BEFORE THE
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

DOCKET NO. _____

IN RE ENVIRONMENTAL RADIATION
PROTECTION STANDARDS FOR NUCLEAR POWER
OPERATIONS, 40 C.F.R. 190

AMERICAN MINING CONGRESS' PETITION FOR RECONSIDERATION AND REVISION

Edward A. McCabe, Esquire
Anthony J. Thompson, Esquire
HAMEL, PARK, McCABE & SAUNDERS
1776 F Street, N. W.
Washington, D. C. 20006

Attorneys for the
American Mining Congress,
Uranium Environmental Subcommittee
(202) 785-1234

Of Counsel:

Larry A. Boggs, Esquire
American Mining Congress
Suite 300
1920 N Street, N. W.
Washington, D. C. 20036
(202) 861-2800

TABLE OF CONTENTS

TABLE OF CONTENTS - Cont'd

BEFORE THE
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

DOCKET NO. ____

IN RE ENVIRONMENTAL RADIATION
PROTECTION STANDARDS FOR NUCLEAR POWER
OPERATIONS, 40 C.F.R. 190

AMERICAN MINING CONGRESS' PETITION
FOR RECONSIDERATION AND REVISION

REQUEST FOR RELIEF

Pursuant to Section 4(e) of the Administrative Procedure Act (APA), 5.U.S.C. 553(e), the American Mining Congress (AMC) petitions the Environmental Protection Agency (EPA) to reconsider and revise, in part, the environmental radiation protection standards for nuclear power operations contained in 40 CFR 190. Specifically, AMC requests that EPA formally reopen rulemaking proceedings, reexamine the radiation protection standards as they pertain to uranium mills; and develop, through a process that includes public hearings, 1/ more realistic, more explicitly defined, and cost-effective standards for uranium mills. Further, AMC requests EPA to stay the effective date of the regulations as they pertain to uranium milling operations (presently December 1, 1980) pending reconsideration and revision of the standards.

1/ Hearings in this continuing proceeding are proper in light of Section 189(a) of the Atomic Energy Act, 42 U.S.C. 2239(a), which provides that "[i]n any proceeding under this chapter *** for the issuance or modification of rules and regulations dealing with the activities of licensees, *** the [Atomic Energy] Commission [EPA's predecessor agency with respect to radiation protection standards] shall grant a hearing upon the request of any person whose interest may be affected by the proceeding ***." [Emphasis added.] See Note 18, infra, at 35.

I.

INTRODUCTION AND SUMMARY

A. AMC's RIGHT TO RECONSIDERATION

AMC is an association of over 500 companies that represents the producers of most of America's metals, coal, industrial and agricultural minerals, and the manufacturers of mining and mineral processing machinery, equipment and supplies, including the major producers and processors of uranium. AMC actively participated in the rulemaking process that resulted in the existing 40 CFR 190 standards. AMC is entitled to a reconsideration of this regulation as a matter of law. Section 4(e) of the APA, 5 U.S.C. 553(e), expressly states: "Each agency shall give an interested person the right to petition for the issuance, amendment, or repeal of a rule." 2/ Under this provision of law, and in view of important new information developed since the promulgation of 40 CFR 190, EPA must reconsider its regulation. Geller v. FCC, 610 F.2d 973, 977-979 (D.C. Cir. 1979); Investment Company Institute v. Board of Governors, 551 F.2d 1270, 1280-1282 (D.C. Cir. 1977); Oljato Chapter of Navajo Tribe v. Train, 515 F.2d 654, 665-668 (D.C. Cir. 1975); Functional Music, Inc. v. FCC, 274 F.2d 543 (D.C. Cir.) cert.denied, 361 U.S. 813 (1959). Moreover, this right is implicit in Section 189(a) of the Atomic Energy Act (AEA), 42 U.S.C. 2239(a), which provides for a right to a hearing in any proceedings "for the issuance or modification of rules and regulations dealing with the activities of licensees." In any event, 10 CFR 2.801 (1979) specifically states that rulemaking may be initiated "on the petition of any . . . interested person." See Note 18, infra, at 35.

The AMC, as a party to the rulemaking proceedings, and as an association with member companies that are directly affected by the standards established in 40 CFR

2/ This request for reconsideration and revision is also an exercise of AMC's right to petition for redress of grievances guaranteed by the First Amendment to the United States Constitution. See California Motor Trans. Co. v. Trucking Unlimited, 404 U.S. 508, 510-511 (1972).

190, is an "interested person" within the meaning of Section 4(e) of the APA and 10 CFR 2.801. See Warth v. Seldin 422 U.S. 490, 511(1975); Hunt v. Washington Apple Advertising Commission, 432 U.S. 333, 343 (1977).

The right to reconsideration is reinforced by EPA's actions and statements during the rulemaking proceedings. In promulgating 40 CFR 190, EPA recognized that the radiation protection standards were tentative and subject to future reconsideration and revision (40 Fed. Reg. 23420, Appendix B-1).3/ In discussing the final standards, EPA stated:

> . . . that the Agency has previously (40 FR 23420) made public its intent to maintain a continuing review of the appropriateness of these environmental [radiation] standards * * * and to revise them, if necessary, on the basis of information that develops in the interval . . . . We will, of course, welcome the submission of additional factual data on the matters concerned as it becomes available. (42 Fed. Reg. 2858 n.1, Appendix B-2).

This commitment was made because EPA recognized that sufficient data to prove or disprove the underlying principles of the regulation were not then available and because the environmental models used to develop the standards were not then well-defined (40 Fed. Reg. 23420-23421, Appendix B-1). In view of the existence of new data, including newly developed dispersion and dosimetry codes, which are fully discussed in the body of this petition, EPA must now honor that commitment.

B. THE REGULATORY BACKGROUND

At the time 40 CFR 190 was promulgated in January 1977, the only express authority to issue radiation standards for protection of the general public was stated in Section 161(b) of the AEA, 42 U.S.C. 2201(b). That section authorized the Atomic Energy Commission (AEC) to "establish by rule, regulation or order, such standards *** to govern the possession and use of special nuclear material, source material, and byproduct material as the Commission may deem necessary [or] desirable *** to protect health or to minimize danger to life or property." Under this authority, the AEC had

3/ Appendices referred to herein include: Appendix A which contains new information and Appendix B which contains pertinent portions of the existing record.

established radiation standards for unrestricted areas, i.e., areas not covered by an applicable license. This standard limited individual annual whole body exposure to 500 millirems (10 CFR 20.105).

Under Reorganization Plan No. 3 of 1970, 84 Stat. 2086, 42 U.S.C.A. 4321 note, the newly created EPA assumed "the functions of the Atomic Energy Commission under the Atomic Energy Act of 1954, as amended, *** to the extent that such functions of the Commission consist of establishing generally applicable environmental standards for the protection of the general environment from radioactive material." 84 Stat. at 2088. Standards as used in this context were defined to mean "limits on radiation exposures or levels, or concentrations or quantities of radioactive material, in the general environment outside the boundaries of locations under the control of persons possessing or using radioactive material [i.e., in unrestricted areas]." Id.

Under this authority, EPA soon thereafter prepared a draft radiation protection regulation for the nuclear fuel cycle. This proposal had different standards for different segments of the nuclear fuel cycle. For example, more stringent limitations were placed on reactors than on mills. (Draft Proposed Rules, Environmental Protection Requirements For Normal Operations of Activities in the Uranium Fuel Cycle, Appendix B-3 at 7). The AEC asserted, however, that this use of EPA's authority was inconsistent with Reorganization Plan No. 3. The AEC contended that EPA's authority was limited to issuing ambient standards generally applicable to all fuel cycle operations (Memorandum of October 19, 1973, to the President from AEC Chairman, Dixy Lee Ray, Appendix B-4 at 1-2). "Since effluents, controls and their costs differ for different classes of activity," EPA responded that "standards [must] necessarily vary for different classes in the fuel cycle." (Memorandum of October 19, 1973 to the President from EPA Administrator, Russel E. Train, Appendix B-5 at 1-2.) By memorandum of December 7, 1973 (Appendix B-6 at 2), Roy L. Ash, Director of the Office of Management and Budget, for the President determined:

> ...that EPA should continue, under its current authority, to have responsibility for setting standards for the total amount of radiation in the general environment from all facilities combined in the uranium fuel cycle, i.e., an ambient standard which would have to reflect AEC's findings as to the practicability of emission controls.

Thereafter, on May 29, 1975, EPA published new proposed environmental radiation protection standards for nuclear power operations (40 Fed. Reg. 23420-23425, Appendix B-1). Simultaneously, EPA issued a draft environmental impact statement (DEIS) on this proposal as required by Section 102 of the National Environmental Policy Act (NEPA), 42 U.S.C. 4332. On July 28, 1975, and September 15, 1975, AMC submitted comments on the proposed standards. At hearings held by EPA on March 8-10, 1976, the comments of AMC's scheduled witness, Dr. Robley D. Evans, were submitted for the record.

At these same hearings the Nuclear Regulatory Commission (NRC) 4/ testified extensively on the proposed regulation. Essentially, NRC asserted that (1) EPA had incorrectly assessed radioactive effluent control technology and the practicability of compliance with the proposed standards; (2) the proposed standards would be impracticable to implement for technical and economic reasons for major components of the uranium fuel cycle, notably mills; and (3) that it would be impossible to demonstrate compliance at the low levels specified in the standards using environmental monitoring.

On January 13, 1977, EPA promulgated the final standards (42 Fed. Reg. 2858-2861, Appendix B-2). The regulation as promulgated was revised in minor respects from the May, 1975, proposal; however, the basic exposure standards (25 millirems to the whole body and to all internal organs other than the thyroid, which was set at 75

4/ The AEC was abolished by the Act of October 11, 1974, P.L. 88-438, 88 Stat. 1237, 42 U.S.C. 5814(a). The newly created NRC assumed "all the licensing and related regulatory functions of the Atomic Energy Commission ***." 42 U.S.C. 5841(f).

millirems) were unchanged. 5/ Recognizing that mills presented some "unique" problems, the effective date of the 25 millrem standard for uranium milling operations was deferred four years until December 1, 1980. At the same time, EPA issued its final environmental impact statement (FEIS).

Purportedly, the regulation changed the primary focus of the radiological protection of the public from nuclear power industry operations from limitations on dose to the maximally exposed individual to limitations on dose to the total population (40 Fed. Reg. 23420, Appendix B-1). Furthermore, EPA ostensibly established the 25 millirem standard of 40 CFR 190 on a "cost-effectiveness" basis, because this approach was "best designed to strike a balance between the need to reduce health risks to the general population and the need for nuclear power" (40 Fed. Reg. 23421, Appendix B-1). Allegedly, EPA looked at the practicability of controls; the development, operating experience and cost of control technology; and basic radiological health and risk assessment assumptions. On this basis, EPA concluded:

> Such an examination made it possible to propose the standards at levels consistent with the capabilities of control technology and at a cost judged by the Agency to be acceptable to society, as well as reasonable for the risk reduction achieved. Thus, the standards generally represent the lowest radiation levels at which the Agency has determined that the costs of control are justified by the reduction in health risk. Id. [Emphasis added].

This alleged adherence to cost-effectiveness in promulgating 40 CFR 190 was based on EPA's realization that it:

> ...cannot and should not set [radiation protection] standards without such consideration for two reasons: 1) [because] it is prudent to assume that there is no threshold level for radiation effects in setting standards, that is, risk is proportional to dose all the way down to zero dose. Since there is no safe level of radiation [exposure], there is no logical way to set radiation standards other than to balance risks against costs of control; and 2) the nuclear industry is too important to the nation's future power supply to ignore cost and technology considerations. (Train Memorandum, supra, Appendix B-5 at 1-2). [Emphasis added.]

5/ For convenience, the radiation protection standards are hereinafter referred to collectively as the "25 millirem standard."

Notwithstanding this recognition of a need for cost-effective and realistic standards, EPA failed to follow through with this "logical" approach in promulgating 40 CFR 190 and failed to develop evidence to support the approach it ultimately adopted.

C. BASIS FOR REQUESTED RELIEF

As is more fully developed hereafter, three considerations warrant reconsideration and revision of the 25 millirem standard of 40 CFR 190.

First, relevant developments have occurred since the promulgation in January 1977 of 40 CFR 190 that render this regulation unreasonably burdensome on the uranium milling industry. These developments include: EPA's new model mill which differs from the model used to develop the existing standards (EPA Radiological Impact Caused by Emissions of Radionuclides into Air in the United States, hereafter RI 1979); new dispersion and dosimetry codes (AIRDOS-EPA and NRC-MILDOS); new dose conversion factors (Killough et al. 1979); new health effects conversion factors (ICRP 26 1977 and BEIR III 1980); and new cost data for source term controls (NRC GEIS and industry surveys). These new developments establish that the 40 CFR 190 radiation protection standards are neither practicable nor cost-effective.

Second, even EPA has recognized that the health effects of particulate emissions from uranium milling are "quite small" (40 Fed. Reg. 23421, Appendix B-1). Moreover, it is beyond dispute that the relative risk of uranium milling, even to the maximally exposed individual, is small when compared with other risks of every day life. In these circumstances, the stringent standard for mills, which for whole body dose is radically reduced from 500 millirems 6/ to 25 millirems per year, should be reconsidered in light of the recent decision involving benzene. Industrial Union Department, AFL-CIO v. American Petroleum Institute, _____ U.S. _____, 65 L. Ed.2d 1010 (1980) (hereinafter, Benzene).

6/ See 10 CFR 20.105

Third, the 25 millirem standard as applied to uranium mills should be reconsidered in view of serious inadequacies in the existing administrative record for 40 CFR 190. For example, no explanation of the basis for the 25 millirem standard is given. Why this number is chosen — rather than 50 or 500 — is a mystery. In view of this, and other deficiencies which are detailed below, the 25 millirem standard cannot stand. National Lime Ass'n v. EPA, No. 78-1385 (D. C. Cir. May 19, 1980) (hereinafter, National Lime).

In summary, when the new information and the inadequacies of the administrative record are considered together in light of recent judicial precedent, EPA failed to fulfill its rulemaking responsibility to set a standard that is appropriate for the milling segment of the uranium fuel cycle. Being neither practicable nor cost-effective, 40 CFR 190 as applied to uranium milling is "arbitrary, capricious, an abuse of discretion and otherwise not in accordance with law." 5 U.S.C. 706(2)(A).

II.

REASONS FOR GRANTING THE PETITION

A. THE RADIATION PROTECTION STANDARDS, AS APPLIED TO THE MILLING SEGMENT OF NUCLEAR FUEL OPERATIONS, ARE NOT BASED ON COST-EFFECTIVENESS ANALYSIS AND ARE IMPROPER

1. Elements of Cost-Effectiveness Analysis

Cost-effectiveness analysis is one of a number of of approaches that have been accepted for the balancing of risks and benefits in the development appropriate controls to avert potential environmental effects of a particular industrial activity. The elements of cost-effectiveness analysis, as used in this rulemaking proceedings, are as follows. A hypothetical model is developed that is representative of the facilities that will be regulated. Based on this model, the maximum environmental effect of the regulated activity is quantified at a level of control which is assumed to be the current level of control for the facilities. 7/ Next, the cost and efficiency of additional control technologies are determined. Using the model, control technologies are then applied to reduce environmental effects in order of cost-effectiveness, beginning with the technology with the lowest cost per effect averted. Finally, the resulting incremental costs of averting environmental effects are judged against a predetermined acceptable societal cost. Through this mechanism a cost-effective control standard can be set.

2. Legal Requirements for Application of Cost-effectiveness Analysis in Setting Radiation Protection Standards

At a minimum, cost-effectiveness analysis or some other form of risk-benefit balancing must be applied in establishing the radiation protection standards of 40 CFR 190.

First, the duty to conduct cost-effectiveness analysis is imposed, in this instance, by the APA's requirement for reasoned rulemaking. See National Lime, supra, at 73.

7/ In the case of radiological sources, the environmental effects are health effects.

This follows from EPA's reliance on the linear non-threshold theory. 8/ In EPA's own words, by relying on this theory, "there is no logical way to set radiation standards other than to balance risks against costs of control ***" (Train Memorandum, supra, Appendix B-5 at 1-2). This was reaffirmed by EPA in the FEIS:

> It would be irresponsible to set standards that impose unnecessary health risks on the public (unnecessary in the sense that exposures permitted by the standards can be avoided at a small or reasonable cost to the industry), and it would be equally irresponsible to set standards that impose unreasonable costs on the industry (unreasonable in the sense that control costs imposed by the standards provide little or no health benefit to the public). (FEIS at 21).

Second, this requirement is implicit in the mandate of the AEA under which the standards have been promulgated. Section 1 of the AEA (Declaration) expressly states that the policy of the United States is:

> a. [T]he development, use, and control of atomic energy shall be directed so as to make the maximum contribution to the general welfare, subject at all times to the paramount objective of making the maximum contribution to the common defense and security; and
>
> b. [T]he development, use, and control of atomic energy shall be directed so as to promote world peace, improve the general welfare, increase the standard of living, and strengthen free competition in private enterprise. 42 U.S.C. 2011 [Emphasis added].

In Section 2(a) of that Act (Findings), Congress found that: "The development, utilization, and control of atomic energy for military and for all other purposes are vital to the common defense and security." 42 U.S.C. 2012(a) [Emphasis added]. In Section 3(f) (Purpose), Congress declared that the administration of the Act "will be consistent with the foregoing policies *** ." 42 U.S.C. 2013(f) [Emphasis added].

These provisions explicitly adopt a policy of promoting the development of atomic energy. Accordingly, any environmental regulation developed by EPA under Section 161(b) of the AEA, 42 U.S.C. 2201(b), must be based on a process that balances the benefits of developing nuclear energy with the need for appropriate environmental safeguards. Cost-effectiveness analysis is such a process.

8/ AMC does not endorse the validity of the linear non-threshold theory. AMC asserts only, consistent with EPA's own statements, that if this theory is used in developing standards, a cost-effectiveness approach must be employed. See Appendix B-9 at 12-4, 12-5, quoted, infra, at 42.

Third, use of cost-effectiveness analysis in setting radiation protection standards is supported by the National Environmental Policy Act (NEPA), 42 U.S.C. 4321 et seq. Section 101(a) sets forth the NEPA's basic substantive policy that the government:

> [U]se all practicable means and measures, including financial and technical assistance, in a manner calculated to foster and promote the general welfare, to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans. 42 U.S.C. Section 4331(a) [Emphasis added].

Section 101(b) also states that "it is the continuing responsibility of the Federal Government to use all practicable means, consistent with other essential considerations of national policy," to the end that the Nation may:

* * *

> (2) assure for all Americans safe, healthful, productive, and esthetically and culturally pleasing surroundings;
>
> (3) attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable or unintended consequences;
>
> * * *
>
> (5) achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities. 42 U.S.C. Section 4331(b) [Emphasis added].

Under these provisions, Congress clearly recognized, as a general matter, that environmental considerations should be balanced against costs of environmental controls. Calvert Cliffs' Coordinating Committee v. United States Atomic Energy Commission, 449 F.2d 1109, 1112-1113 (D.C. Cir. 1971). 9/

9/ See EPA Office of Radiation Programs, Staff Report, "Considerations Relative to Setting Environmental Radiation Standards and Criteria" (November 10, 1971, as revised December 1, 1971), which states:

"Implementation of the Calvert Cliffs decision regarding the application of the National Environmental Protection Act (NEPA) has introduced a very major change in the information required in Environmental Impact Statements. In particular, the requirements to evaluate the consequences of potential accidents leading to release of radioactive materials and quantitative benefit-risk/cost assessment on a facility-by-facility basis are important new requirements." (Appendix B-7 at 6).

In view of these provisions of law, and EPA's stated intent to use cost-effectiveness analysis as the balancing method, radiation protection standards which are not cost-effective are arbitrary, capricious, an abuse of discretion, and not in accordance with law.

3. EPA's Purported Compliance with the Required Cost-Effectiveness Analysis

Purportedly, EPA conducted cos -effectiveness analysis as the approach to risk-benefit balancing in establishing the radiation protection standards of 40 CFR 190. The FEIS considers the various elements of cost-effectiveness analysis, relying on EPA's 1973 "Environmental Analysis of the Uranium Fuel Cycle" (FCA 1973) and its "Environmental Analysis of the Uranium Fuel Cycle, Part IV - Supplementary Analysis - 1976" (FCA 1976).

In applying cost-effectiveness analysis to uranium milling, EPA used a hypothetical model n ill located in Wyoming. Releases of airborne radionuclides were assumed to be 0.22 curies per year (Ci/yr) based on published estimates (FCA 1973 at 24-27). Potential health effects for these releases were estimated using a simple Gaussian dispersion model to determine airborne radionuclide concentrations (FCA 1973 at A-2). Radionuclide concentrations were converted to doses to humans using dose conversion factors derived from ICRP Publication 2 (1959) and a report of the United Nations' Scientific Committee on the Effects of Atomic Radiation (UNSCEAR 1972) (FCA 1973 at A-1). Calculated health effects for these doses were based on the 1972 National Academy of Sciences' "Report on the Biological Effects of Ionizing Radiation" (BEIR I 1972) (FCA 1973 at A-1). Costs of control technologies were based on available literature and on EPA's own estimates (FCA 1973 at B-1). EPA's determination of an acceptable societal cost per health effect averted was $250,000-$500,000.

In its purported "cost-effectiveness" analysis, EPA committed two fundamental errors. First, EPA's data base was inadequate. The cost-effectiveness analysis in the

FEIS combined all of the components of the fuel cycle and applied a given control technology to a given fuel cycle component across the board in what was deemed the most cost-effective order. Only if the quality of the data (such as the source terms and the costs and efficiencies of control technologies) were equal for each of the components would the outcome be comparable to performing separate analyses on each of the individual components. The data were not. The FEIS itself illustrated the disparity in quality of data available for the various components of the nuclear fuel cycle (FEIS, Vol. I at 52-68). 10/

Second, contrary to its basic commitment and the requirements of law, EPA ultimately rejected the results of the cost-effectiveness analysis when it set the 40 CFR 190 standards for mills. The FEIS states:

> Finally, although the primary consideration involved in developing these standards was reduction of the total potential health impact of radioactive effluents on large populations, doses to individuals must also be examined, since even though the total potential health impact may be at an acceptable level, extreme maldistribution of that impact may result in a few individuals receiving unreasonably high doses. A few such situations exist, for example, radioiodines from reactors and particulates from mills, where inequitably high dose levels may occur even after cost-effective control of total population impact has been achieved. Although the absolute risk to any given individual is quite small for these doses, which are generally below a few hundred millirems, EPA believes that such doses should also be minimized, especially when the individual at risk is not the direct recipient of the benefits of the activity producing them. In these cases, the approach to setting standards for maximum individual dose was to weigh the cost-effectiveness of individual dose reduction and the cost of control relative to total capital cost, in order to arrive at a judgment whether or not it was possible, at reasonable cost, to reduce these few individual exposures to the same general levels that are achievable for large populations for other sources of environmental radiation exposure from the uranium fuel cycle. (FEIS Vol. I at 26).

The effect of EPA's approach is to regulate uranium mills solely on the basis of the maximum dose to a given individual, an approach for which no cost-effectiveness, risk assessment or any other analysis was ever presented. Again, this is arbitrary, capricious, an abuse of discretion, and otherwise not in accordance with law.

10/ See Also Statement of Roger J. Mattson, Director, Division of Siting, Health & Safeguards, NRC (March 8, 1979) (Appendix B-8 at 8-9).

B. ANALYSIS OF THE NEW EVIDENCE SHOWS EPA'S 25 MILLIREM STANDARD IS UNREASONABLE

1. Dose Calculations Using New Evidence

In its 1976 estimation, EPA concluded uranium mills could meet the 25 millirem standared by using: (1) a wet impingement scrubber on the crusher and fine ore bins, (2) a high-energy venturi scrubber on the yellowcake drying stack, and (3) a clay core dam retention system for tailings. EPA estimated that the present value of this control level would be $290,000 for the 1976 model mill (FCA 1976, Table 9.0-1 at 35).

EPA's approach in developing the 25 millirem standard was based on available scientific information, which was even then admittedly ill-defined (40 Fed. Reg. 23420-23421, Appendix B-1). As AMC has indicated, a substantial body of new data and other evidence has been developed since the standard was promulgated in January, 1977. Applying this new evidence to the methodology used by EPA in developing 40 CFR 190, the 25 millirem standard is unreasonable for uranium mills. For example, EPA's new dispersion and dosimetry code apparently will predict violations of the 40 CFR 190 standards in many cases where the analytical method used in 1976 would not. Under these circumstances, the 40 CFR 190 record must be reopened and the standards reconsidered.

Table 1, infra, at 15, compares the results of analyzing the maximum individual dose for EPA's 1976 model mill using EPA's new AIRDOS-EPA dispersion and dosimetry computer program with EPA's 1976 dose estimates.[11/] It is evident from inspection of the Table that the new AIRDOS-EPA dispersion and dosimetry code has made a dramatic change in the calculated control level required to meet the 25 millrem standard

---

11/ It must be emphasized that these calculations are not intended to endorse the modeling approach to setting standards, these new models and codes, or the precise results of the calculations. AMC is presenting these calculations merely to demonstrate that the agency must reopen the record and reconsider the 40 CFR 190 standards for uranium mills.

TABLE 1
CALCULATED MAXIMUM DOSE TO INDIVIDUAL[1]
1976 MODEL MILL
MILLIREMS/YEAR

Controls[*]	Total Body	Red Marrow	Lung	Endosteal Tissue	Stomach	Lower Large Intestine	Thyroid	Liver	Kidneys	Testes	Ovaries
1. 1976 EPA Estimate[2]											
A1;B1	-	-	200	-	-	-	-	-	-	-	-
A1;B2	-	-	73	-	-	-	-	-	-	-	-
A1;B3	-	-	34	-	-	-	-	-	-	-	-
A2;B3[5]	-	-	**24[4]**	-	-	-	-	-	-	-	-
A2;B3;C2	-	-	15	-	-	-	-	-	-	-	-
A2;B4;C2	-	-	6	-	-	-	-	-	-	-	-
A3;B4;C2	-	-	1.5	-	-	-	-	-	-	-	-
A4;B4;C2	-	-	0.3	-	-	-	-	-	-	-	-
2. 1980 AIRDOS-EPA[4][5]											
A1;B1	99.4	104.6	224.3	1034.0	9.6	15.3	14.9	64.7	32.3	16.4	15.1
A1;B2	86.5	95.5	75.7	925.8	9.3	10.9	13.2	48.0	27.8	13.9	12.8
A1;B3	83.3	93.2	38.7	898.3	9.2	9.9	12.7	43.8	26.8	13.3	12.2
A2;B3	45.0	50.5	23.3	487.8	5.7	5.4	6.9	24.3	14.2	7.2	6.6
A2;B3;C2	19.61	21.68	16.92	208.83	2.83	2.48	3.00	10.65	6.45	3.16	2.91
A2;B4;C2	18.88	21.16	8.50	202.68	2.81	2.24	2.90	9.70	6.20	3.03	2.77
A2;B4;C2	4.53	5.04	2.73	48.48	0.50	0.55	0.69	2.37	1.49	0.73	0.67
A4;B4;C2	0.99	1.08	1.30	**10.48[3]**	0.10	0.13	0.15	0.57	0.33	0.16	0.15

(1) Dose calculations assume each control combination to include clay core dam retention system with seepage return (C1).
(2) Dispersion estimated by an average (χ Q) max. Lung was assumed to be as the critical organ and only lung dose was considered.
(3) Indicates the level of control needed to meet 25 millirem standard.
(4) Individual subjected to maximum dose as most recently assumed by EPA is a person living 500 meters from the source. For this analysis, as in prior EPA AIRDOS-II analyses, distances of 570 meters from the tailings and 503 meters from milling operations were selected for use. Emissions of radon and its daughters in gaseous form are not included. Radon daughters in tailings and generated following deposition and decay of airborne radionuclides are included. While AMC considers all radon daughters to be excluded under 40 CFR 190, the referenced radon daughters have been included in these calculations to make them consistent with EPA's interpretation of the standard.
(5) All AIRDOS-EPA based calculatons are from Appendix A-1.

(*) KEY

A. Gaseous (Crusher and Fine Ore Bins)
1.Orifice Scrubber
2.Wet Impingement Scrubber
3.Low Energy Venturi Scrubber
4.Bag Filters

B. Gaseous (Yellowcake Drying and Packaging)
1.Wet Impingement Scrubber
2.Low Energy Venturi Scrubber
3.High Energy Venturi Scrubber
4.High Energy Venturi Scrubber + HEPA Filters

C. Liquids, Solids, and Windblown Particulate Matter
1.Clay core Dam Retention System with Seepage Return
2.Chemical Control of Windblown Dust from Tailings Pond Beach

for the same model mill with the same source terms. The critical organ has shifted from the lung in 1976 to the endosteal tissue in 1980 with AIRDOS-EPA. The theoretical level of control required to meet the 25 millirem standard has increased to (1) a bag filter operating at 99.9% efficiency for the ore crusher, (2) a high-energy venturi scrubber with HEPA filters operating at greater than 99.9% efficiency for the yellowcake stack, (3) a clay core dam to reduce seepage, and (4) total suppression of particulates from tailings beaches by chemical stabilization. This control level is designated as A4, B4, C2 in Table 1 (supra, at 15). This theoretical control level, of course, assumes that the control efficiencies used by EPA can be routinely achieved in practice, which is questionable. This changed control level will triple the costs incurred to install the equipment at a new mill according to EPA's own estimates, and, the reconstruction that would be required at an existing mill would be even more expensive. On this basis alone the 25 millirem standard is unreasonable, and EPA should undertake a reconsideration of the standard.

2. Increased Control Costs Further Undermine the EPA Standard

The 1976 EPA estimate of the present value for the A4,B4,C2 control combination was $867,000 ($ 1974), nearly three times higher than the cost of the control combination EPA predicted would be sufficient to meet the 40 CFR 190 standard (FCA 1976, Table 9.0-1 at 35). The cost for uranium mill operators to comply with the 40 CFR 190 standard is substantially higher today, when recent cost information generated by AMC and NRC is applied and costs are presented in 1980 dollars. The 1980 cost of the necessary controls is almost $2 million (See Table 2 infra, at 17).

AMC has updated costs to control emissions from uranium mills using recently published literature and a survey of mill operators' experience (See Appendix A-4 for the details of the AMC cost survey). When compared to 1980 operating experience,

TABLE 2

COMPARISON OF EPA AND AMC CONTROL COST ESTIMATES (1)
FOR THE 1976 MODEL MILL
PRESENT VALUES

Controls(*)	1976 EPA ($ 1974)(1)	1976 EPA ($ 1980)(2)	1980 AMC ($ 1980)(3)
None	0	0	0
A_1; B_1	172,000	267,000	533,000(4)
A_1; B_2	172,000	267,000	533,000
A_1; B_3	262,000	407,000	865,000(5)
A_2; B_3	290,000	450,000	864,000
A_2; B_3; C_2	432,000	671,000	1,709,000
A_2; B_4; C_2	561,000	871,000	1,869,000
A_3; B_4; C_2	701,000	1,089,000	1,876,000
A_4; B_4; C_2	867,000	1,346,000	1,814,000

(1) Dose calculations assume each control combination to include clay core dam retention system with seepage return (C1); however, consistent with EPA's approach, costs of this control technology were not included in the control cost estimates.

