to permit such modifications as may be appropriate in surveillance and monitoring programs or in technical specifications defining limiting conditions for operation. This is elaborated under implementation in Chapter V below. Accordingly, although we have not included quantity limits, we believe that by these means and by inclusion of the requirement that all augments

with a favorable cost-benefit ratio be included in the radwaste system we have, as described in detail below, obtained the necessary protection for potential future uses of the environs.

2. Shall Primary Consideration Go to Neighboring Individuals or to the General Population?

The record contains considerable controversy on whether the design objectives should be based on radiation exposure of the population at large or on exposure of individuals who live near light-water-cooled nuclear power plants.

It is abundantly clear that at radiation dose levels well below those described in existing radiation standards (such as those of FRC) the levels of risk to the health of an individual are very small. Accordingly, statistically significant risks from very low levels of radiation can be calculated only for large population groups.

On the other hand, it is equally clear that the individual living near the light-water-cooled nuclear power plant is concerned about the risk to himself and to his family and has only a secondary interest in the (obviously lower) average risk to the general population.

The Consolidated Utility Group (CU) argued that the controlling consideration in establishing numerical dose objectives should be radiation doses to the general population rather than to

individuals. They held[24] that, although for regulatory simplicity it might be desirable for Appendix I to continue to express its design objectives in terms of off-site individuals, the choice of the individual dose objective and of the individual to whom it applies should reflect the paramount importance of the population dose objective and should not be more stringent than can be justified on a cost-benefit basis in terms of population dose reduction.

In spite of this contention, CU, apparently for the sake of regulatory simplicity, stated its recommendations on design objectives in terms of dose to individuals. However, CU would make the individual dose compatible with a primary population dose objective[25] and would specify[26] that the individual selected for dose calculation be one whose living and recreational habits, including the source of his water and food and the quantity of his consumption of both, are representative of a significant number of individuals living in the general vicinity of the plant.

24/ Consolidated Utility Group, Statement of Position, Jan. 19, 1974, p. 9.
25/ Ibid., pp. 26-27.
26/ Ibid., p. 69.

Andrew P. Hull also favored primary consideration to total population dose and subordination of individual dose limits to that limit. In his view[27] the available biological data would not justify going beyond the specification of an overall population limit, and, since the benefit of a nuclear power plant is the amount of electricity generated, this population dose limit ought to be specified with relation to plant capacity rather than on a per plant basis.

Ebasco Services, Incorporated, also argued that population dose should be recognized as an important factor in decisions regarding Appendix I. R. M. Hartman[28] stated for Ebasco that, in his opinion, AEC had gone too far in details for implementing the dose limit to the nearest off-site individual and not far enough in considering the dose to a sizeable nearby population group.

General Electric (GE), on the other hand, would specify the numerical guides for the nearest neighbors. The GE closing statement[29] suggested that the ALAP numerical guides be established in terms of dose-limiting objectives for the nearest neighbors of a light-water-cooled power reactor and. equal 1% of the present Federal Radiation Council Guides for the whole body and each body organ.

27/ Andrew P. Hull (Limited Participant), Feb. 11, 1974, p. 4.
28/ Tr., pp. 111-114.
29/ General Electric, Closing Statement, Jan. 21, 1974, p. 13.

The State of Minnesota clearly supported the position that individual dose levels and not the average doses to a large population should be the controlling factors.[30/] In this connection Minnesota also noted that, "in keeping with the American tradition of the importance of the individual, no one (and one might add, no one's offspring) should be required to assume a disproportionate amount of the risk."[30/]

The Regulatory Staff has taken the position that, although average population exposure is important and should be minimized, primary attention must be given to limitations on the dose to individuals living in close proximity to the reactor site.[31,32/] The record shows that this position did not substantially change throughout the hearing. During oral argument, Lester Rogers stated[33/] for the Regulatory Staff:

> "I think the primary objective of the regulation is, number one, to reduce the exposures and the risk to individuals, actual individuals that exist at the present time near the site, to as low as practicable levels. At the same time I think you must take into account the exposure to potential individuals, and by that I mean future users of the environment."

30/ State of Minnesota, Final Statement of Position, Feb. 1, 1974, pp. 12-17.
31/ Regulatory Staff, Exhibit 1, Tab. 1, Jan. 7, 1972.
32/ Regulatory Staff, Exhibit 1, Tab. 3, Jan. 7, 1972.
33/ Oral Argument, Tr., pp. 23-24.

We agree that radiation dose levels to the general population are important considerations and that these levels should be kept to low values. We do not, however, agree that specification of an average population dose level alone will suffice. It seems clear to us that, in general agreement with the position of the Regulatory Staff and several other parties, Appendix I must take into account those individuals who live near the light-water-cooled power reactor facility.

It is axicmatic that, if the near neighbors of a nuclear plant, and consequently those maximally exposed to its emissions, receive low radiation doses, then the general public will receive very low doses. It does not necessarily follow, however, that such population doses will in all cases be as low as practicable. A light-water-cooled nuclear power station in a very remote location (or even one employing tall stacks instead of augments for removal of radioactive material from gas streams) might ensure adequately low doses to its neighbors yet permit higher than necessary doses to the general population.

We believe that the design-objective guides that we adopt afford the needed and reasonable balance in this regard. The primary thrust of the numerical guides is the protection of near neighbors of the reactor. At the same time, the requirement for inclusion of all radwaste equipment with a favorable

cost-benefit ratio serves to assure that, regardless of the reactor site characteristics, the general public is protected.

We are mindful of the position espoused by the State of Minnesota[30/] that no group of individuals should be expected to assume a disproportionate amount of the radiation risk. We would certainly subscribe to the view that no group of individuals should be exposed to undue radiation risk in order to provide a benefit to other, less exposed, individuals -- and we believe that Appendix I is consistent with that premise. But total equality of risk, however desirable, can seldom be realized in our modern industrial society. Wherever power plants, either nuclear or non-nuclear, are constructed, persons living near those plants will be exposed to marginally greater amounts of emissions than those residing farther away, and the same situation obtains in regard to other types of industrial facilities. We believe, however, that the design-objective guides which we adopt assure that even those individuals living closest to nuclear facilities will be exposed to emissions at exceedingly low levels, with consequent risks which are acceptable from a social as well as legal standpoint.

3. Shall the Guides Apply to Each Site or to Each Reactor?

Whether the design-objective guides should be applied to each water-cooled nuclear reactor or to all such reactors on a site

is a fundamental question that provoked strongly contested and conflicting positions and for which the record shows no agreement. The several arguments are, in brief, the following.

Throughout the hearing, the Regulatory Staff took the position that the design-objective guides should apply to doses from effluents from all light-water-cooled power reactors at a site.[34,35/] The Regulatory Staff position is based in part on the argument that near neighbors of multi-reactor sites should not be required to accept radiation dose levels higher than those required of near neighbors of a single reactor. The State of Minnesota, apparently on the ground that "...no group of individuals should be expected to assume a disproportionate amount of the radiation risk" supported this position.[30/]

Both the General Electric Company (GE) and the Consolidated Utility Group (CU) strongly recommended that the design-objective guides limit doses from individual reactors at a site. They supported these recommendations by several arguments. General Electric contended[36/] that a per-reactor design-objective guide that is as low as practicable for a single reactor will remain as low as practicable even if several reactors are congregated on a single site and that equipment augments

34/ Regulatory Staff, Exhibit 1, Tab. J
35/ Regulatory Staff, Concluding Statement of Position, Feb. 20, 1974, p. 61.
36/ General Electric, Reply, Mar. 14, 1974, p. 33.

unjustified on a cost-benefit basis for a single reactor can never be justified on a cost-benefit basis for multiple-reactor facilities. Indeed, GE suggested[36/] that the environmental and other advantages of multi-reactor siting indicate that more lenience should be allowed for per-reactor emissions from a multi-reactor facility since these advantages will offset any added per-reactor radiological detriment and the added lenience would encourage the desirable clustering of power-generating installations.

General Electric contended further[37/] that per-reactor application of the guides is justified by the ALAP cost-benefit considerations that control Appendix I and argued[37-39/] that the Regulatory Staff has performed no cost-benefit analyses indicating the contrary.

In its statement of position,[40/] CU expressed its belief that there are strong economic and environmental reasons for encouraging maximum use of existing sites and for planning and developing new sites for two or more reactor units. They pointed out that obvious economic advantages lie in the sharing of a large tract of land, in the sharing of facilities, and in the sharing of much of the expense of site investigation,

37/ General Electric, Reply, Mar. 14, 1974, p. 32.
38/ Tr., pp. 3479-80 and 3482.
39/ Tr., pp. 3486-87.
40/ Consolidated Utility Group, Statement of Position, Feb. 19, 1974, pp. 57-58.

engineering, licensing, construction management, and operating supervision and that environmental advantages flow from minimizing the inevitable environmental impacts associated with the development of new industrial sites.

The Consolidated Utility Group[40/] insisted that, at the dose levels contemplated in the proposed rule (particularly with respect to gaseous releases), the effect of a site limitation would be to discourage and possibly prevent multiple reactor units from being placed on a single site and that it would also work an unnecessary hardship on existing multi-unit stations, including several three- or four-unit stations now planned or under construction. In a similar vein[41/] CU pointed out that, although the proposed limits on doses from liquid effluents may not prove unduly burdensome for multi-reactor sites, the limits on doses from noble gases and iodine may severely limit the number of reactors at a site unless stacks and, in come cases, radwaste augments that it considers unjustified on a cost-benefit basis are employed.

General Electric restated with added emphasis its position and that of CU in its closing statement[42/] in the following words:

> "Both the Consolidated Utility Group and GE took the position in the ALAP hearings that the Appendix I

41/ Consolidated Utility Group, Reply, Mar. 7, 1974, pp. 21-25.
42/ General Electric, Closing Statement, Jan. 21, 1974, pp. 28-29.

numerical guides must make special allowance for multi-reactor installations at a single site in order to preserve the overall environmental and economic advantages of minimizing the total number of power generation sites. The FES analyses, even when carried out with a 'best-estimate' dose evaluation, show that application of ALAP design objectives as overall site limits, regardless of the number of reactors present, may limit the number of units on a site below that number that may be desirable for environmental and economic reasons. Such a forced geographic distribution of reactor sites of one or two units each will not reduce total population radiation dose from LWR effluents; in fact, it could increase total population dose if the distributed sites in toto have a lesser degree of local isolation than would the probably more favorable sites that would be selected for multi-unit use."

None of the other parties in this hearing directly addressed this question of whether the limits should have a per-reactor or per-site basis. Consolidated National Intervenors[43/] (in their belief that, since we cannot prove that radiation at any level is harmless, we should permit no radiation releases at all) would seem certainly to prefer whichever limitation is the more stringent; this would presumably imply

43/ Anthony J. Roisman to Algie A. Wells, et al., Feb. 15, 1972.

a preference for a strict limit upon emissions from all reactors at a site. Andrew P. Hull, who advocated[44/] limits based primarily on doses to the population at large and who has suggested 2 man-rems per megawatt (electric) as a limiting design objective, seemed to favor essentially a per-reactor limitation. A similar observation may be made concerning the testimony of R. M. Hartman in a limited appearance for Ebasco Services, Incorporated, who recommended[45/] that 0.1 man-rem to the average individual per 1000 megawatt (thermal) be employed as a limit on population dose.

The Consolidated Utility Group would apparently place no limit, other than that obtained by the per-reactor limit, on doses from multi-reactor sites, but they insisted[46/] that the resulting off-site dose to individuals living near multi-unit sites would still be a small fraction of Part 20 limits and of generally accepted radiation standards and would constitute a trivial incremental risk to the health of the individuals.

On the other hand, GE would, despite its arguments described above, place an additional limit on dose levels from a multiple

44/ Andrew P. Hull (Limited Participant), Final Statement of Position, Feb. 11, 1974, p. 4.
45/ Tr., pp. 109-116.
46/ Consolidated Utility Group, Statement of Position, Feb. 19, 1974, p. 16.

light-water-cooled nuclear reactor site. In its closing statement[47/] GE recommended the language:

> "For any combination of nuclear power reactors on one site, on adjacent sites, or on nearby sites, the applicant or applicants shall, in addition, provide reasonable assurance that the total incremental annual exposure (from either airborne or waterborne effluents) to any individual in unrestricted areas will not exceed four (4) percent of the Federal Radiation Protection Guides, as set forth in Federal Radiation Council Reports Numbers 1 and 2, May 13, 1960 and September 1961, for doses to the total body or any organ."

In support of that recommendation, GE argued[48/] that the recognition in 10 CFR Part 50.34a that "as low as practicable" must be defined "in relation to the utilization of atomic energy in the public interest" requires allowance of slightly increased, but still trivial, exposures in order to achieve a doubling or tripling of electrical output at a site and the other environmental advantages of multiple-unit siting. Further, GE noted

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47/ General Electric, Closing Statement, Jan. 21, 1974, p. 28.
48/ Ibid., pp. 28-29.

that allowing the nearest-neighbor dose resulting from a number of closely located light-water reactors, each meeting the regular single-reactor ALAP guides, to approach 4% of the Federal Radiation Protection Guides would still limit such doses to a small fraction of permissible dose and to a fraction of natural background exposure and would keep such doses within the variation in natural background radiation within the United States. In addition, GE pointed out that such a limit also addresses the subject of total dose to individuals from nearby but separate sites, which was not covered in proposed Appendix I.

We note that, though much qualitative argument was presented, the hearing record contains little specific information that will permit evaluation of dose levels from emissions from sites containing several light-water-cooled nuclear power reactors.

The Regulatory Staff prepared the Final Environmental Statement and did its cost calculations on the basis of tes containing two reactors. In its concluding statement[4] the Staff discussed the effects its recommended design-objective (per site) doses would have on limiting the number of reactors per site. From these considerations the Staff concluded[50] that

49/ Regulatory Staff, Concluding Statement of Position, Feb. 20, 1974, pp. 84-131.
50/ Ibid., p. 62.

the design-objective doses for liquid and gaseous effluents, other than iodine, pose no practical limitations on the number of reactors per site. The design-objective thyroid dose for iodine poses limitations on the number of reactors per site for those sites where milk is a pathway of exposure within 500 to 1000 meters of the site unless stacks or extensive in-plant iodine-removal equipment is used. If stacks are used or if milk is not a pathway of exposure within 3000 or 4500 meters of the site, there appears to be no practical limitation on the number of reactors per site even with the iodine design objective.

With respect to liquid releases, CU stated:[51] "while neither we nor the staff have done the refined calculations necessary to establish the effect of multiple reactors on doses from liquid effluents, we would not expect that the proposed site limit on such doses would be a major factor in limiting the number of reactors per site."

However, CU argued that the situation for doses from iodine and noble gases is entirely different and pointed out that the Staff's findings, which confirm the CU calculations,[52] show that for sites with a cow-milk-infant food pathway in close

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51/ Consolidated Utility Group, Reply, Mar. 7, 1974, p. 22.
52/ Ibid., pp. 22-24.

proximity to a 500-meter site boundary the site limits of 15 millirems to the skin from noble gases and 15 millirems to the thyroid would be severely limiting. They indicated that for such cases boiling-water reactors with all augments justifiable by their cost-benefit analysis would be limited to 2 per site by the skin-dose limit and to zero by the thyroid-dose limit. Pressurized-water reactors with augments justified by cost-benefit analysis would not be appreciably limited (7 to 10 would be possible) by the skin-dose limit, but the thyroid-dose limit would permit no reactor to be built. Adding 100-meter stacks, which do nothing to reduce doses to the general population, would permit 4 to 6 boiling-water reactors or 2 pressurized-water reactors to be built.

The grouping of light-water-cooled nuclear power reactors on well chosen and suitable sites may have the potential for genuine advantages in the use of atomic energy in the public interest. This is a matter subject to separate and intensive study pursuant to Congressional mandate in the Energy Reorganization Act of 1974. Appendix I certainly should not foreclose such a course at this time.

We adopt, accordingly, an Appendix I that designates dose limitation guides to any individual in an unrestricted area on a per-reactor basis alone. The hearing record does not, we believe, provide quantitative information that can substantiate

the values that a per-site guide should have. We are mindful that doses to the general population will not be increased and that they may be minimized by grouping light-water-cooled nuclear power plants. We are also of the opinion that it will be at least several years before sites containing as many as five light-water-cooled nuclear power plants are developed. Consequently, we see no way that design-objective guides set on a per-reactor basis can, in the near future, result in individual exposures that are more than 5% of present-day (10 CFR Part 20) radiation standards. Indeed, we believe that, with the required inclusion of all radwaste augments justified on a cost-benefit basis and with the realization that several reactors cannot physically be placed so as to all be a minimum distance from the maximally exposed individual, the actual doses received by individuals will be appreciably less than this small percentage.

Our decision based as it must be on the record cannot include items not covered by that record. The ALAP hearing properly did not address the possibilities or the problems of sites containing many nuclear reactors along with other nuclear facilities or even many light-water-cooled nuclear power plants. It may be that so-called nuclear energy centers - or even sites that contain many light-water-cooled nuclear power plants - have special virtues.

We do not know. By the time such multi-reactor sites are necessary or desirable, technologies not now known may be available for minimizing radioactive materials in effluents from them. Again, we do not know. It seems clear that such installations will require large and favorably situated sites and that such installations are several years, at least, in the future. Meanwhile, much valuable experience will be gained concerning radioactive emissions from sites containing a few light-water-cooled nuclear plants. It would seem to us that, in due course and when experience is available, the question of the desirability of a per-site limitation on emissions from multi-reactor sites should be examined further.

4. What Shall Be the Numerical Values of the Design-Objective Guides?

A superficial examination of the record might suggest only minor disagreement over the numerical values of the design objectives. A more detailed examination, however, reveals that this notion of minor disagreement is illusory. In fact, the general similarity of the design-objective values recommended by the several parties tends to mask the considerable differences in the bases on which these values are suggested. This is another question on which we have had to decide among conflicting views.

The proposed Appendix I limited the annual dose to any individual from radioactive materials in each effluent type (liquids, gases, and as radioiodine and particulate matter) from all reactors on a site to 5 millirems to the total body or to any organ.[53,54]

General Electric (GE) recommended[55] that the design-objective dose values for nearest neighbors of each light-water-cooled nuclear power reactor be set at 1% of the FRC radiation protection guides from each of the effluent types. They recommended specifically that the objectives for each effluent type and from each reactor should be 5 millirems per year for the total body, 15 millirems per year for the thyroid, and 30 millirems per year for the skin.

Consolidated Utility Group strongly urged[56] the adoption of a per-reactor value equal to 1% of ICRP whole-body and organ dose values for individuals in the general population for each effluent type including ICRP values for organs other than the whole body. They suggested that the individual thyroid-dose objective should be changed to 15 millirems for children and 30 millirems for adults and that the individual skin dose be changed to 30 millirems.

53/ Regulatory Staff, Exhibit 1, Tab. 1.
54/ Regulatory Staff, Concluding Statement of Position, p. 48.
55/ General Electric, Closing Statement, Jan. 21, 1974, pp. 13, 26 and 28.
56/ Consolidated Utility Group, Statement of Position, Jan. 19, 1974, pp. 68-69.

The State of Minnesota in its final statement appeared to endorse the proposed Appendix I position to limit the annual dose from each effluent type and from all reactors at a site to 5 millirems to the total body or any organ.[57] Douglas LaFollette has also indicated his strong support of this position.[58]

Several other suggestions were made. The Tennessee Valley Authority suggested[59] that "the costs and consequences of achieving 1% of Part 20 limits should be carefully balanced against the costs and consequences of achieving instead, for example, 10% of Part 20 limits." Merril Eisenbud suggested, on behalf of the Atomic Industrial Forum, the value 5 millirems to the whole body, gonads, or bone marrow and 15 millirems to all other organs.[60,61] Consolidated National Intervenors,[62] argued that no radioactive discharges should be permitted. At the other extreme, G. Hoyt Whipple[63,64] considered that numerical guidelines other than those given in 10 CFR Part 20 are

57/ State of Minnesota, Final Statement of Position, Feb. 1, 1974, pp. 8 and 17.
58/ Final Environmental Statement, WASH-1258, July 1973, Vol. 3, p. 38.
59/ Ibid., p. 314.
60/ Ibid., p. 96.
61/ Tr., p. 86, Statement by Merril Eisenbud, p. 5.
62/ Anthony J. Roisman to Algie A. Wells, et al., Feb. 15, 1972, p. 7.
63/ Final Environmental Statement, WASH-1258, July 1973, Vol. 3, p. 94.
64/ G. Hoyt Whipple, Testimony on the Proposed Appendix V to 10 CFR Part 50, Feb. 20, 1972.

unnecessary since the interpretation of 10 CFR Part 20 by the nuclear industry has resulted in performance so excellent that there is no need for further incentive.

Andrew P. Hull, who was a limited participant throughout the Hearing, argued[65/] that a boundary limit of 25 millirems per year whole-body dose to individuals would be consistent with his proposal of 2000 man-rems per year limit for population dose from each 1000 megawatt (electric) reactor.

The Regulatory Staff modified its original position as a result of the Hearing. In its concluding statement[66/] the Regulatory Staff agreed that the limiting dose to the thyroid from radioiodine and particulate matter in gaseous effluents should be changed from 5 to 15 millirems per year. They made this change because as a practical matter the dose to a child's thyroid is controlling for purposes of design objectives; evidence developed in the record shows that a design objective of 5 millirems per year is not practicable with respect to the state of technology and the costs of iodine-removal equipment, where milk cows graze in the near vicinity of the site.

The Regulatory Staff also recommended[66/] that the skin dose due to external exposure from beta and gamma radiation released in gaseous effluents from all reactors on a site be changed

65/ Andrew P. Hull, Final Statement of Position, Jan. 30, 1974.
66/ Regulatory Staff, Concluding Statement of Position, Feb. 20, 1974, pp. 48-49 and 25-30.

from 5 to 15 millirems per year because it is not practicable to design to limit the beta dose to 5 millirems per year.

The Regulatory Staff continued to recommend that the design-objective dose from radioactive materials in liquid effluents from all light-water-cooled nuclear power reactors at a site be kept at 5 millirems per year to the total body or to any organ.[67] The Staff argued that both CU[68] and GE[69] agree that this design objective is practicable for liquid effluents.

In its reply statement, however, CU insisted that it no longer agreed completely with that summation.[70] CU indicated its agreement with that assessment for standard river sites. CU contended, however, that at standard lakeshore and seashore sites, with some combinations of reactor types and cooling modes, and with the Staff's bases, cost estimates, and conservative models it was necessary to include augments over and above those justified by its cost-benefit analyses (at $1000 per man-rem and $333 per man-thyroid-rem) to meet the per site design objective of 5 millirems to the total body and to any organ. Careful consideration of the testimony

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[67] Ibid., p. 50.
[68] Tr., pp. 3996-98.
[69] General Electric, Closing Statement, Jan. 21, 1974, p. 16.
[70] Consolidated Utility Group, Reply, Mar. 7, 1974, pp. 15-17.

of Walton A. Rodger[71] indicates that when liquid radwaste augments justified on a cost-benefit basis for two-reactor stations on standard river sites are used on all standard sites the calculated doses to maximally exposed individuals are quite low. Maximum total body dose to an individual appears to be about 1.1 millirems per year for a two-reactor PWR station with cooling towers on a lakeshore site; all other total body doses from two-reactor stations are less, and many are markedly less, than half this value. With these same liquid radwaste augments the maximum individual organ doses are calculated to be 6 millirems to the thyroid from a two-reactor BWR station with cooling towers on a seashore site and 1.8 millirems to the thyroid from a two-reactor PWR station with cooling towers on a seashore site; all other cases show maximum organ doses well below, with many markedly below, these values.

We are mindful of the claims by CU[70] that for some of these cases the liquid radwaste augments are not justified by the cost-benefit analysis. Indeed a careful evaluation of data in Dr. Rodger's testimony suggests that effective radwaste augments that can be justified on a cost-benefit basis (at the high man-rem and man-thyroid-rem worths be used) for all cases except that of two-reactor PWR

71/ Tr., p. 3909, Additional Testimony of Walton A. Rodger on Behalf of the Consolidated Utility Group, Nov. 9, 1973.

stations with cooling towers at seacoast sites. */ Moreover, we are aware that the values $1000 per man-rem and $333 per man-thyroid-rem used by Walton Rodger in his cost-benefit analysis may ultimately prove to be unrealistically high, and that some real sites may yield higher calculated individual doses to the maximally exposed individual than do these standard sites. In addition, we realize that in many cases liquid effluents from a single reactor will lead to calculated doses that are only slightly less than those from a two-reactor station.

After consideration of the CU testimony regarding doses from liquid effluents from light-water-cooled power reactors with technologically sound radwaste augments we are convinced that design-objective guides with 5 millirems total-body dose and 15 millirems as the dose to any organ would be unduly lenient on the per-reactor basis proposed by CU and by GE. However, the same testimony indicates that, for liquid effluents, the staff's suggested limit of 5 millirems to any organ is somewhat too restrictive; this limit is not met for a two-reactor station using BWRs with cooling towers at a standard seacoast site even if the radwaste system includes some augments that lack a favorable cost-benefit ratio for that site.

*/ For that combination, radwaste augments of the type proposed for other twin-PWR stations can provide very low doses; they are not cost-beneficial (at $1000 per total-body man-rem and $333 per man-thyroid-rem) for this case because the population dose for the base case is very low and its further decrease has a low monetary value.

After careful consideration of the entire record, including the views of all parties, in light of the definition of "as low as practicable" which requires "taking into account the state of technology and the economics of improvements in relation to benefits to the public health and safety", we have chosen to adopt as the design-objective guides for liquid effluents from each light-water-cooled power reactor the requirement that the annual dose or dose-commitment from all pathways of exposure shall not exceed 3 millirems to the total body or 10 millirems to any organ. For calculation of such doses, it is assumed that rivers are used as sources of drinking water and that rivers or other pertinent bodies of water are used as sources of fish or other seafood unless positive evidence is provided to prove otherwise. The models also assume (as discussed in more detail under Implementation, Chapter 5) that near neighbors of the light-water-cooled nuclear power reactor include individuals with habits differing significantly from the average. We believe that the record indicates that for virtually all reactor sites this design objective can readily be met.

The design objective to control exposure from gaseous effluents has been expressed in terms of a limitation on the annual dose due to gamma radiation or beta radiation from each reactor at or beyond the boundary of the site. This design objective, in effect, provides flexibility for considering site-related meteorology and the distance from the reactor to the site boundary, but it requires the assumption that people may live just outside the site boundary.

The Regulatory Staff recommended in its Concluding Statement that the skin dose due to external exposure from beta and gamma radiation released in gaseous effluents be set at 15 millirems per year and that the total-body dose from these sources be held at 5 millirems per year. The Staff, however, maintained that these should be the limiting doses from all reactors at a site. GE[55/] and CU[56/] argued, in effect, that the total-body dose limit should be 5 millirems per year, the skin dose limit should be 30 millirems per year, and that these limits should apply to each individual reactor.

On this point again the testimony[71/] of Dr. Walton Rodger is germane. He has shown that gaseous radwaste augments justifiable on a cost-benefit basis (again at $1000 per man-rem and $333 per man-thyroid-rem) are available for both PWRs and BWRs at any type of standard site. On standard sites (500 meter site boundaries) two-reactor BWR stations with these justifiable gaseous radwaste augments can barely meet the skin dose limit of 15 millirems per year and can meet the total body limit of 5 millirems per year by slightly more than two-fold. Two-reactor PWR stations with their justifiable augments show somewhat lower doses.

Accordingly, we see no justification for a per-reactor design objective guide limit of 30 millirems to the skin as proposed

by CU and GE. Indeed, it might be argued that per-reactor limits slightly below 5 millirems to the total body and 15 millirems to the skin could be justified. However, we realize that the cost-benefit bases of $1000 per man-rem and $333 per man-thyroid-rem may prove to be too high and that actual site characteristics and meteorology may differ substantially from those of the standard sites upon which the calculations were done. We have, accordingly, specified dose rates of 10 millirads per year for gamma radiation and 20 millirads per year for beta radiation; these levels would normally be considered to limit doses to individuals in unrestricted areas to not more than 5 millirems to the total body and to less than 15 millirems to the skin. Provisions are made to decrease this annual dose if for a particular site there are special circumstances that necessitate such a decrease to ensure that an individual in an unrestricted area shall not receive more than 5 millirems total-body exposure. Provision is made for an increase in this release rate if special site characteristics or circumstances indicate that such an increase will not lead to individual doses above 5 millirems per year to the total body or 15 millirems to the skin. We believe the record indicates that this design objective is practicable for individual light-water-cooled power reactors at essentially all sites.

The design-objective guide for limits upon individual dosages from radioiodine and radioactive material in particulate form probably proved the most difficult and most strongly contested issue in this rulemaking proceeding.

In its concluding statement[66/] the Regulatory Staff recommended that the limiting dose to the thyroid should be set at 15 millirems per year. They concluded that a design objective of 5 millirems per year is not practicable, considering the state of technology and the costs of iodine removal equipment where milk cows graze in close proximity to the site. Walton Rodger[71/] testified that two-reactor stations with either PWRs or BWRs and with all gaseous radwaste augments justified on his cost-benefit basis ($1000 per total-body man-rem and $333 per man-thyroid-rem) yielded very high thyroid doses (490 millirem/year for PWRs and 850 millirem/year for BWRs) via the iodine-grass-cow-milk-infant pathway when the Staff's conservative assumptions were used and when cows grazed close to the 500 meter site boundary. Indeed, Dr. Rodger's testimony shows that very expensive augments would be required to approach 15 millirems/year to the child's thyroid where milk cows graze close to the site.

As indicated under Implementation (Chapter 5), the design-objective quantity is to be calculated at the location of the nearest milk cows that are actually present at the time of

licensing of the reactor. As a consequence we see no basis for increasing the limit on design-objective dose to any organ from radioiodine and radioactive materials in particulate form above 15 millirems per year. For virtually all cases, the thyroid dose will be the only one of real consequence from this source. However, we do not find in the record compelling evidence to justify reducing the design-objective limit. We have, accordingly, set the design objective to ensure that emission of radioiodine and radioactive material in particulate form from each light-water-cooled nuclear power reactor shall not result in an annual dose to the thyroid for any individual in an unrestricted area from all pathways of exposure in excess of 15 millirems. Future uses of the environment with respect to food pathways will be protected by limiting conditions of operation that require monitoring and surveillance programs designed to identify changing land uses that may result in exposure of individuals to iodine. Appropriate control measures, including the modification of land uses, would be required if monitoring programs during operation indicate that the design-objective guide levels are being exceeded.

As a further requirement, in addition to the design-objective guides described above, the radwaste systems shall include all items of reasonably demonstrated technology that can for a favorable cost-benefit ratio effect reductions in total-body

and thyroid dose to the population within 50 miles of the reactor. Such a provision will ensure that selection of a very large and isolated site or of a site where the nearest milk cows are far away cannot justify the release of large quantities of radioactive materials, and especially radioiodine, simply because no substantial individual doses would result.

5. What Are the Bases on Which Cost-Benefit Evaluations Will Be Made?

A balance of benefits to the general public from the generation of electricity by light-water-cooled nuclear power plants with the associated costs is not germane to the decisions concerning Appendix I. The cost-benefit balance appropriate to decisions regarding Appendix I deals with the cost from installation (and use) of augments to sophisticated radwaste systems versus the benefits obtained through their use.

The cost for addition and for operation of an augment to the radwaste system is generally expressed in dollars; to establish such costs -- and the annualized cost -- is easy in principle and (as described in section 5a, below) is only moderately difficult in practice. Calculation of the decrease in radiation dose to the population within 50 miles of the reactor that would result from addition of an augment also seems to be relatively straightforward (see section 5b, below).

A recent and generally accepted evaluation[72/] of the effects of ionizing radiation is available; it was used by the Regulatory Staff in preparation of its Final Environmental Statement.[73/] It is accordingly possible to estimate in a straightforward and almost certainly conservative way the benefits to the public health obtained by decreasing the radiation doses to the population. The casting of these benefits into monetary terms -- as the dollar value of decreasing by a total-body man-rem and by a man-thyroid-rem (or other essentially equivalent quantities) the dosage to the population -- is, therefore, the only missing information required to strike the cost-benefit balance.

We are of the opinion, after careful consideration, that the hearing record will not support an unambiguous choice of a specific dollar value for the worth of a unit decrease in radiation exposure to the population. On the other hand, we believe that cost-benefit balances should be used to define the limiting population dose from a light-water-cooled power reactor under the as low as practicable criterion. Accordingly, we propose to conduct a rulemaking hearing to determine the appropriate monetary value for reduction of radiation doses to the general population.

72/ National Academy of Sciences - National Research Council. The Effect on Populations of Exposure to Low Levels of Ionizing Radiation (The BEIR Report), Report of the Advisory Committee on the Biological Effects of Ionizing Radiations, November 1972.

73/ Final Environmental Statement, WASH-1258, July, 1973.

When better values (or other appropriate criteria) for the worth of a total-body man-rem and a man-thyroid-rem are established and adopted, they shall be used in the cost-benefit analyses required by this Appendix I. Meanwhile, as an interim measure, we adopt the values described in section 5-c below.

These values can be used in the interim to translate into dollars per year the value of a radwaste augment's contribution to the decrease in man-rem and man-thyroid-rem per year to the population within 50 miles of the reactor. In this way the worth in dollars per year can be established for radwaste augments when each is added to the radwaste system sequentially, and in order of diminishing monetary worth.

We intend that radwaste augments necessary to satisfy the limits on maximum doses to individuals will be required in all cases. Additional augments will be required when, and only when, the worth of each equals or exceeds the annualized cost of its installation, maintenance and operation.

a. What Are the Monetary Costs of Augments to Radwaste Systems?

During the initial phase of the ALAP Hearing (prior to May 6, 1972), the Regulatory Staff presented preliminary information[74,75]

74/ Regulatory Staff, Exhibit 1, Tab. 2.
75/ Tr., pp. 536-590.

concerning the costs of radwaste systems. Other information concerning costs of radwaste systems was also presented in this initial phase of the hearing by CU[76,77/] and to a limited extent by GE.[78/] Walton Rodger, who presented what might fairly be called the only comprehensive formulation of costs[76/] and of annualized costs[77/] during this period, criticized[79/] the Staff's data.

The Regulatory Staff's publication of the Draft Environmental Statement, its consideration of the many diverse comments on this document, and its subsequent publication of the Final Environmental Statement[80/] were important steps in providing a basis for proper costing of radwaste systems and for cost-benefit analyses. Comments on the Draft Environmental Statement showed, as might have been expected, some disagreement with the estimated cost of radwaste equipment.

Consolidated Edison Company of New York, Inc., stated[81/] that the cost estimate in the Draft Environmental Statement seemed to

76/ Walton A. Rodger, Statement on Behalf of the Consolidated Utility Group, Mar. 17, 1972, incorporated in Tr., pp. 1748-52.
77/ Walton A. Rodger, Supplemental Statement on Behalf of the Consolidated Utility Group, Apr. 26, 1972, incorporated in Tr., p. 2753.
78/ General Electric, Exhibit 3, Apr. 26, 1972, items 4 and 5.
79/ Walton A. Rodger, Statement on Behalf of the Consolidated Utility Group, Mar. 17, 1972, p. 41.
80/ Notice of Availability of the Draft Environmental Statement was published in the Federal Register, Jan. 16, 1973 (38 F.R. 1616).
81/ Final Environmental Statement, WASH-1258, Vol. 3, July 1973, pp. 311-312.

be generally lower than their experience would indicate. They showed a few specific examples in which the estimated costs appeared to be low by at least a factor of 3.

In its comments on the Draft Environmental Statement,[82] CU had only minor criticisms of the estimated costs of individual items of radwaste equipment. However, CU argued strongly[83] that the cost picture was badly distorted by the use in the Draft Environmental Statement and the Final Environmental Statement of a two-reactor site in which much of the radwaste equipment was shared between the two reactors.

Moreover, after publication of the FES, CU insisted[84] that, since costs in the FES were nearly a factor of 2 less than in the draft statement, they could no longer avoid taking issue with the Staff's cost estimates. After a detailed elaboration of many points on which they found the Staff's cost estimates deficient, CU concluded[85] that the FES radwaste systems could not possibly be built and operated for less than twice the costs indicated and that more likely the cost would be three to four times that given in the FES.

82/ Ibid., p. 243.
83/ Ibid., p. 244.
84/ Tr., p. 3909; Walton A. Rodger, additional testimony on Behalf of the Consolidated Utility Group, Nov. 19, 1973, pp. 38-39.
85/ Consolidated Utility Group, Statement of Position, Jan. 1974, p. 36.

The Regulatory Staff, on the other hand, continued to defend the cost estimates presented in the FES. In its concluding statement[86] the Staff pointed out that the CU data were based on "industrial experience" and included overtime and other exceptional factors and that CU had included backfitting experience[87,88] and optional redundant equipment. The Staff argued[86] that none of these items should be included in the cost of radwaste systems for cost-benefit analysis.

The Staff did include redundant components in costing the radwaste systems in the Draft Environmental Statement but, at least partly because of criticisms in comments on the draft, removed such redundancy "...which is not required for meeting ALAP or licensing requirements and therefore should not be included in costs for meeting dose reduction in cost-benefit analyses," from the systems evaluated in the FES.[89]

The Consolidated Utility Group took the position that redundant radwaste equipment is often necessary. They pointed out[90] that it is not the practice of utilities to install such systems without the provision of adequate redundancy for safe and reliable operation nor is it likely in actual practice that license conditions would permit them to do otherwise.

86/ Regulatory Staff, Concluding Statement of Position, Feb. 20, 1974, pp. 43-45.
87/ Tr., p. 3975.
88/ Tr., p. 3985.
89/ Regulatory Staff, Concluding Statement of Position, Feb. 20, 1974, pp. 44-45.
90/ Walton A. Rodger, Additional Testimony on Behalf of Consolidated Utility Group, Nov. 9, 1973, p. 49.

After consideration of the several differences between the Staff and the CU estimates, the Staff concluded[91/] that there were no significant unexplained differences with respect to cost estimates.

We believe after consideration of the record that the Staff's cost estimates for construction and operation of radwaste systems may be slightly low but that they are quite unlikely to be in error by factors of 3 or 4. It seems to us that to the extent - and only to the extent - that equipment redundancy is required by the licensing process the cost of such redundant items should be included in the total costing of the system. It seems equally clear that the additional costs, if any, due to increased attention to quality assurance should be included in the radwaste-system costs. It does not seem reasonable to include costs of overtime or other special features that may have in specific instances contributed to higher than normal costs of installation. On the other hand, the costs of operating the augmented equipment should be realistically estimated; such estimates should include reasonable allowances for maintenance of equipment and for the increased work force and payroll based, insofar as is possible, on actual experience as this experience exists or becomes available.