(2) From FCA at 35.

(3) EPA 1974 dollars were adjusted to 1980 dollars using a factor of 1.553 (Chem. Eng. Plant Cost Index, 1980)

(4) Consistent with EPA's approach the value of recovered yellowcake has been accounted for by not including the cost of B_1 or B_2 in the cost estimates.

(5) Cost of A_1 not available from AMC survey; value used is from NRC's GEIS with adjustment for control capacity.

(6) Costs of A_3,B_2 and B_4 based on Sears et al., 1975.

(*) KEY

A. Gaseous (Crusher and Fine Ore Bins)
1.Orifice Scrubber
2.Wet Impingement Scrubber
3.Low Energy Venturi Scrubber
4.Bag Filters

B. Gaseous (Yellowcake Drying and Packaging)
1.Wet Impingement Scrubber
2.Low Energy Venturi Scrubber
3.High Energy Venturi Scrubber
4.High Energy Venturi Scrubber
+ HEPA Filters

C. Liquids, Solids, and Windblown Particulate Matter
1.Clay core Dam Retention System with Seepage Return
2.Chemical Control of Windblown Dust from Tailings Pond Beach

the costs of several of the control technologies as estimated by EPA in 1976 are low even when the 1976 EPA estimates are adjusted to 1980 dollars.[12]/

For example in 1976, EPA calculated that the present value for chemical control of windblown dust from tailings pond beaches would be $142,000 ($1974) for the 1976 model mill. When converted to 1980 dollars, this represents an investment of $220,000. AMC survey results, however, show that a present value of $835,000 ($1980) is a more realistic estimate of the cost for this control technology. EPA estimated that the present values of a wet impingement scrubber (B1) and high energy venturi scrubber (B3) for the yellowcake drying and packaging area would be $107,000 and $300,000, respectively. AMC information indicates that the costs for these controls would really be $423,000 (B1) and $400,000 (B3) ($1980). Furthermore, EPA's 1976 analysis assumed that ore haul roads and ore storage areas inside the NRC-licensed area would not contribute to radionuclide emissions. The AMC survey results show that the costs to control airborne radionuclide emissions from these sources are significant for the model mill and have a total present value of $325,000 ($1980).

As indicated above, Table 2 (supra, at 17) compares 1976 EPA cost estimates for various levels of control for the model mill ($ 1980) with results of the AMC industry survey and recently published literature. The sequence of control combinations was selected by EPA because it was the most cost-effective for the dose reduction achieved. The irregular progression of AMC cost results from the sequence of control levels (A1, B1 through A4, B4, C2) suggests that this is no longer the most cost-effective order of control levels. Based on this analysis, EPA should re-examine its selection of controls for each incremental reduction in dose. In any event, it is apparent that the 1976 EPA estimates are low by a factor of two, even when they are updated to 1980 dollars. From the information presented above, it is obvious that the cost estimates

12/ EPA 1976 costs, which were in 1974 dollars, were adjusted to 1980 dollars by multiplying by a factor of 1.553 (Chem. Eng. Plant Cost Index, 1980).

performed by EPA in 1976 are inadequate and cannot be used, if a meaningful cost-effectiveness analysis is to be developed for the 40 CFR 190 standard. In the process of re-examining the standard, EPA should recalculate the costs of uranium mill emissions controls.

C. COST-EFFECTIVENESS CALCULATIONS USING NEW EVIDENCE

1. New Technical Data Significantly Change the Cost-Effectiveness of Control Technology at Mills

Since EPA conducted its environmental analysis of the uranium fuel cycle in 1973 and 1976, a significant amount of relevant scientific data has been developed, much of it by EPA itself. These new findings impact virtually every element necessary for cost-effectiveness analysis and have important implications with respect to the appropriateness of the existing radiation protection standards.

First, EPA recently reconsidered and revised the characteristics for a model uranium mill. This new model was developed as part of a study of airborne radionuclide emissions pursuant to Section 122 of the Clean Air Act, 42 U.S.C. 7401. Information on the new model has been published in a preliminary EPA report (RI 1979). The new model mill, which is located in the Grants uranium production belt in New Mexico, has particulate radionuclide emissions of 0.38 Ci/yr. Emissions from the mill itself are based on EPA's FCA 1976 which, in turn, is based on data reported by Oak Ridge National Laboratory in 1975 (ORNL 1975). 13/ Doses due to particulate emissions from mill tailings are also based on ORNL 1975.

Second, concentrations of airborne radionuclides reported in RI 1979 were calculated using a new dispersion and dosimetry code developed by EPA and designated AIRDOS II. This computer program represented a substantial change from the rudimentary approach employed in FCA 1976, but now it has been replaced by a new code. The new code is described in an Oak Ridge National Laboratory report entitled, "AIRDOS-EPA: A Computerized Methodology For Estimating Environmental Concentrations And Dose to Man from Airborne Releases of Radionuclides" (1979) (hereafter AIRDOS-EPA). As pointed out by Impact Limited in Appendix A-1, despite the improvements, even this code does not represent the state of the art.

13/ Sears et al., "Correlation of Radioactive Waste Treatment Costs and the Environmental Impact of Waste Effluents in the Nuclear Fuel Cycle for Use in Establishing 'As Low As Practible Guides' — Milling of Uranium Ores" (ORNL 1975).

Third, concentrations of radionuclides at various receptor distances from the source are now converted to doses in AIRDOS-EPA using a series of new dose conversion factors. These dose conversion factors are recommended in the AIRDOS-EPA documentation and were published in the fall of 1979 by Killough, et al. of Oak Ridge National Laboratory.[14]/

Fourth, the factors used to calculate the health effects resulting from a given dose based on the linear non-threshold hypothesis have also changed since EPA prepared its FEIS for 40 CFR 190. New scientific data on these factors was published in 1977 as "Recommendations of the International Commission on Radiological Protection" (ICRP 26). More recently, the BEIR Committee published a third report (BEIR III 1980), which further changes these health effects factors (See Report of Dr. G.H. Whipple, Appendix A-3). These recent studies indicate substantial differences exist from the data in BEIR I (1972) relied on by EPA in preparing its 1976 FEIS.

Fifth, the data currently available on control costs are of significantly higher quality than the literature survey and in-house estimates relied upon by EPA in its 1976 analysis. New data were published in NRC's 1979 draft Generic Environmental Impact Statement (GEIS) on uranium milling. In response to the GEIS the Atomic Industrial Forum also prepared a cost survey based on industry experience. In addition, AMC is making available the results of a recently completed industry cost survey, which was specifically directed to determining the costs for radionuclide particulate controls (AMC Cost Survey, Appendix A-4).

2. Results of AMC's Cost-Effectiveness Analysis

AMC carried out an analysis of EPA's 1976 model mill with EPA's AIRDOS-EPA dispersion and dosimetry code to examine the cost-effectiveness of the control technologies considered by EPA. Health effects conversion factors based on ICRP 26

14/ Killough, G.G., et al, Estimates of Internal Dose Equivalent to 22 Target Organs for Radionuclides Occurring in Routine Releases From Nuclear Fuel-Cycle Facilities (ORNL/NUREG/TM-190/Vol. 2) (Oak Ridge National Laboratory, 1979).

were used to predict health effects and risk factors for the regional population associated with the model mill. These are shown in Table 3 (infra, at 23).

Control technology costs were then determined for these various control technology levels by adjusting to 1980 dollars the cost data contained in FCA 1976. The adjusted costs are shown in Table 2 (supra, at 17).

Finally, these predicted health effects and risk factors are related to the corresponding control costs. That is, control costs associated with proceeding from one control level to the next level were compared to the incremental benefit in health risk reduction predicted for this increment of additional control. These figures are compared against EPA's cost-effectiveness criteria to determine which control level is cost-effective (see Table 4, infra, at 24). As is detailed in the following discussion, the results demonstrate that the 25 millirem standard is not cost-effective for uranium mills.

In its 1976 FEIS, EPA selected a cost-effectiveness cutoff level of $250,000 to $500,000 per health effect averted as appropriate, noting that this range of values found ample support in the literature. Table 4 shows the results of a 1980 cost-effectiveness analysis of the regional population associated with the 1976 model mill. All of the levels of cost-effectiveness (beyond the level designated A_1, B_2, which EPA indicated would pay for itself as a result of additional yellowcake recovery) far exceed the criteria. Further, since the calculated values range from $19 million to $1,202 million per health effect averted, adjusting the cutoff level for inflation will not affect the obvious conclusion: none of the controls are cost-effective for mills. The incremental cost per health effect averted to meet the 25 millirem standard using the level of control dictated by AIRDOS-EPA (A4, B4, C2) is over one billion dollars, a cost that EPA has described as "clearly [an] unreasonable burden upon society" (FEIS Vol. I at 136). Accordingly, 40 CFR 190 must be reconsidered and revised. 15/

15/ Analysis using the 1979 model mill (RI 1979) with its changed dosimetry assumptions indicates the same conclusion (See Appendix A-2 at 26, Table A).

TABLE 3

CALCULATED HEALTH EFFECTS
REGIONAL POPULATION(1)
1976 MODEL MILL - AIRDOS - EPA (2)

Controls(*)	Health effects Per Year (3)	Lifetime Health Effects(4)	Lifetime Risk per Million Persons
A1;B1	0.000298	0.00894	0.25
A1;B2	0.000226	0.00677	0.19
A1;B3	0.000208	0.00625	0.17
A2;B3	0.000133	0.00400	0.11
A2;B3;C2	0.0000507	0.00152	0.042
A2;B4;C2	0.0000421	0.00127	0.035
A3;B4;C2	0.0000094	0.000283	0.0078
A4;B4;C2	0.0000023	0.000069	0.0019

(1) Dose calculations assume each control combination to include clay core dam retention system with seepage return (C1).

(2) Calculations and methodology are detailed in Appendix A-1 and Appendix A-2.

(3) Lifetime risk of cancer as a result of a single-year's discharge from the model mill.

(4) Cumulative lifetime risk of cancer as a result of 30 years discharge from the model mill.

(*) KEY

A. Gaseous (Crusher and Fine Ore Bins)
   1. Orifice Scrubber
   2. Wet Impingement Scrubber
   3. Low Energy Venturi Scrubber
   4. Bag Filters

B. Gaseous (Yellowcake Drying and Packaging)
   1. Wet Impingement Scrubber
   2. Low Energy Venturi Scrubber
   3. High Energy Venturi Scrubber
   4. High Energy Venturi Scrubber + HEPA Filters

C. Liquids, Solids, and Windblown Particulate Matter
   1. Clay core Dam Retention System with Seepage Return
   2. Chemical Control of Windblown Dust from Tailings Pond Beach

TABLE 4

COST-EFFECTIVENESS[1] OF VARIOUS LEVELS OF CONTROL
1976 MODEL MILL - AIRDOS - EPA

Controls(*)	Lifetime Health Effects [2]	Cost per Health Effects Averted (MM $ 1980)[3]
A1; B1	0.00894	-
A1; B2	0.00677	0
A1; B3	0.00625	268
A2; B3	0.00400	19
A2; B3; C2	0.00152	89
A2; B4; C2	0.00127	769
A3; B4; C2	0.000283	222
A4; B4; C2	**0.000069**	**1202**

1) Calculated as the incremental cost for each successive level of control divided by the incremental health effects averted.

2) From Table VIII and Appendix A-2.

3) EPA 1976 cost estimates adjusted to 1980 dollars. From Table 2.

(*) KEY

A. Gaseous (Crusher and Fine Ore Bins)
   1. Orifice Scrubber
   2. Wet Impingement Scrubber
   3. Low Energy Venturi Scrubber
   4. Bag Filters

B. Gaseous (Yellowcake Drying and Packaging)
   1. Wet Impingement Scrubber
   2. Low Energy Venturi Scrubber
   3. High Energy Venturi Scrubber
   4. High Energy Venturi Scrubber + HEPA Filters

C. Liquids, Solids, and Windblown Particulate Matter
   1. Clay core Dam Retention System with Seepage Return
   2. Chemical Control of Windblown Dust from Tailings Pond Beach

D. THE LEVELS OF RISK TO THE MAXIMALLY EXPOSED INDIVIDUAL DO NOT SUPPORT EPA'S ALLEGATION OF UNREASONABLY HIGH DOSES

1. Risk to the Maximally Exposed Individual

Even if dose to the maximally exposed individual — rather than dose to regional population — were to govern in establishing radiation protection standards, which even EPA admits it should not, the 25 millirem standard cannot be considered acceptable. As indicated above, EPA assumed that the maximally exposed individual resides 500 meters downwind from the model uranium mill. The AIRDOS-EPA dispersion and dosimetry computer model further assumes that the maximally exposed individual produces at his residence virtually all of the milk, meat, and vegetables he consumes each year throughout the life of the model mill. While AMC regards these assumptions as unrealistic, they have been adhered to in AMC's initial analysis of risks to individuals for purposes of this petition.

The health risks to the maximally exposed individual have been calculated for the doses set forth in Table 1 (supra, at 15) by use of the same factors and assumptions used to estimate the risks to the regional population shown in Table 4 (supra, at 23). The results appear in Appendix A-2, Table 10 at 28. The results of analyzing EPA's 1976 model mill with AIRDOS-EPA demonstrate that the average days of life expectancy lost with the base control case (A1, B1) is 4.8 days. Implementation of the maximum level of controls (A4, B4, C2) (which is the control level required to meet the 25 millirem standard according to AIRDOS-EPA) only reduces the 4.8 days of life expectancy lost to .04 days.

Moreover, even those small numbers (4.8 and .04 days) are suspect, because the AIRDOS-EPA methodology includes two assumptions which render the calculated doses to individuals to be too high. First, it assumes that the maximum dose is that dose occurring at the end of 100 years of mill operation at full capacity, despite the fact that the model mill is assumed to operate no more than 20 years. Second, the code assumes that the maximally exposed individual does not wash any of his vegetables,

most of which are produced on his premises. More reasonable assumptions would be that the maximum dose occurs during the twentieth year of mill operation and that the maximally exposed individual washes his food before consuming it. The combined effect of these assumptions reduces the maximum individual dose by a factor of two. As a result, the average days of life expectancy theoretically lost will be on the order of 2-3 days for the base control case (See Appendix A-2 at 12). The following discussions of comparative risks make it clear that a loss of average life expectancy of 2-3 days is indeed a minimal risk.

2. Comparative Risk Considerations

EPA stated in its analysis that the risks from releases to particulate radionuclides from uranium milling were "quite small," even to the maximally exposed individual. AMC agrees. However, "small" is a term susceptible of differing interpretations. To put the term in a proper perspective, it is useful to compare the risks associated with milling releases with risks that are associated with everyday life activities.

Table 5 (infra, at 28) provides an extensive listing of a wide variety of risks expressed in terms of average days of life expectancy lost. Some selected values which highlight the estimated risk to the maximally exposed individual from exposure to uranium milling emissions at the A1, B1 control level (assumed by EPA as the present control level) are shown below: 16/

16/ See B.L. Cohen & I. S. Lee, "A Catalogue of Risks," 36 Health Physics 701-722 (June 1979).

COMPARISON OF RISK FOR MAXIMALLY EXPOSED INDIVIDUAL

Source Risk	Loss of Life Expectancy (Days):
Diet Drinks	2
Oral Contraceptives	6
Coffee	6
Fire-burns	27
All Catastrophies Combined	35
Falls	39
Drowning	41
Homicides	90
Home Accidents	95
Pneumonia-influenza	141

As this comparison of selected values shows, the risk to the maximally exposed individual is about the same as that for diet drinks, one-half of that for coffee drinking, one-tenth that for falls drowning, and about one-thirtieth that for home accidents, and one-fiftieth that for pneumonia. It is also about one one-hundredth that of a dangerous job, one twenty-fifth that of the average job, and one-tenth that of the safest job.

TABLE 5

LOSS OF LIFE EXPECTANCY DUE TO VARIOUS CAUSES[1]

CAUSE	DAYS
Being Unmarried - Male	3500
Cigarette Smoking - Male	2250
Heart Disease	2100
Being Unmarried - Female	1600
Being 30% Overweight	1300
Cancer	980
20% Overweight	900
8th Grade Education	850
Cigarette Smoking - Female	800
Low Socioeconomic Status	700
Stroke	520
Army in Vietnam	400
Cigar Smoking	330
Dangerous Job - Akccidents	300
Pipe Smoking	220
Increasing Food Intake 100 Calories/Day	210
Motor Vehicle Accidents	207
Pneumonia - Influenza	141
Alcohol (U.S. Average)	130
Accidents in Home	95
Suicide	95
Diabetes	95
Being Murdered (Homicide)	90
Legal Drug Misuse	90
Average Job - Accidents	74
Drowning	41
Falls	39
Accidents to Pedestrains	37
Safest Jobs - Accidents	30
Fire - Burns	27
Illicit Drugs (U.S. Average)	17
Poison (Solid, Liquid)	17
Suffocation	13
Firearms Accidents	11
Natural Radiaiton (BEIR)	8
Mekdical X-Rays	6
Poisonous Gases	7
Coffee	6
Oral Contraceptives	5
Accidents to Pedacycles	5
All Catastrophes Combined	3.5
Frequent Airline Passenger[2] (Radiation Only)	2.5
One Transcontinental Flight Per Year (Radiation+Acciden)[2]	2.5
Maximally Exposed Individual[3]	2-3
Diet drinks	2
Person in Room with a Smoker[2]	1.5
Living in a Brick vs. Wood House[2]	0.8

[1]Source unless otherwise noted: "A Catalog of Risks", B.L. Cohen, I.S. Lee, Health Physics, Vol. 36, June 1979, p. 701-722.

[2]Adapted from Richard Wilson, direct testimony presented on OSHA Docket No. H-090, Proposed Regulations for Identification, Classification, and Regulation of Toxic Substances Posing a Potential Occupational Carcinogenic Risk. Conversion values to life expectancy lost used were 20 years for cancer and 30 years for accidents.

[3]Risk corrected to conditions at 20th year of plant operation and washing of home grown vegetables before eating.

3. Other Risk Benefit Considerations

Beyond the recognition that the predicted risks from uranium mill radionuclide particulate releases are small, even in comparison to accepted daily life risks, there are other aspects of risk considerations which should be weighed before setting a standard. This is especially true for the maximally exposed individual.

The FEIS refers to the "extreme maldistribution of . . . impact" on a model individual and states that doses to such individuals should be minimized when "the individual at risk is not the direct recipient of the benefits of the activity producing them" (FEIS Vol I. at 26). EPA apparently decided, without saying how, that the maximally exposed individual for a uranium mill is subjected to such an "extreme maldistribution of risk." Viewed in the perspective presented above, the risk - even to admittedly few maximally exposed individuals [17] - is insignificant. The concept of "maldistribution of risk" to maximally exposed individuals should not be controlling, except where the risks presented are, in fact, extremely disproportionate to those of the general population. Such is not the case .

Additionally, EPA neglected to consider the full risk benefit equation for this theoretical individual. First, it cannot be said that this individual receives no direct benefit from the uranium mill. In most instances, a mill makes a very significant contribution to the economic vitality of the local and regional community — the community this individual must rely on for a supply of goods and services and other daily needs. Indeed, it is possible that this individual derives his income from actually working for the mill or the mining activities it serves or one of the industries providing service to the mill. In some instances he may benefit from the mill through rental of land rights for the mill or for related mining operations. At the very least, as an energy consumer, he benefits from the product of the mill when it is used to produce electric energy, even if he is not in the immediate service area of a utility

---

[17] See FEIS Vol. I at 26 and 93.

which utilizes nuclear power capacity. The power delivery system in this country is a broadly integrated network with constant intermixing of electricity generated from different sources. Once in the system, a kilowatt of electricity from nuclear power is no different from a kilowatt derived from hydraulic power, coal, oil or natural gas; the system as a whole, and each of its consumers, benefits from all power sources.

On the risk side of the balance, it is inappropriate to isolate and highlight the maximally exposed individual's risk from uranium mills. The individual risks from uranium mill emissions for purposes of risk distribution must be compared to the similar risks to an average individual in the total population. Further, the total risk picture from all sources must be examined. For instance, among the risks that are likely to be experienced by the average individual who lives in or near a much larger community than the individual near the mill (most of which are at remote sites) are the following:

Loss of Life Expectancy Due to Various Causes

Cause	Days
Motor vehicle accidents	207
Being murdered (homicide)	90
Accidents to pedestrians	37
Total	334 days

The individual near the remote mill site would experience some of these risks, but certainly to a much lesser extent. The total risk exposure of the person living near the mill must be compared with the total risk to the average individual. Only in this way can judgments be made about the equity of risk exposures.

E. CONTINUING UNCERTAINTY IN DOSIMETRY CALCULATIONS RENDERS ENFORCEMENT OF 40 CFR 190 UNLAWFUL

1. Dosimetry Codes are a Critical Element in the Formulation and Enforcement of the 25 Millirem Standard.

As noted previously, EPA used a very rudimentry analytical approach to predict the dispersion and dosimetry of radionuclide emissions from nuclear facilities in 1973 and 1976. Since 1976, however, EPA developed two sophisticated computer codes: AIRDOS I and the more recent AIRDOS-EPA. Moreover, EPA has acknowledged that it is currently working on modifications of AIRDOS-EPA.

EPA has not exposed the analytical method used in the formulation of 40 CFR 190, nor any of the subsequent codes referred to above, to public comment in any kind of rulemaking process. This is error. Where an agency chooses to use a modeling approach to standard-setting it is inappropriate that the key predictive tool used to develop and monitor enforcement with the standard — (a) has not been formally subjected to public comment and (b) is continually revised without public comment. This would seem to be at odds with EPA's general view regarding proper regulatory reliance on scientific or technical materials. In response to a comment EPA stated in the FEIS:

> ...the Agency believes it is not desirable to base Federal Regulations on unpublished materials, which are not available to the general public and which have not withstood the test of peer review and analysis. (Vol. II at 30) [Emphasis added].

EPA will monitor NRC's enforcement of the 25 millilrem standard on a continued basis (FEIS, Vol. I at 145). Presumably, EPA will use its most current state-of-the-art predictive tool (i.e., its most recentn computer code) to do so. AMC submits, however, that to do so is to insert the more recent code into the standard without

review and comment. This violates the requirements off the APA, 5 U.S.C. 553, as well as the Fifth Amendment to the United States Constitution. To avoid this result, EPA must honor its commitment to reopen rulemaking (40 Fed. Reg. 23420, Appendix B-1; 42 Fed. Reg. 2858, Appendix B-2).

The problems associated with EPA's use of dosimetry codes are further complicated by the fact that NRC will use its own dispersion and dosimetry codes to enforce 40 CFR 190. Like EPA, NRC has used or developed a number of different versions of dosimetry codes (UDAD 1-9) and has recently released a new code (MILDOS), which is already undergoing revisions. NRC's MILDOS code has not been subject to public comment in any rulemaking proceeding.

The uranium milling industry, therefore, must attempt to comply with a regulation, compliance with which will be evaluated by EPA on the basis of a continually changing code (that has never been subjected to public comment), and, which will be enforced on the basis of a still different predictive code used by NRC (that has not been subject to comment and which also continually changes).

Again, this inequitable situation violates the requirements of the APA as well as the due process requirements of the United States Constitution. Cleveland Electric Illuminating Company v. EPA, 572 Fed. 2d 1150, 1160-1164 (6th Cir. 1978); Cincinnati Gas & Electric Co. v. EPA, 578 F.2d, 660, 663-664 (6th Cir. 1978).

2. The Uncertainties and Inadequacies of Dosimetry Calculations Demonstrate the Need for EPA NRC to Develop One Code After Extensive Public Participation

Such a high degree of uncertainty presently exists in the state-of-the-art dosimetry calculations that neither EPA nor NRC can ascertain with any reasonable degree of certainty whether a uranium mill is, or will be, in compliance with the 40 CFR 190 standards. This, of course, makes it impossible for mill licensees to know whether

they are in compliance with the standard, or whether any given capital expenditure will bring them into compliance. To attempt to enforce the present standard, or any similar standard, under these circumstances would be arbitrary, capricious, and an abuse of discretion under the law. National Lime, supra.

As noted above, the current dosimetry codes are much more sophisticated than methods used by EPA in 1973 and 1976. However, a study of both AIRDOS-EPA and MILDOS by Impact, Ltd., demonstrates that both codes have serious deficiencies which need correction. This study, which is attached as Appendix A-1, itemizes the deficiencies in the two codes and contains technical advice and reference materials that should prove useful in correcting them.

Moreover, in spite of the advances over the rudimentary procedures employed by EPA in FCA 1973 and FRC 1976, a high degree of uncertainty remains. This is demonstrated by comparing the doses calculated by AIRDOS-EPA and those calculated by MILDOS for an identical case. The Impact, Ltd. study (Appendix A-1 at 56-66) shows that the organ doses calculated by the two codes typically vary by a factor of ten or more. With this much variance between the results, enforcing agency should work together to develop one code between them; a code which is finally developed only after public peer review and comment.

3. Dose Conversion Factors are an Additional Special Concern

Another special concern is the selecton of appropriate dose conversion factors. These factors are used to convert predicted concentrations for airborne radionuclides derived from dispersion calculations into organ doses. The results of a study by Dr. G. H. Whipple of agency publications as well as those of eminent scientific authorities in the radiation field forms Appendix A-3 to this Petition. Dr. Whipple discovered that differences of greater than a factor of ten exist among the dose conversion factors published by the various authorities in the field. Because calculated doses are directly proportional to dose conversion factors (i.e., these differences will result in calculated

doses varying by a factor of ten), the dose conversion factors should be very carefully selected and clearly identified whether they are to be used for development or enforcement of a standard. For EPA to proceed without a full explanation of its methodology in applying dose conversion factors in these circumstances, as it has done so, is a failure to perform its responsibility imposed by law. See International Harvester Co. v. Ruckelhaus, supra, at 643.

In reopening the record, EPA should entertain the views of all affected parties and the scientific community prior to any final decision on dose conversion factors.

F. THE EXISTING RECORD IS INADEQUATE TO SUPPORT THE 25 MILLIREM STANDARD

1. An Adequate Administrative Record is Required.

The flawed bases of the 25 millirem standard, which have been highlighted by the new information discussed above, serve to reemphasize the deficiencies in the original rulemaking record. Although some of these deficiencies were pointed out by AMC and others during that rulemaking process, a complete treatment of the problems associated with the 25 millirem standard is nonetheless appropriate at this time. See Investment Company Institute v. Board of Governors, supra, 551 F.2d at 1280-1282.

The necessity of a clear, discernible factual base supporting agency decisions is well established. In SEC v. Chenery Corp., 318 U.S. 80, 87 L.Ed. 626 (1943), the Court remanded a reorganization plan promulgated by the SEC because the proof necessary to justify its decision was not in the record. The Court held that "the process of review requires that the grounds upon which the administrative agency acted be clearly disclosed and adequately sustained." 318 U.S. at 94, 87 L.Ed. at 636 [Emphasis added]. See also Camp v. Pitts, 411 U.S. 138, 143, 36 L.Ed.2d 106, 111 (1973).

Section 189 (b) of the AEA establishes the standard of review for a court considering 40 CFR 190. 18/ This Section provides:

> Any final order entered in any proceeding of the kind specified in subsection a. of this section shall be subject to judicial review in the manner prescribed in the Act of December 29, 1950, as amended [ch. 1189, 64 Stat. 1129], and to the provisions of section 10 of the Administrative Procedure Act, as amended. 42 U.S.C. 2239 (b).

18/ Under 5 U.S.C. 907 (a), the substantive and procedural requirements of the AEA and the regulations of AEC/NRC are applicable to EPA after the transfer of authority for the establishment of radiation protection standards under Reorganization Plan No. 3 of 1970. No authority has been found in Reorganization Plan No. 3 or elsewhere which rescindes or modifies existing AEC/NRC laws or regulations. Thus, all laws and regulations which were in effect prior to the transfer of functions from AEC to EPA, and which relate to such transferred functions, remain in full force and effect after the effective date of Reorganization Plan No. 3.

Section 10 of the APA requires a Court to hold unlawful and set aside agency action found to be "arbitrary, capricious, an abuse of discretion, or otherwise not in accordance with law." 5 U.S.C. 706 (2) (A).

Under this standard, courts review not only an agency's procedures for compliance with the APA and the applicable statute, but also "the evidence and fact findings to see both that the evidentiary fact findings are supported by the record and that they provide a rational basis for inferences of ultimate fact." Leventhal, "Environmental Decisionmaking and the Role of the Court," 22 U. Pa. L. Rev. 509, 511 (1974). Especially where technical considerations are involved, courts have required "agencies to develop a more complete record and a more clearly articulated rationale to facilitate review for arbitrariness and caprice." National Lime, supra, at 70, n. 126. See also Essex Chemical Corp. v. Ruckelshaus, 486 F.2d 427, 434 (D.C. Cir. 1973), cert. denied, 416 U.S. 969 (1974); 19/ NRDC v. NRC, 547 F.2d 633 (D.C. Cir. 1967, rev'd on other grounds, 435 U.S. 519, 55 L. Ed 2d 460 (1978)

Further, assumptions made must be expressly stated. As the court in National Lime, supra, at 73-74, held:

> However expressed, these more substantive concerns have been coupled with a requirement that assumptions be stated, that process be revealed, that the rejection of alternate theories or abandonment of alternate courses of action be explained and that the rationale for the ultimate decision be set forth in a manner which permits the public to exercise its statutory prerogative of comment and the courts to exercise their statutory responsibility upon review. [Footnotes omitted].

19/ In Essex the court stated:

> Our "expertise" is not in setting standards for emission control but in determining if the standards as set are the result of reasoned decision making. Yet, even this limited function requires that we foray into the technical world to the extent necessary to ascertain if the Administrator's decision is reasoned. While we must bow to the acknowledged expertise of the Administrator in matters technical we should not automatically succumb thereto, overwhelmed as it were by the utter "scientificity" of the expedition.

Moreover, the burden was on EPA to demonstrate the adequacy of the methodology it employed in arriving at a standard. As the Court in International Harvester Co. v. Ruckelshaus, 478 F.2d 615, 643 (D.C. Cir. 1973), held:

> It is the Administrator who must bear the burden on this matter, because the development and use of the methodology are attributable to his knowledge and expertise. When certain (material lies particularly within the knowledge) of a party he is ordinarily assigned the burden of adducing the pertinent information.

In the context of this proceeding, this requires that EPA bear a burden of adducing a reasoned presentation supporting the reliability of its methodology.