91/ Regulatory Staff, Concluding Statement of Position, Feb. 20, 1974, p. 45.

b. How Should Cost-Benefit Balances Be Calculated?

The costs of installation and operation of radwaste systems were, as indicated above, a matter of controversy; but an even more fundamental difference of opinion existed (primarily between the Regulatory Staff and CU) on the manner in which cost-benefit balancing was to be done.

The Regulatory Staff has, in effect, added for each effluent type the several radwaste augments as a unit to the base-case dual light-water-cooled nuclear power reactor system.[80/] From estimates of the cost of the radwaste augment package and of the resulting decrease in radiation exposure to the population, the Staff obtained a value in dollar cost per man-rem of the resulting reduction in population dose.

The major thrust of the CU argument against the Staff's cost-benefit balances concerned the practice of adding the several radwaste augments together as a unit to the base-case. As Walton Rodger stated for CU:[92/]

> "The thrust of the Testimony which we filed on November 9, 1973 was to break down into their component parts the cost-benefit analyses presented in the FES. The first purpose for doing this was to demonstrate that while some augments to the gaseous and liquid radwaste systems

92/ Tr., p. 3912; Walter A. Rodger, Summary of Additional Testimony dated Nov. 9, 1973, on Behalf of the Consolidated Utility Group, p. 1.

of PWR and BWR are justified on a cost-benefit basis, others are not. In fact many of the augments considered in the FES result in the expenditures of incredibly large numbers of dollars for every dollar of value returned. The "lumped" approach used in the FES cost-benefit analyses completely hides this fact."

In effect, Dr. Rodger used the Regulatory Staff's dose calculational models and the Staff's values for annual releases of radioactivity and annual costs for the radwaste augments and conducted the cost-benefit study by adding augments individually and sequentially to the liquid, the noble-gas, and the iodine and particulate radwaste systems.

We agree that by this technique of sequential addition of the most effective radwaste augments (so that in effect each addition constitutes with the other augments already present a new base-case to which the next augment is to be added), the cost-benefit evaluation can show the true worth of each individual augment -- that is, the decrease in total-body man-rem and in man-thyroid rem for which the augment is responsible. The cost-benefit calculations required by Appendix I should include assessment of the worth of each augment by this procedure.

c. Can the Monetary Value of Dose Reduction to the General Population Be Determined?

The Regulatory Staff agreed that it was desirable to express the cost-benefit balance in dollars on both sides of the equation,[93] but the Staff has been reluctant to assign a dollar value to the worth of reduction of radiation dose to the general population. The Staff took the position[94] that there is no agreement on monetary values for the reduction of risk to human life or suffering or on how such values should be applied. They reason that it is not possible to reflect properly the worth of reduction of risk to human life in monetary terms since there are overriding moral values that cannot be quantified.

The Staff cites in the record[95] the several published estimates of the monetary cost of radiation exposure of the public; these range from $10 to $980 per man-rem. No values have been suggested for dose to single organs, such as the thyroid. However, the relative risk of the dose to the thyroid compared to the total body might suggest a lower value for a man-thyroid-rem than for a man-rem.

On the other hand, the Staff holds that despite the inherent difficulties in the direct use of monetary values, it appears

93/ Final Environmental Statement, WASH-1258, July 1973, Vol. 1, p. 8-3.
94/ Ibid., pp. 8-2 and 8-3.
95/ Ibid., p. 83.

useful to express, to the extent practicable, both costs of reduction of risk and benefits to society from such reduction in monetary units as at least one of the factors to be considered in arriving at judgments on reducing risk to as low as practicable limits.

In both the FES[96] and its concluding statement,[97] the Staff does use in its estimates of radwaste-system cost and the resultant reduction in population dose, values for cost per man-rem reduction. They do not, however, accept or reject radwaste systems because of the cost of such reduction.

It is clear from the record[98] that the Staff would leave to us the decision as to dollar value of man-rem reduction in population dose and the extent to which such a value would be given weight along with other considerations in the ALAP ruling.

In contrast, the Consolidated Utility Group did choose[99-101] a value for the worth of a man-rem. For CU, Walton Rodger

96/ Final Environmental Statement, WASH-1258, July 1973, Vol. 1, p. 8-2.
97/ Regulatory Staff, Concluding Statement of Position.
98/ Tr., pp. 3472-73.
99/ Consolidated Utility Group, Exhibit 5, Walton A. Rodger, Additional Testimony on Behalf of the Consolidated Utility Group, Exhibit 9, 1973.
100/ Consolidated Utility Group, Exhibit 6, Summary of Additional Testimony dated Nov. 9, 1973, of Walton A. Rodger on Behalf of the Consolidated Utility Group, p. 2.
101/ Tr., pp. 3913-15.

stated[100/]

> "You may duck the issue all you want but in order to make a meaningful cost-benefit analysis you simply have to 'bite the bullet' and assign a value to a man-rem. We recognize that this isn't easily done, that there are great subjective factors involved, and that this is an area in which reasonable persons may reasonably disagree. Nonetheless, we chose a value. We chose $1000/man-rem (and 1/3 of that for a man-thryoid-rem). The FES quotes a number of estimates for this value ranging from $10 to $980 with most being in the range of $100 to $600. A very current new estimate is $250. We deliberately chose a value above the range quoted for two reasons:
>
> (1) to be conservative in our assessment of the value of augments,
>
> (2) to make allowance for 'overriding moral values' and other intangibles which are hard to quantify."

As the record makes clear[102,103/] these values of $1000 per total body man-rem and $333 per man-thyroid-rem represent no independent assessment. They were obtained by CU simply by taking a value somewhat higher than the range of values[95/]

102/ Tr., pp. 3944-45.
103/ Consolidated Utility Group, Statement of Position, Jan. 19, 1974, p. 31.

for the worth of a total-body man-rem suggested by the several studies cited, and the ratio of thyroid dose limits to total-body dose limits recommended by FRC and ICRP.

While generally accepting the cost-benefit analyses presented by CU, GE seems to have made no recommendations for the worth of a man-rem.

The State of Minnesota made no assignment or decision as to the worth of a man-rem.[104/] Minnesota has argued consistently that releases of radioactivity should be minimized but it has not tied this recommendation to the resultant dose effect nor has it made cost-benefit analyses in support of its recommendations.[104/] However, it seems clear from the record that the State of Minnesota would put a very high value on a man-rem.[105/]

We agree with the Regulatory Staff and with CU that there are great subjective factors to be considered in any judgment of the worth of reduction of a man-rem in dose to the general population. We are also well aware that a dollar figure for such worth is desirable -- and is the only missing value -- for the cost-benefit analysis that would provide a useful basis for decision concerning a portion of the guidance in Appendix I.

104/ Tr., pp. 1778-79.
105/ State of Minnesota, Final Statement of Position, Feb. 1, 1974, p. 14.

We are, however, of the view that the hearing record provides an insufficient basis for a decision as to the monetary worth for reduction in radiation dosage to the population.

The hearing record contains previously published estimates of worth of a total-body man-rem, but no comparable figures for worth of a man-thyroid-rem were presented. One of the participants[100/] selected a value of $1000 per total-body man-rem and arbitrarily set the worth of a man-thyroid-rem at one third of that value. The hearing record, accordingly, contains no evidence of its own regarding monetary values for either of these quantities.

We are mindful that Appendix I applies only to effluents from light-water-cooled nuclear power reactors and cannot -- based as it is on a record so limited -- be construed to apply to reactors of other types or to other facilities in the nuclear fuel cycle. But we are also mindful that the choice of a value for the monetary worth of a man-rem reduction in population dose to the general public cannot be reasonably claimed to apply to only a single class of nuclear facility. We are therefore convinced that this (properly) limited record cannot be used to establish appropriate general values for the monetary worth of a man-rem reduction in total-body or of a man-thyroid-rem organ dose to the population.

Sound and unambiguous values for the worth of these quantities (or some other essentially equivalent criteria) are clearly needed for ultimate quantification of the as low as practicable concept. Accordingly, we propose to initiate a further rule-making to ascertain the monetary worth of reduction in radiation doses to the population.[106/] When such better established values become available for adoption, we intend that they be used in the cost-benefit analyses required in this Appendix I.

Meanwhile, since the record cannot provide firm guidance as to worth of a total-body man-rem we believe it is the better course to accept, for the interim purpose specified hereinafter, the conservative value of $1000 for reduction of a man-rem in total-body dose to the population.

It can be argued that the worth of reducing the thyroid dose by a man-thyroid-rem is smaller. However, the record offers insufficient guidance upon this point. In this context we have accepted, as an interim measure, the value $1000 per man-thyroid-rem for purposes of the required cost-benefit balance.

106/ We are aware that the National Academy of Sciences - National Research Council Advisory Committee on Biological Effects of Ionizing Radiations is currently studying and developing methodologies for benefit-risk-cost analysis for activities involving radiation exposure. It is possible that information on monetary values for the worth of reduction of radiation dose, as well as useful methodology, may be provided by this study.

We emphasize that these are conservative outer limit figures and are accepted for use as such, as set forth below. It may well be that final values for the worth of these quantities will be smaller.

Consistent with the foregoing, as an interim measure and until more suitable values or other criteria can be established, we have decided that $1000 per total-body man-rem and $1000 per man-thyroid-rem -- or such lesser values as may be demonstrated by the applicant to be suitable in a particular case -- shall be used in the required cost-benefit balances.

6. Shall Exceptions to the Design-Objective Guides Be Allowed If Radwaste Systems Contain "Baseline In-Plant Control Measures"?

In its concluding statement the Regulatory Staff introduced the recommendation that exceptions to the design-objective guides for liquid effluents[107/] and for radioiodine and radioactive materials in particulate form[108/] be allowed if certain "baseline in-plant control measures" were included in the radwaste-systems design.

For liquid effluents the design-objective guides proposed by the Staff stated that[107/] the calculated annual total quantity of all radioactive material from all light-water-cooled nuclear

107/ Regulatory Staff, Concluding Statement of Position, Feb. 20, 1974, pp. 26-27.
108/ Ibid., pp. 29-30.

power reactors at a site should not result in an annual dose or dose commitment to the total body or to any organ of an individual in an unrestricted area from all pathways of exposure in excess of 5 millirems, and the calculated annual total quantity of radioactive material, except tritium and dissolved gases, should not exceed 5 curies for each light-water-cooled reactor at a site. However, if the applicant had proposed baseline in-plant control measures (of which several typical examples were listed), the calculated annual total quantity could be permitted to exceed the 5-curie limit for each light-water-cooled nuclear power reactor provided the design-objective guide for the dose limit was met.

The Staff has proposed no increase in its design-objective (per site) dose level even if the baseline in-plant control measures are included in the liquid-radwaste system. We believe that inclusion of such measures would certainly not justify an increase in the (per reactor) design-objective dose levels that we have adopted. Accordingly, since we have not included quantity limits in our design-objective guides,[109/] we include no provision for baseline in-plant control measures for liquid effluents in the Appendix I that we adopt.

109/ Section B4 of this chapter, above.

For emissions of radioactive iodine and radioactive material in particulate form, the Staff proposed that an exception to the design-objective dose be allowed if the baseline in-plant control measures were included in the radwaste-system design.[108] The Staff recommended that the (per site) annual dose limit from radioiodine and radioactive material in particulate form should not exceed 15 millirems to any organ of an off-site individual and that the calculated annual total quantity of iodine-131 in gaseous effluents should not exceed 1 curie for each reactor. If the applicant had proposed baseline in-plant control measures (of which several typical examples were listed), he could be permitted releases of radioiodine and radioactive material in particulate form in quantities that did not exceed four times the quantity that would yield the 15 millirem dose to any organ of an off-site individual.

Both GE and CU argued strongly against inclusion of such baseline in-plant control measures in Appendix I. They claimed that the baseline in-plant control measures approach is unwarranted since the ALAP record shows that most of the "measures" are unjustifiable on a cost-benefit basis,[110-113]

110/ General Electric, Reply, Mar. 14, 1974, pp. 22-23.
111/ Walton A. Rodger, Additional Testimony on Behalf of the Consolidated Utility Group, Nov. 9, 1973, pp. 1-38.
112/ Consolidated Utility Group, Statement of Position, Jan. 19, 1974, pp. 29-41.
113/ Consolidated Utility Group, Reply, Mar. 7, 1974, pp. 6-7.

that monitoring data at operating light-water-cooled nuclear power reactors show that most of these "measures" are unnecessary to meet the design objectives;[114,115] and that, should augmentation for building air ventilation releases be necessary, most of the suggested "measures" would be technically and economically inappropriate for reducing such emissions.[115]

In addition, GE argued[116] that, until the release of the Regulatory Staff's concluding statement, the guides of proposed Appendix I and the alternative provisions proposed by other parties to the proceeding had been drawn exclusively as performance standards. The suggested incorporation of equipment criteria represented a fundamental change in the underlying regulatory approach and would allow the Staff to prescribe specific effluent-treatment equipment--thereby intruding on the traditional role and responsibility of the applicants and their engineering consultants--without reference to the performance and cost-benefit status of the equipment prescribed.

We deem it the sounder course that the design-objective guides should be drawn as performance goals and should not, unless necessary for the protection of the public health and safety, incorporate requirements for specific equipment. Our assessment of the record does not support a conclusion that

114/ Regulatory Staff, Exhibit 24, Oct. 1973.
115/ General Electric, Exhibit 5, Nov. 9, 1973.
116/ General Electric, Reply, Mar. 14, 1974, p. 21.

installation of the baseline in-plant control measures -- and the consequent relaxation of the design-objective guides on doses to individuals -- is necessary or desirable for such protection of the public health and safety.

We note that CU has stated[117] that PWR's and BWR's using the assumptions in the FES and with the radwaste augments justifiable on a cost-benefit basis (and which we would require) would release about 0.6 and 0.3 curies per year of iodine-131, respectively. Such releases of iodine-131 from a typical reactor site would be expected to result in total doses of about 60 and 30 man-thyroid-rem to the population within 50 miles. Additional radwaste augmentation may well be required to limit the thyroid dose to specific individuals via the milk pathway where cows graze close to a site. However, we believe that, with the design-objective values of our adopted Appendix I, the near neighbor of the light-water-cooled nuclear power reactors will be adequately protected and that the baseline in-plant control measures would seldom, if ever, be necessary. Accordingly, we have not included provisions for such measures in the Appendix I that we adopt.

117/ Consolidated Utility Group, Reply, Mar. 7, 1974, pp. 12-13.

7. Shall Limits Upon Direct Gamma Radiation From Reactors and Associated Equipment Be Included?

The State of Minnesota took the position that Appendix I boundary-dose calculations should specifically include the contributions from direct gamma radiation from the reactor site (gamma shine).[118] Consolidated National Intervenors[119] also raised this point concerning radiation other than that from radioactive materials in effluents from light-water-cooled nuclear power reactors. An early position of the Environmental Protection Agency (EPA)[120] also included the suggestion that direct gamma radiation should be considered. The Environmental Protection Agency no longer holds this view; it states:[121] "We recognize that the scope of the present rulemaking is limited to material effluents, and that for this reason did not address the issue of direct and indirect gamma radiation from onsite locations. We suggest the Commission deal with this category of exposure through early issuance of limiting criteria for doses for such radiation."

The hearing record reveals that experience has shown the highest radiation dose rate at the site boundary to be generally less than 10 millirems per year from this source;

118/ State of Minnesota, Final Statement of Position, Chapter II-E, Part 3, Feb. 1, 1974.
119/ Anthony Roisman to Algie Wells, et al., Feb. 15, 1972, p. 6.
120/ Final Environmental Statement, WASH-1258, July 1973, Vol. 3, pp. 263-264.
121/ W. D. Rowe to L. Manning Muntzing, received Mar. 12, 1974, p. 3.

since the dose rate decreases rapidly to negligible levels with distance from the site boundary, this source contributes only a fraction of a man-rem per year to the population dose.[122/]

This hearing has been concerned from the beginning with keeping "as low as practicable" the risks to the public from radioactive materials in effluents from light-water-cooled power reactors. Moreover, as the Regulatory Staff testified,[123/] proposed Appendix I was not intended to include direct radiation from the nuclear facility.

We agree that such direct or scattered gamma radiation from the turbine building and from waste storage tanks and other equipment containing radioactive material should continue to be taken into account in the licensing process. Such gamma radiation should be carefully controlled by proper design and operation of the reactor and associated equipment. It may be appropriate to issue in due course further guidance on levels "as low as practicable" from this radiation source, but we believe that such guidance should clearly be separate from Appendix I.

8. Will Increased Occupational Exposure to Radiation Prejudice the Favorable Effect of Appendix I?

The Consolidated Utility Group (CU), the Atomic Industrial

122/ Regulatory Staff, Concluding Statement of Position, Feb. 20, 1974, p. 65.
123/ Tr., pp. 595-598.

Forum (AIF), and to a lesser extent the General Electric Company showed concern about the possible effect of proposed Appendix I on occupational exposure.

The AIF, in commenting on the Draft Environmental Statement,[124] deplored that statement's lack of consideration of potential increases in occupational radiological exposures with the implementation of proposed Appendix I and suggested that the additional holdup and storage of radioactive materials necessary could result in substantial increases in on-site exposures.

In its closing position statement,[125] CU concluded that there is a serious danger that the reduction in off-site doses sought through proposed Appendix I will be more than offset by an increase in occupational exposure.

In objecting to equipment required as a result of "farfetched assumptions," GE in its closing statement[126] stated that such equipment could, in fact, produce a net increase in the exposure of the human gene pool to radiation by increasing the doses to the employees of the light-water-reactor facility. These positions of CU and GE seem to be based to a substantial

124/ Final Environmental Statement, WASH-1258, July 1973, Vol. 3, p. 98.
125/ Consolidated Utility Group, Statement of Position, Docket RM-50.2, Jan. 19, 1974, p. 17.
126/ General Electric, Closing Statement, Docket RM-50-2, Jan. 21, 1974, p. 34.

extent on the testimony of Morton I. Goldman[127,128/] concerning likely increases in occupational exposure due to augments to radwaste systems and of the relative importance of such radiation exposure compared to radiation exposure to the population.

In assessing the probable impact of Appendix I on occupational exposure, the Regulatory Staff attempted an analysis of data equivalent to that presented by Dr. Goldman. They found that no conclusions were warranted on the basis of the data and that a more detailed evaluation was necessary. The Staff proceeded to study occupational exposure by visiting 11 selected operating nuclear power plants, reviewing exposure records, and holding discussions with utility personnel.[129/] This study suggested that augmentation of the radwaste-treatment systems to meet the objectives of proposed Appendix I might be expected to increase occupational exposure by about 7%. The observation that little if any of the increase in exposure would be unavoidable seems of even more significance. The general conclusion of the Regulatory Staff is that "implementation of Appendix I need not significantly increase

127/ Morton I. Goldman, Additional Testimony on Behalf of the Consolidated Utility Group (Part 1), Occupational Exposure, Docket RM-50-2.
128/ Tr., pp. 3605-14 and 3999-4048.
129/ Charles A. Willis, A Study of the Occupational Radiation Exposure Due to Radwaste Treatment Systems at Nuclear Power Plants, Docket RM-50-2, Exhibit 23.

occupational exposure".[130] This conclusion seems not to be challenged in the replies by CU[131] and GE[132] to the concluding statement of position of the Regulatory Staff.

We continue to be concerned about the level of occupational exposure in nuclear power plants, and steps are being taken to reduce the occupational exposures to levels that are "as low as practicable." Regulatory Guide 8.8, issued in July 1973, details the occupational-exposure control information that should be provided in license applications. This information is now being reviewed in the licensing process, and applicants are being asked to improve plans, procedures, and designs where appropriate to reduce exposure. The SAR Standard Format document has been revised to increase emphasis on occuptional-exposure control. Thus, the importtance of keeping occupational exposure "as low as practicable" is recognized, and progress is being made toward that objective. We believe that with proper attention to this point, increases in occupational exposures resulting from implementation of Appendix I can be made small if not negligible.

130/ Regulatory Staff, Concluding Statement of Position, Docket RM-50-2, Feb. 20, 1974, p. 64.
131/ Consolidated Utility Group, Reply, Mar. 7, 1974.
132/ General Electric, Reply, Mar. 14, 1974.

CHAPTER IV

GUIDES ON TECHNICAL SPECIFICATIONS FOR LIMITING CONDITIONS FOR OPERATION

Section 50.36a(b) of 10 CFR Part 50 provides that licensees shall be guided by certain considerations in establishing and implementing operating procedures specified in technical specifications which take into account the need for operating flexibility and at the same time ensure that the licensee will exert his best efforts to keep levels of radioactive materials in effluents as low as practicable. The Appendix I that we adopt provides more specific guidance to licensees in this respect.

A. The Rule

Section IV of Appendix I specifies action levels for the licensee. If, for any individual light-water-cooled nuclear power reactor, the quantity of radioactive material actually released in effluents to unrestricted areas during any calendar quarter is such as to cause radiation exposure, calculated on the same basis as the design-objective exposure, which would exceed one-half the annual design-objective exposure, the licensee shall make an investigation to identify the causes of these high release rates, define and initiate a program of action to correct the situation, and report these actions to the Commission within 30 days of the end

of the calendar quarter. On the basis of reports required by section 50.36a (2) and Appendix I and any additional information that the Commission may obtain from the licensee and others, the Commission may from time to time require the licensee to take such action as the Commission deems appropriate in the public interest.

These provisions will, we believe, ensure the necessary operating flexibility for light-water-cooled nuclear power reactors and at the same time ensure that radiation exposures to any individual in an unrestricted area will be at the most a small fraction of exposures permitted by present radiation protection standards.

The licensee is also required (1) to conduct an appropriate surveillance and monitoring program to provide data on quantities of radioactive materials released in liquid and gaseous effluents to ensure that the provisions of this Appendix I are met, (2) to provide data on measurable levels of radiation and radioactive materials in the environment so that the relationship between quantities of radioactive materials released and radiation dosages to individuals can be evaluated, and (3) to identify changes in the use of unrestricted areas so that monitoring programs for evaluating the doses to individuals from principal pathways of exposure can be modified.

It is further provided that, if the data developed in the surveillance and monitoring program described above show the relationship between quantities of radioactive materials released in effluents and the dose to individuals in unrestricted areas is significantly different from that assumed in the calculations used to determine design-objective limits, the Commission may modify the quantities in the technical specifications defining the limiting conditions for operation in the license that authorizes operation of the light-water-cooled nuclear power reactor. If radioactive-iodine design objectives are determined on the basis of conditions existing at the time the reactor is licensed without regard to future land use, an augmented surveillance and monitoring program may be required.

B. Discussion of Section IV of Appendix I

1. Action Levels and Licensee and Commission Action

We expect that the annual releases of radioactive materials in effluents from light-water-cooled nuclear power reactors can generally be maintained within the levels set forth as numerical guides for design objectives. It is certainly expected that the licensee will, under all circumstances, exert his best efforts to keep levels of radioactive materials in effluents from light-water-cooled nuclear power reactors within the design-objective

guides. At the same time the licensee should, in our opinion, be permitted some flexibility of operation, consistent with sound considerations of public health and safety, to ensure that the public is provided with a dependable source of power even under unusual conditions of operation that may temporarily lead to releases of radioactive materials higher than those specified as the design-objective guides.

The Regulatory Staff has consistently argued[1,2] that operating flexibility is necessary, especially in view of the very low release levels inherent in the Staff's versions of Appendix I. As the record shows, there is some disagreement as to the need for such operating flexibility and a diversity of opinion on the formulation of guidelines in this regard.

The Consolidated Utility Group has argued,[3] "the degree of operating flexibility provided in [the originally] proposed Appendix I is too restrictive and may threaten power system reliability." Similar arguments were presented by the Atomic Industrial Forum,[4] the Gulf General Atomic Company,[5] the Bechtel Power Corporation,[6] Ebasco Services,[7] and the American

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1/ Regulatory Staff, Exhibit 1, Tab. 1.
2/ Regulatory Staff, Concluding Statement of Position, pp. 32 and 68-70.
3/ Consolidated Utility Group, Statement of Position, p. 16.
4/ Tr., p. 86; Merril Eisenbud, Statement, p. 6.
5/ Final Environmental Statement, p. 61.
6/ Final Environmental Statement, pp. 91-92.
7/ Tr., pp. 109-116.

Electric Power Service Corporation.[8] On the other hand, Consolidated National Intervenors contended that no provisions for operating flexibility were necessary or desirable.[9] Moreover, the State of Minnesota in its final statement[10] argued that there has been no showing by the utilities of a need for operating flexibility, that such provisions for operating flexibility should be deleted, and that the numerical guides for design objectives should be treated as maximum limits never to be exceeded. Nevertheless, Minnesota recommended guidelines for limiting conditions for operation.

The evidence shows that there will be variations in the performance of fuel elements and radwaste equipment, that these variations may, on a transient basis, result in levels of radioactivity in effluents which exceed the design-objective guide values, and that operational flexibility, within the very low ranges of release rates involved, is necessary if nuclear reactors are to have adequate reliability as a source of power. The arguments to the contrary are not supported in evidence. Arguments of the several parties that the limiting conditions for operation would be

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[8] Letter from Robert S. Hunter to Secretary, U. S. Atomic Energy Commission, Feb. 22, 1972.

[9] Anthony Roisman to Algie A. Wells et al., Feb. 15, 1972.

[10] State of Minnesota, Final Statement of Position, pp. 4-5.

too restrictive were specifically directed to the guidelines originally proposed. In our judgment the guidelines we have adopted are necessary and reasonable.

We have decided to omit the proposed level for initiating Commission action, since the Commission is already free to act and a numerical guide at this point might suggest that the Commission would be inattentive to releases of smaller magnitude.

2. Surveillance and Measurements in Operating Plants

Experience with operating light-water-cooled nuclear power reactors and with measuring effluents from these plants was recognized by the Commission as one of the substantial bases on which the as low as practicable provisions of 10 CFR Part 50 were proposed and adopted in 1970.[11/] The quantitative data that can be acquired in the future through programs of measurement and surveillance in the plant as well as in the environment have been noted by several participants as being of special importance in implementing the "as low as practicable" policy and Appendix I.

Quantitative measurement of radioactive materials released in effluents has always been required of persons licensed to

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11/ 35 F.R. 5414 and 18387.

operate nuclear power plants. Indeed, the amendments to Part 50, published December 3, 1970, require that all such licensees periodically report to the Commission "the quantity of each of the principal radionuclides released to unrestricted areas in liquid and in gaseous effluents...and such other information as may be required by the Commission to estimate maximum potential annual radiation doses to the public resulting from effluent releases."[12/] It is clear that information derived from actual observation and measurement of environmental factors should be an essential part of the data supplied to the Commission pursuant to paragraph 50.36a(a)(2) cited above.

From the standpoint of ensuring control during reactor operation, measurement of effluents and exposures at the low levels proposed in the hearing record are difficult. Edward P. Radford, testifying for the Consolidated National Intervenors, would prefer higher design-objective doses if that were necessary to make measurement of human dose practicable.[13/] This preference for measured confirmation of estimates was shared by other participants. As discussed in Chapter V, the incentives for improving calculational models, which

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12/ 10 CFR 50.36a(a)(2).

13/ Edward P. Radford, Testimony on Behalf of National Intervenors: National Intervenors, Exhibit 3, p. 3; Tr., p. 2072; and Tr., p. 2077.

must necessarily be used in establishing design objectives for each reactor, are strong.[14] Measurements at operating reactors are a means for making improvements.[15] We are in sympathy with those who cite the virtues of designing and operating effluent-control systems with the enlightenment of real experience rather than with arbitrarily conservative calculational models. Measured levels of environmental radioactivity are generally small in comparison with values calculated from known or presumed release rates.[16]

Deviations of measured from calculated doses are not altogether a result of deficient calculational methods. Measurements of environmental exposures and quantities of radioactive materials in the environs are complicated by the very low concentrations encountered, compared to background, and by the fact that a multitude of factors, many varying in time and space, affect the concentration. Thus the correlation of the best of measurements with the best of calculations is tedious and difficult.[17]

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[14] General Electric, Closing Statement, p. 5; Consolidated Utility Group, Statement of Position, pp. 13-14, item 7.

[15] Regulatory Staff, Concluding Statement, p. 16; Lester Rogers, Testimony for the Regulatory Staff, Tr., p. 3409.

[16] Consolidated Utility Group, Statement of Position, p. 36; General Electric, Reply, pp. 16-18.

[17] See the discussion of the iodine pathway study in the Final Environmental Statement, Regulatory Staff, Exhibit 21, Vol. 1, pp. 9-16 to 9-21; Regulatory Staff, Exhibit 24; and discussion of this study at Tr., pp. 3522-84.

We are not in the position of being able to avoid calculational procedures in implementing the design-objective guidelines of Appendix I or to depend completely on monitoring, measurement, and environmental surveillance to indicate compliance of operating plants. Programs of measurement and surveillance entail cost to the utilities;[18] however, we are assured that surveillance and monitoring are feasible for the more sensitive pathways to radiation exposure.[19] Studies involving environmental measurements are not likely to be of practical value in relating emissions to dosage except in cases of those specific radionuclides and exposure pathways which make major contribution to design objectives;[20] accordingly, licensees should be expected to make environmental studies only of the sensitive pathways.

The pathway of greatest concern is the radioiodine course from air to grass to cow to milk to child. The Commission and the Environmental Protection Agency made a study of this pathway, including a program of independent measurements in the vicinity of three operating light-water-cooled nuclear power plants.[21] This study and further evidence in the

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[18] James M. Smith, Testimony for General Electric, Exhibit 7, pp. 12-21, and Regulatory Staff, Exhibit 26.

[19] General Electric, Closing Statement, p. 41; James M. Smith, Testimony for General Electric; General Electric, Exhibit 7.

[20] National Intervenors, Exhibit 3 (Dr. Radford), pp. 2-3.

[21] Final Environmental Statement, Regulatory Staff, Exhibit 21, Vol. 1, pp. 9-16 to 9-21; Regulatory Staff, Exhibit 24; Tr., pp. 3522-84.

record show the practicability of making useful measurements pertaining to the radioiodine pathway in situations in which radioiodine releases are substantial.[22/] We have required, by Appendix I, special surveillance measures for such situations and have adopted an implementation policy that should encourage applicants to use the best data available in any case.

22/ See for example Regulatory Staff, Exhibit 26.

CHAPTER V

IMPLEMENTATION

Two aspects regarding the implementation of Appendix I were considered in the hearing. The manner in which the new rule is applied to existing reactors and to other reactors in various stages of licensing is one problem. This matter, including the question of backfitting, is covered below under the heading "Applicability." The other sense in which implementation was considered concerns the guidance given by the Commission to the Regulatory Staff and to applicants in applying the numerical guidelines to the design objectives of a specific reactor. This is discussed under the heading "Numerical Guidelines." Appendix I incorporates these two matters in Section V, Effective [illegible] and Section III, Implementation, respectively.

A. Applicability

1. The Rule

The guides for limiting conditions for operation set forth in Appendix I shall be applicable in any case in which an application was filed on or after January 2, 1971, for a permit to construct a light-water-cooled nuclear power reactor.

For each light-water-cooled nuclear power reactor constructed pursuant to a permit for which application was filed prior to January 2, 1971, the holder of the permit or a license authorizing operation of the reactor shall, within a period of twelve months from June 4, 1975, file with the Commission:

(1) such information as is necessary to evaluate the means employed for keeping levels of radioactivity in effluents to unrestricted areas as low as practicable, including all such information as is required by section 50.34a not already contained in his application; and

(2) plans and proposed technical specifications developed for the purpose of keeping releases of radioactive materials to unrestricted areas during normal reactor operations, including expected operational occurrences, as low as practicable.

2. Discussion of Applicability

The "as low as practicable" amendments to 10 CFR Part 50 published on December 3, 1970, (sections 50.34a and 50.36a) instituted new requirements for:

(a) information contained in applications for permits to construct nuclear power reactors;

(b) information contained in applications for licenses to operate such reactors; and

(c) particular technical specifications to be included in each operating license with respect to operating procedures and reports to the Commission.

These amendments contained no guidance concerning the manner in which the additional information in applications would be considered nor criteria for acceptance of a proposal. Considerations by which licensees would be guided in establishing and implementing operating procedures to be included in technical specifications were included in the amendments.

The requirement that applications for construction permits identify design objectives and the means to be employed for keeping levels of radioactive material in effluents to unrestricted areas "as low as practicable" applies, according to those amendments, to cases in which applications are filed on or after January 2, 1971. Other provisions of the amendments became effective on January 2, 1971.

Neither the language of section 50.34a nor the accompanying statements of consideration required that persons who already held licenses to operate nuclear power reactors conform to the specific provisions of section 50.34a -- i.e.,

to submit "design-objectives" for already-constructed facilities. In its original statement of considerations, the Commission stated:[1/]

> "The Commission believes that, in general, the releases of radioactivity in effluents from light-water-cooled power reactors now in operation have been within ranges that may be considered 'as low as practicable'."

Rather, the formal imposition of the "as low as practicable" requirement on all categories of licensees and applicants was achieved through the combined application of sections 20.1(c), 50.34a and 50.36a. Furthermore, while section 50.36a does not explicitly exclude preexisting licensees from its sphere of applicability, the specific requirements of this section all refer to certain actions that are required of applicants or licensees only under section 50.34a. One of these is the identification of design objectives, an action which would be untimely for a licensee whose plant is already operating and for which no further modification is planned. It is desirable to provide clear guidance in Appendix I on the procedures by which persons who hold permits to construct or licenses to operate light-water-cooled nuclear power reactors, may comply with the "as low as practicable" requirement.

1/ 35 Fed. Reg. 5414.

It should be noted that all licensees who may not otherwise be required to establish design objectives relative to radioactive materials in effluents must establish equivalent objectives with respect to quantities of radioactive material released in effluents in order to comply with section 50.36a(a)(2).

Appendix I as now adopted contains two types of guidance pertaining to the amendments cited above. The first is concerned with determination of "design objectives" and "means to be employed" that would be acceptable to the Commission.[2/] The other is concerned with "limiting conditions for operation" to be included in technical specifications.[3/] The manner and timing for applying the additional guidelines of Appendix I to various cases are matters that stimulated considerable debate in the hearing.

The essence of the Regulatory Staff's position is:[4/]

> "...that the limiting conditions for operation described in Section IV of Appendix I be applicable

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2/ 10 CFR 50.34a(a).

3/ 10 CFR 50.36(c) (2) and 50.36a.

4/ Regulatory Staff, Concluding Statement, pp. 73-74.

upon publication to technical specifications included in any license authorizing operation of a light-water-cooled nuclear power reactor constructed pursuant to a construction permit for which application was filed on or after January 2, 1971. For all other operating licenses, technical specifications in conformity with the guides in Section IV should be developed within 24 months from the effective date of Appendix I and included in any license authorizing operation of a light-water-cooled nuclear power reactor. The amendments to Part 50, sections 50.34a and 50.36a requiring that levels of radioactivity in effluents from light-water-cooled nuclear power reactors [be kept as low as practicable] have been in effect for more than three years and substantial progress has been made by licensees in augmenting radwaste systems. It is the staff's view that 24 months is a reasonable period of time to complete modifications that may be required to meet the Appendix I limiting conditions of operation to be included in technical specifications of operating licenses."

General Electric, in its reply to this Staff proposal, commented only on the merits of backfitting, that is augmenting of plants already constructed or in operation with additional control equipment.[5/] They argued that the facts require that the numerical guides of Appendix I, if they are to be consistent

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[5/] General Electric, Reply, pp. 34-35.

with the basic standard, must make special allowance for currently operating plants and that guides and limits that are "as low as practicable" for plants that still exist only on paper must necessarily be lower than "practicable" for plants that can install augmented effluent-treatment systems only on a more costly backfit basis. The Consolidated Utility Group also favored a case-by-case consideration of backfitting.[6/]

Although the backfitting issue arose over the part of proposed Appendix I that dealt only with "limiting conditions for operation," it is clear that the implication of this part of Appendix I would have been that persons holding licenses for light-water-cooled nuclear power plants now in operation would have been required to comply with the design-objective provisions as well, even if such compliance involved backfitting.[7/] We note that the record shows that some such licensees had already undertaken steps, including backfitting, to comply with proposed Appendix I, even though it was not an effective part of the Commission's regulations.[8/] The Regulatory Staff agreed, however, that backfitting should be considered on a case-by-case basis.[9/]

6/ Consolidated Utilities, Reply, p. 25.

7/ Lester Rogers, Testimony for the Regulatory Staff, Tr., pp. 340-341.

8/ Tr., p. 4147.

9/ Lester Rogers, Testimony, Tr., pp. 3591-92.

The record clearly shows that the costs of augmenting an existing plant would generally be substantially greater than the cost of installing similar control equipment in a plant that is still being designed.[10,11] Furthermore, the information on the quantities of radioactive material in effluents of these plants indicates no need for any precipitous action that would be applicable to all existing plants alike.[12] These two factors lead us to conclude that the licenses for existing plants should be considered case-by-case. As noted elsewhere in this opinion, the design-objective guidelines of Appendix I do not preclude an applicant from prosecuting his case on the fundamental definition of the term "as low as practicable" in 10 CFR sections 20.1(c) and 50.34a(a). Under the terms of Appendix I as presently adopted, a person holding a license to operate an existing plant has no less right to follow such a course. Hence, it is unnecessary and would be redundant to include any statement for this special case specifically permitting a case-by-case evaluation. Likewise, we consider it superfluous to state, in the detail suggested by General Electric,[13] the methods that would be permissible

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10/ Final Environmental Statement, Vol. 1, pp. 3-4 and 3-5.

11/ Regulatory Staff, Exhibit 25, pp. 4 and 10.

12/ Regulatory Staff, Exhibit 27.

13/ General Electric, Closing Statement, pp. 54-56.

as bases for establishing design objectives. We agree that it would be preferable to base evaluations of design objectives on actual operating experience with the reactor in question in cases where substantial relevant information has been accumulated during plant operations.