In establishing a standard in an area "where scientific knowledge is imperfect and the precise quantification of risks is therefore impossible" an agency must bear the "normal burden of establishing the need for a proposed standard." Benzene, supra, at 1041. In other words, and in the context of promulgating radiation protection standards, the burden was on EPA "to show, on the basis of substantial evidence, that it is at least more likely than not that long-term exposure to" 25 millirem per year of radiation from uranium milling operations is actually occurring and "presents a significant risk of material health impairment." Id. In view of its statement that "the absolute risk to any given individual is quite small" from milling operations, it seems clear that EPA has not carried this burden (FEIS, Vol. I at 26).

The deficiencies in the original rulemaking record must now be considered in the context of these legal requirements.

2. The Reasons the 25 Millirem Standard was Chosen by EPA cannot be Traced in the Record

The 25 millirem standard was apparently plucked from the air. 20/ An assessment of the radiological aspects of 40 CFR 190 prepared for AMC came to this conclusion:

> Nowhere in the 1976 FEIS or in any of its published supporting documents does EPA explicitly justify the radiation limits in the 40 CFR 190 standard, i.e., 75 mrem per year to the thyroid and 25 mrem per year to the total body and to all other organs and tissues. The figure of 25 mrem per year is presented with the implication that judgment, cost-effectiveness analysis, and controls readily available to the industry have all been considered carefully prior to its formulation. However, nowhere is there any explanation sufficiently quantitative to support 25 mrem, as opposed to say 50 or 100 mrem per year. (Whipple, Appendix A-3, at 2-3) [Emphasis added].

The rulemaking record is, therefore, deficient with respect to an explanation of the reasons for deciding upon the particular number chosen. This deficiency alone requires a reopening of the proceeding for development of the basis on which the number was chosen. See Kennecott Copper Corporation v. EPA, 462 F.2d 846 (D.C. Cir. 1972). 21/

20/ Roger J. Mattson, Director, Division of Siting, Health and Safeguards Standards, NRC, indicated as much in his statement at EPA's hearings on 40 CFR 190 in 1976 He said:

> The criteria contained in the proposed standard cannot be traced to the technical analyses in the draft environmental impact statement or supporting documents. The numerical values for the criteria apparently were chosen as arbitrary limits and the feasibility of compliance was rationalized by comparison to effluent control values published by AEC and NRC in connection with the Appendix I rulemaking, in environmental impact statements, and in case-by-case licensing actions. (Statement of Roger J. Mattson, March 8, 1976 Appendix B-8 at 7) [Emphasis added].

21/ In Kennecott, a national secondary ambient air quality standard of 60 micrograms of sulfur oxide per cubic meter of air was challenged on the grounds that the data base was inadequate for that particular level of control. The court held:

> Inherent in the responsibility entrusted to this court is a requirement that we be given sufficient indication of the basis on which the Administrator reached the 60 figure so that we may consider whether it embodies an abuse of discretion or an error of law. 462 F.2d at 849 [Emphasis added and footnote omitted].

3. The 25 Millirem Standard was Never Cost-Effective for General Populations

EPA set forth its justification for the proposed standards in its FEIS (Vol. 1 at 68-72; Figure 3 at 39). EPA emphasized that the standard was developed using cost-effective levels of control for reduction of total population impacts, using such controls for reduction of maximum individual doses, and finally accounting for the potential for long-term environmental contamination. EPA also stressed that the levels chosen were confirmed as "representative of levels achievable at real sites and by actual operations" (FEIS Vol. 1 at 69). Further, EPA steadfastly maintained that application of the standards to all segments of the fuel cycle would be "easily satisfied by levels of control that are cost-effective for the risk reduction achieved; [that the 25 millirem standard] is achievable at all sites for which environmental statements have been filed; and, [that] on the basis of operating experience at existing sites, [this standard] can be readily achieved in practice" (FEIS Vol. 1 at 69). But here EPA was mixing apples and oranges.

In the above cited statements, EPA was referring only to reactor facilities. When it came to discussing doses from particulate radionuclide releases from mills, a significant qualification crept into EPA's explanation:

> the achievement of doses within 25 mrem/yr may not be cost-effective, because of the small populations involved near many fuel supply facilities. However, because of the low cost of these control measures, individual doses of higher magnitude than those permitted by the proposed standards are not judged to be necessary or reasonable. (FEIS Vol. 1 at 72) [Emphasis added].

Thus, EPA admitted that the 25 millirem standard was not cost-effective for milling facilities. That it is not cost-effective is further demonstrated by reference to Appendix A-2, Table 8 at 26. This Table shows that the incremental cost per health effect averted would be $13.3 million in 1976 dollars at the levels of control recommended by EPA (wet impingement scrubber on the crusher and fine ore bins and

high energy venturi scrubber on the yellowcake dryer) compared to the $250,000 - $500,000 level considered appropriate in the FEIS.

The failure of the 25 millirem standard to be cost-effective for general population exposures required EPA to tie the standard to control of doses to individuals which it claimed could be achieved at low costs. In order to make its position appear more reasonable, EPA made some interesting changes in supporting documents. EPA effectively changed the treatment of mills in the FEIS to base the 25 millirem standard on "extreme maldistribution of risk" to individuals, rather than the cost-effectiveness analyses for general populations. EPA's DEIS had indicated that the only controls on mills necessitated by the 25 millirem standard would be those based on cost-effectiveness analyses and that the only sources to be regulated based on "extreme maldistribution of risk" would be reactors (DEIS Table 3 at 38).

Next EPA published FCA 1976 which addressed several areas, particularly milling - in which new information had become available. Conveniently, this involved an assumption that a new model would more appropriately depict the milling industry, a model mill which emitted fewer radionuclides than the model used by EPA in 1973. EPA used information published in 1972 22/ that allowed it to reduce calculated doses by a factor of two. In turn, this enabled EPA to show a reduction in maximum individual dose from 450 mrem/yr in 1973 to 200 mrem/yr in 1976. 23/

By changing these two sets of assumptions EPA was able to claim that only modest outlays would be necessary for mills to meet the 25 millirem standard.

22/ International Commission on Radiological Protection, The Metabolism of Compounds of Plutonium and Other Actinides (Pergammon Press, New York, 1972) (ICRP Publication 19).

23/ Interestingly, EPA based its model mill in RI 1979 on technical data from the same report which served as the basis for the 1976 model mill, but in 1979 the maximum individual dose is raised to 350 mrem/yr.

EPA did acknowledge that tailings ponds at ten uranium mills would require "remedial measures of varying degrees to comply with the standards" (FCA 1976 at 36.) EPA gave little attention to the mills themselves, stating only that any retrofitting cost for mills would be "approximately the same order of magnitude as the cost to install the same control systems in a new mills" (Id.). When the 25 millirem standard is applied to actual mills employing EPA's revised dosimetry, however, it suggests some reconstruction of existing mills will be necessary, coupled with major redesign of many tailings disposal facilities. The costs associated with major redesign of ponds and reconstruction of mills bear no reasonable relation to the "modest outlays" contemplated as sufficient for compliance by EPA in 1976. Further, it stands to reason that if control of doses cannot be achieved at a reasonable cost for a large regional population, the costs of control for protection of a "few" individuals in a nearby area exposed to risks that are "quite small" would be completely unreasonable.

4. The Record Contains nothing to Justify the Dose Limits to individuals

The administrative record does not reveal how EPA actually chose the 25 millirem standard. Purportedly, this standard was reached by applying cost-effectiveness analysis. This choice of methodology was determined by EPA's basic decision to rely upon the linear non-threshold theory based on the recommendation of the 1972 BEIR Report 24/. Dr. Allan C. B. Richardson, Assistant to the Director for Standards Development, Office of Radiation Programs, EPA, described the relationship between these two decisions :

> The rejection of a threshold relationship has basic significance for standards setting, of course, and that is that there is no acceptable non-zero dose level based on elimination of health risk alone. Thus, at any level of exposure we must examine the benefits associated with an activity producing public radiation exposure and the cost-effectiveness of risk-reduction through effluent control. In carrying forward the process of developing standards based on this examination, we must proceed to make a series of decisions on judgmental issues. These include such matters as the appropriate limiting level of spending for measures to reduce exposure, the equity of both absolute and relative distributions over the population of risks and finally, the implications of the distribution in time of these risks. (Appendix B-9 at 12-4, 12-5) [Emphasis added]. 25/

24/ EPA selected from the BEIR I those recommendations which conveniently fit its analysis. For instance, the decision to set the standard at 25 millirem for individuals as well as for the general population conflicts with the BEIR I's recommendation. BEIR I states:

> (d) There should be an upper limit of man-made non-medical exposure for the general population. The average exposure permitted for the population should be considerably lower than the upper limit permitted for individuals (BEIR I 1972 at 3).

25/ The outlines of this approach were stated numerous times during the rulemaking process: 40 Fed. Reg. 23420-23421 (Appendix B-1); Train Memorandum (Appendix B-5 at 1-2); Opening Statement of William D. Rowe, Deputy Administrator for Radiation Programs, EPA, at Public Hearings of March 8, 1976 (Appendix B-10 at 3-4); EPA Supplementary Information, Supplement B, Dose-Effect Assumptions Used as A Basis for Proposed Standards (January 5, 1976) (Appendix B-11 at 5-6); FEIS Vol. I Appendix B at B4.

However, when its analysis of mills indicated that controls necessary to meet the 25 millirem standard were not cost-effective (FEIS Vol. I at 72), the basis for the standard for the milling segment of the uranium fuel cycle was effectively changed from cost-effectiveness to controlling the maximum doses to individuals. EPA explained in the FEIS:

> [A]lthough the primary consideration involved in developing these standards was reduction of the total potential health impact of radioactive effluents on large populations, doses to individuals must also be examined, since even though the total potential health impact may be at an acceptable level, extreme maldistribution of that impact may result in a few individuals receiving unreasonably high doses. (FEIS Vol. I at 26) [Emphasis added]. 26/

Contrary to the recommendation of the 1972 BEIR report, no distinction between doses to general population and individuals was made. The FEIS explains:

> Although the absolute risk to any given individual is quite small for these doses, which are generally below a few hundred millirems, EPA believes that such doses should also be minimized especially when the individual at risk is not the direct recipient of the benefits of the activity producing them. (FEIS Vol, I at 26) [Emphasis added].

In spite of its recognition that the risk to individuals would be "quite small", 27/ and the "futility of excess control measures" for short-lived radioactive materials associated with mills (FEIS Vol. I at 25-26), EPA justified an individual dose standard for these

---

26/ See NRC Staff Comments (1975) that 1020 of the 1030 potential health effects to be averted by the year 2000 are based on protection from long-lived radionuclides (Appendix B-12). See also NRC Supplementary Analysis (1976), Appendix B-13 at 61-64).

27/ In the Benzene case, the Court overturned the Labor Secretary's reduction from 10 ppm to 1 ppm of permissible benzene levels in air at workplaces. In doing so, the Court concluded the Secretary had failed to prove that a level of 10 ppm presented any "significant risk" of harm (supra, at 1042-1043) and that the Secretary's reduction of the standard was based on "a series of assumptions indicating that some leukemia might result from exposure to 10 ppm and that the number of cases might be reduced by reducing the exposure level to 1 ppm." Id. at 1030 [Emphasis added]. There is no significant difference between OSHA's actions in that case and in EPA's actions in this case.

standard for these material on the grounds the it would be "inequitable" to allow greater doses to individuals than to the general population, because the cost of necessary control measures would not be unreasonable (Appendix B-14 at 7).

In the FEIS, EPA states:

> However, because of the low cost of these control measures, individual doses of higher magnitude than those permitted by the proposed standards are not judged to be necessary or reasonable. (FEIS Vol. I at 72 [Emphasis added]; see also, FEIS Vol. I at 52, 68).

Neither the DEIS nor the FEIS contain any support for EPA's conclusory statements, as NRC stated:

> EPA does not explain how the dose limits for individuals were justified by '. . . weighing cost effectiveness and cost of control relative to the total capital cost . . .' [DES, p. 24]. If the values selected for the annual dose limits for individuals are justified only on the basis of the cost of controls relative to the capital cost of the facility, the procedure would not preclude arbitrary decisions to require controls which are not cost-effective. (Appendix B-13 at 41 [Emphasis in original]; see also Appendix B-14 at 7).

NRC later reiterated this position:

> We are unable to determine how EPA selected the values for annual dose limits for individuals in the proposed standard. We do not find a rationale in the EPA reports which indicates that the somatic risks at current RPG values are unacceptably high or that EPA's proposed reduction in annual dose limits for individuals is based on a finding of cost-effectiveness. In fact, we cannot relate the annual dose limits for individuals proposed in the standard to any technical base developed in the EPA reports. (Appendix B-13 at 59-60) [Emphasis in original].

In the FEIS, EPA attempted to answer the comments criticizing the lack of any basis for the numerical limits for doses to individuals. EPA stated:

> The Final Environmental Statement has been expanded to provide a more extended exposition of the relation between the capabilities of control technology, the benefits of reduced dose to individuals and populations, the costs of achieving these benefits, and the standards . . . . In general, however, Table 3 of the statement specifies the dose levels attainable using typical cost-effective levels of control, and the standards in most cases simply reflect these levels plus consideration of the need for a margin of operating flexibility. (FEIS Vol. II at 13-14) [Emphasis added].

This response addresses the criticism obliquely, if at all.

Such a failure to fully respond to legitimate criticisms of a proposed agency action has been held by the United States Court of Appeals for the District of Columbia Circuit to constitute grounds for remand to the agency. In Portland Cement Association v. Ruckelshaus, 486 F.2d 375, 392 (D. C. Cir. 1973), the Court held that "a critical defect in the decision-making process [is the] seeming refusal of the agency to respond to what seem to be legitimate problems with the methodology of these tests." See also NRDC v. NRC, supra, at 655.

The greater failing, however, is EPA's total failure to support the standard in the administrative record. This failure renders the agency action arbitrary, capricious, an abuse of discretion, and otherwise contrary to law. Benzene, supra; SEC v. Chenery Corp., supra; National Lime, supra.

5. The 25 Millirem Standard does not Adequately Account for Variability in the Nuclear Fuel Cycle and EPA has Failed to Show that it is Practicable or Achievable for Mills

Although EPA claims to have set standards which would account for variability in various segments of the nuclear fuel cycle, 28/ the foregoing discussion demonstrates that the 25 millirem standard does not provide adequate variability for the milling segment of the cycle. As noted above, EPA stated that certain fuel supply facilities [i.e., mills] might have problems achieving the standard on a cost-effective basis. AMC's analysis using EPA's new AIRDOS-EPA code demonstrates that the standard is not practicable for mills.

The standard must be achievable and practicable to be valid. In its declaration, findings and purpose, the AEA explicitly recognizes the importance of nuclear energy to the national welfare. 29/ Although there must, of course, be regulation of atomic energy consistent with appropriate safeguards to public health and safety, the Act - in calling for a program of administration which would be consistent with basic congressional policies - precludes imposition of standards that are not achievable. 42 U.S.C. Sections 2011-2013. Accordingly, any regulatory program under the AEA which is not achievable

---

28/ EPA stated that the levels it set included a "margin" added to provide for "operating flexibility to accomodate minor deviations from anticipated performance levels, differences in specific parameters of actual sites, and the possibly somewhat greater impact of larger numbers of facilities on larger sites" (FEIS Vol. 1 at 69). But EPA's major focus was on reactors for which volumes of large scale commerical operating data were available (See Memorandum of June 27, 1975 from Paul C. Tompkins, Senior Science Advisor, to Roger Strelow, Assistant Administrator for Air and Waste Management, EPA, Appendix B-15). If EPA is to promulgate standards which apply to all facilities in the nuclear fuel cycle, then those portions of the standards which most heavily impact a single segment of the fuel cycle must first address that most impacted segment as the base case, rather than some other segment of the fuel cycle. Accordingly, the 25 millirem standard, which has its most significient impact on mills, should have been based on mills, rather than reactors or some other segment of the fuel cycle.

29/ The Administrator of EPA, at the time the standard was originally being formulated, recognized the importance of nuclear energy. He also stated: "The standards were determined to be reasonable by considering both the cost and the technical feasibility of control technology" (Train Memorandum, supra, Appendix B-5 at 1).

in a practicable sense — particularly where it is conceded by all that the risks to individuals are "quite small" — cannot stand. This was recognized in the Ash Memorandum as follows:

> ...and that EPA should continue, under its current authority, to have responsibility for setting standards for the total amount of radiation in the general environment from all facilities combined in the uranium fuel cycle, i.e., an ambient standard which would have to reflect AEC's findings as to the practicability of emission controls. (Appendix B-6 at 2) [Emphasis added] 30/

Since the proposed standards do not properly account for variables within the nuclear fuel cycle and, in fact, are not practicable or demonstrably achieveable by the milling segment of the fuel cycle, they cannot withstand serious scrutiny. This is abundantly clear from the recent National Lime case, where the court overturned an emission standard for lime manufacturing plants on the grounds that EPA had failed to carry its burden of proving the feasibility and achievability of the proposed standard.31/ The court there stated:

> Promulgation of standards based upon inadequate proof of achievability would defy the Administrative Procedure Act's mandate against action that is "arbitrary, capricious, an abuse of discretion, or otherwise not in accordance with the law." (Id. at 22) [Footnote omitted].

The court rejected EPA's contention that the achievability of that standard had been proven just because six actual plants tested by EPA were able to comply. The court stated: "The Agency's failure to consider the representativeness . . . of the data relied upon is the primary reason for our remand." Id. at 27.

In this case EPA relied on a seriously flawed model mill and failed to compare that model to an operating mill at even one actual site. When considered in the light

---

30/ NRC questioned the practicability of the standards for portions of the uranium fuel cycle in which undemonstrated effluent controls would have to be used to meet the proposed standard (See Appendix B-11 at 8-9; Appendix B-13 at 4, 11, 34; Appendix B-8 at 4-9). NRC also noted that during its own rulemaking proceedings for Appendix I, the proposed levels were raised at least twice to account for practicability (Appendix B-8 at 8).

31/ The Clean Air Act expressly required achievability, so does the Atomic Energy Act. See, supra, at 10, 46.

of the unsettled state of the art of dosimetry calculations, EPA falls far short of the minimum requirements established by the APA and recognized in National Lime. The administrative record must support the "achievability" ("practicability") of the promulgated standards for the industry as a whole. In discussing variables in the industry the court in National Lime went on to say:

> "This necessarily asserts that a standard which does not account for certain routine variations in conditions is 'unachievable.' We agree, where, as here, there is no evidence in the record that the 'costs' of adjusting for such routine variations (assuming such adjustments be possible) were considered by the Agency in promulgating its standard. (Id. at 23 n.46) [Emphasis added]."

A similar line of reasoning is followed in International Harvester Company, et al. v. Ruckelshaus, 478 F.2d 615 (D.C. Cir. 1973). Again the court remanded standards promulgated by EPA under the authority of the Clean Air Act for EPA's failure to prove achievability.

The foregoing discussion demonstrates beyond question that the milling segments of the fuel cycle can not cost-effectively achieve the standard. Furthermore, the considerable problems which have been pointed out regarding compliance and enforcement, 32/ as a result of the complexities and inadequacies of varying and ever changing dispersion and dosimetry codes, further complicate the situation for licensees. It seems apparent, therefore, that if EPA is to promulgate a valid standard which will provide the necessary variability for all segments of the fuel cycle, it must support the standard with a showing that it is practicable and achievable for all segments of the cycle. Its failure to do so to date, renders the standard arbitrary, capricious, an abuse of discretion, and not in accordance with law.

32/ The mere fact that EPA builds flexibility into the enforcement section of a standard is insufficient.

> ...the flexibility appropriate to enforcement will not render 'achievable' a standard which cannot be achieved on a regular basis, either for the reasons expressly taken into account in compliance determination regulations . . . or otherwise. National Lime, supra, at 23 n. 46.

CONCLUSION

In view of the important new data now available, and EPA's commitment to reconsider in such circumstances, the 40 CFR 190 rulemaking proceeding should be reopened for reconsideration and revision of the 25 millirem standard through a process that includes public hearings. Further, a stay of the effective date of the regulations as they pertain to uranium mills (presently December 1, 1980) should be granted pending reconsideration of this standard.

During the course of reconsidering 40 CFR 190 as applied to uranium mills, EPA should specifically examine the methodology used in setting the standard. In particular, EPA should (1) evaluate in detail its model mills and their underlying assumptions; (2) validate its dispersion methodology by comparison to actual mills; (3) reassess its dosimetry and risk assessment procedures to reflect changes in the state-of-the-art; (4) settle on common codes and dose conversion assumptions with NRC; and (5) adopt a truly cost-effectiveness approach applicable to uranium mills. If reopened, AMC will participate in the rulelmaking proceedings to help EPA set a cost effective and environmentally sound radiation protection standard for uranium mills.

Respectfully submitted,

Edward A. McCabe, Esquire
Anthony J. Thompson, Esquire

HAMEL, PARK, McCABE & SAUNDERS
1776 F Street, N.W.
Washington, D.C. 20006

Attorneys for the American
Mining Congress,
Uranium Environmental Submittee
(202) 785-1234

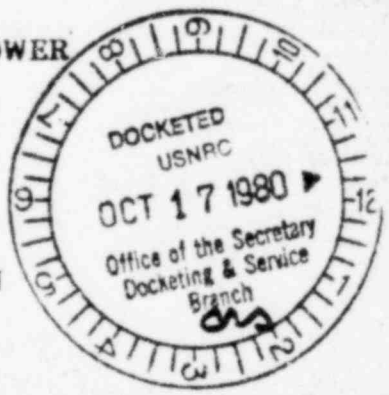
Of Counsel:

Larry A. Boggs, Esquire
American Mining Congress
1920 N. Street, N.W.
Washington, D.C. 20036
(202) 861-2876

BEFORE THE
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

DOCKET NO. ____

IN RE ENVIRONMENTAL RADIATION PROTECTION STANDARDS FOR NUCLEAR POWER OPERATIONS, 40 C.F.R. 190



APPENDIX A IN SUPPORT OF THE AMERICAN MINING CONGRESS' PETITION FOR RECONSIDERATION AND REVISION

Edward A. McCabe, Esquire
Anthony J. Thompson, Esquire
HAMEL, PARK, McCABE & SAUNDERS
1776 F Street, N. W.
Washington, D. C. 20006

Attorney for the
American Mining Congress,
Uranium Environmental Subcommittee
(202) 785-1234

Of Counsel:

Larry A. Boggs
Counsel
American Mining Congress
Suite 300
1920 N Street, N. W.
Washington, D. C. 20036
(202) 861-2800

TABLE OF CONTENTS

The Reliability of EPA and NRC Computer Codes for Regulatory Evaluation of Uranium Mill Radiological Impacts

prepared for

The American Mining Congress
Uranium Environmental Subcommittee
September, 1980

by

Impact Environmental Consultants, Ltd.
1409 Larimer Square
Denver, Colorado 80202

EXECUTIVE SUMMARY

From 1972 to 1977 the U.S. Environmental Protection Agency conducted a series of analyses of uranium fuel cycle activity radiological impacts - Environmental Analysis of the Uranium Fuel Cycle; Parts I, II, and III, (USEPA, 1973) and Part IV, Supplementary Analysis (USEPA, 1976). Those studies culminated in the promulgation of 40 CFR 190 - Environmental Radiation Protection Standards for Nuclear Power Operations. Those standards specify in part that no member of the general population shall receive a dose to any body organ which exceeds 25 millirems as a result of uranium fuel cycle operations.

During studies which led to the standard, the EPA considered various uranium fuel cycle operations including uranium mills. For each operation doses resulting from application of various control technologies were evaluated. Then an analysis of control technology costs vs. reduced health risks was conducted. Using these tools the EPA derived the 25 millirem standard in 1973 and then sought to support it in 1976.

In deriving dose estimates in 1973 and 1976 the EPA used radionuclide release estimates (source terms) assumed for a model mill in conjunction with dispersion calculational methods documented by the Atomic Energy Commission (USAEC, 1973). Since those dose estimates were made there have been studies which have provided more detailed information on mill release rates and there have been significant advances in dispersion and dosimetry modeling. In 1979, the EPA published a new model mill concept in a Clean Air Act analysis document - Radiological Impact Caused by Emissions of Radionuclides Into Air in the United States (RICERAUS), (USEPA, 1979b) - and also released and documented its latest dispersion and dosimetry computer code, AIRDOS-EPA. That Code is far more sophisticated than the AEC methods used in 1973 and 1976. In addition the Nuclear Regulatory Commission has recently released the MILDOS Code, their dispersion and dosimetry counterpart to AIRDOS-EPA, which is being used for enforcement of the 40 CFR 190 standard.

Impact, Ltd. was commissioned to examine these recent developments in codes and model mill concepts. Three specific tasks were assigned; to emulate the EPA's 1976 environmental analysis of uranium milling using their latest model mill concept and dosimetry code to evaluate the adequacy of AIRDOS-EPA, and to compare the results of a MILDOS Code analysis with those of an AIRDOS-EPA analysis when both are applied to the same model mill.

To complete the first task the 1976 EPA control technology analysis was emulated using the AIRDOS-EPA Code to analyze the RICERAUS model mill. The 1976 control technology scenarios were analyzed to determine what mill controls were needed to enable the model mill to meet the 25 millirem standard for an assumed maximally exposed individual. Using the lung as the critical organ the 1976 analysis indicated that a wet impingement scrubber for ore processing, a high energy scrubber for yellowcake operations, and no tailings control would be adequate. Our 1980 analysis using endosteal tissue as the critical organ indicates that considerably more extensive controls would be necessary; a bag filter for ore processing, a high energy Venturi scrubber and a HEPA filter for yellowcake operations, and 100% tailings control. Clearly, the most recent EPA tools produce significantly different results than those used in 1976.

The next study task was to critically examine the AIRDOS-EPA code to determine its adequacy for use in development of radiological standards. Our approach to this review was to individually examine each of the Code's submodels e.g. radionuclide release, atmospheric dispersion, terrestrial transport, and dose to man, followed by an assessment of the composite Code. The submodel examination led to the conclusion that significant uncertainty is inherent in the Code which derives from three factors; insufficient basic research and validation studies, insufficient modeling sophistication, and the use of single parameter values to represent wide ranges of research data. We recommend that an attempt to quantify the uncertainty be made and priorities for improvement be set by conducting a sensitivity analysis of the AIRDOS-EPA Code. We have also concluded that it is unlikely that possible improvements in the Code will drastically reduce uncertainty in predicted dose estimates.

The final study task involved a comparison of the theory and approach of AIRDOS-EPA to that of MILDOS and a comparative analysis of MILDOS and AIRDOS-EPA dose predictions for the RICERAUS model mill. Significant differences in submodel formulation and parameter values were found and the mill analysis comparison showed AIRDOS-EPA dose predictions to be greater than those of MILDOS with differences ranging from a factor of 5 to a factor of 30 depending on the target organ.

Study results lead to two primary conclusions:

* Recent developments in EPA's conceptual model mill and dispersion and dosimetry calculational methods have resulted in significantly different results than were demonstrated during development of the 40 CFR 190 standards. Those standards as they apply to uranium mills should be reexamined.

* Qualitative and quantitative analyses of the AIRDOS-EPA and MILDOS Codes demonstrate significant differences in Code predictions. This would indicate that the current practice in standards development of using model predictions as precise or absolute projections is invalid and that an approach to standards development which accounts for model uncertainty is mandated. Until such an approach is developed and current standards such as 40 CFR 190 are revised, those standards must be considered to be scientifically unfounded and unsupportable.

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

From 1972 to 1977 the U.S. Environmental Protection Agency conducted a series of analyses of uranium fuel cycle activity radiological impacts - Environmental Analysis of the Uranium Fuel Cycle; Parts I, II, and III, (USEPA, 1973) and Part IV, Supplementary Analysis (USEPA, 1976). Those studies culminated in the promulgation of 40 CFR 190 - Environmental Radiation Protection Standards for Nuclear Power Operations. Those standards specify in part that no member of the general population shall receive a dose to any body organ which exceeds 25 millirems as a result of uranium fuel cycle operations.

During studies which led to the standard, the EPA considered various uranium fuel cycle operations, including uranium mills. For each operation doses resulting from application of various control technologies were evaluated. Then an analysis of control technology costs vs. reduced health risks was conducted. Using these tools the EPA derived the 25 millirem figure in 1973 and then sought to support it in 1976.

EPA's dose estimates for mills were derived in essentially the same manner in 1973 and 1976. Information available in each year was synthesized to develop a conceptual model mill. In 1973 the model was based on Exxon's Highland Mill in Wyoming. In 1976 the model mill was based on data presented in an Oak Ridge National Laboratory report on the U.S. uranium industry (Sears, 1975). Dispersion calculations using model mill source terms were made based on methods presented in a 1973 Atomic Energy Commission environmental statement for light water reactors (USAEC, 1973) to derive concentrations at a hypothetical maximally exposed receptor. The USAEC methods were derived for light water reactors and did not account for particle depletion at the ground surface. No justification was provided for extrapolation to uranium mills. Concentrations at the receptor were converted to lung doses using dose conversion factors. Only lung doses and the inhalation pathway were considered.

Since 1976 additional information on model mill characterization has been developed. In 1979, the EPA formulated another model mill concept for use in a Clean Air Act analysis, Radiological Impact Caused by Emissions of Radionuclides Into Air in the United States (RICERAUS), (USEPA, 1979b). The RICERAUS model mill differs from that used in EPA's 1976 analysis in that different tailings emissions are assumed. In addition, the Nuclear Regulatory Commission has developed yet another model mill for use in the Draft Generic Environmental Impact Statement on Uranium Milling (USNRC, 1979).

Since 1973 dispersion and dosimetry calculational approaches have become far more sophisticated than the calculations used by the EPA in their uranium fuel cycle analyses. In 1974 the EPA produced the computer code, AIREM, which was basically a Gaussian dispersion model with no consideration of terrestrial transport. Then in 1975 Oak Ridge published a computer code called AIRDOS (Moore, 1975), a Gaussian dispersion model which was augmented by a terrestrial transport model called TERMOD (Booth and Kaye, 1971). The AIRDOS Code accounted for plume depletion and for doses due to inhalation, ingestion,

and external exposure. This Code was available in 1976 but the EPA chose not to use it. The AIRDOS Code was superceded by the AIRDOS-II Code in 1977 (Moore, 1977) and the EPA further revised that Code into the AIRDOS-EPA Code in 1979 (USEPA, 1979). The Codes have become increasingly more sophisticated.

The NRC has responsibility for enforcing the 40 CFR 190 regulation and that agency has also been developing computer codes for modeling uranium mill radiological impact. In 1978 and 1979 the Code used was the UDAD Code (Momeni, 1979) which in many ways is similar to the AIRDOS series of Codes but which was specifically developed for uranium mills. In late 1979 the NRC began using the MILDOS Code (USNRC, 1980) which is a revision of the UDAD Code.