The scheduling of compliance with section 50.36a in the light of the new guidance of Appendix I is a further matter for which varying resolutions were proposed. All parties considering this point in concluding statements agreed that guidelines with respect to both design objectives and limiting conditions for operation should be applicable, as soon as effective, to all cases for which an application for a construction permit was filed on or after January 2, 1971. For all other cases, the Regulatory Staff originally proposed a 36-month period for compliance and finally proposed a 24-month period.[14,15/] General Electric proposed that 36 months be allowed for compliance;[16/] while the Consolidated Utility Group would set no deadline except for a 12-month period within which holders of permits or licensees would have to file plans with the Commission.[17/]

[14/] 36 FR 11113.

[15/] Regulatory Staff, Concluding Statement, p. 35.

[16/] General Electric, Closing Statement, pp. 54-57.

[17/] Consolidated Utility Group, Statement of Position, pp. A7-A8.

In view of the facts already noted, namely, that there is no hazard presently and generally being imposed by plants that were not licensed in accordance with the specific guidelines of Appendix I, we have concluded that it is reasonable to allow 12 months for development and submission of plans for Commission approval. In arriving at this time allowance, we have little factual evidence from any party as to the time actually needed. The information in the Regulatory Staff's concluding statement on the actions of licensees to comply with "the staff's interim licensing design objectives and guidelines" would have been of little value for this purpose, even if it had been undisputed or a part of the evidentiary record.[18/] We believe, however, that with official notice being taken of the times actually elapsed from dates of application to dates of issuance of permits and licenses the period allowed for compliance is adequate.

B. Implementation of Numerical Guidelines

1. The Rule

We have decided that Appendix I should explicitly include Commission guidance to the Regulatory Staff and to other

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18/ Regulatory Staff, Concluding Statement, p. 73 and Annex.

interested persons with respect to the use of conservative or realistic calculational procedures in the application of the numerical guides for design objectives. Accordingly, Section III of Appendix I states that compliance with the guides on design objectives shall be demonstrated by calculational procedures based on models and data such that the actual exposure of an individual through appropriate pathways is unlikely to be substantially underestimated, all uncertainties being considered together. Account shall be taken of the cumulative effect of all sources and pathways within the plant contributing to the particular type of effluent being considered. For determination of design objectives in accordance with the guides of Section II of Appendix I, the estimation of exposure shall be made with respect to such potential land and water use and food pathways as could actually exist during the term of plant operation, provided that, if special surveillance measures are carried out, the requirements of paragraph C of Section II with respect to radioactive iodine may be made on the basis of such food pathways and individual receptors as actually exist at the time the plant is licensed. The characteristics attributed to a hypothetical receptor for the purpose of estimating internal dose commitment shall take into account reasonable deviations of individual

habits from the average. The applicant may take account of any real phenomena or factors actually affecting the estimate of radiation exposure, including the characteristics of the plant, modes of discharge of radioactive materials, physical processes tending to attenuate the quantity of radioactive material to which an individual would be exposed, and the effects of averaging exposures over times during which determining factors may fluctuate.

If the applicant determines design objectives with respect to radioactive iodine on the basis of existing conditions and if potential changes in land and water use and food pathways could result in exposures in excess of the guide-line values of paragraph C of Section II, the applicant shall provide reasonable assurance that a monitoring and surveillance program will be performed to determine:

(a) the quantities of radioactive iodine actually released to the atmosphere and deposited relative to those estimated in the determination of design objectives;

(b) whether changes in land and water use and food pathways which would result in individual exposures greater than originally estimated have occurred; and

(c) the content of radioactive iodine in foods involved in the changes, if and when they occur.

2. Discussion

The numerical guidelines of Appendix I, when applied in accordance with the conditions specified therein, are a quantitative expression of the meaning of the requirements that radioactive material in effluents released to unrestricted areas from light-water-cooled nuclear power reactors be kept as low as practicable. These guidelines, particularly with respect to design objectives, are expressed as specific numerical limits for three types of effluents. The numerical aspects of this translation of the basic rule of section 50.34a, standing alone, are clearly a compromise of the rule in the sense that a quantitative level that might be precisely as low as practicable in one case would not necessarily be so in another. The numerical guidelines were chosen on the basis that the record shows these limits to be practicably achievable for almost all cases to which we consider them applicable. Furthermore, in view of the elements of conservatism and realism inherent in the evaluations presented in the hearing, we believe the record supports the conclusion that the maximum individual exposure likely to ensue from operation of nuclear power reactors in conformance with Appendix I is sufficiently small that no

additional expense could be justified for reducing the exposure of an individual further than required by Appendix I.

It must be understood in discussing the matters of calculational conservatism and realism that Appendix I means, implicitly, that any facility that conforms to the numerical and other conditions thereof is acceptable without further question with respect to section 50.34a. It is just as essential that Appendix I be understood as not implying, conversely, that any facility not conforming is necessarily unacceptable. The numerical guidelines are, in this sense, a conservative set of requirements and are indeed based upon conservative evaluations.

The numerical guideline values were adopted in the light of numerous evaluations of typical nuclear plants at various types of sites. These evaluations, presented by various parties, were based on calculations of radiation doses which generally could be understood as estimates of the level of exposure of individuals in the general public from hypothetical releases of radioactive material. Similar estimates will have to be made on a case-by-case basis by applicants for licenses for light-water-cooled nuclear power reactors in order to establish appropriate

design objectives. Thus the use of calculational procedures based at least partially upon hypotheses is unavoidable.

It is evident from the record that numerical estimates of radiation exposure may vary widely, depending upon the particular assumptions made. These assumptions involve the selection of appropriate mathematical expressions of natural phenomena, including the assignment of numerical values to the parameters contained in the expressions. Inasmuch as results of calculations can vary widely, an issue has been raised by some participants as to how the numerical guidelines can be implemented in consonance with the process of their adoption. The necessity and importance of adequate attention to numerical calculational procedures was aptly expressed by Hearing Board member Walter H. Jordan:[19] "[t]he interpretation of Appendix I is almost going to be as important a factor in what is practicable as the regulation itself."

Some parties severely criticized the conservatism of the Regulatory Staff and proposed that Appendix I include guidance on implementation in order to ensure that applicants have the opportunity to use reasonably realistic assumptions

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19/ Tr., pp. 2547-48.

in their procedures for estimating radiation exposure.[20-22] The necessity of explicit guidance is suggested in the argument that the procedures used by the Regulatory Staff for calculating doses show a predisposition to make unnecessarily conservative assumptions. The draft Regulatory Guides circulated by the Directorate of Regulatory Standards with the Staff's concluding statement reflect a tendency toward the use of unnecessarily conservative calculational assumptions. The calculational methods described in the Final Environmental Statement and in draft Regulatory Guides are opposed in some particulars;[23] furthermore it was also argued that the Staff has, in the course of reactor licensing actions, generally been quite conservative in its quantitative assessment of effluent controls.

Particular areas of controversy shifted as the hearing progressed.[24] It was not clear to participants whether or not models and assumptions used in the Final Environmental Statement were also intended by the Regulatory Staff

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[20] General Electric, Closing Statement, pp. 26-45, Reply, p. 10.

[21] Consolidated Utility Group, Statement of Position, pp. 13-14, 71, and A-4.

[22] Andrew P. Hull, Final Statement of Position, p. 4.

[23] Closing Statement of General Electric and Statement of Position by Consolidated Utility Group referenced above; see also Testimony in General Electric, Exhibits 6 and 7 and the Oral Argument, Tr., pp. 110-127.

[24] Consolidated Utility Group, Statement of Position, p. 44.

to be applicable to the analysis of individual applications for licenses in the implementation of Appendix I. Examples of allegedly unnecessarily conservative implementation methods, as they have been used in current licensing, include: excessive source-term assumptions with regard to radioiodine emissions; neglect, with regard to such emissions, of their chemical form, actual release points and modes, and expected plume behavior; overestimation of deposition rates and retention factors for radioiodine on forages; and postulation of nonexistent dairy cows and unrealistic milk-consumption patterns.[25/]

Following the filing of the Regulatory Staff's concluding statement, General Electric noted what it believed to be important improvements in the Staff's proposed Appendix I, including some dealing with calculational models; but GE further noted that the Staff's proposed Appendix I still failed to specify whether the calculational assumptions and models to be used in implementation are to be established on a "conservative" basis or, as GE urged, on the basis of best-estimates of the relevant physical phenomena.[26/]

The Staff argued neither for nor against including guidance on calculational assumptions in Appendix I, although in

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25/ General Electric, Closing Statement, p. 5.

26/ General Electric, Reply, pp. 2-3.

testimony the Staff's principal witness conceded that particularly critical points had been raised in the hearing with respect to implementation and that at the time of issuance of Appendix I some specific understanding should be attained.[27/]

We believe the evidence at hand supports the decision that Appendix I should include Commission guidance respecting the use of conservative or realistic calculational procedures in the application of the numerical guides for design objectives. We summarize below the matters involved in reaching this conclusion and in applying the guidelines in accordance with Commission intent.

Calculational procedures used in the application of Appendix I for making the numerical estimates of radiation doses have been variously called by such terms as "calculational assumptions and models," "models and input data," "assumptions and models," or simply "models." Such procedures require the skillful use of mathematical expressions characterizing natural phenomena. It is evident that such expressions are generally expected to yield quantitative results that are, at best, approximations to reality. Some models are capable of providing estimates more relevant to real situations than are models which are conceived to describe an idealized case.

27/ Lester Rogers, Testimony, Tr., p. 3412.

Simpler models, for example, ones that would lack facilities for taking into account differences in plant design, would not be expected to produce estimates as close to reality for a wide variety of designs as would more complex models.

Calculational procedures used for dose estimations in essence describe, albeit approximately:

(a) sources of radioactive materials and the pathways inside a plant by which such materials are released;

(b) the natural processes by which released material is transported through the environs; and

(c) the model receptor, i.e., a real or hypothetical individual ultimately exposed to radiation.

The selection of specific models for each of these three portions of the procedure involves two types of determinations. First, one must select models and data that represent the situation deemed to be important. For example, the choice of a hypothetical receptor rather than an existing individual might reflect, in part, the intent to use the guidelines as a mechanism to provide for future changes in occupancy of areas near the site. The Regulatory Staff properly identifies this as a means of expressing regulatory intent.[28/] Second, models and data must be found which represent the physical phenomena involved with some useful

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28/ Regulatory Staff, Closing Statement, p. 52.

precision. Conflicting views have been advanced, in evidence and in argument, on all portions of the calculational procedures and for both types of selections.[29-33]

It was observed by both General Electric and the Consolidated Utility Group that considerable progress toward agreement on models was made in the course of the hearing, although the intent of the Regulatory Staff in future implementation of the numerical guidelines on a case-by-case basis remained in doubt after the Staff's concluding statement was filed.[34] We believe we have developed a suitable resolution of the differences for all practical purposes. Our resolution strongly favors the suggestions that calculational methods be realistic, which in turn has influenced our adoption of particular numerical guideline values for dose objectives. This resolution, thus, has been a strong factor in our reconciliation of the differences among parties as to those values for, as one party stated:[35] "The evidence is clear

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29/ General Electric, Closing Statement, pp. 26-45.
30/ Ned R. Horton, Testimony, General Electric, Exhibit 6.
31/ James M. Smith, Testimony, General Electric, Exhibit 7.
32/ Oral Argument, Tr., pp. 110-127.
33/ Consolidated Utility Group, Statement of Position, pp. 13-14 and 71.
34/ General Electric, Reply, p. 2.
35/ General Electric, Reply, p. 24.

that, realistically applied, the dose objectives now presented in [the Staff's proposed] Revised Appendix I can be met without reliance on exceptions or special provisions...."

The essence of our conclusions on how calculational procedures should be used in determining design objectives is given in the five following points.

(1) *An applicant should be free to use as realistic a model for characterizing natural phenomena, including plant performance, as he considers useful. An applicant may take into account situations not adequately characterized by such standardized models as may be available with respect to specific features of plant design, proposed modes of plant operation, or local natural environmental features which are not likely to change significantly during the term of plant operation.*

General Electric noted several effects that should be recognized,[36] and we restate some of them here to illustrate natural phenomena that might be partially or entirely neglected in standard models but could be properly considered:

(a) radioisotopic composition of effluents;

(b) radioactive decay of released nuclides prior to exposure of the receptor;

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[36] General Electric, Concluding Statement, pp. 28-32.

(c) waterway flow and the associated diffusion and dilution;

(d) removal of radioactive material from solution or suspension in the water by sedimentation or other naturally occurring mechanisms or by water-treatment processes;

(e) exposure modes and occupancy or use factors;

(f) release conditions (to the atmosphere) including elevation of release point, effluent stream buoyancy and momentum, and building geometry;

(g) local meteorological and aerodynamic conditions influencing airborne effluent plume dispersion;

(h) beta and gamma radiation energies for the radioisotopes released and the associated dose effects;

(i) chemical form and physical behavior of the effluent constituents;

(j) plume elevation, size, and depletion;

(k) shielding effects;

(l) partitioning, filtration, and other retention and depletion effects;

(m) deposition rates and velocities for the various chemical forms of released radioiodine on offsite vegetation, ground, and other surfaces, with

appropriate apportionment to the vegetation of its capture fraction; and

(n) weathering and other loss factors for radioiodine on grass and other vegetation.

Clearly other natural phenomena must also be adequately taken into account in models used for determining design objectives, but these are sufficiently established in practice that they need not be repeated here.

Although both General Electric and the Consolidated Utility Group asserted that the Regulatory Staff's intentions are uncertain, Staff testimony clearly shows that case-by-case consideration of realistic models different from standard models is an acceptable practice.[37/] In their concluding statement the Staff quoted from the statement published with each Regulatory Guide:[38/]

> "Regulatory Guides are not substitutes for regulations and compliance with them is not required. Methods and solutions different from those set out in the guides will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a permit or license by the Commission."

37/ Lester Rogers, Testimony, Tr., pp. 3391, 3411; Peter O. Strom, Tr., p. 3447; Earl H. Markee, Tr., p. 3380.

38/ Regulatory Staff, Concluding Statement, p. 83.

The models last proposed by the Regulatory Staff[39] are different from the highly criticized versions used in the evaluations presented in the Final Environmental Statement.[40] Testimony of the Staff indicates that the models used by the Staff and described in Regulatory Guides will continue to change.[41] We believe Regulatory Guides to be useful; however, Regulatory Guide models should not be applied as a norm to be abandoned at the peril of the applicant. We believe the testimony of Staff witnesses in this hearing might, by some reasonable persons, indeed be construed as indicating that the Staff has been excessively zealous in applying Regulatory Guide models. We particularly expect all parties to licensing actions to which Appendix I applies to note both the potential utility of Regulatory Guides and their subordinate status relative to Commission regulations and opinions.

(2) *Where selection of data is strictly a matter of interpreting experimental evidence, both the applicant and the Regulatory Staff should use prudent scientific expertise to select those values which would be expected to yield estimates nearest the real case.*

39/ Attachment to Concluding Statement of Position of the Regulatory Staff.

40/ Regulatory Staff, Exhibit 21.

41/ Lester Rogers, Tr., p. 3409.

The matter of how to deal with uncertainties in choosing data has been an implicit part of the evaluations made by participants in the hearing. The data used by the Staff in the evaluations presented in the Final Environmental Statement were considered by General Electric and the Consolidated Utility Group to be overly conservative.[42-45] The Staff has conceded that conservatisms existed and were being reevaluated continually.[46] It is our judgment in consideration of the detailed discussions of the models and data in testimony, in closing statements, and in oral argument that specific models and data should not be standardized by incorporation in Appendix I, as proposed by the State of Minnesota.[47] Neither do we intend to judge in this decision which of the many controversial parameter values would be particularly appropriate for use in implementing the design-objective guidelines. We believe that the opportunity to modify models and data as new experimental information comes

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42/ General Electric, Closing Statement, pp. 5 and 29-43.

43/ Ned R. Horton, Testimony, General Electric, Exhibit 6.

44/ Consolidated Utility Group, Statement of Position, pp. 13-14 and 42-50.

45/ Walton A. Rodger, Testimony, Tr., 3909.

46/ Lester Rogers, Testimony, Tr., pp. 3409, 3439-40, and 3460; Earl H. Markee, Tr., pp. 3432-33; and John T. Collins, Tr., pp. 3449-52.

47/ State of Minnesota, Concluding Statement, p. 11.

to light could have substantial advantages over a rigid rule, which is a persuasive argument for permitting this matter to be dealt with by the preparation of Regulatory Guides and by case-by-case evaluations.

(3) *If approximations implicit in a model can produce a deviation from the true result the direction of which is either uncertain or would tend to underestimate dosage or if available experimental information leaves a substantial range of uncertainty as to the best estimate of some parameter values, or both, data should be chosen so as to make it unlikely, with all such deviations and uncertainties taken into account together, that the true dose would be underestimated substantially.*

Two potential sources of deviation from a realistic dose estimate are of concern here. One is the use, at an applicant's preference, of a simplified model, which necessitates, in good judgment, the use of some conservatism in setting design objectives. The other is the existence, in spite of the best efforts of all parties, of experimental uncertainties in parameter values.

Mathematical models describing the various sequences of natural phenomena which relate releases of radioactive material to radiation dose vary in detail and complexity. This was frequently observed in the hearing. Through circumstances peculiar to his case, one applicant may be able

to present to the Regulatory Staff adequate support for his proposal through the use of simple models and conservative parameter values, while another applicant cannot prove his case so easily. There is no regulatory necessity for performing the most realistic dose estimates that are technologically achievable if a less complex and less expensive analysis can be made to demonstrate compliance with licensing requirements. The use of the simpler procedure may, however, introduce a wider range of uncertainty in estimated doses than a more complicated analysis. Hence the proper choice of parameter values for a simple calculation might be more conservative than values appropriate for a more precise calculation.

The matter of dealing with uncertain data was discussed at several points in the oral arguments.[48/] There was an apparent reluctance of participants to express in concise language a general definition of the degree of conservatism or realism considered appropriate or a precise definition of "best estimate." We also are reluctant to propound a precise general rule on this point because the situations presented vary too widely to permit us to do so. The record shows that the quality and quantity of experimental data are far

48/ Oral Argument, Tr., pp. 21, 35-40, 104-110, and 129-130.

from uniform from case to case, site to site, and phenomenon to phenomenon.

The models described in the hearing record and the evidence and arguments advanced with regard to numerical estimation of dose lead us to the conclusion that one should try to attain realistic estimates; but, where uncertainties exist, one should choose calculational procedures that are unlikely to produce substantial underestimates. We believe, furthermore, that it is in the best interest of the public to make realistic estimates, even with uncertain data, and to depend upon the programs for improving models and data, particularly programs of in-plant measurements, to determine whether proper case-by-case design decisions were made.[49/] Surveillance and quantitative monitoring of effluents are already required by existing regulations; additional guidelines for collection of data for each operating plant necessary for this purpose are included in Appendix I.

49/ Regulatory Staff, Concluding Statement, pp. 60-61.

(4) The models used in describing effluent releases should take into account all real sources and pathways within the plant; and the estimated releases should be characteristic of the expected average releases over a long period of time, with account taken of normal operation and anticipated operational occurrences over the lifetime of the plant.

The record is free from significant controversy as to the general model of an operating plant which should be assumed for the purpose of determining design objectives. The schedule of operation assumed by an applicant, if it turns out to be unrealistic, may later impose some inconvenience or expense on him through the influence of limiting conditions of operation adopted in accordance with Appendix I. This possibility is one to which the applicant would normally be sensitive, but it would not diminish the protection of the public from the effects of radioactive discharges.

(5) The model of the exposed individual and the assumed characteristics of the environs with respect to human occupancy and to land and water use should be determined in each case in accordance with the intent indicated below for each particular category of effluent for which design-objective guidelines are given.

(a) For design objectives affected by assumptions as to consumption of water or food (other than milk) produced in the environs, one should consider the model individual

to be that hypothetical individual who would be maximally exposed with account taken only of such potential occupancies and usages as could actually be realized during the term of plant operation.

(b) For design objectives affected by exposure as a direct result of human occupancy (immersion exposure), the model individual should be the hypothetical individual maximally exposed with account taken only of such potential occupancies, including the fraction of time an individual would be exposed, as could actually be realized during the term of plant operation.

We are persuaded by the evidence that, at most sites with realistic modeling of the natural phenomena affecting these exposure pathways, design objectives based on reasonable occupancy times and intake values could conform to guideline values at reasonable cost of control, even for a hypothetical receptor.[50/]

The Consolidated Utility Group presented substantial evidence, as an extension of Regulatory Staff evaluations presented in the Final Environmental Statement, to establish a level of effort they consider to be "justified on a cost-benefit basis." They concluded that in-plant controls for liquid effluents augmented as justified on a cost-benefit basis in

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50/ General Electric, Reply, p. 24.

terms of population dose reduction would meet the individual whole-body dose objective of 5 millirems.[51] We note that the Consolidated Utility Group presented further conclusions, after the evidentiary hearing concluded, that certain lake-shore and seacoast situations would require unjustifiably costly augments to conform to the guidelines for liquid effluents if "the staff's conservative dose models" were used.[52] While we are not adopting their opinion as our own, this conclusion and the further conclusions of the Consolidated Utility Group in this same place[53] with respect to justification of noble-gas effluent controls, when considered with the numerical guidelines of Appendix I now issued, point to a fortunate capacity to control effluents from the light-water-cooled reactors in most expected circumstances on the basis of a hypothetical individual.

We considered and rejected the possibility of specifying that all design objectives be determined solely on the basis of actual human occupancy at the time of plant design, as was proposed by the Consolidated Utility Group.[54] To adopt guidelines that would generally leave all consideration of

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51/ Regulatory Staff, Statement of Position, p. 33.

52/ Consolidated Utility Group, Reply, pp. 15-17.

53/ Consolidated Utility Group, Statement of Position, items 2 and 3, pp. 33-34.

54/ Consolidated Utility Group, Statement of Position, items 2 and 3, p. A-4.

future use of the environs to post-licensing regulation would be unwise in the instances where it has been clearly shown that an accommodation of reasonable potential future uses can be accomplished at reasonable cost. This is the case for all effluents except radioactive iodines and particulates released to the atmosphere. We believe the record shows it would be better in these instances to determine the design objectives with respect to potential future uses. This takes not only the economic balance into account but also the less tangible but equally important values of environmental quality and protection of the individual.

We have taken into account the fact that the analyses that have led to such a general conclusion were based on conservative hypotheses. We are mindful, as already mentioned, that numerical guidelines cannot coincide exactly with the effects of measures that are "as low as practicable" in every case. Therefore, the Appendix I guidelines should not and do not prohibit an applicant for whom the guidelines are not practicable from proceeding on the basis of the definition of "as low as practicable" alone. We anticipate that some special circumstances may arise which would make it advantageous to the applicant to base his case principally on a cost-benefit analysis. Such circumstances may involve: currently operating reactors for which the cost-benefit status of equipment augments is highly

site-dependent and differs substantially from that for plants in the design stage; multi-reactor sites to which certain environmental and economic considerations not fully explored in the hearing may apply; or unique or highly unusual sites or reactor installations.[55] We believe this option will provide adequate relief in such cases. The record shows that licensees are generally willing to include a requirement that all in-plant control measures which can be justified by a cost-benefit analysis for a particular site be included.[56]

There is substantial controversy in the record on the proper assumptions respecting such factors as the location of the source of drinking water, the habitat of fish caught and consumed locally, and individual intake of water, fish, and other foods. Some of these assumptions, in our view, are in the realm of natural phenomenology and, therefore, should be dealt with in accordance with points 1-3 above. For example, dilution of effluents in receiving waters, fish habits, and normal human intakes of food and water should be considered on the basis of scientifically evaluated experimental evidence.

We do believe, however, that the particular habits of the hypothetical receptor should take into account a reasonable

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[55] General Electric, Reply, pp. 23-24.

[56] Consolidated Utility Group, Reply, p. 10.

and real departure of the habits of some people from the average. We do not think it reasonable, on the other hand, to assume such bizarre characteristics as those of a hypothetical gardener who receives all his fresh vegetables from a hypothetical fence-post garden and consumes them immediately upon harvesting without washing or other processing, as was assumed for some of the evaluations of the Final Environmental Statement.[57/]

Such extreme assumptions have served their purpose in simplifying the evaluations involved in reaching a decision on Appendix I but would not be appropriate in case-by-case implementation of the guidelines. With realistic calculational models, food chains, and occupancy taken into account, we believe the record shows that one should and can account for persons who are not average, even in a local sense.

> *(c) For design objectives relative to thyroid dose as affected by consumption of milk, the iodine pathway through the environs of a plant and the characteristics of the model receptor should be essentially as they actually exist at the time of licensing.*

There was strong agreement among participants throughout much of the hearing that the iodine pathway leading to thyroid exposure through consumption of milk would be the

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[57/] Tr., pp. 3402-03 and 4329-30.

most difficult one to accommodate in the context of originally proposed numerical guidelines for establishing design objectives. At this time it is still an exceptional case. The estimated economic costs of instituting in-plant controls of iodine emissions are high enough to change the overall balance of the decision in favor of requiring that only actually existing food pathways need to be taken into account. Of course, this does not deny to any applicant who considers it practicable the privilege of assuming more conservative hypothetical pathways and thus avoiding the task of keeping up in detail with future changes in the environs.

Many elements of conservative estimates of radiation exposure discussed in points 1 to 4 above were of serious concern to the parties only with respect to the iodine-milk-thyroid pathway. The implementation guidance respecting attainment of more realistic estimates will permit many plants to conform to the thyroid-dosage guidelines irrespective of whether a real or hypothetical environmental pathway is the basis of design objectives. Nevertheless, on the basis of present knowledge of the entire pathway from in-plant source to receptor, there would be many plants that could not meet the numerical guideline on the basis of a hypothetical food pathway to an individual without in-plant controls the cost

of which outweighs the incremental benefit to the population at large.

In adopting this guideline for radioactive iodines and particulates discharged into the atmosphere, we have considered the following special questions:

> Is every individual adequately protected from excessive exposure? Is individual freedom of access and use of unrestricted areas assured? Is the likely cost of implementation in this way less than that of providing additional in-plant controls at the outset? Is the possible curtailment of future productivity of the environs justifiable?

The record supports an affirmative answer to each of these questions. Individual protection for real persons is accomplished by existing radiation protection standards; the design objectives adopted here for as low as practicable purposes for each reactor amount to only 1% of the radiation protection guides recommended by the Federal Radiation Council. Special requirements for surveillance are included to detect any important changes in land uses that would lead to exposures that exceed these design objectives. If such changes were to occur, the licensee, not the member of the public, would

be obligated to take appropriate action, namely, to control emissions or other elements of the exposure pathway in such a way as to maintain individual exposures in conformance with design-objective guidelines. Thus an individual would be free of any infringement upon his rights to use the environs.

The practicability of deferring some controls until real necessity is imminent is evident from the evaluations of the Regulatory Staff, General Electric, and the Consolidated Utility Group. Such a course was recommended in the closing statements of these three parties. General Electric expresses the principal arguments in one place as follows:[58]

> "In the extremely rare instance where, after licensing, plans are developed and actions are taken to bring about such production and consumption patterns, doses as large as those predicted by the staff will, in all probability, still not result because the design margins customarily built into LWR equipment will normally cause actual emissions to remain below their design basis values.... Even if doses exceeding the numerical guides should result, reasonable and inexpensive steps

[58] General Electric, Closing Statement, p. 35. See also further argument on pp. 39-41.

would almost certainly be available at that time to reduce such exposures without the necessity of expensive equipment augmentation such as that which the staff's approach would mandate in each instance during initial plant construction."

Furthermore the evidence shows that with additional experience and data from operating plants the most likely result will be that estimates based upon present-day models and assumptions are unrealistically high.[59] This factor will be of transitory value, however, in providing a buffer against having to backfit because, as models used at the time of plant design become more realistic, there is less chance of proving significant improvement in computational methods with further experience. It is our judgment, therefore, that the most beneficial use of resources in control of these particular effluents will be attained by permitting the use of actually existing pathways in determining design objectives for radioactive iodine release to the atmosphere.

It should be noted that it would be permissible for a licensee to effect compliance with Appendix I by making arrangements with persons holding land rights in the vicinity of a nuclear

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[59] See Regulatory Staff, Final Environmental Statement, Vol. 1, p. 9-16; Regulatory Staff, Exhibit 24; Henry L. Loy, Testimony, General Electric, Exhibit 4; Paul R. Hill, Exhibit 5; and Paul R. Hill and James M. Smith, Tr., pp. 3750-93.

plant so as to control or restrict the production and consumption of milk. The impact of ary such controls on the potential productivity of a local region would, at worst, be negligible.

By the Commission.

SAMUEL J. CHILK
Secretary of the Commission

Dated at Washington, DC
this 30th day of April, 1975.

* Tables are from NUREG-0521.

TABLE 3

AIRBORNE EFFLUENT COMPARISON BY YEAR

BOILING WATER REACTORS

NOBLE GASES (TOTAL CURIES)

Facility	1970	1971	1972	1973	1974	1975	1976	1977
Big Rock Point 1	2.80E+05	2.84E+05	2.58E+05	2.30E+05	1.88E+05	5.06E+04	1.52E+04	1.34E+04
Browns Ferry 1,2&3	-	-	-	-	6.40E+04	9.24E+04	<8.05E+04	<1.66E+05
Brunswick 1&2	-	-	-	-	-	1.90E+02	1.90E+04	2.46E+05
Cooper	-	-	-	-	2.00E+03	1.98E+04	3.80E+04	1.27E+03
Dresden 1	9.00E+05	7.53E+05	8.77E+05	8.40E+05	9.80E+04	5.20E+05	4.52E+05	5.20E+05
Dresden 2&3	-	5.80E+05	4.29E+05	8.80E+05	6.27E+05	3.69E+05	3.23E+04	3.13E+05
Duane Arnold	-	-	-	-	-	1.98E+03	5.26E+03	3.87E+03
J. A. Fitzpatrick	-	-	-	-	-	4.08E+03	4.41E+04	2.33E+04
Edwin I. Hatch	-	-	-	-	-	2.70E+02	2.80E+03	1.90E+03
Humboldt Bay 3	5.40E+05	5.14E+05	4.30E+05	3.50E+05	5.72E+05	2.97E+05	9.30E+04	4.40E-05
LaCrosse	1.00E+03	1.00E+03	3.10E+04	9.10E+04	4.90E+04	5.71E+04	1.24E+05	4.25E+04
Millstone Point 1	-	2.76E+05	7.26E+05	7.90E+04	9.12E+05	2.97E+06	5.07E+05	6.20E+05
Monticello	-	7.60E+04	7.51E+05	8.70E+05	1.57E+06	1.55E+05	1.14E+04	6.87E+03
Nine Mile Point	1.00E+04	2.53E+05	5.17E+05	8.72E+05	5.58E+05	1.30E+06	1.76E+05	3.53E+03
Oyster Creek	1.10E+05	5.16E+05	8.66E+05	8.10E+05	2.79E+05	2.06E+05	1.67E+05	1.77E+05
Peach Bottom 2&3	-	-	-	<1.00E+03	<1.00E+03	1.30E+04	2.09E+05	7.11E+04
Pilgrim	-	-	1.80E+04	2.30E+05	5.46E+05	4.60E+04	1.83E+05	4.13E+05
Quad Cities 1&2	-	-	1.32E+05	9.00E+05	9.50E+05	1.10E+05	3.36E+04	2.56E+04
Vermont Yankee	-	-	5.50E+04	1.80E+05	6.40E+04	4.08E+03	3.03E+03	3.35E+03

1257 208

ENCLOSURE C*

TABLE 4

AIRBORNE EFFLUENT COMPARISON BY YEAR

PRESSURIZED WATER REACTORS

NOBLE GASES (TOTAL CURIES)

Facility	1970	1971	1972	1973	1974	1975	1976	1977
Arkansas 1	-	-	-	-	1.96E+02	1.03E+03	5.69E+03	1.39E+04
Beaver Valley 1	-	-	-	-	-	-	1.07E+00	4.73E+01
Calvert Cliffs 1	-	-	-	-	-	7.72E+03	9.40E+03	2.23E+04
Cook 1	-	-	-	-	-	2.64E+00	9.75E+02	3.80E+03
Crystal River	-	-	-	-	-	-	-	3.35E+03
Davis Besse	-	-	-	-	-	-	-	1.27E+0[illegible]
Fort Calhoun	-	-	-	6.70E+01	[illegible]3E+02	4.29E+02	1.94E+03	3.81E+03
R. E. Ginna	1.00E+01	3.20E+01	1.20E+01	5.76E+02	7.57E+02	1.04E+04	5.52E+[illegible]	3.20E+03
Haddam Neck	1.00E+00	3.00E+00	1.00E+00	3.20E+01	7.00E+00	4.80E+02	4.52E+0[illegible]	3.12E+03
Indian Point	-	-	-	1.50E+01	5.58E+03	8.20E+03	1.16E+04	1.60E+04
Kewaunee	-	-	-	-	3.35E+03	2.45E+03	1.40E+03	2.4[illegible]+03
Maine Yankee	-	-	<1.00E+00	1.61E+02	6.36E+03	4.09E+03	1.30E+03	2.86E+02
Millstone Point 2	-	-	-	-	-	-	1.57E+03	2.28E+[illegible]3
Oconee 1,2&3	-	-	-	9.30E+03	1.94E+04	1.51E+04	[illegible].39E+04	3.56E+04
Palisades	-	-	1.00E+00	4.54E+02	<1.00E+00	2.61E+03	.99E+01	[illegible].95[illegible]01
Point Beach 1&2	-	<1.00E+00	3.00E+00	5.75E+03	9.74E+03	4.45E+04	.91E+03	1.13[illegible]03
Prairie Island 1&2	-	-	-	8.72E+00	3.62E+02	2.17E+03	1.74E+03	6.73[illegible]+02
Rancho Seco	-	-	-	-	-	1.18E+02	1.27E+02	2.00E+03
H.B. Robinson	-	1.00E+00	<1.00E+00	3.10E+03	2.31E+03	1.17E+03	5.40E+02	4.76E+02
Salem	-	-	-	-	-	-	<1.00E-02	1.96E+01
San Onofre 1	<1.00E+00	8.00E+00	1.90E+01	1.10E+04	1.78E+03	1.11E+03	4.16E+02	1.54E+02
St. Lucie	-	-	-	-	-	-	1.72E+03	2.54E+04
Surry 1&2	-	-	<1.00E+00	8.66E+02	6.86E+03	8.04E+03	1.91E+04	1.90E+04
Three Mile Island 1	-	-	-	-	9.16E+02	3.63E+03	2.76E+03	1.66E+04
Trojan	-	-	-	-	-	-	6.66E+02	3.07E+03
Turkey Point 3&4	-	-	-	5.30E+02	4.66E+03	1.34E+04	1.56E+04	2.33E+04
Yankee Rowe	<1.00E+00	<1.00E+00	<1.00E+00	3.50E+01	1.00E+01	2.24E+01	2.57E+01	1.25E+02
Zion 1&2	-	-	-	4.00E+00	2.99E+03	4.88E+04	1.14E+05	3.22E+04

TABLE 5

AIRBORNE EFFLUENT COMPARISON BY YEAR (CURIES)

I-131 AND PARTICULATES

BOILING WATER REACTORS (HALF-LIFE EQUAL TO OR GREATER THAN 8 DAYS)

Facility	1970	1971	1972	1973	1974	1975	1976	1977
Big Rock Point 1	1.30E-01	6.10E-01	1.50E-01	4.60E+00	1.60E-01	1.20E-01	5.00E-02	1.00E-02
Browns Ferry 1,2&3	-	-	-	-	1.20E-01	2.70E-01	<7.00E-02	1.04E-01
Brunswick 1&2	-	-	-	-	-	<1.00E-02	4.60E-01	9.32E-01
Cooper	-	-	-	-	2.40E-01	5.00E-02	<4.00E-02	<1.91E-02
Dresden 1	3.30E+00	6.70E-01	2.75E+00	4.00F-02	6.80E-01	9.60E-01	8.40E-01	4.93E+00
Dresden 2&3	1.60E+00	8.68E+00	5.89E+00	6.70E+00	6.50E+00	4.31E+00	5.49E+00	6.86E+00
Duane Arnold	-	-	-	-	-	1.10E-03	8.18E-02	2.29E-02
J. A. Fitzpatrick	-	-	-	-	-	<4.00E-02	6.80E-01	1.73E-01
Edwin I. Hatch	-	-	-	-	-	<1.00E-02	<1.00E-02	5.67E-03
Humboldt Bay 3	3.50E-01	3.00E-01	4.80E-01	2.90E-01	8.40E-01	1.06E+00	8.36(-2)	4.04E-03
LaCrosse	<6.00E-02	<1.00E-02	7.10E-01	2.00E-01	4.00E-02	1.00E-01	<7.06E-02	1.67E-01
Millstone Point 1	-	4.00E+00	1.32E+00	2.00E-01	3.26E+00	9.98E+00	2.33E+00	4.86E+00
Monticello	-	3.60E-02	5.78E-01	1.20E+00	5.70E+00	3.71E+00	1.71E-01	8.51E-02
Nine Mile Point	<1.00E-02	6.00E-02	9.70E-01	1.98E+00	8.90E-01	2.78E+00	2.20E+00	1.99E-01
Oyster Creek	3.20E-01	2.14E+00	6.48E+00	7.02E+00	3.51E+00	5.64E+00	6.39E+00	9.05E+00
Peach Bottom 2&3	-	-	-	<1.00E-02	1.00E-02	4.00E-02	9.75E-01	2.73E-01
Pilgrim	-	-	3.00E-02	4.70E-01	1.45E+00	2.58E+00	6.74E-01	6.90E-01
Quad Cities 1&2	-	-	7.50E-01	5.50E+00	8.88E+00	1.31E+00	1.33E+00	1.69E+00
Vermont Yankee	-	-	1.70E-01	7.00E-02	3.60E-01	1.00E-02	<1.00E-02	1.44E-02

TABLE 6

AIRBORNE EFFLUENT COMPARISON BY YEAR (CURIES)

I-131 AND PARTICULATES

(HALF-LIFE EQUAL TO OR GREATER THAN 8 DAYS)

PRESSURIZED WATER REACTORS

Facility	1970	1971	1972	1973	1974	1975	1976	1977
Arkansas 1	-	-	-	-	5.00E-02	7.40E-01	5.73E-02	9.04E-03
Beaver Valley 1	-	-	-	-	-	-	<1.00E-02*	1.52E-04
Calvert Cliffs 1	-	-	-	-	-	7.00E-02	1.38E-01	3.07E-01
Cook 1	-	-	-	-	-	<1.00E-02	<1.00E-02	7.45E-02
Crystal River	-	-	-	-	-	-	-	2.53E-03
Davis Besse	-	-	-	-	-	-	-	2.57E-04
Fort Calhoun	-	-	-	<1.00E-02	<1.00E-02	<1.00E-02	<2.04E-02	1.34E-02
R. E. Ginna	5.00E-02	1.70E-01	4.00E-02	<1.00E-02	<1.00E-02	2.00E-02	3.17E-02	2.55E-02
Haddam Neck	<1.00E-02	3.00E-02	2.00E-02	5.00E-02	<1.00E-02	<1.00E-02	<1.00E-02	1.74E-03
Indian Point	-	-	-	<1.00E-02	4.30E-01	1.62E+00	2.42E-01	5.59E-02
Kewaunee	-	-	-	-	2.00E-02	6.60E-01	<1.00E-02	2.40E-02
Maine Yankee	-	-	<1.00E-02	9.40E-01	5.00E-02	<1.00E-02	<1.00E-02	5.05E-03
Millstone Point 2	-	-	-	-	-	1.00E-02	1.25E-02	4.47E-03
Oconee 1,2&3	-	-	-	1.00E-02	3.00E-02	1.00E-02	2.72E-01	5.35E-01
Palisades	-	-	<1.00E-02	3.10E-01	1.00E-02	3.80E-01	4.16E-02	1.63E-02
Point Beach 1&2	-	<1.00E-02	3.00E-02	5.50E-01	1.60E-01	7.00E-02	1.85E-02	5.02E-03
Prairie Island 1&2	-	-	-	<1.00E-02	<1.00E-02	2.12E-02	1.14E-02	7.56E-03
Rancho Seco	-	-	-	-	-	<1.00E-02	<1.00E-02	5.02E-03
H.B. Robinson	-	-	3.00E-02	3.00E-01	5.00E-02	2.00E-02	9.96E-02	3.88E-03
Salem	-	-	-	-	-	-	ND	2.34E-07
San Onofre 1	<1.00E-02	<1.00E-02	<1.00E-02	1.61E+00	<1.00E-02	4.00E-02	<1.00E-02	1.86E-04
St. Lucie	-	-	-	-	-	-	<1.00E-02	1.48E-01
Surry 1&2	-	-	<1.00E-02	4.00E-02	1.40E-01	5.00E-02	3.46E-01	1.20E-01
Three Mile Island 1	-	-	-	-	<1.00E-02	<1.00E-02	1.07E-02	3.39E-02
Trojan	-	-	-	-	-	-	1.64E-02	5.05E-02
Turkey Point 3&4	-	-	-	6.00E-02	3.63E+00	4.30E-01	4.22E-01	1.04E+00
Yankee Rowe	<1.00E-02	<1.00E-02	<1.00E-02	1.90E-01	5.30E-01	1.00E-02	<1.00E-02	8.70E-05
Zion 1&2	-	-	-	<1.00E-02	1.00E-02	1.40E-01	9.00E-02	5.38E-02

*I-131 not included.