Impact, Ltd. was commissioned to examine recent developments in the codes and source terms. Three specific tasks were assigned; to repeat the EPA's 1976 environmental analysis of uranium milling using their latest model mill concept and dosimetry code, to evaluate the accuracy of AIRDOS-EPA, and to compare the results of a MILDOS Code analysis with those of an AIRDOS-EPA analysis when both are applied to the same model mill. This report addresses these tasks as follows:

Section 2 - Results of a repeat of the EPA's 1976 analysis are provided. The AIRDOS-EPA Code was applied to the RICERAUS model mill concept using an approach designed to emulate that used by the EPA in conducting the RICERAUS analyses using the AIRDOS-II Code. Several model mill source term variations were also analyzed.

Section 3 - A critical review of the AIRDOS-EPA Code is presented. Code submodels are critiqued, suggestions for improvement are offered, and conclusions are drawn about the accuracy of AIRDOS-EPA and its use in standards development.

Section 4 - MILDOS/AIRDOS-EPA comparison results are presented. The two Codes are compared first on a qualitative basis and then results of a MILDOS analysis of the RICERAUS model mill are presented and compared to the AIRDOS-EPA results.

Section 5 - Overall study conclusions are drawn.

2.0 AIRDOS-EPA MODEL MILL CONTROLS ANALYSES

To quantify EPA computer code and administrative developments between 1976 and the present Impact repeated the EPA's 1976 uranium mill controls analysis (USEPA, 1976) using the EPA's most current computer code and model mill data. Model mill data used were those presented in the RICERAUS document. The computer model used was the AIRDOS-EPA Code.

In the 1976 analysis the EPA derived an assumed mill configuration and estimated radionuclide releases. The effectiveness of eight combinations of possible control technologies in reducing the radiological impact of the model mill were then evaluated (excluding consideration of radon and its daughters). The eight control technologies and their assumed control efficiencies are presented in the Table 2.1. The base case technologies assumed for the model mill were an orifice scrubber on the crusher and fine ore bins, a wet impingement scrubber in the yellowcake drying and packaging areas, and no tailings controls. EPA's 1976 individual and population dose analyses of these technologies are presented in Table 2.2.

The results of Impact's AIRDOS-EPA Code re-analysis of the eight control technology combinations are presented in Tables 2.3 and 2.4. Source terms used for each control technology application are listed in Table 2.1 and were derived from the assumed base case control source terms taken from Table 4.2-4 of the RICERAUS document. Sources of input data used during the Code analyses are presented in Appendix A.

EPA's 1976 analysis for the lung indicated an A_2, B_3 control level (wet impingement scrubber - ore processing, high energy venturi scrubber - yellowcake, no tailings control) was sufficient to meet the 25 millirem standard. The increased control levels represent condsiderably expense. Our analysis indicates that if the endosteal tissue is taken as the critical organ then a control level of A_4, B_4, C_2 (bag filter - ore processing, high energy venturi scrubbers and HEPA filters - yellowcake, and 100% tailings control) is required.

In addition to using AIRDOS-EPA to evaluate the RICERAUS model mill, Impact was requested to conduct several related analyses. The AIRDOS-EPA Code was used to simulate the RICERAUS analysis and evaluate both maximum individual and population doses for three other source term sets:

1. 1979 Source Terms with Ra-226 daughters excluded - The radionuclide release rates assumed for the RICERAUS analysis (see Table 2.1) were used. Dose contributions from Ra-226 daughters ingrown following deposition on the ground were excluded.

2. 1976 Source Terms with Ra-226 daughters included - EPA's 1976 source terms were used. These release rates were the same as for 1979 except that the 0-10 micron tailings release was assumed to be 0.5 mCi/yr for U-238 and U-234, 5.8 mCi/yr for Th-230, and 5.3 mCi/yr for Ra-226 and its daughters and no release was assumed for 10-80 micron tailings particles.

3. 1976 Source Terms with Ra-226 daughters excluded - Source terms were the same as in 2 but doses were calculated as in 1.

Results of these analyses are presented in Tables 2.5 to 2.10.

CONTROL METHOD	PERCENT EFFLUENT REDUCTION (%)	SOURCE TERM mCi/yr			
		U-238	U-234	Th-230	Ra-226 [1]
A. Gaseous (Crusher and Fine Ore Bins)					
1. Orifice Scrubber	93.6	4.5	4.5	4.5	4.5
2. Wet Impingement Scrubber	97.9	1.49	1.49	1.49	1.49
3. Low Energy Venturi Scrubber	99.5	.35	.35	.35	.35
4. Bag Filters	99.9	.07	.07	.07	.07
B. Gaseous (Yellowcake Drying and Packaging)					
1. Wet Impingement Scrubber	97.9	85.0	85.0	4.7	0.2
2. Low Energy Venturi Scrubber	99.5	20.2	20.2	1.12	.047
3. High Energy Venturi Scrubber	99.9	4.05	4.05	.223	.0095
4. High Energy Venturi Scrubber & HEPA Filters	99.99	.405	.405	.0223	.00095
C. Liquids, Solids, and Windblown Particulate Matter					
1. Clay Core Dam Retention System with Seepage Return and 0.6 Meters (2 feet) of Earth Cover Plus Rock Stabilization	--	2.1E-3	2.1E-3	4.2E-2	4.2E-2
2. Chemical Control of Windblown Dust From Tailings Pond Beach	100	--	--	--	--
3. Asphalt Liner For Tailings Pond	100	--	--	--	--

Table 2.1

Model Mill Alternative Control Technologies

[1]Values for Pb-214, Bi-214, Pb-210, and Po-210 assumed same as for Ra-226

Controls (Table 2.1)	Maximum Lung Dose to an Individual (mrem/y)	Collective Lung Dose - Population (person-rem/yr)
A1; B1	200	2.5
A1; B2	73	
A1; B3	34	
A2; B3	24	
A2; B3; C2	15	
A2; B4; C2	6	
A3; B4; C2	1.5	
A4; B4; C2	0.3	

Table 2.2
EPA's 1976 Control Level Analysis Results

Alpha emitting radionuclides as insoluble, respirable particulate matter excluding radon and daughters.

For the assumed worst case of an individual permanently occupying a location exhibiting a χ/Q of $6 \times 10^{-}$ s/m .

Population doses only calculated for base case.

CONTROLS (TABLE 2.1)	TOTAL BODY	RED MARROW	LUNGS	ENDOSTEAL TISSUES	STOMACH WALL	LOWER LGE. INTEST. WALL	THYROID	LIVER	KIDNEYS	TESTES	OVARIES
A1, B1	2.16E+02	2.35E+02	2.42E+02	2.26E+03	2.31E+01	2.90E+01	3.32E+01	1.14E+02	6.92E+01	3.49E+01	3.20E+01
A1, B2	2.04E+02	2.26E+02	9.33E+01	2.15E+03	2.27E+01	2.46E+01	3.14E+01	9.75E+01	6.48E+01	3.25E+01	2.97E+01
A1, B3	2.00E+02	2.24E+02	5.63E+01	2.13E+03	2.26E+01	2.36E+01	3.10E+01	9.34E+01	6.37E+01	3.19E+01	2.91E+01
A2, B3	1.62E+02	1.81E+02	4.09E+01	1.72E+03	1.84E+01	1.91E+01	2.51E+01	7.39E+01	5.11E+01	2.57E+01	2.35E+01
A2, B3, C2	1.97E+01	2.16E+01	1.69E+01	2.09E+02	2.11E+00	2.49E+00	3.00E+00	1.07E+01	8.45E+00	3.17E+00	2.91E+00
A2, B4, C2	1.89E+01	2.11E+01	8.49E+00	2.03E+02	2.09E+00	2.24E+00	2.90E+00	9.71E+00	6.20E+00	3.03E+00	2.78E+00
A3, B4, C2	4.53E+00	5.03E+00	2.72E+00	4.85E+01	4.95E-01	5.50E-01	6.95E-01	2.37E+00	1.49E+00	7.27E-01	6.68E-01
A4, B4, C2	9.95E-01	1.08E+00	1.30E+00	1.05E+01	1.03E-01	1.35E-01	1.51E-01	5.71E-01	3.27E-01	1.61E-01	1.49E-01

TABLE 2.3

ALTERNATIVE CONTROL SCENARIOS
ESTIMATED RADIOLOGICAL IMPACTS
INDIVIDUAL DOSE
MILLIREM/YEAR
1979 SOURCES
RICERAUS MILL

1) INDIVIDUAL SUBJECTED TO MAXIMUM DOSE AS MOST RECENTLY DEFINED BY EPA IS A PERSON LIVING 500 METERS FROM THE SOURCE. FOR THIS ANALYSIS, AS IN PRIOR EPA AIRDOS-II ANALYSES, DEFAULT DISTANCES OF 570 METERS FROM THE TAILINGS AND 503 METERS FROM MILLING OPERATIONS WERE SELECTED FOR USE.

2) EMISSIONS OF RADON AND ITS DAUGHTERS NOT CONSIDERED.

CONTROLS (TABLE 2.1)	TOTAL BODY	RED MARROW	LUNGS	ENDOSTEAL TISSUES	STOMACH WALL	LOWER LGE. INTEST. WALL	THYROID	LIVER	KIDNEYS	TESTES	OVARIES
A1, B1	3.13E+00	3.45E+00	2.17E+00	3.46E+01	1.97E-01	3.14E-01	3.51E-01	1.53E+00	9.61E-01	3.86E-01	3.61E-01
A1, B2	2.98E+00	3.32E+00	8.71E-01	3.31E+01	1.93E-01	2.48E-01	3.28E-01	1.31E+00	9.02E-01	3.54E-01	3.30E-01
A1, B3	2.94E+00	3.29E+00	5.48E-01	3.28E+01	1.92E-01	2.31E-01	3.22E-01	1.25E+00	8.87E-01	3.46E-01	3.22E-01
A2, B3	2.37E+00	2.65E+00	4.13E-01	2.64E+01	1.54E-01	1.84E-01	2.58E-01	1.01E+00	7.14E-01	2.77E-01	2.58E-01
A2, B3, C2	2.92E-01	3.23E-01	1.48E-01	3.23E+00	1.91E-02	2.72E-02	3.29E-02	1.35E-01	8.89E-02	3.57E-02	3.33E-02
A2, B4, C2	2.83E-01	3.16E-01	7.45E-02	3.14E+00	1.88E-02	2.35E-02	3.16E-02	1.23E-01	8.55E-02	3.39E-02	3.15E-02
A3, B4, C2	6.77E-02	7.54E-02	2.38E-02	7.50E-01	4.47E-03	5.87E-03	7.57E-03	3.01E-02	2.05E-02	8.16E-03	7.60E-03
A4, B4, C2	1.47E-02	1.61E-02	1.14E-02	1.61E-01	9.37E-04	1.54E-03	1.67E-03	7.26E-03	4.50E-03	1.83E-03	1.71E-03

TABLE 2.4

ALTERNATIVE CONTROL SCENARIOS
ESTIMATED RADIOLOGICAL IMPACTS
POPULATION DOSE
PERSON-REM/YR
1979 SOURCES
RICERAUS MILL

1) DOSE TO POPULATION WITHIN A 70 KILOMETER RADIUS OF THE MODEL MILL. EXCLUSIONARY ZONE AROUND THE MILL AND TAILINGS IS ASSUMED TO EXTEND TO A DISTANCE OF 500 METERS IN ALL DIRECTIONS.

2) EMISSIONS OF RADON AND ITS DAUGHTERS NOT CONSIDERED.

CONTROLS (TABLE 2.1)	TOTAL BODY	RED MARROW	LUNGS	ENDOSTEAL TISSUES	STOMACH WALL	LOWER LGE. INTEST. WALL	THYROID	LIVER	KIDNEYS	TESTES	OVARIES
A1, B1	1.65E+02	2.05E+02	2.17E+02	2.20E+03	3.78E-01	9.19E+00	7.78E+00	8.29E+01	1.76E+01	1.11E+01	1.08E+01
A1, B2	1.52E+02	1.96E+02	6.87E+01	2.09E+03	2.21E-01	5.02E+00	6.23E+00	6.65E+01	1.37E+01	8.86E+00	8.72E+00
A1, B3	1.49E+02	1.94E+02	3.16E+01	2.06E+03	1.81E-01	3.98E+00	5.85E+00	6.24E+01	1.27E+01	8.31E+00	8.18E+00
A2, B3	1.21E+02	1.57E+02	2.10E+01	1.66E+03	1.44E-01	3.16E+00	4.70E+00	4.88E+01	1.00E+01	6.62E+00	6.52E+00
A2, B3, C2	1.49E+01	1.88E+01	1.46E+01	2.03E+02	2.81E-02	6.68E-01	6.62E-01	7.76E+00	1.56E+00	9.71E-01	9.53E-01
A2, B4, C2	1.42E+01	1.83E+01	6.15E+00	1.97E+02	1.91E-02	4.32E-01	5.74E-01	6.84E+00	1.34E+00	8.46E-01	8.32E-01
A3, B4, C2	3.42E+00	4.38E+00	2.17E+00	4.71E+01	5.28E-03	1.22E-01	1.43E-01	1.69E+00	3.36E-01	2.11E-01	2.07E-01
A4, B4, C2	7.63E-01	9.42E-01	1.19E+00	1.02E+01	1.87E-03	4.59E-02	3.71E-02	4.30E-01	8.84E-02	5.43E-02	5.31E-02

TABLE 2.3

ALTERNATIVE CONTROL SCENARIOS
ESTIMATED RADIOLOGICAL IMPACTS
INDIVIDUAL DOSE
MILLIREM/YR
1979 SOURCES
DAUGHTERS EXCLUDED

1) INDIVIDUAL SUBJECTED TO MAXIMUM DOSE AS MOST RECENTLY DEFINED BY EPA IS A PERSON LIVING 500 METERS FROM THE SOURCE. FOR THIS ANALYSIS, AS IN PRIOR EPA AIRDOS-II ANALYSES, DEFAULT DISTANCES OF 570 METERS FROM THE TAILINGS AND 503 METERS FROM MILLING OPERATIONS WERE SELECTED FOR USE.

2) EMISSIONS OF RADON AND ITS DAUGHTERS NOT CONSIDERED.

CONTROLS (TABLE 2.1)	TOTAL BODY	RED MARROW	LUNGS	ENDOSTEAL TISSUES	STOMACH WALL	LOWER LGE. INTEST. WALL	THYROID	LIVER	KIDNEYS	TESTES	OVARIES
A1, B1	2.51E+00	3.16E+00	1.94E+00	3.39E+01	4.83E-03	1.42E-01	1.16E-01	1.19E+00	2.56E-01	1.63E-01	1.61E-01
A1, B2	2.36E+00	3.04E+00	6.55E-01	3.24E+01	2.79E-03	7.76E-02	9.48E-02	9.73E-01	2.04E-01	1.33E-01	1.32E-01
A1, B3	2.32E+00	3.01E+00	3.34E-01	3.20E+01	2.28E-03	6.15E-02	8.95E-02	9.19E-01	1.91E-01	1.26E-01	1.25E-01
A2, B3	1.87E+00	2.43E+00	2.42E-01	2.58E+01	1.69E-03	4.84E-02	7.18E-02	7.39E-01	1.53E-01	1.01E-01	9.99E-02
A2, B3, C2	2.33E-01	2.96E-01	1.26E-01	3.16E+00	4.18E-04	1.05E-02	1.01E-02	1.03E-01	2.19E-02	1.41E-02	1.39E-02
A2, B4, C2	2.24E-01	2.89E-01	5.33E-02	3.07E+00	3.03E-04	6.88E-03	8.88E-03	9.04E-02	1.89E-02	1.24E-02	1.23E-02
A3, B4, C2	5.37E-02	6.89E-02	1.88E-02	7.34E-01	8.13E-05	1.94E-03	2.20E-03	2.24E-02	4.72E-03	3.07E-03	3.04E-03
A4, B4, C2	1.18E-02	1.47E-02	1.03E-02	1.58E-01	2.69E-05	7.21E-04	5.57E-04	5.67E-03	1.23E-03	7.79E-04	7.69E-04

TABLE 2.6

ALTERNATIVE CONTROL SCENARIOS
ESTIMATED RADIOLOGICAL IMPACTS
POPULATION DOSE
PERSON-REM/YR
1979 SOURCES
DAUGHTERS EXCLUDED

1) DOSE TO POPULATION WITHIN A 70 KILOMETER RADIUS OF THE MODEL MILL. EXCLUSIONARY ZONE AROUND THE MILL AND TAILINGS IS ASSUMED TO EXTEND TO A DISTANCE OF 500 METERS IN ALL DIRECTIONS.

2) EMISSIONS OF RADON AND ITS DAUGHTERS NOT CONSIDERED.

CONTROLS (TABLE 2.1)	TOTAL BODY	RED MARROW	LUNGS	ENDOSTEAL TISSUES	STOMACH WALL	LOWER LGE. INTEST. WALL	THYROID	LIVER	KIDNEYS	TESTES	OVARIES
A1, B1	9.94E+01	1.05E+02	2.24E+02	1.03E+03	9.63E+00	1.53E+01	1.49E+01	6.47E+01	3.23E+01	1.64E+01	1.51E+01
A1, B2	8.65E+01	9.55E+01	7.57E+01	9.26E+02	9.26E+00	1.09E+01	1.32E+01	4.80E+01	2.79E+01	1.39E+01	1.28E+01
A1, B3	8.33E+01	9.32E+01	3.87E+01	8.99E+02	9.16E+00	9.85E+00	1.27E+01	4.39E+01	2.68E+01	1.33E+01	1.22E+01
A2, B3	4.51E+01	5.04E+01	2.33E+01	4.88E+02	4.93E+00	5.37E+00	6.85E+00	2.44E+01	1.42E+01	7.22E+00	6.62E+00
A2, B3, C2	1.97E+01	2.16E+01	1.69E+01	2.09E+02	2.11E+00	2.49E+00	3.00E+00	1.07E+01	6.45E+00	3.17E+00	2.91E+00
A2, B4, C2	1.89E+01	2.11E+01	8.49E+00	2.03E+02	2.09E+00	2.24E+00	2.90E+00	9.71E+00	6.20E+00	3.03E+00	2.78E+00
A3, B4, C2	4.53E+00	5.03E+00	2.72E+00	4.85E+01	4.95E-01	5.50E-01	6.95E-01	2.37E+00	1.49E+00	7.27E-01	6.68E-01
A4, B4, C2	9.95E-01	1.08E+00	1.30E+00	1.05E+01	1.03E-01	1.35E-01	1.51E-01	5.71E-01	3.27E-01	1.61E-01	1.49E-01

10

TABLE 2.7

ALTERNATIVE CONTROL SCENARIOS
ESTIMATED RADIOLOGICAL IMPACTS
INDIVIDUAL DOSE
MILLIREM/YEAR
1976 SOURCES
DAUGHTERS INCLUDED

1) INDIVIDUAL SUBJECTED TO MAXIMUM DOSE AS MOST RECENTLY DEFINED BY EPA IS A PERSON LIVING 500 METERS FROM THE SOURCE. FOR THIS ANALYSIS, AS IN PRIOR EPA AIRDOS-II ANALYSES, DEFAULT DISTANCES OF 570 METERS FROM THE TAILINGS AND 503 METERS FROM MILLING OPERATIONS WERE SELECTED FOR USE.

2) EMISSIONS OF RADON AND ITS DAUGHTERS NOT CONSIDERED.

CONTROLS (TABLE 2.1)	TOTAL BODY	RED MARROW	LUNGS	ENDOSTEAL TISSUES	STOMACH WALL	LOWER LGE. INTEST. WALL	THYROID	LIVER	KIDNEYS	TESTES	OVARIES
A1, B1	1.79E+00	1.94E+00	2.02E+00	1.96E+01	1.16E-01	2.17E-01	2.11E-01	6.54E-01	3.36E-01	1.44E-01	1.40E-01
A1, B2	1.63E+00	1.82E+00	7.25E-01	1.81E+01	1.12E-01	1.51E-01	1.88E-01	4.36E-01	2.77E-01	1.12E-01	1.10E-01
A1, B3	1.59E+00	1.78E+00	4.02E-01	1.78E+01	1.11E-01	1.35E-01	1.82E-01	3.82E-01	2.62E-01	1.04E-01	1.02E-01
A2, B3	1.02E+00	1.14E+00	2.67E-01	1.14E+01	7.27E-02	8.77E-02	1.18E-01	1.35E-01	8.89E-02	3.57E-02	3.83E-02
A2, B3, C2	2.92E-01	3.23E-01	1.48E-01	3.23E+00	1.91E-02	2.72E-02	3.29E-02	1.35E-01	8.89E-02	3.57E-02	3.33E-02
A2, B4, C2	2.83E-01	3.16E-01	7.45E-02	3.14E+00	1.88E-02	2.35E-02	3.16E-02	1.23E-01	8.55E-02	3.39E-02	3.15E-02
A3, B4, C2	6.78E-02	7.54E-02	2.38E-02	7.50E-01	4.47E-03	5.87E-03	7.57E-03	3.01E-02	2.05E-02	8.16E-03	7.60E-03
A4, B4, C2	1.47E-02	1.61E-02	1.14E-02	1.61E-01	9.37E-04	1.54E-03	1.67E-03	7.26E-03	4.50E-03	1.83E-03	1.71E-03

TABLE 2.8

ALTERNATIVE CONTROL SCENARIOS
ESTIMATED RADIOLOGICAL IMPACTS
POPULATION DOSE
PERSON-REM/YR
1976 SOURCES
DAUGHTERS INCLUDED

1) DOSE TO POPULATION WITHIN A 70 KILOMETER RADIUS OF THE MODEL MILL. EXCLUSIONARY ZONE AROUND THE MILL AND TAILINGS IS ASSUMED TO EXTEND TO A DISTANCE OF 500 METERS IN ALL DIRECTIONS.

2) EMISSIONS OF RADON AND ITS DAUGHTERS NOT CONSIDERED.

CONTROLS (TABLE 2.1)	TOTAL BODY	RED MARROW	LUNGS	ENDOSTEAL TISSUES	STOMACH WALL	LOWER LGE. INTEST. WALL	THYROID	LIVER	KIDNEYS	TESTES	OVARIES
A1, B1	7.82E+01	9.20E+01	2.14E+02	1.01E+03	2.83E-01	7.14E+00	4.47E+00	5.18E+01	1.09E+01	6.56E+00	6.39E+00
A1, B2	6.58E+01	8.32E+01	6.54E+01	9.00E+02	1.25E-01	2.98E+00	2.92E+00	3.54E+01	7.04E+00	4.34E+00	4.26E+00
A1, B3	6.27E+01	8.10E+01	2.84E+01	8.73E+02	8.58E-02	1.94E+00	2.53E+00	3.13E+01	6.07E+00	3.79E+00	3.72E+00
A2, B3	3.40E+01	4.38E+01	1.78E+01	4.74E+02	4.90E-02	1.11E+00	1.39E+00	1.77E+01	3.39E+00	2.10E+00	2.06E+00
A2, B3, C2	1.49E+01	1.88E+01	1.46E+01	2.03E+02	2.81E-02	6.68E-01	6.62E-01	7.76E+00	1.56E+00	9.71E-01	9.53E-01
A2, B4, C2	1.42E+01	1.83E+01	6.15E+00	1.97E+02	1.91E-02	4.32E-01	5.74E-01	6.84E+00	1.34E+00	8.46E-01	8.32E-01
A3, B4, C2	3.42E+00	4.38E+00	2.17E+00	4.71E+01	5.28E-03	1.22E-01	1.43E-01	1.69E+00	3.36E-01	2.11E-01	2.07E-01
A4, B4, C2	7.63E-01	9.42E-01	1.19E+00	1.02E+01	1.87E-03	4.59E-02	3.71E-02	4.30E-01	8.84E-02	5.43E-02	5.31E-02

TABLE 2.9

ALTERNATIVE CONTROL SCENARIOS
ESTIMATED RADIOLOGICAL IMPACTS
INDIVIDUAL DOSE
MILLIREM/YEAR
1976 SOURCES
DAUGHTERS EXCLUDED

1) INDIVIDUAL SUBJECTED TO MAXIMUM DOSE AS MOST RECENTLY DEFINED BY EPA IS A PERSON LIVING 500 METERS FROM THE SOURCE. FOR THIS ANALYSIS, AS IN PRIOR EPA AIRDOS-II ANALYSES, DEFAULT DISTANCES OF 570 METERS FROM THE TAILINGS AND 503 METERS FROM MILLING OPERATIONS WERE SELECTED FOR USE.

2) EMISSIONS OF RADON AND ITS DAUGHTERS NOT CONSIDERED.

CONTROLS (TABLE 2.1)	TOTAL BODY	RED MARROW	LUNGS	ENDOSTEAL TISSUES	STOMACH WALL	LOWER LGE. INTEST. WALL	THYROID	LIVER	KIDNEYS	TESTES	OVARIES
A1, B1	1.44E+00	1.78E+00	1.89E+00	1.92E+01	4.05E-03	1.18E-01	7.57E-02	8.03E-01	1.74E-01	1.08E-01	1.06E-01
A1, B2	1.29E+00	1.65E+00	5.98E-01	1.77E+01	2.00E-03	5.32E-02	5.46E-02	5.89E-01	1.22E-01	7.79E-02	7.70E-02
A1, B3	1.26E+00	1.62E+00	2.77E-01	1.74E+01	1.49E-03	3.71E-02	4.93E-02	5.35E-01	1.09E-01	7.05E-02	6.98E-02
A2, B3	8.03E-01	1.04E+00	1.85E-01	1.11E+01	9.06E-04	2.39E-02	3.16E-02	3.55E-01	7.13E-02	4.57E-02	4.52E-02
A2, B3, C2	2.33E-01	2.96E-01	1.26E-01	3.16E+00	4.18E-04	1.05E-02	1.01E-02	1.03E-01	2.19E-02	1.41E-02	1.39E-02
A2, B4, C2	2.24E-01	2.89E-01	5.33E-02	3.07E+00	3.03E-04	6.88E-03	8.88E-03	9.04E-02	1.89E-02	1.24E-02	1.23E-02
A3, B4, C2	5.37E-02	6.89E-02	1.88E-02	7.34E-01	8.13E-05	1.94E-03	2.20E-03	2.24E-02	4.72E-03	3.07E-03	3.04E-03
A4, B4, C2	1.18E-02	1.47E-02	1.03E-02	1.58E-01	2.69E-05	7.21E-04	5.57E-04	5.67E-03	1.23E-03	7.79E-04	7.69E-04

TABLE 2.10

ALTERNATIVE CONTROL SCENARIOS
ESTIMATED RADIOLOGICAL IMPACTS
POPULATION DOSE
PERSON-REM/YR
1976 SOURCES
DAUGHTERS EXCLUDED

1) DOSE TO POPULATION WITHIN A 70 KILOMETER RADIUS OF THE MODEL MILL. EXCLUSIONARY ZONE AROUND THE MILL AND TAILINGS IS ASSUMED TO EXTEND TO A DISTANCE OF 500 METERS IN ALL DIRECTIONS.

2) EMISSIONS OF RADON AND ITS DAUGHTERS NOT CONSIDERED.

3.0 AIRDOS-EPA CODE CRITICAL REVIEW

This section presents the results of Impact's critical examination of the AIRDOS-EPA Code. Our approach to this review was to divide the Code into the submodels of which it is comprised and to examine each submodel individually. Submodel evaluations were then used as a basis for assessing the usefulness of the Code as a whole for radiological impact assessment.

There are four major submodels of the AIRDOS-EPA Code. These in turn are comprised of more specialized components. The four attempt to simulate the consecutive processes of radionuclide release, atmospheric dispersion, terrestrial transport including uptake of radionuclides by vegetation and transfer to humans and animals, and dose to man due to radionuclide inhalation, ingestion and external exposure.

Shaeffer (1979) presents an approach to model evaluation which is of use in putting this review in perspective. She divides the methodology into six major tasks:

1) model examination

2) algorithm examination

3) data evaluation

4) sensitivity analyses

5) validation studies, and

6) code comparisons

Our review focused on the first three tasks of this list. The Code as a whole was examined to determine its appropriateness for radiological assessments and the algorithms used in the formulation of submodels were critiqued. In addition, available data were examined to determine the adequacy of various submodel parameters. Parameter values examined were those used by EPA in their RICERAUS analysis and those recommended in the AIRDOS-EPA documentation (USEPA,1979a). Primary evaluation criteria for both submodel algorithms and parameter values were level of inherent uncertainty, conformity with state of the art developments, and appropriateness of application to uranium milling.

The last three tasks of the above list have also been considered. When validation studies have been conducted for a particular submodel, the results are discussed. With respect to code comparisons, alternative submodels are discussed when possible. (In addition, a comparison of the AIRDOS-EPA Code to the Nuclear Regulatory Commission's MILDOS Code is presented in Section 4.0 of this report). Finally, considering the sensitivity analysis task, one of the major conclusions of the review is that a sensitivity analysis of the AIRDOS-EPA Code should be mandated by the EPA in order that the most important Code deficiencies may be identified and priorities for further research be set.

3.1 RADIONUCLIDE RELEASE CHARACTERIZATIONS

It is important to accurately describe the quantity and quality of radionuclide releases from uranium mills. The release rates presented in the RICERAUS report were derived from a previous 1976 analysis (USEPA, 1976) and a report published by Oak Ridge National Laboratory in 1975 (Sears, 1975). Releases considered include those from mill process operations, a composite of releases from ore storage, handling, and crushing activities and yellowcake production, and two size ranges of tailings, 0-10μm and 10-80μm. Two primary problems have been identified with the release values assumed; the inaccuracy of the tailings release estimate, and the inadequate characterization of particle sizes for all emissions.

3.1.1 Tailings Release Estimate

The tailings emission values presented in RICERAUS are based on the assumption that the emissions flux from tailings is directly proportional to the cube of the wind velocity. In 1976 this was a generally accepted theorem because little validation data was available. However, a recent study published by Battelle Northwest Laboratory which details field study results indicates that no relation between mill tailings emissions and wind velocity could be established (Schwendiman, 1979). In fact, that study's results indicate there is no presently available valid method for estimating mill tailings releases.

Note, however, that the results of that study cannot be easily extrapolated to all tailings areas. The pond studied was associated with a carbonate alkaline leach process (most mills now use an acid leach process) and had an unusual configuration in that the dike was built from coarser material separated from the fines by a trailer mounted mobile cyclonic separator.

More study is needed to determine if a method for modeling tailings releases could be developed. Until such studies are completed estimates such as those used in the RICERAUS analysis are not valid. So little information is available that the uncertainty associated with such estimates cannot be estimated.

3.1.2 Particle Size Assumptions

It is important to accurately specify particle size distributions for assessment of the lung burden resulting from mill releases. In general, the larger the small particle fraction the greater the dose delivered. If particle sizes are assumed to be too small, predicted doses will be over-estimated.

In the RICERAUS analysis mill source emissions were characterized as one micron in size. Few empirical measurements are available to support this sizing assumption. For both yellowcake drying and packaging, and ore crushing and grinding activities, the control technologies used (generally wet impingement scrubbers) do discriminate heavily in terms of removal efficiency for particle sizes between 0 and 50 but do not usually reach the 99% removal level for particles below 2 microns. Selection of 1 micron value is basically a worst case assumption. Empirical data for actual mill dust releases are needed.

RICERAUS tailings particle size and associated radioactivity assumptions were also examined. Thirty percent of the radioactivity released was assumed to be associated with particles sized between 0 and 10 microns which in turn were all characterized as being one micron in size (a conservative assumption). The remaining activity was assumed to be associated with particles sized between 10 and 80 microns for which no general particle size assumption was made. Again, there are few, if any, empirical measurements available to support these assumptions.

The Schwendiman study (1980) did indicate that a relatively large fraction of tailings radioactivity is associated with particles smaller than several microns. In addition, the activity per gram for particles larger than 20 microns was shown to be an order of magnitude lower than that for small particles. The report also specifically states that "ideally the source term should be calculated for each particle size of interest". EPA's assumptions about tailings emissions sizing and activity are fraught with uncertainty, are conservative, and should be reexamined in light of the Schwendiman study results. Other field data are needed.

3.2 EMISSION DISPERSION AND PLUME DEPLETION SUBMODEL

Historically, the bulk of the computer models developed for radiological modeling have been in the environmental transport area, with the greatest percent of those in atmospheric transport and dry deposition. More than 70% of the 83 computer codes developed deal with atmospheric transport, 40% with dry deposition, less than 30% with wet deposition, and less than 5% with resuspension. Although 83 different codes have been identified, nearly all of the codes dealing with atmospheric transport are based on a gaussian plume dispersion model. The older ones were derived from the work of Sutton and the newer ones from that of Pasquill. This means that they do not account for either spatial or temporal meteorological variations (although some have been modified to account for ground deposition and depletion in the plume) nor for the occasional presence of a lid on the atmospheric diffusion layer. Modifications to model transient meteorological conditions accurately have not been made.

The submodel used in the AIRDOS-EPA Code to simulate dispersion of radionuclides is a Gaussian diffusion model. The basic assumptions inherent in a Gaussian dispersion model are constant wind speed, no wind shear, Fickian diffusion, flat topography, and straight line transport. Some limitations of this type of dispersion treatment are discussed in the AIRDOS-EPA documentation. Our review of recent modeling study results and developments indicate that the following topics are important when considering an application of the AIRDOS-EPA Code:

* general submodel limitations
* complex terrain
* plume depletion
* low wind speed conditions
* reciprocal average wind speeds
* wind shear
* dispersion coefficients
* accuracy of predictions at distant locations
* plume rise
* mixing height estimates
* plume trapping and lid penetration

3.2.1 General Submodel Limitations

The Gaussian dispersion treatment of AIRDOS-EPA requires assumptions of a continuous plume extending infinitely outward from the source with single, constant values for wind speed, wind direction, and atmospheric stability class, and uses a single data set for annual average meteorology. These

assumptions do not account for local topography and turbulence nor for spatial meteorological variations. Maximum individual dose concentrations are probably most affected by local topography and turbulence and population dose assessments are most affected by deviations from site specific meteorology.

In the AIRDOS document (USEPA, 1979a), Oak Ridge mentions the limitations of assumptions of constant wind speed, low wind shear, flat topography, Fickian diffusion, and no chemical or physical interaction of plume components during plume travel. They also point out several other limitations in the theory such as failure to treat dispersion in the downwind direction.

3.2.2 Complex Terrain

Evaluations of uranium mill operations by the EPA to date have been generic assessments. They do not account for complex terrain effects because no specific topography is assumed. Most western milling operations are located in complex terrain and therefore in areas of enhanced diffusion. The AIRDOS-EPA Code predictions do not account for this phenomenon, assuming instead that low level releases are generally terrain following and that planar models would thus apply. Thus, they overpredict concentrations in the generic assessments.

Data to support this contention are provided in the results of several recent studies intended to validate the application of Gaussian models in complex terrain (Hinds, 1970), (Hovind, Spangler, Anderson, 1974), (MacCready, et.al., 1974), (Start, Dickson, Wendell, 1975), (Start, Ricks, Dickson, 1975). Results show that Gaussian models may underestimate diffusion by factors ranging from 2 to 15 depending on the particular situation. Underestimating diffusion normally results in overestimating particulate concentrations.

It is possible that the EPA could account for complex terrain in their generic assessments by assuming a typical topographical situation. This is the approach taken by the NRC in the draft GEIS. However, if such an approach is taken a terrain modification procedure should be incorporated into the Code. Such modifications have been made by the EPA to several of their Gaussian dispersion models including the Valley Model (Burt, 1977). If the AIRDOS-EPA Code is to be applied in site specific situations, such a terrain modification would certainly be necessary. Results of the previously mentioned studies indicate, however, that even these modified Gaussian models underestimate diffusion in complex terrain situations. Ultimately the application of finite difference modeling should bring more accuracy to this portion of the analysis.

3.2.3 Plume Depletion and Surface Air Concentration Calculations

The AIRDOS-EPA Code provides for depletion of radionuclides from the plume and subsequent calculation of surface air concentrations by application of four mechanisms: gravitational settling, dry deposition, precipitation scavenging, and radiological decay. The amount of depletion due to these mechanisms is then computed using a source depletion model. A fifth mechanism which affects calculated air concentrations, resuspension, has not been explicitly modeled.

Resuspension - Once particles have been deposited on the ground, a portion will be picked up again by the wind, i.e., resuspended. Three basic mechanisms exist for this resuspension; surface creep, saltation and suspension. As a general guideline particles larger than 1 millimeter in diameter will remain on the surface. Particles 1 millimeter to 0.5 millimeters will roll or slide along the surface of the ground due to the force of wind. This process is known as surface creep. Particles between 0.5 millimeters and 0.1 millimeters will rise into the air to a height of several centimeters. This is known as saltation. Particles less than 0.1 millimeters will be suspended for significant periods of time and will be subject to the process of turbulent diffusion (Horst, 1977). Most resuspension and deposition theory deals with particles less than 10 microns since this generally represents the upper limit of the respirable fraction.

AIRDOS-EPA does not explicitly address the resuspension process. The Code thus fails to account for losses from the surface and additional dispersion of radionuclides throughout the area surrounding the facility.

The net effect of the deposition-resuspension process is generally a reduction in the annual average total surface concentrations. A conservative estimate of the annual exposure to particulates can be made by ignoring both processes. The reduction is a direct consequence of the climatological effect of windspeeds and atmospheric stabilities, the contaminant being preferentially deposited during periods of limited vertical mixing and high surface air concentrations, and being resuspended during turbulent periods.

Plume Depletion - The two basic theories developed for handling plume depletion due to deposition are the source depletion model developed by Chamberlain (Van der Hoven, 1969) and the surface depletion model based on the "K" theory diffusion equation for an infinite crosswind oriented line source developed by Markee, (1967). The source depletion model accounts for dry deposition by multiplying the surface concentration by a deposition velocity to obtain the amount deposited. This loss is distributed throughout the entire column in a manner designed to preserve the Gaussian shape of the vertical profile. The method therefore produces artifically enhanced vertical mixing and greater concentrations near the ground with the greatest depletion in the early stages of plume travel. In contrast, the surface depletion model reduces concentrations only at the surface thus avoiding artificial mixing and leaving more material airborne. Investigations have indicated that the models vary most near the source when the ratio of deposition velocity to transport windspeed is large and as atmospheric stability increases.

A source depletion model is used in the AIRDOS-EPA Code to account for removal of particulates by dry deposition. Horst (1976) has shown that the method used to account for the dry deposition depletion may result in concentrations being overestimated by factors as high as four at receptors close to the source (less than 10 kilometers). Horst's surface depletion model more accurately depicts the deposition process but requires significantly greater computational resources. He has recently developed another model, a hybrid source depletion model, which provides many of the advantages of the surface depletion model (Horst, 1979). A model of this type should be considered for inclusion in the AIRDOS-EPA Code.

A one-dimensional, finite difference plume depletion model has been developed (Machta, 1966) which may indicate promise for extended travel time and distances for aerosols. This model was tested by Draxler & Elliott (1976) and results indicated substantial differences in the suspended concentrations after the first 24-hour period.

Precipitation Scavenging - Precipitation scavenging or wet removal is also accounted for in the AIRDOS-EPA Code but no reference is provided for the approach used. There are numerous methodologies that have been proposed to account for this phenomenon. The method used in the AIRDOS-EPA Code is based on an assumed scavenging coefficient and the average concentration in a column above the point of concern. An alternative method for accounting for wet removal was recommended by an Oak Ridge review group (Hoffman, et al., 1978). In this method a wet deposition velocity is calculated based on near surface level air concentrations, surface level precipitation pollutant concentrations, and yearly average precipitation.

No references are provided for the methods used to account for plume losses due to precipitation scavenging and radiological decay. Both methods as described in the AIRDOS-EPA Code documentation are dependent upon a time value calculated by assuming straight line transport to receptors. This is not an accurate representation of the physical processes involved. The wind does not blow continuously in one direction at one speed for a certain percentage of the year and then change to another speed and/or direction as is assumed. Although this approximation is commonly used to predict long term average pollutant concentrations, its use in calculating the time available for precipitation scavenging or radiological decay has not been justified. Validation data supporting this method must be provided before it can be considered acceptable.

3.2.4 Low Wind Speed Conditions

As discussed in the AIRDOS-EPA documentation, Gaussian dispersion models are generally not applicable in low wind speed conditions. Studies of low wind speed conditions in rough terrain (common to uranium milling regions) demonstrate that Gaussian models overestimate concentrations by up to a factor of 8 (Wilson, et al, 1976), (Sagendorf & Dixon, 1976). The NRC has included a correction factor to account for the situation in their method for estimating potential accident consequences at nuclear power plants (Letizia, 1979). For assessments of milling operations, the EPA should consider incorporating a similar correction into the AIRDOS-EPA Code.

3.2.5 Reciprocal Average Wind Speeds

In order to save computer time a wind speed simplification was introduced to replace separate calculations for each wind speed category in each sector and stability class with a single reciprocal averaged wind speed. The modification reduces a 576 element distribution to only 96 elements. This was originally suggested by Gifford (ORNL retired) and Porter (Texas Air Control Board) and used in the Texas Climatological Model (TCM) (Christianson and Porter, 1976). When TCM predictions were compared to those of the EPA's Climatological Dispersion Model (CDM) (Busse and Zimmerman, 1973), the correlation coefficient was nearly unity. However, to our knowledge, no sensitivity analysis has been performed to isolate the effects of this rather major alteration.

Although it may be reasonable to use average wind speed for stability categories A, B, E, F and G it is probably inappropriate to use an average for categories C and D. Any windspeed can occur within these two categories leading to extremely misleading results by the use of a single average. While yet to be tested quantitatively, it would seem that this short cut would weight lower wind speeds more heavily thus increasing concentrations close to the source.

The code is inconsistent in that it uses the true average wind speed for calculating plume rise and the reciprocal average wind speed for dispersion. If the plume rise option is used plume rise is underestimated (See Section 3.2.9) and calculated concentrations are overestimated. As discussed above, use of average wind speeds also causes concentration overestimates. The combination of the two results in calculated concentrations two or more times as great as that which would be expected to occur.

The AIRDOS-EPA documentation expresses concern about calms which seems overreactive. It is relatively meaningless to discuss plume rise during calms in the first place since the Gaussian dispersion equations do not apply, and secondly, the computer model assumes a minimum windspeed of one meter per second.

3.2.6 Wind Shear

Most recent EPA dispersion programs developed since the Climatological Dispersion Model (CDM) address wind shear. This is accomplished by multiplying the observed wind speed at 10 meters by the ratio between the actual stack height and 10 meters raised to an exponent that varies with stability class. Wind speed profiles have been ignored in AIRDOS-EPA. The effect is that dispersion from elevated sources such as the yellowcake stack will be underestimated while that of ground level sources will be overestimated.

3.2.7 Dispersion Coefficients

The values for horizontal and vertical dispersion coefficients were derived by Briggs in 1974. They are contained in the third edition of the ASME publication "Recommended Guide for the Prediction of the Dispersion of the Airborne Effluents" (ASME, 1979). Although the coefficients are an improvement on the Pasquill-Gifford coefficients for intermediate and longer distances no presently used EPA model employs them. Use of these values is an unusual infusion of state of the art theory.

The Briggs coefficients were intended primarily for use in association with elevated stack sources (Turner, 1979). They are based primarily on work derived from TVA power plants, plumes which are both bouyant due to thermal effect and enhanced due to stack exit velocity.

While the use of these coefficients may be appropriate for crusher baghouse exhaust or yellowcake dryer emissions they are inappropriate for surface releases from tailings ponds. Some buoyancy may exist in a dryer exhaust but it most certainly will not in a crusher exhaust although momentum effects may be appropriate for both. A review group sponsored by Oak Ridge National Laboratory has recommended that for surface level releases the most

appropriate curves are those of Pasq ill-Gifford with an adjustment for averaging time and with a roughness coefficient adjustment (Hoffman, et al., 1978).

3.2.8 Accuracy of Predictions at Distant Locations

The Pasquill-Gifford or Briggs dispersion coefficients are generally considered to be accurate only to distances ranging between 1 and 10 kilometers. Predictions become more uncertain as distances increase. This is often due to the fact that meteorological conditions change at distances a few miles from the source.

Results of a recent study at an existing mill operation (Schwendiman, 1980) suggest that mass flux from mill tailings could be as great as one order of magnitude greater than background at 4 kilometers and that soil surface concentrations approach background only at distances of 10 kilometers. These results would indicate that any model predicting concentrations at distances greater than 5 to 10 kilometers would be questionable.

3.2.9 Plume Rise

The AIRDOS-EPA Code allows one to elect various options for plume rise: direct input, a momentum dominated plume rise calculation by Rupp, or a thermally dominated plume rise calculation by Briggs. Clearly, some of the point sources in a mill have definite plume rise characteristics. However, in their model mill analysis the EPA has elected to assume zero plume rise.

EPA in other models uses formulas developed by Briggs to calculate momentum plume rise. For unstable cases this gives twice the plume rise predicted by Rupp in the subject code. Stable cases is a more complex equation.

AIRDOS-EPA adopts a plume leveling theory for distances more than 10 times the stack height from the point of release adding conservatism to distant concentrations. Briggs' plume rise theory uses a distance proportional to buoyancy flux. For stable categories AIRDOS-EPA uses a multiplier of 2.9 in the plume rise calculation where EPA air quality modelers recently in their own documentation have adopted a value of 2.6 (Briggs, 1980).

There is an apparent problem in the documentation for AIRDOS-EPA indicating an increase in temperature with altitude.

3.2.10 Mixing Height Estimates

The height above the surface through which relatively vigorous mixing occurs is defined as the mixing height or lid height. A single annual average mixing height is provided as input to the AIRDOS-EPA Code. Mixing height will vary according to season, day, and stability class. A desirable modification which is included in other Gaussian dispersion models including the CDM and Valley Models, would be to calculate an annual average mixing height for each stability class.

3.2.11 Plume Trapping & Lid Penetration

When a plume is trapped between the ground and an upper level stable layer, that phenomenon is called plume trapping. A method developed by Turner (1969) is used in the AIRDOS-EPA Code to account for plume trapping at specified distances from the emission source. Turner has suggested a preferable alternative method (Turner, 1969) which is more commonly employed in recent Gaussian models, and which should be incorporated in the AIRDOS-EPA Code.

A phenomenon not accounted for in the AIRDOS-EPA Code is lid penetration, the effects of which are discussed in the AIRDOS-EPA documentation. Lid penetration occurs when the lid is low enough that stack emissions penetrate the lid and do not disperse downward. Although this is a rare phenomenon in some regions, by not accounting for such an effect the Code will overestimate concentrations.

3.3 TERRESTRIAL PATHWAYS

The models of terrestrial pathways for the transport of radionuclides to man used in AIRDOS-EPA have their origins in the code HERMES. According to Soldat (in Hoffman et. al., 1978, p. 88) HERMES is the basis for a more simple code, FOOD, and FOOD is the basis of the models promulgated by the NRC in Regulatory Guide 1.109 (USNRC, 1977).

In general the terrestrial pathways codes have evolved primarily in terms of updated parameter values. The formulations are deterministic, using simple multiplicative chain equations with constant empirical parameters. Use of the models is limited to grossly averaged conditions representing a non-stochastic, time invariant, steady-state (equilibrium) environment and source term.

When these models were first developed the uncertainty and errors associated with them were not of concern. Model predictions were solely intended to be conservative; that is, to overestimate the radionuclide transport to man (Hoffman et. al. 1978, p. 1). Assumptions about exposure pathways, parameter values, and model structure all were used to reduce the possibility of underestimating the radionuclide transport to man. It is understandable then, that need now exists for re-evaluation of all phases of the terrestrial transport models in an effort to provide more realistic assumptions about exposure pathways, more applicable parameter values for the sites of interest, and more detailed and realistic model structures.

The models derived from HERMES for indicating the pathways of major concern have been important in the early stage of the development of pathways modeling techniques development. However, the conservativism throughout these models makes them inappropriate for any use where the values are to be considered predictive of actual population or individual doses (Hoffman et. al. 1978, p. 1).

Little and Miller (1979) investigated the uncertainty associated with some environmental transport models, using published data and models. Among the models investigated were FOOD and NRC Regulatory Guide 1.109. The investigation of terrestrial pathways models was abortive since no validation studies were found to test the predictions of the models. On the basis of the stated conservatism in the development of these models it is felt that determining model validity under any known set of circumstances must be given great importance. Until such work is done the use of these models, including AIRDOS-EPA, for predicting radionuclide concentrations in terrestrial food chains is a theoretical exercise with no practical validity.

In the following subsections the AIRDOS-EPA terrestrial pathways submodel is evaluated. First the formulation of the submodel components is discussed, then specific parameters and their values are reviewed.

3.3.1 Submodel Formulation

The major thrust of this examination is to determine whether the models include all of the important physical and biological phenomena which influence the concentrations of radionuclides in the environmental media surrounding a uranium milling facility in the western United States. For this purpose the processes included in AIRDOS-EPA are compared to a general conceptual model.

In order to clarify the discussions, flow diagrams are used. Arrows represent the flow of radionuclides from one compartment to another according to a given process. The compartments are represented by boxes and correspond to physical entities in the environment. The processes are the actual physical and biological phenomena which control the movement of the radionuclides. AIRDOS-EPA is not strictly a compartmental model and is thus not easily represented by a standard flow diagram. However, an attempt has been made to represent the processes included in AIRDOS-EPA in diagrammatic form for ease of discussion.

The terrestrial transport models of AIRDOS-EPA may be broadly broken into two sections. The first describes the transfers from atmosphere to plant-tissue. The second describes the transfers from plant-tissues to processed meat, milk, and vegetables. These two sections are discussed separately below.

3.3.1.1 Atmosphere To Plant-Tissues Pathways - A diagram of AIRDOS-EPA atmosphere to plant-tissue pathways as determined from the AIRDOS-EPA documentation is presented as Figure 3.1. The plant interior and plant surface compartments are summed to give total plant values.

For comparison, the second diagram following is considered to be a more complete representation of the processes and interactions actually functioning in the atmosphere to plant-tissue transport system than that of AIRDOS-EPA. For pathways not included in AIRDOS-EPA we review the assumptions which allow the pathway to be ignored, and discuss conditions under which the assumptions may not be acceptable.

Deposition - The calculation of radioactivity deposited on soil by AIRDOS-EPA is not obviously correct. In AIRDOS-EPA the total deposition is applied once to the soil, and applied again to plant surfaces where some fraction is retained and the remainder is lost from the system. In nature, the process occurs in the fashion shown in Figure 3.2, where some fraction of the total deposition is intercepted by plants with the remainder intercepted by the soil.

In the sample run of AIRDOS-EPA a retention fraction (interception) of 0.57 is used for pasture and 0.20 for vegetables. AIRDOS-EPA thus seems to calculate an input to the environment of 100% of the total deposition to soil plus another 57% to pasture or 20% to vegetables. Proper use of the parameters should yield 57% to pasture with 43% to soil, or 20% to vegetables with 80% to soil.

The assumption which allows AIRDOS-EPA to handle deposition by this apparently erroneous fashion is that the majority of the radionuclides falling on plants, or taken up by plant roots will be returned to the soil as plowed-under plant waste or cattle manure. Thus 100% of the total deposition eventually will be found in soil if we assume the quantities removed from the system as vegetables, meat, and milk are small in comparison to the quantities in plant and animal wastes returned to the soil.

It should be noted that as an equilibrium model AIRDOS-EPA calculates only the final condition of the environmental system after "n" years of facility operation. The vegetable, meat, and milk doses calculated are from

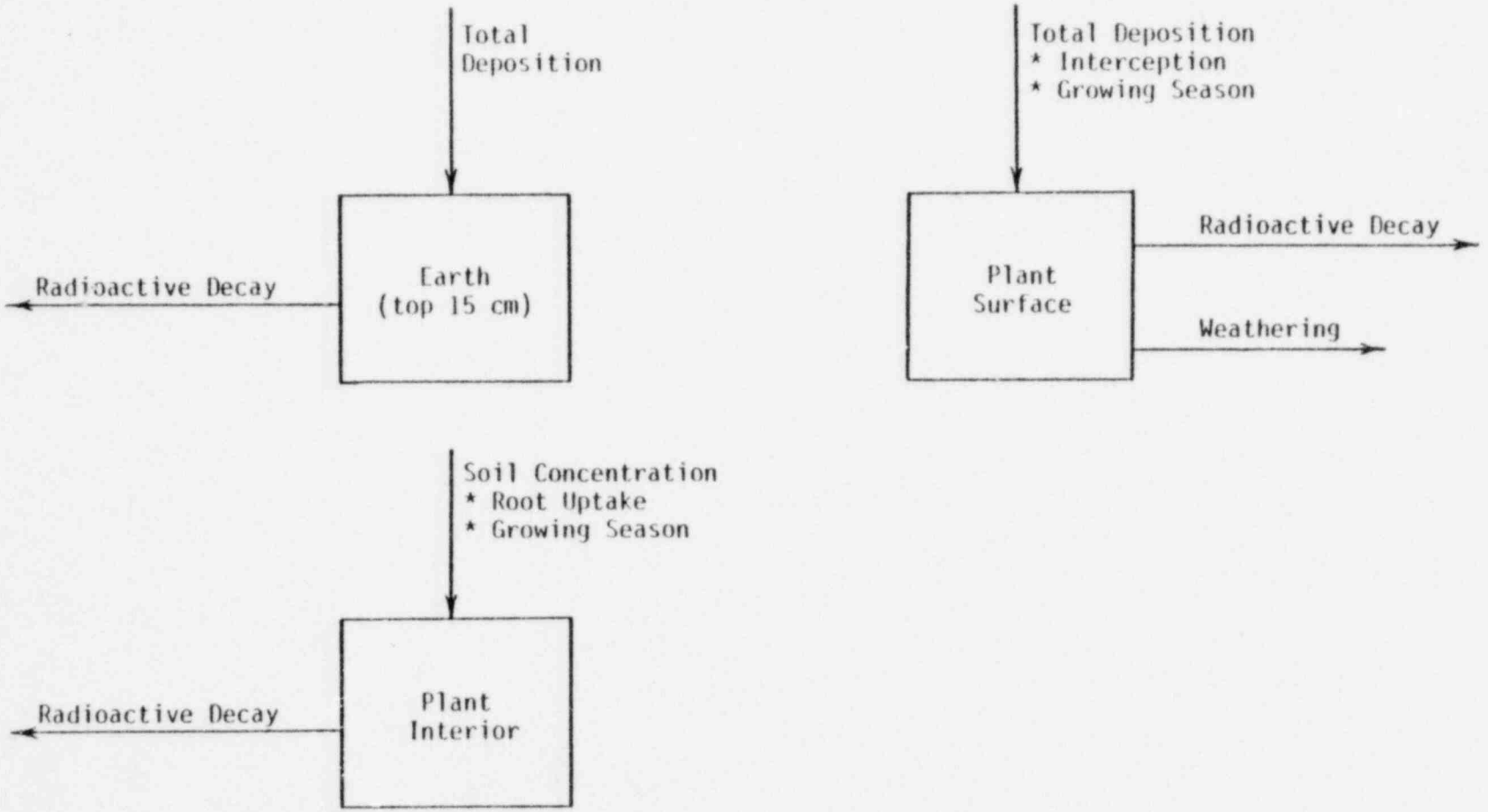


Figure 3.1

Diagram of AIRDOS-EPA as a
Set of Compartments (Atmosphere - Plant Tissues)

impact ltd.

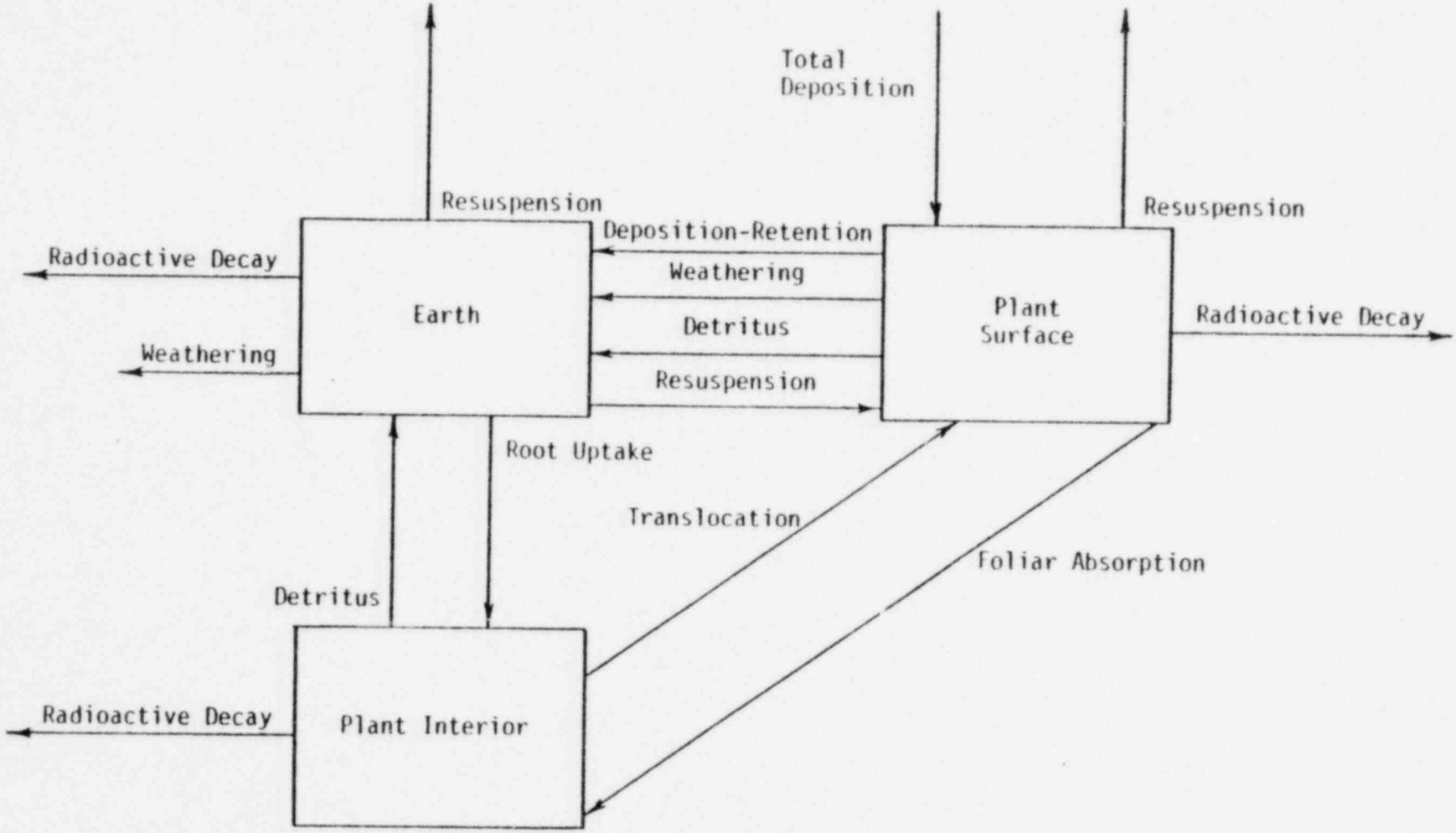


Figure 3.2

A General Compartmental
Model of the Atmosphere to Plant-Tissue System

impact ltd.

only the final year. The 100%-deposition to soil represents the accumulation of "n-1" years of plowed-under plant and animal wastes, plus the actual deposition directly to the soil for all "n" years. It also includes the deposition held on plants for the last year, which is erroneous since the radioactivity is not instantaneously recycled. The error in the final soil concentration due to including the last year's deposition onto plants will depend on the length of time for which the model is run. For a 100-year facility life the soil concentration will be in excess by 1/99; for a 20-year life, by 1/20.

Plant Surface Losses - Radioactivity intercepted by the plant surface may be removed by the weathering effects of wind and rain, incorporation of adsorbed radionuclides into the plant interior, resuspension of radionuclides to the atmosphere, recycling of plant detritus, and radioactive decay. The first pathway is included in AIRDOS-EPA and serves only to remove radioactivity from the plant without transferring it to the soil. This apparently erroneous procedure is compensated, however, by the fact that the radioactivity removed by weathering was already included in the soil inventory as part of the deposition.

The foliar absorption pathway is not included in AIRDOS-EPA. It is unlikely to be important for the natural radionuclides. If foliar absorption were significant its impact would likely be most evident in the vegetable dose to man since the radionuclide content of non-leafy vegetables would increase. For unwashed plant products (cattle feed and pasture) no change would be evident. For washed leafy vegetables the effect of washing will be reduced. This pathway will have no effect on the proportion of radioactivity in plant tissues which is returned to the soil as plant and animal wastes, therefore the fundamental assumption of AIRDOS-EPA is not violated.

Resuspension of radioactive particulates from plant surfaces to the atmosphere is not included in AIRDOS-EPA. This pathway removes radioactivity from the system, thus it could cause an error in the quantity of radioactivity weathered from plant surfaces to soil. The simple assumption that conditions of radionuclide deposition are reasonably uniform on a large areal scale implies that radioactive particulates removed at one location will be replaced from upwind. For the long time span and grossly averaged conditions for which AIRDOS-EPA was originally intended, this assumption is acceptable.

The return of plant detritus to the soil is inherent in the formulation of AIRDOS-EPA. Any significant local practice deviating from this assumption will be an important source of error in the AIRDOS-EPA soil concentrations.

Plant Interior Losses - Mechanisms for the loss of radionuclides from plant tissues are few. Of those identified, radioactive decay receives state of the art treatment in AIRDOS-EPA, and the return of all plant detritus to the soil is inherent in the model formulation. Again, any local agricultural practice which precludes the return of a significant fraction of harvested plant material to the local soil will produce errors in the AIRDOS-EPA soil concentrations.