TABLE 7

LIQUID EFFLUENT COMPARISON BY YEAR (CURIES)

TRITIUM

BOILING WATER REACTORS

Facility	1970	1971	1972	1973	1974	1975	1976	1977
Big Rock Point 1	5.40E+01	1.03E+01	1.04E+01	1.97E+01	5.10E+00	5.73E+00	2.41E+00	8.83E+00
Browns Ferry 1,2&3	-	-	-	-	2.80E+00	1.04E+01	<4.02E+00	2.40E+01
Brunswick 1&2	-	-	-	-	-	3.20E+00	5.90E+00	8.93E+00
Cooper	-	-	-	-	1.70E+00	8.25E+00	8.43E+00	9.04E+00
Dresden 1	5.00E+00	8.70E+00	4.33E+01	1.85E+01	1.88E+01	2.70E-01	2.00E-02	8.90E-02
Dresden 2&3	3.10E+01	3.85E+01	2.59E+01	2.58E+01	2.26E+01	5.40E+01	1.97E+01	5.00E+00
Duane Arnold	-	-	-	-	-	3.30E-01	3.40E-01	2.13E-01
J. A. Fitzpatrick	-	-	-	-	-	5.03E+00	4.20E+00	3.35E+00
Edwin I. Hatch	-	-	-	-	-	6.12E+00	8.98E+00	1.20E+01
Humboldt Bay 3	7.00E+00	7.50E+00	1.30E+01	5.13E+01	3.17E+01	2.01E+01	1.30E+01	5.26E-01
LaCrosse	2.00E+01	9.14E+01	1.20E+02	1.03E+02	1.15E+02	1.27E+02	4.10E+01	4.86E+01
Millstone Point 1	-	1.27E+01	2.09E+01	3.70E+00	2.41E+01	8.03E+01	2.01E+01	4.41E+00
Monticello	-	5.92E-01	<1.00E-01	0.0	0.0	0.0	0.0	0.0
Nine Mile Point 1	2.00E+01	1.24E+01	2.78E+01	4.65E+01	1.87E+01	2.81E+01	2.46E+00	2.49E+00
Oyster Creek	2.20E+01	2.15E+01	6.16E+01	3.59E+01	1.41E+01	1.79E+01	3.86E+01	1.88E+01
Peach Bottom 2&3	-	-	-	<1.00E-01	1.00E+01	3.08E+01	7.37E+01	7.09E+01
Pilgrim	-	-	4.20E+00	4.00E-01	1.05E+01	1.82E+01	4.67E+01	3.27E+01
Quad Cities 1&2	-	-	4.70E+00	2.45E+01	3.40E+01	5.37E+01	4.98E+01	2.64E+01
Vermont Yankee	-	-	-	1.00E-01	0.0	0.0	1.60E+00	8.44E-01

TABLE 8

LIQUID EFFLUENT COMPARISON BY YEAR (CURIES)

TRITIUM

PRESSURIZED WATER REACTORS

Facility	1970	1971	1972	1973	1974	1975	1976	1977
Arkansas 1	-	-	-	-	2.56E+01	4.60E+02	2.12E+02	2.45E+02
Beaver Valley 1	-	-	-	-	-	-	8.60E+00	1.08E+02
Calvert Cliffs 1	-	-	-	-	-	2.63E+02	2.74E+02	5.75E+02
Cook 1	-	-	-	-	-	5.64E+01	1.92E+02	2.86E+02
Crystal River	-	-	-	-	-	-	-	1.66E+02
Davis Besse	-	-	-	-	-	-	-	9.01E+00
Fort Calhoun	-	-	-	1.58E+01	1.24E+02	1.11E+02	1.22E+02	1.57E+02
R. E. Ginna	1.10E+02	1.54E+02	1.19E+02	2.86E+02	1.95E+02	2.60E+02	2.42E+02	1.19E+02
Haddam Neck	7.40E+03	5.83E+03	5.89E+03	3.90E+03	2.24E+03	5.67E+03	4.85E+03	6.67E+03
Indian Point	-	-	-	2.75E+01	4.79E+01	7.94E+01	3.32E+02	3.71E+02
Kewaunee	-	-	-	-	9.24E+01	2.77E+02	1.80E+02	2.95E+02
Maine Yankee	-	-	9.20E+00	1.54E+02	2.19E+02	1.77E+02	3.67E+02	1.53E+02
Millstone Point 2	-	-	-	-	-	7.60E+00	2.77E+02	2.11E+02
Oconee 1,2&3	-	-	-	7.07E+01	3.50E+02	3.55E+03	2.19E+03	1.92E+03
Palisades	-	-	2.08E+02	1.85E+02	8.10E+00	4.16E+01	9.63E+00	5.58E+01
Point Beach 1&2	-	2.66E+02	5.63E+02	5.56E+02	8.33E+02	8.85E+02	6.94E+02	9.99E+02
Prairie Island 1&2	-	-	-	<1.00E-01	1.42E+02	4.54E-01	1.00E-01	1.35E+03
Rancho Seco	-	-	-	-	-	1.32E+02	0.0	8.55E-02
H.B. Robinson	-	1.18E+02	4.05E+02	4.32E+02	4.49E+02	6.24E+02	9.80E+02	6.85E+02
Salem	-	-	-	-	-	-	4.00E-02	2.96E+02
San Onofre 1	4.80E+03	4.57E+03	3.48E+03	4.07E+03	3.81E+03	4.00E+03	3.39E+03	1.79E+03
St. Lucie	-	-	-	-	-	-	1.33E+01	2.42E+02
Surry 1&2	-	-	5.00E+00	4.88E+02	2.45E+02	4.42E+02	7.82E+02	4.08E+02
Three Mile Island 1	-	-	-	-	1.30E+02	4.63E+02	1.89E+02	1.92E+02
Trojan	-	-	-	-	-		3.60E+01	3.11E+02
Turkey Point 3&4	-	-	-	3.29E+02	5.80E+02	7.97E+02	7.71E+02	9.24E+02
Yankee Rowe	1.50E+03	1.68E+03	8.03E+02	6.94E+02	3.14E+02	2.47E+02	1.56E+02	1.39E+02
Zion 1&2	-	-	-	1.00E-01	2.74E+02	1.03E+03	7.47E+02	7.24E+02

TABLE 9

LIQUID EFFLUENT COMPARISON BY YEAR (CURIES)

BOILING WATER REACTORS

MIXED FISSION AND ACTIVATION PRODUCTS

Facility	1970	1971	1972	1973	1974	1975	1976	1977
Big Rock Point 1	4.70E+00	3.50E+00	1.10E+00	2.70E+00	1.10E+00	2.02E+00	7.70E-01	3.92E-01
Browns Ferry 1,2&3	-	-	-	-	8.00E-01	2.70E+00	<3.95E+00	1.19E+00
Brunswick 1&2	-	-	-	-	-	1.89E+00	3.29E+00	6.22E+00
Cooper	-	-	-	-	1.40E+00	1.74E+00	7.00E-02	7.50E-01
Dresden 1	8.20E+00	6.20E+00	6.80E+00	9.20E+00	6.90E+00	8.40E-01	3.60E-01	6.00E-01
Dresden 2&3	-	2.30E+01	2.20E+01	2.59E+01	3.31E+01	8.10E-01	1.21E+00	4.40E-01
Duane Arnold	-	-	-	-	-	<1.00E-02	<1.00E-02	2.[illegible]E-03
J. A. Fitzpatrick	-	-	-	-	-	5.32E+00	6.01E+00	8.85E-01
Edwin I. Hatch	-	-	-	-	-	6.00E-02	4.00E-02	2.50E+01
Humboldt Bay 3	2.40E+00	1.80E+00	1.40E+00	2.40E+00	4.40E+00	3.79E+00	9.90E-01	9.17E-01
LaCrosse	6.40E+00	1.71E+01	4.85E+01	3.59E+01	1.31E+01	1.42E+01	<5.78E+00	2.13E+01
Millstone Point 1	-	1.97E+01	5.15E+01	3.34E+01	1.98E+02	1.99E+02	9.65E+00	5.27E-01
Monticello	-	<1.00E-01	<1.00E-01	0.0	0.0	0.0	0.0	0.0
Nine Mile Point	2.80E+01	3.22E+01	3.46E+01	4.08E+01	2.56E+01	2.10E+01	2.14E+00	3.03E-01
Oyster Creek	1.85E+01	1.20E+01	1.00E+01	4.20E+00	7.00E-01	4.10E-01	2.20E-01	9.81E-02
Peach Bottom 2&3	-	-	-	<1.00E-01	9.00E-01	9.30E-01	3.38E+00	2.23E+00
Pilgrim	-	-	1.50E+00	9.00E-01	4.20E+00	8.01E+00	2.33E+00	3.41E+00
Quad Cities 1&2	-	-	2.40E+00	2.14E+01	3.88E+01	1.71E+01	6.99E+00	1.34E+00
Vermont Yankee	-	-	-	<1.00E-01	0.0	<1.00E-02	<1.00E-02	1.55E-01

TABLE 10

LIQUID EFFLUENT COMPARISON BY YEAR (CURIES)

MIXED FISSION AND ACTIVATION PRODUCTS

PRESSURIZED WATER REACTORS

Facility	1970	1971	1972	1973	1974	1975	1976	1977
Arkansas 1	-	-	-	-	6.50E+00	3.11E+00	1.31E+01	4.50E+00
Beaver Valley 1	-	-	-	-	-	-	1.70E-01	6.52E-01
Calvert Cliffs 1	-	-	-	-	-	1.44E+00	1.18E+00	3.48E+00
Cook 1	-	-	-	-	-	2.60E-01	1.87E+00	1.52E+00
Crystal River	-	-	-	-	-	-	-	1.54E-02
Davis Besse	-	-	-	-	-	-	-	2.60E-02
Fort Calhoun	-	-	-	<1.00E-01	2.30E+00	3.60E-01	5.50E-01	3.63E-01
R. E. Ginna	1.00E+01	9.00E-01	3.00E-01	1.00E-01	1.00E-01	4.20E-01	6.90E-01	6.47E-02
Haddam Neck	6.70E+00	5.90E+00	4.80E+00	3.00E+00	2.20E+00	1.20E+00	1.30E-01	1.71E+00
Indian Point	-	-	-	2.20E+00	4.20E+00	4.93E+00	<4.98E+00	3.02E+00
Kewaunee	-	-	-	-	4.00E-01	7.20E-01	2.83E+00	1.26E+00
Maine Yankee	-	-	<1.00E-01	<1.00E-01	4.00E+00	3.21E+00	<2.84E+00	4.42E-01
Millstone Point 2	-	-	-	-	-	2.00E-02	2.60E-01	1.56E+00
Oconee 1,2&3	-	-	-	2.80E+00	1.90E+00	5.05E+00	7.93E+00	3.62E+01
Palisades	-	-	6.80E+00	2.78E+01	5.90E+00	3.45E+00	4.40E-01	9.29E-02
Point Beach 1&2	-	1.00E-01	1.50E+00	8.00E-01	2.00E-01	2.34E+00	3.24E+00	1.50E+00
Prairie Island 1&2	-	-	-	<1.00E-01	<1.00E-01	4.50E-01	1.00E-01	1.33E-02
Rancho Seco	-	-	-	-	-	<1.00E-02	0.0	0.0
H. B. Robinson	-	7.00E-01	8.00E-01	6.00E-01	2.50E+00	4.50E-01	3.80E-01	3.29E-01
Salem	-	-	-	-	-	-	<1.00E-02	2.88E+00
San Onofre 1	7.60E+00	1.50E+00	3.03E+01	1.60E+01	5.00E+00	1.22E+00	7.43E+00	9.84E+00
St. Lucie	-	-	-	-	-	-	8.00E-02	5.80E+00
Surry 1&2	-	-	2.00E-01	1.00E-01	3.80E+00	9.27E+00	3.37E+01	6.55E+01
Three Mile Island 1	-	-	-	-	1.30E+00	7.00E-02	1.00E-01	1.94E-01
Trojan	-	-	-	-	-	-	2.77E+00	4.19E+00
Turkey Point 3&4	-	-	-	<1.00E-01	1.60E+00	3.07E+00	<8.65E+00	8.90E+00
Yankee Rowe	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	<1.00E-01	2.00E-02	<1.00E-02	1.80E-02
Zion 1&2	-	-	-	<1.00E-01	<1.00E-01	<1.00E-02	1.60E-01	9.50E-01

TABLE 1. Reactor Characteristics and Dose Commitments*

Site	Unit	Type	Licensed Thermal Power (MW)	Electric Energy Generation 1975 (TW·hr)	Augmented Rad-Waste System (1975)	Pop. Dose Commitment (person-rem) Liquid	Air	Total	C/B (person-rem / TW·hr)	Avg. Indiv. Dose Commitment (mrem)
Big Rock Point	1	BWR	240	0.291	No	3.1	1.5	4.6	16	3.5E-2
Browns Ferry	1	BWR	3293	1.38	No					
	2	BWR	3293	1.43	No					
	TOTAL		6586	2.80		0.90	2.0	2.9	1.0	4.5E-3
Brunswick	2	BWR	2436	1.41	No	0.011	0.0073	0.018	0.013	1.0E-4
Cooper	1	BWR	2381	3.85	No	--(a)	0.18	0.18	0.047	1.0E-3
Dresden	1	BWR	700	0.697	No					
	2	BWR	2527	2.94	No					
	3	BWR	2527	2.19	No					
	TOTAL		5754	5.83		--	360	360	62	5.7E-2
Duane Arnold	1	BWR	1658	2.30	No	0.0052	0.17	0.18	0.078	3.0E-4
J.A. Fitzpatrick	1	BWR	2436	2.15	No	0.062	0.028	0.090	0.042	1.0E-4
E.I. Hatch	1	BWR	2436	3.10	No	0.0056	0.0027	0.0083	0.0027	3.0E-5
Humboldt Bay	3	BWR	220	0.383	No	0.0041	18	18	47	1.6E-1
LaCrosse	1	BWR	165	0.263	No	5.4	1.6	7.0	27	2.1E-2
Millstone Point	1	BWR	2011	3.90	No					
	2	PWR	2560	0.135	No					
	TOTAL		4571	4.04		0.15	750	750	190	3.0E-1
Monticello	1	BWR	1670	2.88	Sept 75	--	5.2	5.2	1.8	2.5E-3
Nine Mile Point	1	BWR	1850	3.04	No	14	55	69	23	8.3E-2
Oyster Creek	1	BWR	1930	3.15	No	0.080	47	47	15	1.4E-2
Peach Bottom	2	BWR	3293	5.08	No					
	3	BWR	3293	5.28	No					
	TOTAL		6586	10.4		0.71	1.7	2.4	0.23	5.9E-4
Pilgrim	1	BWR	1538	2.59	Jan 75	0.080	6.1	6.2	2.4	1.4E-3
Quad Cities	1	BWR	2511	4.27	May 75					
	2	BWR	2511	2.48	May 75					
	TOTAL		5022	6.75		16	8.7	25	4.0	3.7E-2
Vermont Yankee	1	BWR	1593	3.56	Yes	--	0.077	0.077	0.022	5.5E-5
Arkansas	1	PWR	2568	4.88	No	0.37	0.013	0.38	0.078	2.4E-3
Calvert Cliffs	1	PWR	2560	4.39	No	0.28	0.22	0.50	0.11	2.0E-4
Connecticut Yankee	1	PWR	1825	4.12	No	0.42	0.12	0.54	0.13	1.6E-4
Cook	1	PWR	2632	4.46	No	0.21	--	0.21	0.047	1.9E-4
Fort Calhoun	1	PWR	1420	2.08	No	0.12	0.0052	0.13	0.062	1.8E-4
H.B. Robinson	1	PWR	2200	4.17	No	9.3	0.058	9.3	2.2	1.5E-2
Indian Point	1	PWR	615	0	No					
	2	PWR	2758	4.89	No					
	TOTAL		3373	4.89		0.71	3.1	3.8	0.78	2.4E-4
[illegible]	1	PWR	1650	3.34	No	8.5	0.036	8.5	2.5	1.4E-2
[illegible] Yankee	1	PWR	2440	4.50	No	0.025	0.070	0.095	0.021	2.0E-4

[illegible] = 3.6E15 joules.
[illegible] indicates fifty year population dose commitment is <0.001 person-rem.

* This table is from a document entitled, "Population Dose Commitments Due to Radioactive Releases from Nuclear Power Plant Sites in 1975," D.A. Backer, J.K. Soldat and E.C. Watson, Battelle Pacific Northwest Laboratories, PNL-2439, October 1977.