The translocation of radionuclides from the plant interior to the plant surfaces is an unlikely pathway except perhaps for radon which may diffuse

through plant fluids and escape through the stomata to the atmosphere. AIRDOS-EPA does not account for the build-up of daughter radionuclides in plant materials.

Soil Losses - In AIRDOS-EPA the only loss considered from soil is that due to radioactive decay. Other pathways for loss have been identified. The loss of radioactivity from the soil surface to the atmosphere via resuspension may be resolved with the same arguments used in discussing resuspension from plant surfaces to the atmosphere. The resuspension from soil to plant surfaces will be returned to the soil as plant or animal wastes (this is, again, the fundamental assumption underlying AIRDOS-EPA). This process will, however, significantly affect the surface contamination of plants. In dry climates where resuspension to plant surfaces is great a surface contamination increase will occur. A method for considering resuspension should be included in AIRDOS-EPA.

The weathering loss pathway from soils is not accounted for in AIRDOS-EPA when considering plant uptake. This will result in dose overestimates. Removal of radionuclides from the soil profile will serve to lower the equilibrium concentration in soil, thus reducing the radionuclide uptake to the plant interior and the importance of soil resuspension to plant surfaces. The lowered plant concentration will propagate to the vegetable, meat, and milk doses, although generally the plant interior contributes little to these doses in comparison to the plant surfaces. For radionuclides which are mobile in soil this pathway must be considered a potential source of significant error in the AIRDOS-EPA formulation.

Baes (in Hoffman and Baes, 1979, pp. 85-92) discusses the loss of radionuclides from soil by percolation, and addresses a mechanism to account for percolation (and other weathering processes) in which a decay constant is used.

An expression allowing for calculation of the coefficient is given by Baes. It depends on the water infiltration rate, the depth of the soil root zone, the soil bulk density, soil water content, and the equilibrium distribution coefficient of the radionuclide between soil and water. Since all of these parameters are highly site-specific and some are radionuclide specific it is essential to provide them if the percolation correction is to be used.

The benefit of using the percolation correction may be estimated using a "typical" value. The range presented by Baes (in Hoffman and Baes 1979, p. 90) is 10^{-7} to 10^{-1} per year. To illustrate the difference in the soil equilibrium term at 100 years with and without percolation an arbitrary value of 10^{-3} per year is selected and Ra-226 is used as an example. About a 5% reduction in the activity in the soil is calculated. For larger decay constants the difference will be larger. For example, by using 10^{-1} instead of 10^{-} the radium activity in the soil is reduced 90%.

Other mechanisms exist for the depletion of radionuclides in soil. These include losses due to erosion and burrowing animal, mixing due to plowing, and uptake by plants having large uptake coefficients.

Under conditions where excessive leaching or erosive losses do not occur the soil loss pathway has little impact.

3.3.1.2 Plant Tissue to Vegetables, Meat and Milk Pathways

A diagram of the pathways as determined from the AIRDOS-EPA documentation is presented as Figure 3.3. For the purpose of this discussion a more detailed process-oriented flow diagram is not needed.

Radioactivity in Processed Vegetables - AIRDOS-EPA calculates the radionuclide concentration in prepared vegetables by summing the surficial and internal contamination, allowing for losses in washing and other preparation. AIRDOS-EPA inherently assumes that the radioactivity removed from vegetables during processing is returned to the soil (it was placed there as part of the deposition). This assumption may cause erroneously high soil concentrations in at least two cases: where radioactivity washed from vegetables is lost via waste water from the system, and where vegetable wastes from processing are not returned to agricultural soils (disposed as garbage). The magnitude of the error depends on the amount of radioactivity lost each year, compounded over the number of years of deposition.

The structure of AIRDOS-EPA allows for a reduction in dose due to the removal of the radionuclides from the vegetables. It does not, however, allow for reduction in dose due to the removal of those same radionuclides from the soil when crops are harvested. In this situation the structure of AIRDOS-EPA precludes direct assessment of the effects of cycling between soil and plant and losses from the system and implies that such losses from the system are small. Ng (1978) gives values for the preparation losses for a number of crops. To cause a significant error in the soil concentration a crop with a large processing loss would have to be cropped intensively over a signifcant area near the source.

Loss of radioactivity from processed vegetables due to radioactive decay is included in AIRDOS-EPA.

Radioactivity in Cattle Feed - AIRDOS-EPA determines the radionuclide content of cattle feed by summing plant surface and interior concentrations, allotting a fraction of the plant material to be considered as pasture grass without a holdup time, and the complementary fraction as stored feed with a holdup time for radioactive decay. The Code does not account for differences in the feeding pattern or quantity between beef and dairy cattle. It inherently assumes that the wasted or spoiled feed is returned to the soil.

Radioactivity in Meat and Milk - AIRDOS-EPA bypasses the cow, transferring radionuclides in cattle feed to milk and meat. Only a small fraction of the radionuclide content of bulk feed is generally assimilated by cattle. The vast majority is excreted and AIRDOS-EPA assumes it to be returned to the soil without loss. In fact some small fraction of radionuclides is lost to the cattle and not returned to the soil. In any case, where this fraction is significant the structure of AIRDOS-EPA will cause erroneously high concentrations in soil.

Radionuclides held in cattle manure may differ in their availability for uptake by plants from those radionuclides in the soil, especially when the dung is left on the surface as it would be on the range. The process of reincorporating the dung in to the soil represents a delay in the availability of the radionuclides to plants which is not included in AIRDOS-EPA.

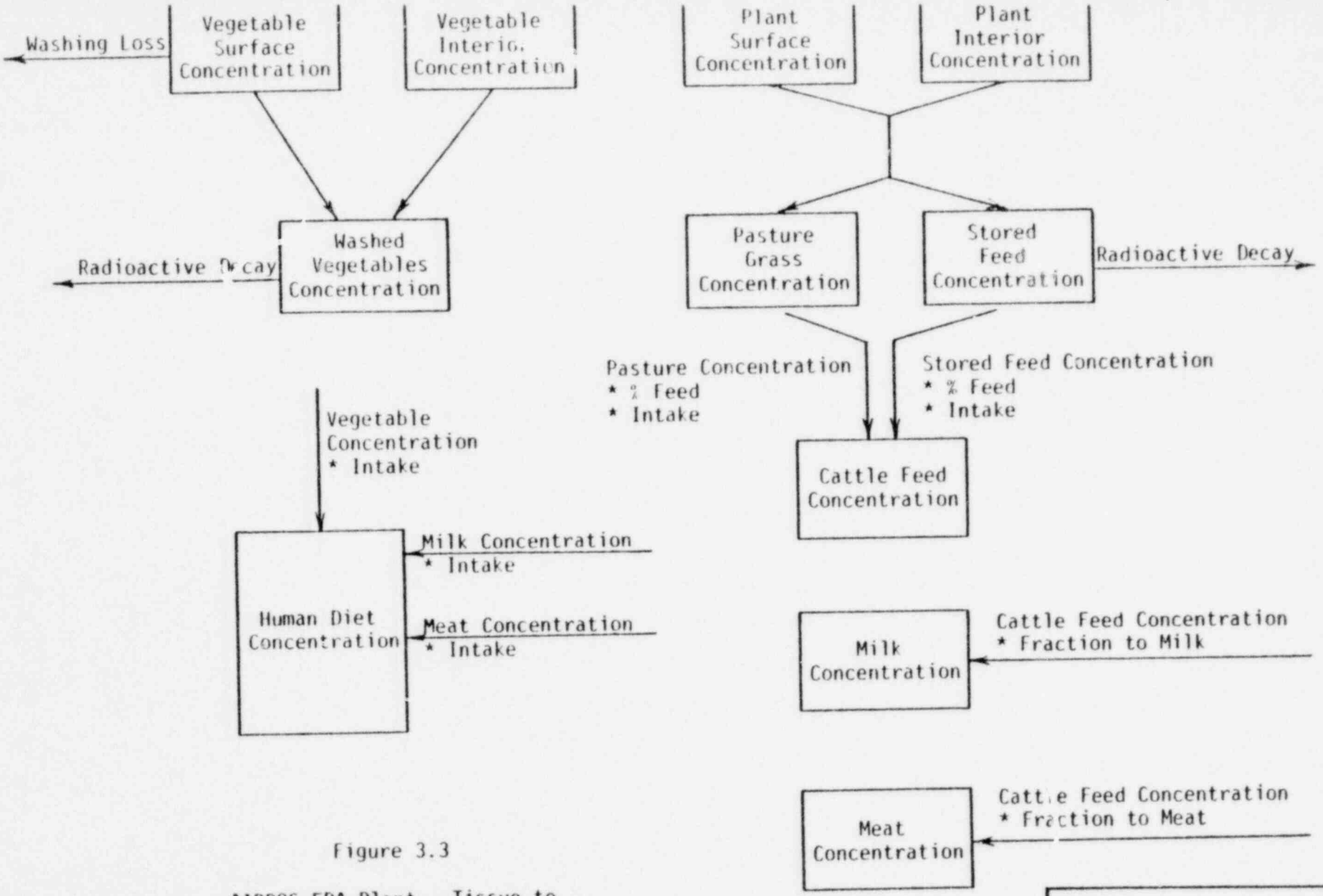


Figure 3.3

AIRDOS-EPA Plant - Tissue to
Prepared Meat, Milk and Vegetables Model Structure

impact ltd.

In addition to the radionuclides transferred from feed to meat and milk, some will be transferred from feed to bone, liver, and other organs. AIRDOS-EPA assumes this activity to be in the soil. This is not generally the case, in fact little animal byproduct material will be returned directly to the local soil. This pathway for the removal of radioactivity from the system will be significant only if the total radionuclide assimilation by cattle is, in some case, large.

3.3.1.3 Submodel Formulation Conclusions

The multiplicative chain structure of AIRDOS-EPA assumes linear transport of radionuclides from compartment to compartment, e.g. air to soil to plant to cow to person. This chain does not allow explicit modeling of additional transfers and cycling between system compartments, e.g. plant back to soil or plant to air. Thus, simplifying assumptions regarding the ultimate fate of the radionuclides are required throughout. While the simplifications seem reasonable and adequate for some cases, at least one case has been found where the assumptions have not held. Technecium is treated in AIRDOS-EPA as a special case, requiring a special set of calculations to account for the fact that this radionuclide is concentrated by plants and the quantities removed from the soil are significant. The result is a "patch" in the model to account for a case where the inherent assumptions do not hold.

Considering the uncertainty attached to much of the data used in AIRDOS-EPA it may be that other such "patches" will be needed for other radionuclides. We question the use of a model which assumes the eventual fate of the radionuclides by its structure: the fate of the radionuclides should be, rather, its predictive end-point. We recommend the use of a different class of model to avoid the need for assumptions which in themselves may determine the outcome of the model.

The use of a pathways-oriented model, where the kinetics of each environmental pathway are represented explicitly, is more appropriate to this application. The use of such a model, where the rate of radionuclide flow along each pathway is modeled, relies on data similar to that used in AIRDOS-EPA. But assumptions which must be made concern the dynamics of the physical processes controlling each individual pathway. Assumptions are not made concerning the overall outcome of all the flows along the network of pathways as is the case in AIRDOS-EPA. A pathways (first-order, linear kinetics) model models transfers and cycling, and allows the interacting processes to determine the fate or eventual distribution of radioactive materials in the environment.

For many cases, where the transfers of radionuclides meet the assumptions inherent in AIRDOS-EPA, the pathways models will provide the same results. But, where particular radionuclides violate the assumptions (e.g., technicium), the only change needed in a pathways model is in the value of the transfer rate for the affected pathway. Two models are documented and currently available which fit this classification, TERMOD, which was originally incorporated in the AIRDOS and AIRDOS-II models, and the model of the Commission of the European Communities (CEC). Both are differential equation type models, use pathways conceptually similar to Figure 3.2, and are integrated numerically. Both are flexible in terms of the time scale of a simulation, and are able to provide 16 environmental concentrations as a

function of time within the period of the simulation. Information such as this is the proper data for comparison with field-collected radionuclide concentrations. AIRDOS-EPA and other models could be replaced with a model of this genre without requiring significantly more or different parameter values. AIRDOS-EPA could be duplicated in such a model simply by setting the rate coefficients of pathways ignored in AIRDOS-EPA to zero. At that point it would be a simple exercise to determine the significance of the ignored pathways by testing the model with a range of values for the appropriate rate coefficients. Other benefit might be derived by examining the time course of the contamination of the environment to determine the length of time required for the most sensitive pathway to yield a predetermined dose to man.

3.3.2 Submodel Parameter Evaluations

AIRDOS-EPA calculations of vegetation, meat, and milk radionuclide concentrations depend upon the same set of parameters found in Reg. Guide 1.109. (See the parameter glossary on the following page). For many of these parameters the user can input data specific to the application if available. If not, the user can use default values provided in the AIRDOS-EPA documentation which are intended to be generic rather than site-specific. For several parameters the default values are those of the NRC from Reg. Guide 1.109. Where newer values have been used, many have been taken from a recent review by Hoffman and Baes (1979).

The following is an evaluation of those default values to determine their applicability to the conditions associated with uranium mining and milling in the American West. A summary of the evaluation approach and results is followed by more detailed discussion of the parameters in context.

Each parameter used in the model and its associated default value has been qualitatively evaluated against three criteria; appropriateness to conditions associated with the uranium industry, availability of site-specific information, and consequences of using an inappropriate value. The last criterion constitutes an estimate of the model's sensitivity to the parameter value.

The estimate of model sensitivity is based upon three principles; the role of the parameter in the pathway - the model will show greatest sensitivity to parameters that appear in calculations which drive several subsequent calculations, the role of the pathway in the model - the model will show greatest sensitivity to parameters that appear in the most direct pathways to man, and the role of the parameters in time-dependencies - the model will show a differential sensitivity to parameters describing the time-dependencies of processes as a function of the half-life of the nuclide of interest.

A general categorization of the reviewed parameters appears in the Tables 3.1 and 3.2. The numerical values are not intended to be precise measures of sensitivity, appropriateness or availability of parameter values. They subjectively and relatively reflect the criteria presented above and the major points of the subsequent discussions. Parameters that combine the properties of high sensitivity, low applicability, and ready availability are those that deserve priority attention. These include R, Y_v, T , Q_f, M_B, and V_B. Other parameters are known only with large uncertainty but have relatively less influence on dose estimates and require difficult or expensive research for

Parameter	Definition
B_{iv}	Concentration factor for uptake of nuclide from soil for pasture and forage
B_{iv}	Concentration factor for uptake of nuclide from soil by edible parts of crops (dry weight)
F_f	Fraction of animal's daily intake of nuclide which appears in each kilogram of flesh
F_m	Fraction of animal's daily intake of nuclide which appears in each liter of milk
f_p	Fraction of year animals graze on pasture
f_s	Fraction of daily feed that is pasture grass when animals graze on pasture
M_B	Muscle mass of meat producing animal at slaughter
ρ	Effective surface density of soil (dry weight)
Q_f	Consumption rate of contaminated feed or forage by an animal (dry weight)
R_1, R_2	Fallout interception fraction for pasture and for vegetable crops respectively
t_b	Period of long-term buildup for activity on soil
t_{e1}, t_{e2}	Period of exposure during growing season; pasture grass and crops or leafy vegetables respectively
t_{h1}	Time delay - ingestion of pasture grass by animals
t_{h2}	Time delay - ingestion of stored feed by animal
t_{h3}	Time delay - ingestion of produce by man
t_{h4}	Time delay - ingestion of produce by man
V_M	Milk production of cow
Y_{v1}	Agricultural productivity by unit area (grass-cow-milk-pathway)
Y_{v2}	Agricultural productivity by unit area (produce or leafy vegetables)
λ_w	Removal rate constant for physical loss from plant surface by weathering

AIRDOS-EPA Terrestrial Pathways Submodel
Parameter Glossary

Parameter	S	Ap	Av
R1	1	3	2
R2	1	1	3
Y_{v_1}	1	3	1
Y_{v_2}	1	2	1
t_{e_1}	1	2	1
t_{e_2}	1	2	1
t_{h_1}	3	3	1
t_{h_2}	3	2	2
t_{h_3}	2	2	2
t_{h_4}	2	2	2
t_b	2	2	1
λ_w	1	3	3
P	2	2	1
f_p	3	2	1
f_s	3	2	1
Q_F	2	2	1
M_B	2	2	1
V_B	2	2	1

S = Sensitivity of model to parameter value
1 = large 2 = moderate 3 = small
Ap = Appropriateness of default value
1 = inadequate 2 = questionable 3 = adequate
Av = Availability of more specific value
1 = readily available 2 = some times available
3 = difficult to obtain

Table 3.1
Terrestrial Pathways Submodel
Nuclide Independent Parameters
Qualitative Evaluations
Sensitivity, Appropriateness, Availability

Parameter		Element					
		U	Th	Ra	Pb	Po	Bi
F_m	S	2	2	2	2	2	2
	Ap	3	3	3	3	3	?
	Av	3	3	3	3	3	3
F_f	S	2	2	2	2	2	2
	Ap	1	1	1	1	1	1
	Av	3	3	3	3	3	3
B_{iv}	S	3	3	3	3	3	3
	Ap	2	2	2	2	2	2
	Av	3	3	3	3	3	3
B_{iv}	S	3	3	3	3	3	3
	Ap	2	2	2	2	2	2
	Av	3	3	3	3	3	3

S = Sensitivity of model to parameter value
1 = large .2 = moderate 3 = small
Ap = Appropriateness of default value
1 = inadequate 2 = questionable 3 = adequate
Av = Availability of more specific value
1 = readily available 2 = some times avilable
3 = difficult to obtain

Table 3.2
Terrestrial Pathways Submodel
Nuclide Dependent Parameters
Qualitative Evaluations
Sensitivity Appropriateness, Availability

reduction of that uncertainty. The nuclide-specific uptake parameters F_f and B_{iv} are examples. Such parameters should be updated as new information is obtained but should not be the first objects of attention. Parameters for which better values are readily available, particularly those reflecting site specific agricultural data, should not be defaulted regardless of the model's sensitivity to them.

3.3 2.1 Vegetation Concentration Calculations

This is the most influential calculation in determining doses from the various ingestion pathways because deposition on the surfaces of leafy vegetables is the most direct pathway to human ingestion. This contention is supported by the fact that doses predicted by AIRDOS-EPA for consumption of vegetables are greater than those for meat and milk ingestion for all nuclides of concern to the uranium industry. In addition, the results of this calculation, with appropriate changes in parameter values, are used to predict concentrations in forage and feed which, in turn, drive the calculations of meat and milk concentrations.

There are two critical parts of the equation for this calculation. The first describes the direct surface deposition and retention; the second describes uptake through plant routes. Tne parameters contained in each part will be addressed separately.

Direct Surface Deposition and Retention on Vegetation - This term always dominates over the root uptake term due to the range of values the various parameters can assume. Direct deposition depends on the following parameters, none of which are considered by AIRDOS-EPA to be nuclide-dependent:

R = the fraction of deposited activity retained on edible portions of crops.

Y_v = the agricultural productivity of the edible portion of vegetation, in kg/m^2.

For forage crops R and Y_v must be considered together as they are highly correlated. The default values are taken to be $R_1 = 0.57$ and $Y_{v1} = 0.28$ resulting in a ratio of $R_1/Y_{v1} = 2.03$, the mean of the distribution described by Miller (Hoffman & Baes, 1979). It would be more appropriate to set a default value for this ratio considered as a single parameter. If the correlation is as strong as suggested by Miller this value should be adequate for a wide range of forage crops.

For vegetable crops a similar correlation can not be demonstrated and the NRC default value of .2 is used. Values for R_2 are generally unavailable. While R_2 should be less than R_1, it would be expected to vary more widely with plant species than R_1. The default value is, therefore, adequate within the large uncertainty inherent in the parameter.

Y_v varies widely with regional differences in crops grown. A weighted average of crops representative of the region of interest (uranium milling regions) should be used for specific applications of the model.

λ_w = the removal rate constant for loss from the surfaces of vegetation by weathering.

The review of Hoffman and Baes (1979) establishes that the default value equivalent to a 14 day half-time is a reasonable one, particularly for the semi-arid west where much of the basic data have been obtained. This is an adequate default value, difficult to improve upon. It is not to be confused with soil weathering losses used for "model adjustment".

t_e = the time period that crops are exposed to contamination during the growing season.

The time period chosen for t_e will determine the influence of λ_w. If t_e exceeds roughly five times the value of the half-time corresponding to λ_w, small corrections in the weathering rate constant will not influence the calculation.

The default value for t_e is taken to be 30 days for pasture and 60 days for vegetable crops. Since agricultural practices vary with climate, crop, and soil, site or region-specific (such as for uranium milling) values should be used for individual applications. Statistics such as planting and harvest dates are readily available from the US Department of Agriculture.

Radionuclide Uptake by Vegetation Through Roots - This calculation is dependent upon the following parameters:

B_{iv} = the concentration factor for uptake of a given radionuclide from soil by edible parts of crops.

This parameter is known to be element-dependent. In some cases it is also known to be species and soil dependent. Thus these values are subject to change as new information appears in the literature. The values used by AIRDOS-EPA are consistent with current literature values but those current values are generally based on inadequate research and have a large inherent uncertainty. If a crop with known values dominates in a given region, appropriate adjustment of B_{iv} should be made.

P = the effective density of the top 15 cm of soil.

The default value is taken to be the mean of the distribution reported by Hoffman and Baes. This is appropriate as a generic value. Since data on this parameter are readily available, a more representative value should always be used for specific applications.

T_b = the period for long-term buildup of activity in soil.

The default value of 100 years for buildup time used in the RICERAUS analysis is not realistic for uranium mill facilities with a 15-20 year expected time of operation. For long-lived nuclides (>500 years) or short-lived ones (< 1 year) this will not greatly influence their dose contribution. However, for Pb-210 with a half-life of 21 years the value will result in an overestimation of about 100%. A more representative value should be used for specific applications of the model to uranium milling.

T_h = a holdup time representing the interval between harvest and consumption of vegetation.

This parameter influences both terms of the plant concentration expression. While the default value of zero is appropriate for pasture, the values for stored feed (2160 hr), and vegetables and produce (336 hr) are not. Site or region-specific values should be used where available.

3.3.2.1 Meat and Milk Concentration Calculations

Concentrations in meat and milk as are calculated using several of the same parameters. Both pathways use the same expression for calculating concentrations in feed. In addition to depending on the parameters discussed above in relation to vegetation concentrations, feed concentrations depend on f_p and f_s. Meat and milk concentrations are also both functions of Q_f. These values are more influential than those affecting only one pathway or the other.

f_p = fraction of the year that animals graze on pasture.
f_s = fraction of daily feed that is pasture grass when animals graze on pasture.

The default values of these parameters are taken from median values described by Hoffman and Baes (1979). However, the range of observations about those means is large (f_s: mean = 0.43, s.d. = 0.13; f_p: mean = 0.40, s.d. = 0.22) reflecting widely varying environmental conditions. It has also not been established that these two parameters are independent.

Since grazing practices vary widely, more representative values should be used. However, note that these parameters have a strong influence on dose estimates only when there is a large difference between contamination levels in pasture and stored feed.

Q_f = the amount of feed consumed per animal per day.

The default value for Q_f is taken to be the median of the distribution described by Hoffman and Baes (1979) for Holsteins and derived from data for Dairy Herd Improvement Association (DHIA) herds. Even though it may be expected that DHIA herds will have a

slightly higher mean than that of the entire U.S. dairy cow population, this value is likely to be adequate for estimating concentration in milk when Holsteins dominate milk production.

For beef cattle this value is inappropriate. A value representative of cattle breed and local conditions should be used.

Parameters exclusively influencing the milk pathway are F_m and V_B. It is expected that there are unquantified correlations between F_m, V_M, and Q_f.

F_m = the fraction of the animal's daily intake of a given radionuclide which appears in each liter of milk.

The values for lead, polonium, radium, thorium and uranium reflect the current knowledge of the parameter. Values for bismuth used for our runs of AIRDOS-EPA (see Section 2.0) were provided by EPA with no documentation.

V_m = daily milk production rate of a cow.

The default value is below the average for the U.S. cow population (USDA, 1977). Since this parameter is dependent on breed of cow and on local conditions, a representative value should be used for specific applications.

Concentrations in Meat - The important parameters exclusively influencing contamination levels in meat are F_f, M_b, and Q_f. There are indications that F_f and M_b are correlated. However, F_f is one of the least well known of the parameters required for this model so that it is unlikely this correlation can be quantified.

F_f = the fraction of the animal's daily intake of a given nuclide which appears in each kilogram of meat.

This is a strongly nuclide dependent parameter that is poorly quantified for most nuclides. AIRDOS-EPA documentation notes that "it has not been conclusively shown that equilibrium between intake rate and meat concentration is ever attained". Even dubious data are unavailable for cattle. Estimates were made from values measured for other ruminant species.

The value of 3.0×10^{-3} for the F_f of radium exceeds the value of 5.1×10^{-4} recommended by the review of McDowell-Boyer (1979). The more recent value should be used. The value for lead of 9.1×10^{-4} is probably adequate.

For uranium, thorium, and polonium no adequate values are available but the estimates cited are consistent with the literature on the parameter. Values used for bismuth in our AIRDOS-EPA runs (see Section 2.0) were provided by EPA with no documentation.

M_B = the mass of muscle per animal at slaughter.

The default value is adequate for generic use, however, the parameter is dependent on the breed of cattle and on local conditions. Representative values should be readily available for individual applications such as for uranium milling.

3.3.2.2 Parameter Conclusions

Based on the discussion of the previous sections the following topics merit special consideration:

Importance of Retention, Resuspension, and Weathering - The most critical parameters in the AIRDOS-EPA formulation are those that determine the concentration of activity on the surfaces of vegetation. The entire model is driven by the results of these calculations. Processes of interception, retention, and weathering, especially for vegetable crops, deserve more careful treatment. The contribution of resuspension from the soil surface onto plant surfaces is known to be important and constitutes a major contaminating process not addressed by the model. The 14 day weathering half-time is characteristic of particle-size distributions similar to those of resuspended soils. The weathering behavior of the one micron particles assumed as the direct-deposition source term is undoubtedly different.

Nuclide Specific Parameter Considerations - Uptake by plants and by animals into meat and milk are governed by element-dependent biochemical processes. Because these processes are not well described, simple concentration ratios are employed. Any more elaborate approach is not supported by existing data.

Certain limitations to the validity of these parameters should be recognized. They all require that equilibrium exist between the two relevant compartments. Only for the feed/milk ratio is this assumption met. For feed/flesh and soil/plant ratios, equilibrium has not been conclusively demonstrated.

Setting aside these considerations, it is clear that a thorough analysis of the available literature on B_{iv}, F_f, and F_m needs to be done for the naturally occurring radionuclides. The review by Hoffman and Baes has proved its value by the number of times it is cited in AIRDOS-EPA and elsewhere. Unfortunately, it contains analysis only for the major fission product nuclides. The EPA or NRC should sponsor a similar analysis for the U-238 series.

Correlation Among Parameters - Several sets of parameters exhibit strong correlations as noted above. The result of this is that care must be taken when using site-specific values. A value of one parameter may be appropriate only when used with certain values of other parameters. Even when proposing generic default values these sets of correlated parameters should be considered together.

Availability of Agricultural Data Base - Clearly the most important parameters in assessing a particular site are those describing the local agricultural environment. Crop production, grazing practices, soil type and so forth have a strong influence on most of the parameters required by AIRDOS-EPA. Data on these parameters have been compiled by the USDA for many areas of the country. These data should be accessed by the EPA when conducting any regionally specific analysis such as that for uranium mills.

3.4 DOSE CALCULATIONS

3.4.1 Individuals

The AIRDOS-EPA Code calculates the dose delivered to selected organs of the body from exposure to selected radionuclides through five pathways: air immersion, exposure to ground surfaces, immersion in contaminated water, inhalation of radionuclides in air, and ingestion of food produced in the area. Dose conversion factors for each of the nuclides of concern are provided for each of these pathways as input to the code. Inhalation and ingestion dose conversion factors recommended in the AIRDOS-EPA documentation are those published in the fall of 1979 by Oak Ridge (Killough, et. al., 1979). Air immersion and surface exposure dose conversion factors used have also been developed at Oak Ridge (Kocher, 1979). For an additional discussion of dose conversion factors see Dr. Hoyt Whipple's report for the American Mining Congress, 1980.

3.4.1.1 Inhalation Doses

To compute inhalation doses, the air concentration at a receptor is multiplied by the breathing rate assumed and dose conversion factors. Inhalation dose conversion factors are dependent on the size of the particle assumed and the solubility of the compound in which the radionuclide is found. The particle size assumptions of the recent RICERAUS uranium mill analysis have been discussed in the section on source terms.

The solubility classification scheme developed by the ICRP Task Group Lung Model includes three classes: D, 0 to 10 days; W, 11 to 100 days; and Y, greater than 100 days. The EPA selected the Y classification for all of the radionuclides in their RICERAUS analysis. Recent information developed from analysis of uranium mill particulate releases indicate that other solubility classes will have to be considered, (Kalkwarf, 1979).

3.4.1.2 Air Immersion Doses

Dose conversion factors for estimating external doses from air containing gamma emitting radionuclides are derived using an infinite cloud assumption. This assumption can result in doses near a low level release being overestimated by one or two orders of magnitude due to limited spreading of the plume close to the source (Hoffman, et al., 1978).

3.4.1.3 Surface Exposure Doses

Estimated doses are directly proportional to calculated ground concentrations. Unlike the terrestrial pathways submodel, a mechanism is provided to account for environmental decay and resuspension. This option was not used in the RICERAUS analysis, therefore predicted surface exposure doses were overestimated.

3.4.1.4 Water Immersion Doses

In general these doses are not considered by the EPA in applying models such as AIRDOS-EPA to uranium milling operations.

3.4.1.5 Ingestion Doses

In calculating these doses ingestion rates of produce, milk, meat and leafy vegetables are assumed. Ingestion fractions are assumed for produce and leafy vegetables grown in a receptors garden and in the region. It appears that the factor for consideration of produce and leafy vegetables produced at a receptor of interest is counted twice, once in the RVEG factor and once in the f_g and f_e factors.

In the RICERAUS runs the default values for market place dilution of foodstuffs consumed in the assessed region, and for local and regional foodstuff availability and processing procedures, were set to very conservative values in order to describe a "worst case" situation. This is extremely unrealistic. For example, individuals were assumed to produce 70% of their vegetables, 44% of their meat, and 40% of their milk with the remaining foodstuffs to be provided by regional sources (within an 80 km radius). In some areas of the West virtually all produce is imported from outside the region being modeled. Efforts to improve the predictive ability of the model, either by improvements in structure or in parameter values, are wasted if available information on the distribution of contaminated food stuffs is ignored.