TABLE 1. Reactor Characteristics and Dose Commitments (Continued)

Site	Unit	Type	Licensed Thermal Power (MW)	Electric Energy Generation 1975 (TW·hr)	Augmented Rad-Waste System (1975)	Pop. Dose Commitment (person-rem) Liquid	Air	Total	C/B (person-rem / TW·hr)	Avg. Indiv. Dose Commitment (mrem)
Oconee	1	PWR	2568	5.29	No					
	2	PWR	2568	4.97	No					
	3	PWR	2568	5.04	No					
	TOTAL		7704	15.3		8.5	0.70	9.2	0.60	1.3E-2
Palisades	1	PWR	2100	2.43	No	0.59	0.032	0.62	0.25	6.0E-4
Point Beach	1	PWR	1518	2.92	No					
	2	PWR	1518	3.74	No					
	TOTAL		3036	6.66		0.044	1.2	1.2	0.18	2.0E-3
Prairie Island	1	PWR	1650	3.69	No					
	2	PWR	1650	3.18	No					
	TOTAL		3300	6.87		0.049	0.067	0.12	0.017	5.7E-5
R.E. Ginna	1	PWR	1520	3.04	No	0.13	0.15	0.28	0.092	2.3E-4
Rancho Seco	1	PWR	2772	1.33	No	0.041	0.0059	0.047	0.035	3.4E-5
San Onofre	1	PWR	1347	3.25	No	0.22	0.056	0.28	0.086	7.6E-5
Surry	1	PWR	2441	3.92	No					
	2	PWR	2441	5.05	No					
	TOTAL		4882	8.97		5.1	0.34	5.4	0.60	3.1E-3
Three Mile Island	1	PWR	2535	5.54	No	0.13	0.44	0.57	0.10	3.2E-4
Turkey Point	3	PWR	2200	4.37	No					
	4	PWR	2200	3.99	No					
	TOTAL		4400	8.36		0.016	0.20	0.22	0.026	1.1E-4
Yankee Rowe	1	PWR	600	1.19	No	0.048	0.060	0.11	0.092	5.9E-5
Zion	1	PWR	2760	4.91	No					
	2	PWR	2760	4.83	No					
	TOTAL		5520	9.74		0.84	5.3	6.1	0.63	9.1E-5
Total for all Sites				170		76	1300	1300	--	--
Average				4.3		2.0	33	34	10	2.0E-2

1 TW·hr = 3.6E15 joules

BACKGROUND INFORMATION ON ASSUMPTION OF LINEAR NON-THRESHOLD HEALTH EFFECTS MODEL

For more than four decades, radiation has been the most throroughly studied carcinogen. Numerous major biological research programs have been completed and others are in progress. These programs have been well documented and may be found in the open literature. While the United States has been the forerunner in radiation research, many other countries also have pursued similar programs and have contributed substantially to the knowledge. While the relationship between ionizing radiation dose and biological effects among humans is not precisely known for all levels of radiation, the principal uncertainty exists at very low dose levels where natural sources of radiation (cosmic and terrestrial) and the variations in these sources are comparable to the doses being evaluated. The most important biological effects from radiation are somatic diseases (principally cancer) and hereditary diseases. Both of these are identical to those which occur normally among humans from other causes. It is this last point in combination with other confounding factors, e.g., magnitude and variations (1) in normal incidence of diseases, (2) in doses from natural radiation sources, (3) in radiation doses from man-made sources other than the nuclear industry, and (4) in exposures to other (non-nuclear) carcinogens, which is responsible for much of the uncertainty in the dose-risk relationship at low dose levels.

Data from studies of animals and humans are reviewed continuously by teams of scientific experts which evaluate radiological information and provide recommendations. In the United States, the principal expertise in radiological matters lies with the National Council on Radiological Protection (NCRP) and the National Academy of Science/National Research Council (NAS/NRC). Federal agencies also retain expertise in the radiologic disciplines in order to fulfill their responsibilities, however, these agencies rely heavily on recommendations of these advisory organizations. Other countries have national advisory organizations similar to those of the United States. Further, there are cooperative international organizations which evaluate data from all sources and present recommendations and conclusions, for example, the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and the International Commission on Radiological Protection (ICRP). In summary, not only have the radiological data been ascertained by the world's outstanding biologists and epidemiologists, but the data have been evaluated independently by their peers.

In lieu of precise knowledge of this relationship, a linear non-threshold extrapolation from high radiation levels to the lower levels is assumed for radiation protection purposes. This means that it is assumed that any dose of radiation, no matter how low, may be harmful.

Several federal agencies, principally the Environmental Protection Agency, Occupational Safety and Health Administration and the Nuclear Regulatory Commission, have responsibilities for regulating exposures to radiation or radioactive material. In all cases, the staffs of these agencies are well aware of the potential health effects and have expertise in biology and the other disciplines needed either within the staff or available to them.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

RADIATION STANDARDS FACT SHEET

Atomic radiation is not new to the world; it is part of our natural "background" environment. This background of natural radiation comes from two sources. One is radiation in the form of high-energy particles that come from outer space and are known collectively as cosmic rays. The other natural source is radioactive substances present in commonplace materials found in the earth (such as granite), in living matter (such as our bodies), in air, and in water. Part of the hydrogen, potassium, and carbon in the human body, for example, is radioactive.

NATURAL RADIATION

The amount of radiation an individual receives is called the "dose" and is measured in units called "rems." The average individual in the United States accumulates a dose of one rem from natural sources about every 10 years. The following table shows a breakdown of the estimated radiation dose typically received by an individual in the United States from natural sources. The doses indoors would be somewhat lower due to shielding by housing.

Source	Annual Radiation Dose Received (in rems)
Cosmic radiation	0.04
Terrestrial radiation	
Radionuclides in the body	0.02
External radiation	0.04
Total	0.10

The exact amount of natural background radiation varies from place to place -- mainly because of differences in the amounts of natural radioactive materials present in the environment and differences in elevation. The dose from radiation is higher in certain states, for example, primarily because of cosmic radiation. Since cosmic rays lose strength as they pass through the earth's atmosphere, cosmic radiation doses are higher at high altitudes than at low altitudes. The annual dose from cosmic radiation varies among the states from about 0.03 rem in Hawaii to 0.13 rem in Wyoming.

The annual dose from materials existing naturally in the ground also varies among the states, ranging from about 0.03 rem in Texas to about 0.115 rem in South Dakota.

Background radiation levels also are higher in certain local areas because some common materials are radioactive. For example, the potential annual dose from working 8 hours a day near a granite wall at the Redcap Stand in Grand Central Station, New York City, is 0.2 rem. A dose of 1 rem may be received in some areas on the beach at Guarapari, Brazil, in only about 9 days because the sand in that region is naturally radioactive.

MAN-MADE RADIATION

Individuals also receive radiation doses as a result of the use of man-made radiation and radioactive materials for various purposes. Such doses result from additional exposures to exactly the same kinds of radiation found in nature. Many people are exposed to radiation for medical reasons, for example. In 1970, an estimated 212 million x-ray examinations were performed in the United States. The dose to the skin from one chest x-ray is usually in the range of 0.03 to 0.05 rem, and the average dose to the skin from an abdominal x-ray is about 0.6 rem. X-rays are also used extensively, of course, for dental examinations. The radiation dose to the skin from one dental x-ray is about 1 rem. In all, radiation used for the purpose of medical diagnosis accounts for about 90 percent of the total man-made annual radiation dose received by the population of the United States.

Much of the man-made radioactive material is subject to the control of the U.S. Nuclear Regulatory Commission (NRC), which licenses individuals to use radioactive materials for purposes such as producing electrical power, controlling the rate of heart beat (pacemakers), and other medical and industrial uses. Other sources of man-made radiation, such as nuclear weapons testing, radar, x-ray, and TV sets, are not subject to NRC's control.

To protect the public health, the Commission requires that its individual licensees meet certain standards for the control of radiation. The reason for these requirements is that radiation, like many things, can be harmful. A large dose to the whole body received in a short period of

time (such as about 400 rems in one day) would probably cause death within several weeks to about half of the persons so exposed, but such large doses can result only from rare accidents.

Control of exposure to radiation is based on the assumption that any exposure, no matter how small, involves some risk. The exposure limits are set so low, however, that medical evidence gathered over the past 50 years indicates that the actual health effects due to exposure to radiation when the doses are within the established limits will usually be so low that they will not be distinguishable from natural occurrences of ill health in the population. The risk to individuals at the current exposure levels is considered to be very low. However, it is impossible to say that the risk is zero. To decrease the risk still further, NRC licensees are expected to keep actual doses as far below the limits as is reasonably achievable.

HISTORY OF CURRENT STANDARDS

In the past, radiation dose limits were based on recommendations of two groups, the International Commission on Radiological Protection (ICRP) and the National Council on Radiation Protection and Measurements (NCRP). Both include in their memberships recognized experts in science and medicine.

The ICRP's recommendations on radiation protection have been widely adopted and form the basis for radiation protection practices throughout the world. In the United States, the NCRP, which is federally chartered, provides recommendations for interested industries and federal and state agencies.

The first recommended radiation exposure limits were offered in 1925, when scientists suggested limiting exposures of radiation workers to 0.5 roentgen per week from x-rays. (A "roentgen" is a unit of measure similar to a rem but used only for x- or gamma radiation.) In 1934 the ICRP recommended a maximum of 1 roentgen per week and the NCRP 0.5 per week, in 1949-50 the two groups recommended 0.3 rem per week, and in 1956-57 they recommended 5 rems per year. This latter recommendation still stands as the basis of today's occupational limit. All of these recommended dose limits were in addition to radiation doses from natural background and medical sources.

In 1959, with atmospheric weapons testing underway and with the growing use of nuclear energy under the Atoms for Peace program, President Eisenhower established the Federal Radiation Council (FRC) to provide guidance with respect to all radiation matters directly or indirectly affecting health, including guidance for all Federal agencies in the formulation of radiation standards for protection of humans from radiation. When the Environmental Protection Agency (EPA) was formed in 1970, this responsibility was transferred to that agency. In addition, the responsibility for establishing generally applicable environmental radiation standards for uses of man-made radioactive materials regulated under the Atomic Energy Act also was transferred to EPA. The NRC has responsibility for implementing and enforcing these standards.

A principal feature of the FRC guidance was the definition of Radiation Protection Guides and Radiation Concentration Guides which are similar to the previously discussed radiation limits. These guides establish maximum values for annual radiation doses and concentrations of radioactive material in the environment, and the FRC, with the approval of the President, has stated that these limits should not be exceeded without careful consideration of the reasons for doing so. The FRC also provided guidance concerning the surveillance and control actions that should be undertaken if radiation levels in the environment became such that individuals could receive more than a certain fraction of the Radiation Protection Guides.

In addition, the FRC, as well as the NCRP and ICRP, recommended several further limitations, including: (1) that no single source of man-made radiation should be allowed to consume the total dose limits and (2) that all exposures to radiation should be kept as far below the recommended limits as is reasonably achievable.

Federal agencies such as the Nuclear Regulatory Commission are responsible for ensuring that licensees under their regulatory control keep radiation levels as low as is reasonably achievable and within the limits recommended by FRC and any generally applicable environmental standards established by EPA.

CURRENT STANDARDS

The following Federal standards currently apply to all sources of man-made radiation except those used for medical purposes:

Category	Dose Limit
Workers in nuclear industry--	
Any 13-week period	3 rems
Lifetime	5 rems times number of years beyond age 18
Individuals who are not radiation workers--in 1 year	0.5 rem
Average population exposure-- in 30 years	5 rems

As a practical matter, the annual dose limit for radiation workers is 5 rems and the annual dose limit for the population is 0.17 rem.

Note that the limit set for an individual in the general population is only one-tenth of that allowed for an individual radiation worker. Moreover, the limit for the general population as a whole is only about one-third of that for individual members of the population. Thus, the standards for the population as a whole are some 30 times more strict than the standards for workers in the nuclear industry.

The above standards were recommended by the FRC and approved by the President and are reflected in NRC's regulations. The current standards also include recommended limits for radiation exposures to individual parts of the body, such as hands and feet, skin, bone, and the lung. In general, these limits are higher than those for the body as a whole.

The NCRP and ICRP also have recommended derived limits related to the dose standards for concentrations of specific radioactive materials in air and water. These limits reflect the physical and chemical nature of the materials and are included in the NRC's regulations.

IMPLEMENTATION OF STANDARDS

Initial responsibility for licensing and regulating nuclear facilities and for implementing Federal radiation standards for workers in the nuclear industry was assigned to the former Atomic Energy Commission. The NRC assumed this responsibility under the Energy Reorganization Act of 1974. The Federal radiation guides and guidance established by FRC are included, therefore, in the NRC's regulations. To implement the guides, NRC has set limits (1) on radiation at the site boundary, (2) on the routine release of radioactive materials from nuclear facilities, and (3) on the dose to workers inside licensed facilities. These limits are based on the Radiation Protection Guide dose limits for radiation workers and for the population and on information about the behavior of radioactive materials in the environment.

To implement the guidance, operators of nuclear facilities licensed by NRC are required to keep releases of radioactive material in effluents as far below the recommended guides as is reasonably achievable. Under NRC regulations, radiation levels in the area surrounding a nuclear power plant are expected to be only a few percent of the natural background level. Specifically, licensees are required to:

(1) Restrict the amount of radioactive material released in liquid effluents from any light-water-cooled nuclear power reactor to levels that would keep the annual dose to an individual in an unrestricted area to not more than 0.003 rem for the whole body and not more than 0.010 rem to any organ.

(2) Restrict releases of radioactive material in gaseous effluents from any light-water-cooled power reactor to keep annual doses to an individual in an unrestricted area to a maximum of 0.005 rem to the whole body and not more than 0.015 rem to the skin.

(3) Restrict the releases of radioactive iodine and other radioactive material in particulate form from any light-water-cooled power reactor to keep annual doses to the thyroid of an individual in an unrestricted area to no more than 0.015 rem.

The NRC has also set an interim dollar value to be used in cost-benefit evaluations to determine, on a case-by-case basis, if reducing doses to the population even further is reasonably achievable. That interim value is $1,000 per total body "man-rem" of dose reduction below the design objectives. (The man-rem is a measure of dose to radiation of large numbers of people; for example, 100 people receiving an average dose of 0.01 rem, or 1,000 people receiving an average dose of 0.001 rem -- each would result in one man-rem.) Thus, if spending $1,000 on extra equipment would result in 1,000 people within 50 miles of a nuclear plant receiving an average of 0.001 rem less radiation dose, licensees would be required to install the extra equipment. Conversely, if an expenditure of $2,000 would be needed to achieve the lower radiation dose, licensees would not be required to install the extra equipment.

In addition to these controls on exposures of the general population, the NRC requires its licensees to conduct a comprehensive monitoring program within nuclear facilities and the surrounding area controlled by the licensees to ensure that occupational dose limits for individual workers are not exceeded. This program includes requiring employees who work in radiation areas to wear instruments to measure the amount of radiation that they receive; keeping records of such exposures; measuring the radiation levels within the facility and allowing employees to spend only a limited amount of time in areas having high radiation levels; and, in major facilities, employing a professional health physicist to advise the licensee and employees on radiation protection matters.

#

April 1976

In January 1977 the EPA enacted a regulation which by the end of 1979 will limit the annual radiation dose to any member of the public from the normal operation of licensed uranium fuel cycle facilities* to the following values:

whole body dose--	0.025 rem
thyroid--	0.075 rem
any other organ--	0.025 rem

Further, the releases of krypton-85, iodine-129 and plutonium-232 will be limited to selected values by 1983. These limits are applicable only to the United States.

*Uranium fuel cycle facilities, as used here, means the operations of milling of uranium ore, chemical conversion of uranium, isotopic enrichment of uranium, fabrication of uranium fuel, generation of electricity by a light-water-cooled nuclear power plant and reprocessing of the fuel.

August 30, 1979

424 Laurel Drive
Hershey, PA 17033

Mr. Joseph M. Hendrie
Chairman
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Hendrie:

I note with much apprehension, that the NRC has recommended licensing of the Berwick Nuclear Plant on the Susquehanna River. You reassure us that "no significant environmental impacts are anticipated from normal operational releases of radioactive materials."

I find this statement to be both arrogant and misleading to the public. First, please define for me what "significant" means. Any low level radiation releases are significant as has been admitted and proven, even by the old AEC and the NRC's own studies. There is no safe level of radiation exposure. How can you say then that releases are of "no significance?"

Secondly, you "anticipate" no environmental impacts. May I remind you that Three Mile Island was not "anticipated" or planned for either. Where man is involved, there will never be a safe nuclear power plant. The nuclear way is an unforgiving way. Once the unanticipated happens, it stays with us for generations.

Thirdly, it is time to tell the public the truth regarding the "normal operational releases" from nuclear plants. How much "normal" radiation will be or is projected to be released by the Berwick plant, how much "normal" radiation is currently being released by the operating plants in this country, and who sets these, and how are these "normal" release ceiling levels set?

The current standards were initially set in order to justify atomic bomb testing. Those standards were kept in order to justify nuclear power plants because the nuclear industry and our government recognizes that no plant operates without "normal" releases of radiation.

Recognizing that the AEC, NRC, and other scientific studies have proven that there is no safe level of radiation exposure, negates the "normal" release standards currently used. Normal may be normal for a nuclear plant, but not for a clean environment and certainly not for the health and safety of the public.

Moreover, the boiling reactor cores at the Berwick plant are untried and unproven as to their overall safety and functioning. It does not matter how remote an accident of any kind may be, a chance is still there, especially with a new design. It only takes one accident to release dangerous radiation. The safety equipment and men at the Berwick plant are untried and unproven just as they were at TMI.

Lastly, let us use honest, straightforward language and tell the truth. "The temporary loss of habitat may have significant adverse impacts on the aquatic community in the vicinity of the site," really means that it would kill all fish and wildlife currently living near the site.

In summary, the Berwick plant is another threat to the Susquehanna River Valley, an added burden and danger not needed by the people of Central Pennsylvania. The plant, as a nuclear facility, should not be licensed and operated. It is not safe to the normal environment of the people in Central Pennsylvania.

It is incumbent on the NRC in its charge "to protect the health and safety of the public" to tell us the truth about the Berwick plant and the other nuclear power plants. Please inform me in whatever scientific or non-scientific terms you wish:

1. What is your definition of <u>significant</u>, and how was it arrived at?

2. On what basis do you calculate the "<u>anticipated</u>" occurrences? The Rasmussen Report has already been proven to be incorrect.

3. How do you define "normal"? Normal operational levels of radiation emission are quite different and separate from normal background levels of radiation already existing in the environment. Also, because of bomb testing and power plants the "normal" levels of background radiation have increased over the past 30 years.

4. What individuals, by name, set these "normal" levels?

5. How much "normal" radiation will be expected to be released in Berwick?

6. What are the NRC's recorded, documented levels of "normal" radiation releases from the operating plants in the United States?

Thank you for your anticipated prompt response to the above.

Sincerely,

Warren L. Prelesnik

cc: Richard T. Kennedy, Commissioner
John F. Ahearne, Commissioner
Peter A. Bradford, Commissioner
Victor Gilinsky, Commissioner
Richard S. Schweiker
H. John Heinz, III
Allen E. Ertel
George W. Gekas
Rudolph Dininni
Stephen R. Reed
Pennsylvania Power & Light