3.4.2 Population Dose

A population dose caused by a facility's activities can be calculated using the AIRDOS-EPA Code. The population dose is defined as the total dose in person-rems received by the population living within an 80 kilometer radius of the facility. The calculation is made by considering a grid superimposed on the 80 kilometer radius area. Grid segments are delineated by the 16 wind direction sectors and 12 concentric annular rings placed at selected distances from the circle center. An individual dose is computed for each segment which is then multiplied by the population assumed for that segment. The total population dose is derived by summing over all segments.

The population dose is thus computed using the same submodels used for individual doses. As discussed in the previous sections there is a large uncertainty associated with each of those submodels which is thus inherent in the population dose calculations. In fact, for the population dose the uncertainty is much larger. Since uncertain individual doses are multiplied by the total population, the uncertainties are also multiplied by a factor as large as the population. In the RICERAUS analysis uncertainties were thus multiplied by a factor of 36,000, the assumed population. To introduce further uncertainty most of the population of concern will be situated at distances more than 10 kilometers from the facility. As stated in the dispersion submodel section of this review, no confidence in the AIRDOS-EPA predicted concentrations is warranted at such distances.

As stated by Oak Ridge reviewers, "the population dose commitment calculation is of very limited value" (Hoffman, et al., 1978). The population dose commitment is considered useful only as a relative index to be used in comparing facilities or technologies. In no sense should these figures be represented as reality, as the EPA seems to have done in their recent uranium mill analysis.

3.5 SUMMARY & CONCLUSIONS - AIRDOS-EPA CRITICAL REVIEW

AIRDOS-EPA submodels and their components formulation are evaluated in Table 3.3. In Table 3.4 selected submodel parameter values are evaluated for accuracy and appropriateness for use in evaluating uranium mill radiological impacts. In both tables suggested recommendations for improvement are identified where possible.

These tables serve to illustrate the uncertainty inherent in each of the AIRDOS-EPA submodels and parameter values. The fundamental causes of error are:

1. Insufficient Submodel Scientific Basis - For some physical processes such as deposition and resuspension there has simply not been sufficient scientific support research conducted to substantiate use of a particular submodel. In other cases, such as terrestrial transport, submodels have been formulated but little or no validation data exist to confirm their accuracy.

2. Lack of Modeling Sophistication - Some physical processes have been studied and are sufficiently complex that no meaningful mathematical simulation method has been developed. Such is the case with the tailings emission generation process.

3. Inapplicability of Parameter Values - Some submodels require single values to be selected for internal constants. Usually these values represent a range of observed data. Thus use of a single value for a particular application introduces uncertainty. For the RICERAUS analysis many of the site related parameter values used were not representative of uranium milling regions thus further limiting model applicability.

Taken alone each submodel has its own inherent uncertainty. Taken together the uncertainty compounds from submodel to submodel so that the final dose predictions may have uncertainty of several orders of magnitude.

If the uncertainty associated with all the individual submodels were precisely known then a statistical analysis could be conducted to determine the uncertainty associated with AIRDOS-EPA dose predictions. An alternative approach to establishing overall uncertainty would be to conduct a sensitivity analysis. This is the fourth task Shaeffer suggests in her suggested review approach discussed in the introduction to this critical review section. Using the sensitivity analysis approach, the model itself is used to derive estimates of total dose uncertainty. The added benefit of a sensitivity analysis is that one can determine which submodel components and parameters most affect dose predictions. Once critical components are identified critical reviews such as this can be focused and priorities for further code development and research can be set. We strongly recommend that the EPA conduct such an analysis of the AIRDOS-EPA Code.

Even with a sensitivity analysis and further research our review indicates that there are certain processes which simply are to complex to be modeled accurately. This realization has important implications for the further use of such codes for setting or enforcing standards.

Submodel Components	Evaluation	Recommended Replacement
Source Terms		
Ore Pad & Grinding	Conservative influence on predicted doses - degree unknown due to insufficient scientific basis	More empirical data on amount and particle size
Yellowcake Drying	Conservative influence on dose predictions - degree unknown	More empirical data on amount and particle size
Tailings Pond Particulates	No confidence in predictions - may be off by several orders of magnitude	No adequate modeling technique available
Air Dispersion		
Gaussian Equations	Limited applicability - not appropriate for uranium milling due to conditions of complex terrain and low wind speeds and other factors	EPA approved terrain modification. Possible use of particle-in-cell or finite difference models. NRC low wind speed correction factor
Plume Rise	Plume rise at model mill stacks should be considered, Brigg's momentum dominated formulation is used in other models	Inclusion in future model mill analyses of Brigg's formulation
Wind Shear	Model does not account for wind speed variation with height	Profile methods used in other EPA dispersion programs

Table 3.3
AIRDOS-EPA Code Formulation Evalutations
(continued on next page)

Submodel Components	Evaluation	Recommended Replacement
Reciprocal Average Wind Speeds	Insufficient model validation studies, inconsistency of application leading to conservatism of factor of 2 or more	Additional study or conventional use of wind speed classes; consistent use of average wind speed
Plume Trapping & Lid Penetration	More accurate alternative plume trapping method; not accounting for lid penetration may cause overestimates	Use Turner's alternative plume trapping method (1970)
Predictions at Long Distances	No validation work	No accurate model exists
Plume Depletion		
Gravitational Settling	Tilted plume factor only should be used in neutral stability conditions	Only apply when appropriate
Source Depletion Model	May result in concentrations overestimated by factor of four at close receptors	Horst's hybrid source depletion model (1979)
Resuspension	Important process which is ignored in AIRDOS-EPA	An accurate simulation model is not available
Precipitation Scavenging	AIRDOS-EPA method is based on columnar average concentrations	Alternative method available based on a surface level concentrations as suggested in Hoffman, et al., 1978.

Table 3.3
AIRDOS-EPA Code Formulation Evaluations
(continuation)

Submodel Components	Evaluation	Recommended Replacement
Radiological Decay	Insufficient research to justify	More study needed
Terrestrial Pathways	Generally insufficient validation studies; models formulated to to be conservative, particularly assumptions of complete recycling to soil	Further research; use of linear kinetics model such as TERMOD or CEC model
Atmosphere to Plant Tissues		
Ground Deposition	Radionuclide cycling not specifically modeled but are implicitly considered	As Above
Plant Surface Concentrations	Weathering and radioactive decay accounted for; foliar adsorption and resuspension ignored	As Above
Plant Interior Concentrations	Uptake from soil does not account for soil properties or element solubilities and is not sufficiently plant or nuclide specific. Recycling to soil assumed but not necessarily true	As Above
Soil Losses	Only radioactive decay and soil percolation addressed. Other pathways exist, e.g. percolation, resuspension, mechanical mixing, etc.	Use λ_e of Hoffman & Baes, 1979

Table 3.3
AIRDOS-EPA Code Formulation Evaluations
(continuation)

Submodel Components	Evaluation	Recommended Replacement
Plant Tissues to Vegetables, Meat and Milk		
Processed Vegetable	Limited applicability of assumptions about radionuclide cycling to soil	As above
Cattle Feed	Does not account for differences in beef and milk cattle feeding or accurately depict recycling to soil	As above
Meat & Milk	Does not account for transfer of radionuclides to soil	As above
Individual Dose Calculations		
Inhalation	Based on latest available models	No better available
Air Immersion	Infinite cloud assumption over-estimates near receptor doses	No better available
Surface Exposure	Omission of surface radionuclide losses causes dose overestimates	Include surface loss mechanisms
Ingestion Doses	Best available models	No better available
Population Dose Calculations	Tremendous inherent uncertainty - orders of magnitude - use only for relative assessments	No better available

Table 3.3
AIRDOS-EPA Code Formulation Evaluations
(continuation)

Submodel Parameter	Accuracy	Appropriateness	Recommended Replacement
Source Terms			
Ore Pad & Grinding & Yellowcake Particle Size	Uncertainty is ± 100%		More accurate measurements to determine most representative size or if more size classifications needed
Tailings Particulates - Particle Size	Uncertainty possibly orders of magnitude	Not adequate	Further Study
Dispersion			
Plume Rise	———	Should be used	Use of 2.6 value for stable categories instead of 2.9
Dispersion Coefficients	Depends on application	Intended primarily for use with elevated stack sources - Only appropriate at distances up to 10 km	Use of adjusted Pasquill-Gifford curves
Mixing Height	± 100% and will vary with stability class	Adequate	Best available
Deposition Velocities	Up to four orders of magnitude uncertainty; uncertainty will primarily affect popuation dose estimates	Values used are too large	Hicks' (1976) model

Table 3.4
AIRDOS-EPA Code Submodel Parameter Evaluations
(continued on next page)

Submodel Parameter	Accuracy	Appropriateness	Recommended Replacement
Scavenging Coefficient	May vary over an order of magnitude	Value used was specific for arid areas	None
Terrestrial Pathways			
R_1/Y_{v_1}	Taken as a ratio, value is adequate for wide range of situations	Adequate	For certain cases, specific values may be better
R_2	Large associated uncertainty	Not adequate	Best available
Y_{v_2}	Varies over an order of magnitude for different crops	Questionable	Use weighted average of crops in milling regions
λ_w	Acceptable	Adequate	Best available
t_e	Can vary by a factor of 3	Questionable	Get representative values
B_{iv}	Order of magnitude range	Inadequate but best available	Adjust to be representative if possible
P	Can vary by a factor of 2	Questionable	Representative value

Table 3.4

AIRDOS-EPA Code Submodel Parameter Evaluations
(continuation)

See parameter glossary in Section 3.3.2 for explanation of terms.

Submodel Parameter	Accuracy	Appropriateness	Recommended Replacement
t_b	Variation from 100 to 20 years results in dose variations of up to 80%	Not appropriate	20 year assumption more reasonable
t_h	Not accurate	Pasture value appropriate, stored feed and vegetable not	Value representative of region
f_p, f_s	Can vary from 0 to 1	Inappropriate	Value representative of region
Q_f	Factor of 2 variation	Adequate for dairy, inappropriate for beef value	Value representative of region
F_m	At least a factor of 10 variation	Adequate	Best available
F_f	Insufficient data to determine. At least a factor of 10 variation	Inadequate	Best available
V_m		Questionable	Representative value
M_B		Questionable	Representative value

Table 3.4
AIRDOS-EPA Code Submodel Parameter Evaluations
(continuation)

Submodel Parameter	Accuracy	Appropriateness	Recommended Replacement
Individual Dose Calculations			
Inhalation			
Particle Size	Questionable	_____	Additional data
Solubility Classes	Inaccurate	Inappropriate	Kalkwarf's (1979) values
Ingestion			
Market place dilution factors IMPFIX, RVEG, RBEF, RMLK, DDI	Inaccurate & conservative	Inappropriate	Representative values
Surface Exposure			
t_B	100 year value is conservative	Inappropriate	Realistic, representative value
f_g, f_e	Conservative	Inappropriate	Representative value

Table 3.4
AIRDOS-EPA Code Submodel Parameter Evaluations
(continuation)

In the past model predictions have been used without regard to accuracy or uncertainty. This practice should not continue. Some means for accounting for the uncertainty inherent in model predictions must be incorporated into the standard setting or decision making process. To develop such a means the EPA should investigate the latest developments in the decision analysis field. Until such a means is developed the EPA should delay implementation of new standards and reconsider standards previously set using such modeling approaches.

4.0 AIRDOS-EPA/MILDOS COMPARATIVE ANALYSIS

The AIRDOS-EPA Code was developed as a generic model to aid in developing standards for radiation protection. The Federal government charges the Nuclear Regulatory Commission (NRC) with enforcement responsibilities for those standards. For enforcement evaluations the NRC has developed its own models which differ from those of the EPA. In the case of uranium mills the NRC uses the MILDOS Code.

Impact examined the differences between the AIRDOS-EPA and MILDOS Codes both in a qualitative manner and through a quantitative analysis, using both models to evaluate the EPA's 1979 RICERAUS model mill. Substantial differences were found. In the following sections the Codes' submodel formulation and parameter values are compared and MILDOS Code model mill run results are presented and compared to AIRDOS-EPA dose predictions.

(Comments presented in the following sections are directed toward Code differences. For further explanation of the AIRDOS-EPA Code see Section 3 of this report. For MILDOS Code elaboration see the UDAD Code section in the American Mining Congress' comments on the NRC's Draft Generic Environmental Impact Statement (AMC, 1979). Comments found there are generally applicable to the MILDOS Code.)

4.1 RADIONUCLIDE RELEASE CHARACTERIZATION

The Nuclear Regulatory Commission has incorporated into the MILDOS Code framework (USNRC, 1979) assumptions about particle sizes, solubilities, etc. similar to those used by EPA in formulating their model mill. Both agencies assumed particle sizes of 1 micron for the ore processing and yellowcake releases and considered two size classes (0-10 microns and 10-80 microns) of tailings. The NRC, however, has assumed and incorporated into the MILDOS Code different densities for ore processing and yellowcake particles, and has assigned a median value of 5 microns to the 0-10 micron size tailings. The EPA assumes uniform densities and a median value of 1 micron for the smaller size tailings. It is unknown whether either approach adequately models true particle size distribution characteristics. For either model mill more empirical data are needed to support selection of source term descriptors and parameters.

In formulating their model the EPA calculated tailings releases based on an assumed proportionality of dust flux to the cube of the wind velocity. The MILDOS Code approach is similar although more sophisticated. Neither approach is satisfactory and recent studies show no satisfactory approach exists (Schwendiman, 1980).

A major difference between the two models is handling of time-varying source terms. MILDOS allows changes in source terms to account for mill expansion, tailings pond size changes, etc. The MILDOS Code can therefore account for various phases of mill operation, decommissioning, reclamation and post-reclamation periods. AIRDOS-EPA has no such provision and assumes steady-state conditions throughout the life of mill.

4.2 EMISSION DISPERSION AND PLUME DEPLETION SUBMODEL

The dispersion submodels of AIRDOS-EPA and MILDOS are similar both in formulation and limitations. Both are based on a sector averaged Gaussian dispersion formulation and account for processes of deposition, precipitation scavenging, gravitational settling, and radiological decay. Neither accounts for complex terrain, wind shear, low wind speeds, plume trapping, or lid penetration. The models differ with respect to plume rise, wind speed, precipitation scavenging, and area source approximation characteristics as follows:

Plume Rise - Ore processing and yellowcake stacks may be subject to velocity or thermally induced plume rise. The MILDOS Code only provides for velocity augmented plume rise. AIRDOS-EPA provides mechanisms for both types of plume rise although the EPA ignored this option in conducting their RICERAUS analysis.

Wind Speeds - Wind speeds are conventionally reported in terms of the percent occurrence of each of six wind speed classes. To save computer time the AIRDOS-EPA Code uses a single wind speed value which is the reciprocal average of all occurences. In contrast, wind speeds are entered according to the six conventional classes in the MILDOS Code. Comparative data are not available to determine the effect of this difference.

Precipitation Scavenging - This process is implicitly modeled in the MILDOS Code by assuming that during rain or snowfall scavenging rates are equal to dry deposition rates. Only dry deposition is then considered. In contrast AIRDOS-EPA explicitly models precipitation scavenging using a method which is not referenced. Alternative approaches have been recommended. In the arid west precipitation scavenging is not a particularly important process.

Area Source Approximations - Two significantly different approaches are used with MILDOS assuming a square configuration projected upwind to a point source and AIRDOS-EPA assuming a source configuration which differs according to the distance from the receptor. The AIRDOS-EPA configuration may vary from a point source at far distances to a circular source centered at the receptor for close distances. No comparative data have been found to establish quantitative differences between the two or the superiority of one.

Deposition is treated similarly in both models. Deposition is calculated using deposition velocities and a source depletion model. The same conservative deposition velocity of 1 cm/sec has been used by both the NRC and EPA to model yellowcake, ore processing, and the 0-10 micron tailings particles. For large (10-80 micron) tailings the EPA has assumed a value of 10 cm/sec and the NRC a value of 8.82 cm/sec. Deposition velocities representative of actual tailings size distributions and western environmental conditions should be used in both.

Gravitational settling is also treated similarly. This process is modeled using a tilted plume method which is being described in Section 3.2.3. Gravitational settling velocities have been assigned equal values in both Codes.

AIRDOS-EPA provides an option for varying the deposition velocity at particular receptors within an assessment area. This is an important option when concerned with an area of varying ground cover.

The Codes both use a source depletion model to account for plume depletion due to dry deposition. Either could benefit from substitution of the recently developed hybrid source depletion model (Horst, 1979) for the source depletion model currently used.

An area in which the two models differ is treatment of resuspension. The AIRDOS-EPA Code does not explicitly address resuspension although deposition velocities could be adjusted to implicitly model the process. This is a generally accepted method although it may introduce its own uncertainty. In contrast the MILDOS Code explicitly models resuspension using a method applied in the Liquid Metal Fast Breeder Reactor (LMFBR) project. Using this method the uncertainty may approach several orders of magnitude.

Omission of resuspension considerations may cause significant differences between the MILDOS and AIRDOS-EPA Codes. For example, in a recent analysis MILDOS Code resupension concentrations contributed approximately 37% of total predicted air concentrations. More research is needed to develop an accurate resuspension model.

The final dispersion-related similarity between the models is the common method used to account for radiological decay during dispersion. Both models calculate the time available for decay by assuming straight line transport between source and receptor. This approach does not accurately model physical processes and no validation data is available to support its use.

4.3 TERRESTRIAL PATHWAYS SUBMODEL

4.3.1 Submodel Formulations

The basic evolution of MILDOS food chain models is the same as that described for AIRDOS-EPA. Each Code is intended to represent the models of NRC Regulatory Guide 1.109, although they have differences in implementation, structure, and parameters. Comments previously made concerning AIRDOS-EPA are true of MILDOS except as specifically discussed below.

4.3.1.1 Atmosphere to Plant Tissues Pathways

The calculational structures of MILDOS and AIRDOS-EPA are depicted in Figures 4.1 and 4.2 respectively. The models are similar in formulation but differences are found in the mechanisms for deposition, losses from both plant interior and surface, and soil losses.

Deposition - As with AIRDOS-EPA, it is not obvious that MILDOS handles the deposition of radionuclides onto plants and soil adequately. At first glance it appears material is counted twice as 100% deposition is assumed for the soil and an additional fractional deposition is assumed for the plants. However the fundamental assumption of both models is that all deposited radionuclides eventually reach the soil. This is often the case because plants usually are returned to the soil by decay or plowing. These processes, however, are not specifically modeled. The apparent error of applying full deposition to the soil, and an additional fractional deposition to plants is explained by realizing that the radioactivity deposited on plants cannot be "cycled" to the soil with this model structure. For specific crops such as sugar beets where the entire plant is harvested this fundamental code assumption will result in dose overestimates.

MILDOS provides particle size dependent deposition onto plants and soil as does AIRDOS-EPA. But MILDOS also provides particle size dependent resuspension from soil and subsequent redeposition to plants. As discussed in the dispersion section this may be a significant difference.

Consideration of resuspension in MILDOS is an improvement over AIRDOS-EPA but it introduces added complexity to the deposition process. The Code must assume a different air concentration for deposition onto soil than for deposition onto plants. Soil deposition is dependent on an initial air concentration which is due to facility operations alone. Deposition on plants is dependent on the initial air concentration plus an additional concentration in air due to the resuspension of radioactivity from the soil surface. The sum of the initial and resuspended air concentrations is the total air concentration.

Radioactivity resuspended from soil is not subtracted from the soil concentration in MILDOS. Likewise resuspended radioactivity deposited from upwind directions is not added to the soil concentration. The assumption underlying this approach is that the site is uniformly contaminated over a large area. Only then will the losses due to resuspension be approximately equivalent to the gains from redeposition of material from upwind.

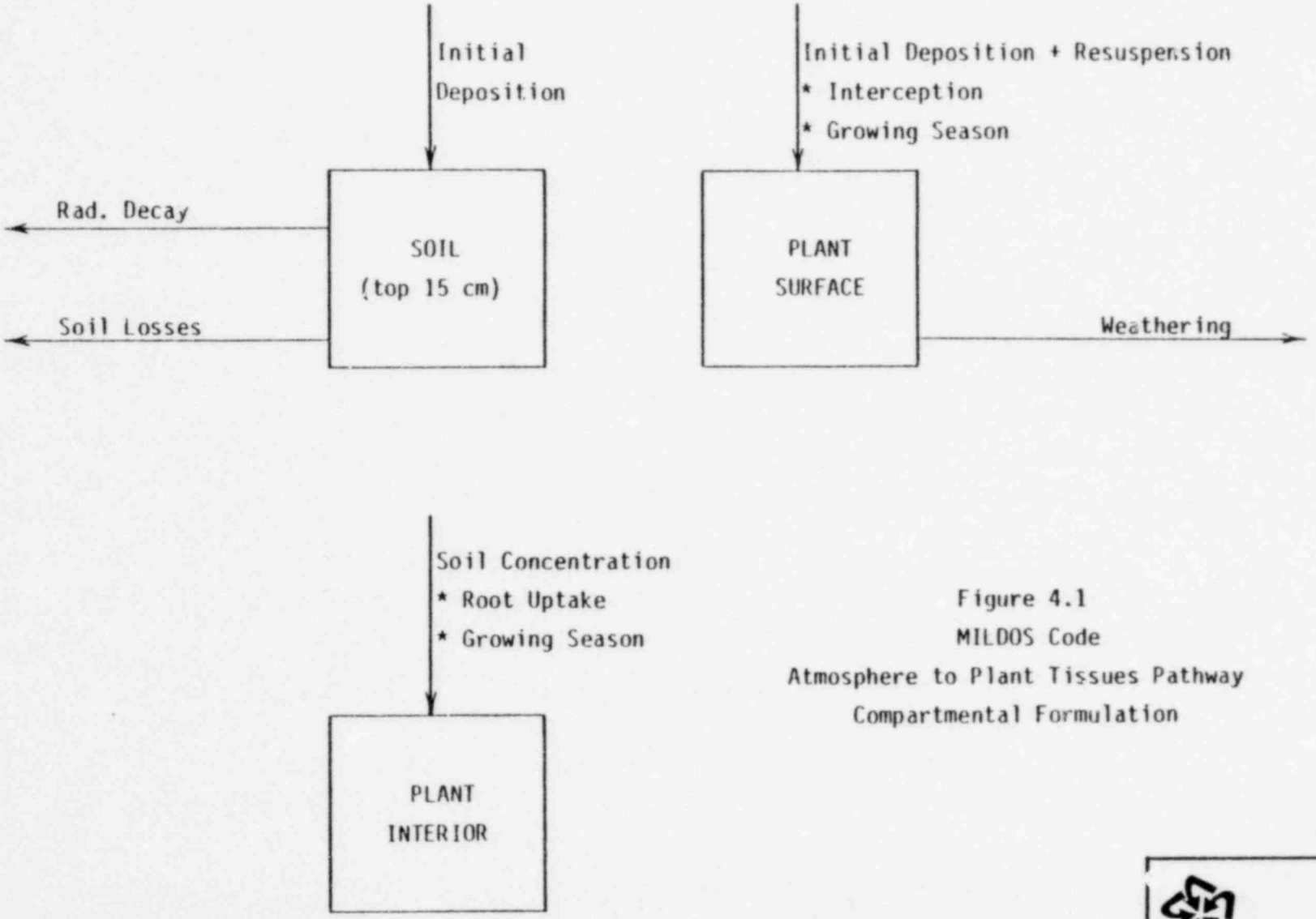


Figure 4.1
MILDOS Code
Atmosphere to Plant Tissues Pathway
Compartmental Formulation

impact ltd.

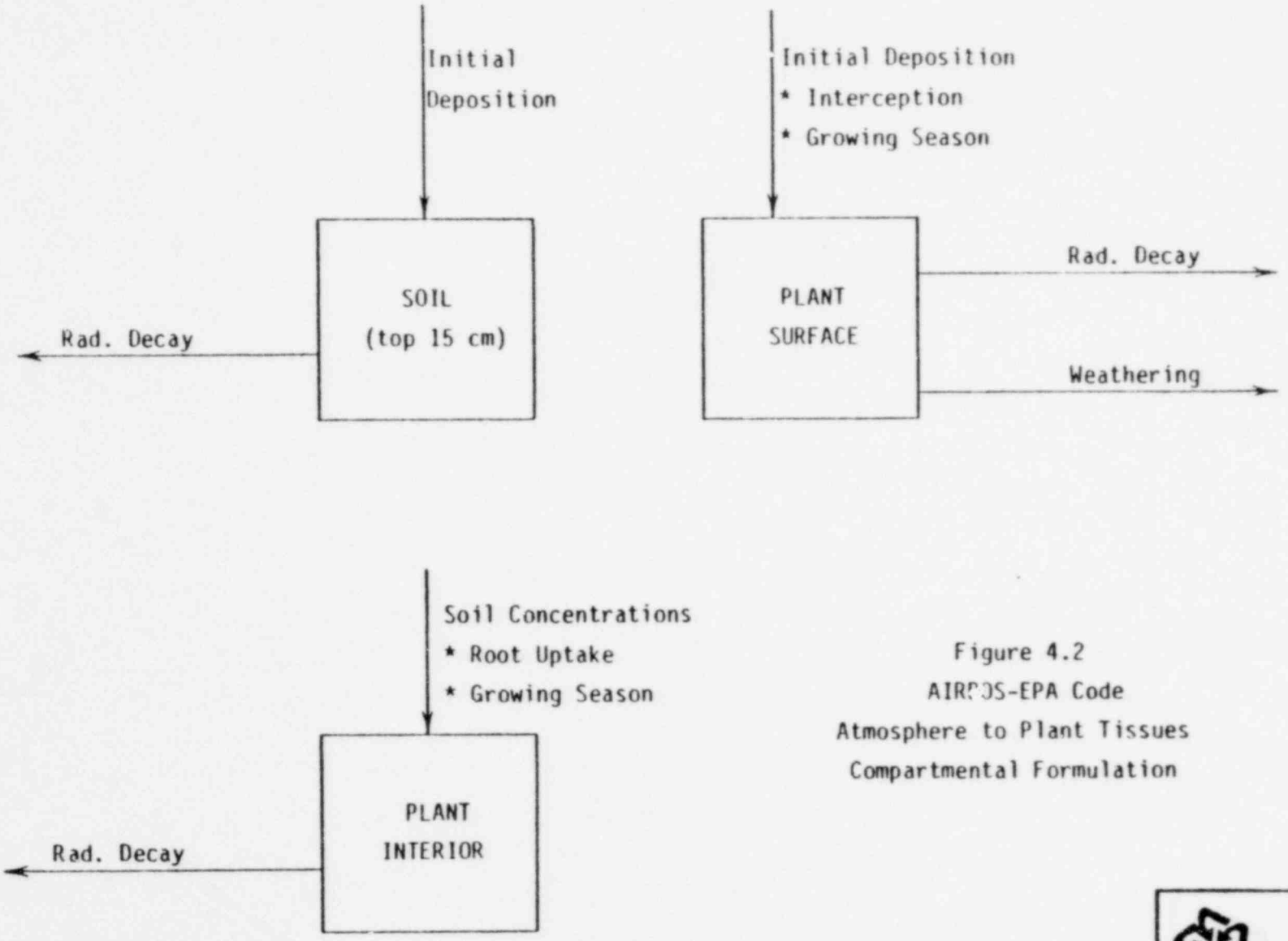


Figure 4.2
AIRDOS-EPA Code
Atmosphere to Plant Tissues
Compartmental Formulation

impact ltd.

In AIRDOS-EPA deposition onto plants is assumed to be cycled to the soil as plant or animal wastes. As long as the quantity of radionuclides lost from the system is small this fundamental assumption appears reasonable, although it does not consider delays in the cycling process. In MILDOS the deposition on plants is greater than in AIRDOS-EPA due to resuspension. But the fundamental assumption is the same, the resuspended radioactivity deposited is plants was not subtracted from the soil inventory, and thus it is assumed to be returned to the soil.

Losses from Plant Surfaces - Unlike AIRDOS-EPA MILDOS does not account for the equilibrium losses from plant surfaces due to radioactive decay. This is of importance only for deposition of short-lived radionuclides not in association with a parent, and may not be necessary for the natural radionuclides.

MILDOS also does not account for the decay of radioactivity on the surface of plants in the holdup period between harvest and consumption. Again this will be of importance only for short-lived radionuclides not deposited in association with a parent.

Losses from the Plant Interior - The MILDOS equation for concentration in the plant interior due to root uptake of radionuclides from the soil does not explicitly show the buildup of radionuclides in soil with time as does AIRDOS-EPA. However, that process is included in the ground concentration parameter used in the calculation.

MILDOS does not account for radionuclide losses from the plant interior during the holdup time from harvest to consumption. Since root uptake is more radionuclide dependent than deposition on plant surfaces, this may be an important omission for a short lived radionuclide taken up in excess of the equilibrium concentration of a parent.

Losses from the Soil - MILDOS incorporates the leaching loss term that was suggested for inclusion in AIRDOS-EPA. This improves handling by MILDOS of the losses of radioactivity from the soil compartment. The loss coefficient is based on a 50 year half-time, which is an internally supplied constant. This parameter should be available for manipulation if site or radionuclide specific data are available to improve the model simulation.

4.3.1.2 Plant Tissues to Processed Vegetables, Meat, and Milk

For these pathways the MILDOS Code is severely limited because constants are used for parameters which require site-specific data. AIRDOS-EPA has defined those same parameters as variables so that site-specific data pertinent to agricultural practices or local market conditions can be used.

Except for the use of constants rather than variables for several parameters, MILDOS and AIRDOS-EPA calculate milk concentrations in the same fashion. For meat concentrations, however, MILDOS does not incorporate radioactive decay losses from meat during the holdup time between slaughter and consumption. This will be important only for short-lived radionuclides present in meat in excess of the equilibrium concentration of a parent.

4.3.2 Parameter Values

Since both the MILDOS and AIRDOS-EPA Codes are implementations of the USNRC Regulatory Guide 1.109 model there are a number of parameters which both use. For some of these parameters the two codes have significantly different default values which will be discussed below.

Some differences, however, exist in structure between these two models which result in differences in the parameters required by each. In the discussion below emphasis is placed on parameters required by the structure of MILDOS but not by AIRDOS-EPA.

The same evaluation criteria have been used for the default values in MILDOS as were put forth for AIRDOS-EPA; appropriateness, sensitivity and availability of better values. The estimate of model sensitivity for parameters unique to MILDOS must be made in the context of the MILDOS formulation.

As mentioned in the previous section, parameter values that appear as input data in AIRDOS-EPA are treated as constants in MILDOS. These constants are identified when they represent significant or highly site-specific quantities.

4.3.2.1 Total Air Concentration Calculations

As discussed previously, a significant difference in structure between MILDOS and AIRDOS-EPA is the inclusion of resuspension in MILDOS. This is a critical difference because resuspension contributes to direct deposition on plant surfaces which then drives all subsequent calculations contributing significantly to radiation dose.

The contribution to total air concentration attributed to resuspension, as calculated by MILDOS, depends entirely on one time and particle size dependent parameter - the resuspension factor, R. Although there is an inherent uncertainty of several orders in magnitude, the MILDOS formulation of the resuspension factor does yield a good fit to the best data available on the phenomenon of resuspension (Anspaugh, 1975). The data was collected for an arid southwestern location and is likely to be representative of the uranium mining regions of the United States.

4.3.2.2 Vegetation Concentration Calculations

The MILDOS calculation of concentrations in and on vegetation is very similar to that found in AIRDOS-EPA. Both the direct deposition term and the root-uptake term are dependent on equivalent parameters. The direct deposition term always dominates over the root-uptake term.

Direct Deposition on Vegetation - In MILDOS direct deposition depends on the following parameters:

E_v = the fraction of retained material reaching edible portions of the vegetation.

F_r = the fraction of deposited material retained on plant surfaces.

Y_v = the agricultural productivity of the edible portion of vegetation.

t_v = the growing season of the vegetation.

λ_w = the weathering rate constant from plant surfaces.

The product of E_v and F_r is equivalent to the retention fraction, R, in AIRDOS-EPA. The default value of 0.2 for F_r used in MILDOS is adequate for vegetable crops but no provision is made for adjusting it for forage crops. The ratio of $(E_v*F_r)/Y_v$ for forage crops should be considered in light of data reported by Miller (1979) and set to 2.03 as was done for AIRDOS-EPA.

For both forage and vegetable crops the default values established for Y_v and t_v in MILDOS are much too restrictive. As noted above parameters such as these, for which regional data are relatively easy to obtain, should be formulated as input data not as model constants so that values specific to a particular application can be used.

Root Uptake by Vegetation - In MILDOS root uptake is governed by the following parameters:

B_{iv} = the ratio between the concentration in vegetation and that in soil.

P = the density of surface soils.

λ_e = environmental loss from soils.

AIRDOS-EPA uses the same set of parameters except λ_e is excluded.

The parameter λ_e influences the calculation of external dose from penetrating radiations as well as the contribution of the root-uptake pathway to internal dose. It is intended to account for the leaching of radioactive material from surface to deeper soils. The default value used in MILDOS is equivalent to a 50 year half-time and is applied to all nuclides, soil conditions, and climatic conditions. This is an unnecessary restriction. Data are available on radionuclide movement through soils that allow more precise descriptions of this phenomenon. The discussion of soil leaching presented by Hoffman and Baes (1979) in conjunction with the nuclide-specific data base reported by Schreckhise (1980) allows the calculation of more appropriate values of λ_e reflecting regional conditions.

MILDOS uses an extensive set of parameters for B_{iv}, distinguishing between above and below ground vegetable crops as well as between forage and vegetables. In all, five categories are used. AIRDOS-EPA uses one single value for vegetables and one for forage. Use of crop specific values by MILDOS reflects a more extensive data base and allows a greater response to regional agricultural conditions than does the approach used by AIRDOS-EPA for this pathway.

4.3.2.3 Concentrations in Meat and Milk

Parameter Appearing in MILDOS - As in AIRDOS-EPA meat and milk concentrations depend on pasture and feed concentrations calculated in the manner described above. The only parameters appearing in the MILDOS formulation are the following:

Q = feed ingestion rate.

F_b = the feed-to-meat transfer coefficient

F_m = the feed-to-milk transfer coefficient

For the two transfer coefficients MILDOS and AIRDOS-EPA use adequate values for all nuclides of interest. However, these parameters suffer from the same inherent uncertainties discussed in the AIRDOS-EPA critical review section of this report.

The value of Q in MILDOS appears to be a wet-weight default value, although the available documentation does not explicitly indicate this. According to the report of Hoffman and Baes (1979) care must be taken to consistently use dry-weight values for forage and for the appropriate B_{iv} data as is done in AIRDOS-EPA. In MILDOS, as in AIRDOS-EPA, the same value for Q is used for both beef and milk herds.

4.3.3 Submodel Summary Evaluation

MILDOS has three features of special merit. The first is a treatment of the resuspension pathway. This phenomenon is of critical importance to modeling the movement of radioactivity in agricultural systems. It affects all subsequent pathways both direct and indirect.

The second feature is the flexibility introduced by the use of crop-specific data for B_{iv}. It is worth noting, however, that the root uptake pathway contributes relatively little to the total dose so that this sophistication has small influence on the outcome of the calculation.

The final feature is that the MILDOS Code provides for losses of radionuclides from the soil which result from environmental processes. There is a problem with the MILDOS approach in that the 50 year environmental half-life assumed will be conservatively long for many applications.

Relative to AIRDOS-EPA, MILDOS has several notable weaknesses. All of these are related to insufficient parameterization of regional agricultural conditions. It is impossible to improve model predictions on the basis of more information if the model will not accept that information as input. Crop production, grazing practices, market place dilution and many other critical issues are ignored in MILDOS.

4.4 DOSE CALCULATIONS

4.4.1 Individuals - Similar calculational approaches are taken in MILDOS and AIRDOS-EPA. Dose conversion factors are used with calculated concentrations and model man ergonometric characteristics to derive predictions of 50 year dose commitments for several organs. In general, although the Codes employ similar methods, the dose conversion factor sets differ markedly between the two models. In addition, the organs considered in the two codes are different with only four organs - total body, lung, kidney and liver - in common.

4.4.1.1 Inhalation Doses - In AIRDOS-EPA, for each organ, radionuclide and particle size and solubility assumption combination, a dose conversion factor is multiplied by an assumed breathing rate. Those conversion factors have been derived from a recent Oak Ridge study (Killough, 1979). The MILDOS Code considers particle density as an additional factor in determining dose conversion factors. In the MILDOS Code, the breathing rate has been included in the conversion factors which were derived using the UDAD Code (Momeni, et al., 1979). By manipulating units the dose conversion factors for the organs common to both models can be compared (selected values are compared in Tables 4.1 and 4.2.

The dose conversion factors for the two models do not compare well and the differences show no consistent pattern. The two sets were supposedly developed using similar models. The differences between these two dose conversion factor sets are prime evidence of the uncertainty inherent in these models. Some of the differences may be explained by the fact that the AIRDOS-EPA factors are based on Y solubility assumptions for all nuclides except Radium-226 where a W assumption was made. MILDOS factors represent the mixture of solubility assumptions recommended by Kalkwarf (1979).

4.4.1.2 Air Immersion and Surface Exposure Doses - Both Codes calculate air immersion and surface exposure doses using dose conversion factors multiplied by predicted air or surface concentrations. Comparative dose conversion factor values are presented in Tables 4.3 and 4.4. AIRDOS-EPA factors (Kocher, 1980) vary according to organ whereas MILDOS total body factors (Momeni, et al., 1979) are assumed to apply to all other organs. Significant differences are observed.

AIRDOS-EPA surface concentrations are calculated considering a deposition rate and a decay rate. The decay rate includes both radiological and environmental decay, the latter of which was conservatively set to zero by EPA in their RICERAUS analysis. MILDOS ground concentrations are computed using a deposition rate and a conservative 50 year environmental decay half-life. As discussed previously surface losses due to resuspension are not considered.

The MILDOS Code provides for a shielding factor of .825 to account for a person's time spent indoors. One hundred percent site occupancy is also assumed. AIRDOS-EPA provides no occupational allowances and is therefore even more conservative.

4.4.1.3 Ingestion Doses - For both models, predicted doses are dependent on concentrations, dose conversion factors, ingestion rates and a preparation factor for vegetables and produce. MILDOS computes ingestion doses for four population age groups; infant, child, teenager, and adult, and total doses are

	Yellowcake			Ore Processing		
	AIRDOS	MILDOS	MILDOS: AIRDOS	AIRDOS	MILDOS	MILDOS: AIRDOS
Whole Body	1.36E+02	9.82E+00	0.0722	1.36E+02	4.32E+00	0.0318
Lung	3.85E+03	1.07E+03	0.278	3.85E+03	1.58E+02	0.0410
Liver	8.83E+00	0.0	0.0	8.3E+00	0.0	0.0
Kidney	1.23E+01	3.78E+01	3.07	1.23E+01	1.66E+01	1.35

	Tailings (0-10μ)			Tailings (10-80μ)		
	AIRDOS	MILDOS	MILDOS: AIRDOS	AIRDOS	MILDOS	MILDOS: AIRDOS
Whole Body	1.36E+02	1.16E+00	0.00853	0.0	7.92E-01	
Lung	3.85E+03	1.24E+03	0.322	0.0	3.33E+02	
Liver	8.83E+00	0.0	0.0	0.0	0.0	
Kidney	1.23E+01	4.47E+00	0.363	0.0	3.05E+00	

Table 4.1
MILDOS/AIRDOS-EPA Comparison
Inhalation Dose Conversion Factors
U-238
(MREM-M^3/PCI-YR)

	Yellowcake			Ore Processing		
	AIRDOS	MILDOS	MILDOS / AIRDOS	AIRDOS	MILDOS	MILDOS / AIRDOS
Whole Body	1.52E+02	3.58E+01	4.25	1.52E+02	3.09E+01	0.203
Lung	4.50E+02	4.88E+03	10.8.	4.50E+02	6.61E+03	14.7
Liver	5.3E+00	4.47E-02	0.00843	5.3E+00	3.87E-02	0.0073
Kidney	5.3E+00	1.26E+00	0.238	5.3E+00	1.09E+00	0.206

	Tailings (0-10μ)			Tailings (10-80μ)		
	AIRDOS	MILDOS	MILDOS / AIRDOS	AIRDOS	MILDOS	MILDOS / AIRDOS
Whole Body	1.52E+02	4.00E+01	0.263	0.0	3.09E+01	
Lung	4.50E+02	2.84E+03	6.31	0.0	7.64E+02	
Liver	5.3E+00	4.97E-02	0.00938	0.0	4.85E-02	
Kidney	5.3E+00	1.[illegible]	0.266	0.0	1.3E+00	

Table 4.2
MILDOS/AIRDOS-EPA
Inhalation Dose Conversion Factors
Ra-226
(MREM-M ^{3}/PCI-YR)

	Whole Body			Lung[1]		Kidney[1]		Liver[1]	
Radionuclide	AIRDOS	MILDOS	MILDOS / AIRDOS	AIRDOS	MILDOS / AIRDOS	AIRDOS	MILDOS / AIRDOS	AIRDOS	MILDOS / AIRDOS
U-238	8.24E-08	3.70E-06	44.9	3.03E-08	122.0	2.18E-08	170.0	2.06E-08	180.0
U-234	1.68E-07	0.0	0.0	9.90E-08	0.0	7.92E-08	0.0	7.92E-08	0.0
Th-230	2.89E-07	6.12E-07	2.12	2.21E-07	2.77	1.83E-07	3.34	1.86E-07	3.29
Ra-226	8.76E-07	9.47E-07	1.08	7.74E-07	1.22	6.34E-07	1.49	6.69E-07	1.42
Pb-214	3.00E-05	3.16E-05	1.05	2.73E-05	1.16	2.38E-05	1.33	2.43E-05	1.30
Bi-214	1.52E-04	1.85E-04	1.22	1.45E-04	1.28	1.23E-04	1.50	1.31E-04	1.41
Pb-210	7.66E-07	2.27E-06	2.96	5.00E-07	4.54	4.46E-07	5.09	3.99E-07	5.69
Po-210	8.94E-10	0.0	0.0	8.43E-10	0.0	8.27E-10	0.0	7.66E-10	0.0

Table 4.3
MILDOS/AIRDOS-EPA
Comparison of Surface Exposure
Dose Conversion Factors
(MREM-M^2/PCI-YR)

[1] MILDOS uses Whole Body dose conversion factors for Lung, Kidney and Liver.

	Whole Body			Lung [1]		Kidney [1]		Liver [1]	
Radionuclide	AIRDOS	MILDOS	MILDOS / AIRDOS	AIRDOS	MILDOS / AIRDOS	AIRDOS	MILDOS / AIRDOS	AIRDOS	MILDOS / AIRDOS
U-238	3.44E-07	1.23E-04	358.0	1.26E-07	976.0	9.11E-08	1350.0	8.61E-08	1430.0
U-234	7.95E-07	0.0	0.0	4.67E-07	0.0	3.75E-07	0.0	3.75E-07	0.0
Th-230	2.18E-06	3.59E-06	1.65	1.66E-06	2.16	1.38E-06	2.60	1.40E-06	2.56
Ra-226	3.82E-05	4.90E-05	1.28	3.36E-05	1.46	2.76E-05	1.78	2.91E-05	1.68
Pb-214	1.37E-03	1.67E-03	1.22	1.25E-03	1.34	1.09E-03	1.53	1.11E-03	1.50
Bi-214	8.74E-03	1.16E-02	1.33	8.30E-03	1.40	7.06E-03	1.64	7.56E-03	3.64
Pb-210	7.56E-06	1.43E-05	1.89	4.94E-06	2.89	4.35E-06	3.29	3.93E-06	0.0
Po-210	4.60E-08	0.0	0.0	4.33E-08	0.0	4.25E-08	0.0	3.93E-08	0.0

Table 4.4
MILDOS/AIRDOS-EPA
Comparison of Air Immersion
Dose Conversion Factors
(MREM-M^3/PCI-YR)

[1] MILDOS uses Whole Body dose conversion factors for Lung, Kidney and Liver.

expressed for each age group classification. AIRDOS-EPA maintains a single adult category. Dose conversion factors are compared in Table 4.5 which shows that variations in differences are observed, with AIRDOS-EPA values generally larger. Ingestion rate assumptions are compared in the Table 4.6 which shows that for each type of food the values of the two Codes are different.

An assumption inherent in MILDOS is that an individual obtains all of his food at his residence. On the other hand AIRDOS-EPA provides a mechanism to account for individual ingestion of site, regional, and imported food. However, AIRDOS-EPA dilution factors which account for imported foods have been set by EPA in the past at conservative values.

4.4.2 Population Dose

Similar methods are used in the two models to calculate population doses.

	Whole Body			Lung			Kidney			Liver		
Radionuclide	AIRDOS	MILDOS	MILDOS: AIRDOS	AIRDOS	MILDOS	MILDOS: AIRDOS	AIRDOS	MILDOS	MILDOS: AIRDOS	AIRDOS	MILDOS	MILDOS: AIRDOS
U-238	1.20E-04	4.54E-05	0.378	6.01E-08	4.54E-05	755.0	5.96E-05	1.75E-04	2.94	4.59E-05	0.0	0.0
U-234	1.40E-04	5.17E-05	0.369	6.46E-08	5.17E-05	800.0	6.70E-05	1.99E-04	2.97	4.59E-05	0.0	0.0
Th-234	0.0	2.13E-09	- -	0.0	2.13E-09	- -	0.0	2.67E-08	- -	0.0	4.71E-04	- -
Th-230	2.80E-03	5.70E-05	0.020	4.62E-09	5.70E-05	12300.0	1.90E-03	5.55E-04	0.297	1.50E-02	1.17E-04	0.0078
Ra-226	1.60E-02	4.60E-03	0.288	1.76E-06	4.60E-03	2610.0	5.90E-04	1.63E-04	0.276	5.90E-04	5.74E-06	0.0097
Pb-214	8.16E-08	0.0	0.0	7.59E-09	0.0	0.0	8.51E-08	0.0	0.0	2.97E-08	0.0	0.0
Bi-214	4.02E-08	0.0	0.0	6.36E-09	0.0	0.0	3.90E-07	0.0	0.0	1.58E-08	0.0	0.0
Pb-210	7.40E-03	5.44E-04	0.0735	6.93E-08	5.44E-04	7850.0	9.40E-04	1.23E-02	13.1	1.40E-03	4.37E-03	3.12
Bi-210	0.0	3.96E-08	0.0	0.0	3.96E-08	- -	0.0	3.83-05	- -	0.0	3.18E-06	- -
Po-210	5.60E-04	8.59E-05	0.153	1.13E-11	8.59E-05	76000000.0	9.30E-03	2.52E-03	0.271	1.60E-03	7.56E-04	0.473

Table 4.5
MILDOS/AIRDOS-EPA
Comparison of Ingestion
Dose Conversion Factors
(MREM/PCI)

	MILDOS [1]	AIRDOS [2]	MILDOS : AIRDOS
Vegetables (Kg/yr)	1.05E+02	1.94E+02	0.541
Meat (Kg/yr)	7.83E+01	9.4E+01	0.833
Milk (L/yr)	1.30E+02	1.12E+02	1.16

Table 4.6
MILDOS/AIRDOS-EPA Comparison
Ingestion Rates of Food by Man (Adults)

[1] Source: J. F. Fletcher and W. L. Dotson (compilers), "HERMES - A Digital Computer Code for Estimating Regional Radiological Effects from the Nuclear Power Industry", Hanford Engineering Development Laboratory, HEDL-TME-71-168, December 1971.

[2] Not referenced in AIRDOS-EPA documentation.

4.5 MILDOS VS. AIRDOS-EPA APPLICATION RESULTS

Using the EPA's 1979 model mill with base case controls as a test case, MILDOS and AIRDOS-EPA Codes were applied and resulting dose predictions compared (see Table 4.7). Table 4.8 gives a comparative breakdown of the three mill source contributions to the two Codes' predicted doses.

These tables have been examined along with dose conversion factors, predicted air concentrations, and other parameter values previously discussed. Due to the number of parameters and the variations in values between models it has been difficult to find an obvious explanation of the differences between model predictions. We offer the following observations and conjectures about the total body and lung dose prediction differences. In addition, since MILDOS predicts bone doses and the most comparable AIRDOS-EPA organ is endosteal tissue, results for these organs are also discussed.

Total Body - Total body doses are primarily determined by the vegetable ingestion pathway for AIRDOS-EPA and the inhalation and vegetable ingestion pathways for MILDOS. We have observed that the air concentrations from the point sources as predicted by MILDOS are greater by a factor of 1.06 than those of AIRDOS-EPA. In contrast, AIRDOS-EPA tailings generated concentrations are higher than those of MILDOS by a factor of 8 for the 0-10 micron tailings and a factor of 1.5 for the 10-80 micron tailings. In AIRDOS-EPA, tailings generated concentrations are generally greater than those from other sources (except for U-238 and U-235) and MILDOS tailings' generated values were comparable to those of the other sources.

We have also observed the importance of resuspension in MILDOS (39% of total predicted air concentrations) and the conservatively high ground concentrations in AIRDOS-EPA, and have noted that AIRDOS-EPA ingestion and inhalation dose conversion factors for total body are greater than those of MILDOS. We conclude that difference in Code dose predictions is probably due to the dose conversion factor differences and the higher AIRDOS-EPA ground concentrations. The influence of the inhalation pathway for MILDOS predictions may be due to a large resuspension concentration and less ground buildup than in AIRDOS-EPA.

Lungs - AIRDOS-EPA predicted doses exceed those of MILDOS by a factor of 1.83. The MILDOS dose was derived primarily from yellowcake whereas AIRDOS values resulted from contributions of all three sources. Doses were due almost totally to inhalation for MILDOS and both inhalation and surface exposure for AIRDOS-EPA. Dose conversion factors are significantly different but are not consistant in their differences. Since so many differences exist no conclusion can be drawn about the determining factors for the two Codes' prediction differences.

Bone (MILDOS) Vs. Endosteal (AIRDOS) - The AIRDOS-EPA prediction for endosteal tissue far exceeds the MILDOS bone prediction. The AIRDOS dose consists primarily of the tailings contribution and results from the ingestion pathway. The MILDOS dose consists of equal contributions from all sources and is primarily due to the inhalation (56%) and vegetable ingestion pathways. AIRDOS endosteal ingestion dose conversion factors for radium and thorium (which are primary constituents of the tailings) are greater by a factor of 5 than MILDOS bone conversion factors for those same radionuclides. Our

	AIRDOS	MILDOS	MILDOS : AIRDOS
Whole Body	2.16E+02	6.07E+00	0.0281
Bone (Endosteal[1])	2.26E+03	7.81E+01	0.346
Lung	2.42E+02	1.32E+02	0.546
Liver	1.14E+02	5.11E+00	0.0448
Kidney	6.92E+01	1.95E+01	0.282

Table 4.7
MILDOS/AIRDOS-EPA Comparison
Maximum Individual - Total Dose
(mrem/yr)

[1]The dose presented for AIRDOS-EPA is to the endosteal tissue, the organ most comparable to the bone used in MILDOS.

	Ore Processing				Yellowcake			
	AIRDOS		MILDOS		AIRDOS		MILDOS	
	Contrib.	% of Total	Contrib.	% of Total	Contrib.	% of Total	Contrib.	% of Total
Whole Body	5.71E+01	26.4%	1.52E+00	25.0%	1.69E+01	7.82%	2.72E+00	44.8%
Bone (Endosteal[1])	6.13E+02	27.1	2.49E+01	31.9	1.42E+02	6.28	3.05E+01	39.1
Lung	2.29E+01	9.46	2.53E+01	19.2	1.95E+02	80.6	9.93E+01	75.2
Liver	2.91E+01	25.5	1.61E+00	31.5	2.19E+01	19.2	1.97E+00	38.6
Kidney	1.87E+01	27.0	6.07E+00	31.1	5.78E+00	8.35	8.61E+00	44.2

	Tailings			
	AIRDOS		MILDOS	
	Contrib.	% of Total	Contrib.	% of Total
Whole Body	1.43E02	66.2%	1.83E+00	30.2%
Bone (Endosteal[1])	1.51E03	66.8	2.27E+01	29.1
Lung	2.40E01	9.92	7.11E+00	5.39
Liver	5.32E01	55.4	1.53E+00	29.9
Kidney	4.47E01	64.6	4.79E+00	24.6

Table 4.8
MILDOS/AIRDOS-EPA Comparison
RICERAUS Base Case Control Analysis Results
Dose Contribution by Source
Maximum Individual
(mrem/yr)

[1]The dose presented for AIRDOS-EPA is to the endosteal tissue, the organ most comparable to the bone used in MILDOS.

conjecture is that the large difference between endosteal and bone doses is due to a combination of greater dose conversion factors, greater tailings concentrations, and greater ground concentrations in AIRDOS-EPA. The MILDOS prediction dependence on inhalation seems to confirm the importance of resuspension particulates.

4.6 SUMMARY AND CONCLUSIONS - AIRDOS-EPA/MILDOS

The AIRDOS and MILDOS Codes were developed to predict the radiological impacts of nuclear facilities. One would assume that the two would be very similar in formulation and, if applied to the same facility, would provide comparable dose predictions. Neither assumption is correct. Formulation differences between the two Codes were found, and, run on the same model mill, AIRDOS-EPA dose predictions were found to be greater than those of MILDOS. The differences in magnitude range from a factor of 5 to a factor of 30 depending on the target organ.

Major differences in formulation and parameter values are listed below. Recommendations for resolution of these differences are provided where appropriate.

* Treatment Of Resuspension - MILDOS models this phenomenon using a resuspension factor which results in total air concentrations being increased by more than 60% with associated increases in deposition rates and dose estimates. In AIRDOS-EPA this process is ignored. Resuspension should be considered in the AIRDOS-EPA Code, however, the MILDOS Code scheme is more of a finger in the dike approach than an accurate simulation.

* Dose Conversion Factors - Substantial differences were found, particularly for the inhalation and ingestion pathways. For example, the U-238 dose conversion factor for the whole body inhalation pathway is 1.16 in MILDOS and 136 in AIRDOS-EPA.

* Input Values Vs. Constants - Values for several terrestrial pathway parameters treated as constants in MILDOS can be provided as input data by an AIRDOS-EPA user. The MILDOS Code should allow such incorporation of site specific data.

* Soil Radionuclide Losses - An environmental loss term is included in MILDOS which should be incorporated into the AIRDOS-EPA Code.

* Tailings Particle Size Assumptions - In the MILDOS Code a 5 micron median value for the 0-10 micron tailings is assumed. In the EPA RICERAUS analysis a 1 micron median value was used. Use of a median value is not necessarily an adequate means for characterizing particle size distributions in tailings. More field study is needed. Of the two code values the 5 micron selection is a less conservative choice.

The fact that such differences exist between the two models' formulation, parameter values, and predictions is prime evidence of the uncertainty inherent in any attempt to model uranium mill radiological impact. The uncertainty in any particular submodel may be due to one or all of several sources; insufficient scientific basis, inadequate modeling sophistication, and representation of wide ranges of research data by a single parameter value. Such uncertainty permeates both the AIRDOS-EPA and MILDOS Codes.

Even if the differences between the two models are resolved and changes which have been suggested in this report are incorporated, the uncertainty associated with the model predictions must still be recognized as substantial. This fact raises serious questions about the validity of the use of models in developing and enforcing radiological standards.

5.0 CONCLUSIONS SUMMARY

Data and observations detailed in this report motivate the following conclusions:

* If the EPA repeated their 1976 analysis of uranium milling operations using current EPA model mill concepts and dispersion and dosimetry Codes they would find that with the additional organs and pathways now considered significantly more sophisticated control measures are required to meet the 25 millirem standard than were published in 1976. The standard must be reexamined.

* The uncertainty inherent in the AIRDOS-EPA Code indicates that the current approach to standards development based on model predictions is simply not acceptable. Even with suggested Code improvements dose predictions will not be sufficiently accurate to specify an exact dose limit. An approach which recognizes and quantifies uncertainty is mandated.

* MILDOS Code predictions will not be the same as those of AIRDOS-EPA for the same case. This reinforces the conclusion that the current modeling approach to standards development is inadequate and also demonstrates the difficulties of trying to enforce such standards once developed.

A new approach to standards development and enforcement is needed which recognizes the uncertainty in dosimetry models. Techniques have been developed by decision analysts to account for such uncertainty in decision making and the EPA might explore these techniques. Until such a technique is developed standards such as 40 CFR 190 must be considered to be scientifically unfounded and unsupportable.

REFERENCES

American Mining Congress., October, 1979. "Comments Concerning the Use of the UDAD Code for Predicting the Radiological Impact of Uranium Mills (Revision One)", Comments on the Draft Generic Environmental Impact Statement (GEIS) on Uranium Milling, Vol. I, NUREG-0511.

American Society of Mechanical Engineers., 1979. Recommended Guide for the Prediction of the Dispersion of Airborne Effluents, Third Edition. New York.

Anspaugh, L. R., et al., 1975. "Resuspension and Redistribution of Plutonium in Soils", Health Physics 29(4): 577.

Booth, R. S., Kaye, S. V. and Rohwer, P. S., 1971. "A Systems Analysis Methodology for Predicting Dose to Man from a Radioactively Contaminated Terrestrial Environment", Proceedings of the Third Symposium on Radioecology, AEC-CONF-710501.

Briggs, G. A., 1980. Personal Communication with R. A. Schultze.

Burt, Edward W., 1977. Valley Model User's Guide, EPA-450/2-77-018. United States Environmental Protection Agency.

Busse, A. D. and Zimmerman, J. R., 1973. User's Guide for the Climatological Dispersion Model, EPA-R4-73-024. United States Environmental Protection Agency.

Christiansen, J. H. and Porter, R. A., 1976. User's Guide to the Texas Climatological Model. Texas Air Control Board.

Draxler, R. R. and Elliot, W. P., 1977. "Long Range Travel of Airborne Material Subjected to Dry Deposition", Atmospheric Environment, Volume II, Pgs. 35-40.

Hicks, B. B., September, 1976. "Some Micrometeorological Aspects of Pollutant Deposition Rates", Atmosphere-Surface Exchange of Particulate and Gaseous Pollutants, CONf-740921.

Hinds, W., 1970. "Diffusion Over Coastal Mountains of Southern California", Atmospheric Environment.

Hoffman, F. O., et al., 1977. Evaluation of Models for Assessing Compliance with Environmental Radiation Regulations, CONF-771109-51. Oak Ridge National Laboratory.

Hoffman, F. O., et al., 1978. Proceedings of a Workshop on the Evaluation of Models Used for the Environmental Assessment of Radionuclide Releases, September 6-9, 1977. Gatlinburg, Tennessee, CONF-77091. Oak Ridge National Laboratory.

Hoffman, F. O. and Baes III, C. F. (eds.)., 1979. A Statistical Analysis of Selected Parameters for Predicting Food Chain Transport and Internal Dose of Radionuclides. Final Report, ORNL/NUREG/TM-282.

Horst, T. W., September, 1976. "A Surface Depletion Model for Deposition from a Gaussian Plume", Atmosphere-Surface Exchange of Particulate and Gaseous Pollutants, CONF-740921.

Horst, T. W., October, 1977. Estimation of Air Concentrations Due to the Diffusion, Deposition, and Resuspension of Contaminants by the Wind, PNL-2426. Battelle-Pacific Northwest Laboratories.

Horst, T. W., 1979. "A Simple Correction to the Source Depletion Model", Pacific Northwest Laboratory Annual Report for 1978 to the DOE Assistant Secretary for Environment, Part 3, Atmospheric Sciences, PNL-2850, Part 3. Pacific Northwest Laboratory.

Hovind, E., Spangler, T. and Anderson, A., 1974. "The Influence of Rough Mountainous Terrain Upon Plume Dispersion from an Elevated Source", Presented at the Symposium on Atmospheric Diffusion and Air Pollution, American Meteorological Society.

Kalkwarf, D. R., 1979. Solubility Classification of Airborne Products from Uranium Ores and Tailings Piles, NUREG/CR-0530. Battelle-Pacific Northwest Laboratory.

Killough, G. G., et al., 1979. Estimates of Internal Dose Equivalent to 22 Target Organs for Radionuclides Occurring in Routine Releases from Nuclear Fuel-Cycle Facilities. Volume 2. ORNL/NUREG/TM-190/Vol 2. Oak Ridge National Laboratory.

Kocher, D. C., 1980. "Dose-Rate Conversion Factors for External Exposure to Photon and Electron Radiation from Radionuclides Occurring in Routine Releases from Nuclear Fuel Cycle Facilities", Health Physics 38(4), 543-621.

Letizia, A. P., Martin Jr., G. and Silvey, J. F., 1979. "Implications for Nuclear Facilities of Change Being Initiated in the NRC Standard Atmospheric Diffusion Model", Presented at the 41st Annual Meeting of the American Power Conference. Chicago.

Little, C. A. and Miller, C. W., November, 1979. The Uncertainty Associated with Selected Environmental Transport Models, ORNL-5528. Oak Ridge National Laboratory.

MacCready, P., Baboolal, L., and Lissaman, P., 1974. "Diffusion and Turbulence Aloft", The Symposium on Atmospheric Diffusion and Air Pollution, American Meteorological Society.

Machta, L., 1966. "Some Aspects of Simulating Large Scale Atmosphere Mixing" Tellus 18, pp. 355-362.

Markee, E. H. Jr., 1967. "A Parametric Study of Gaseous Plume Depletion by Ground Surface Adsorption", Proceedings of the USAEC Meteorological Information Meeting held at Chalk River Nuclear Laboratories, September 11-14, 1967, CONF-670931.

McDowell-Boyer, L. M., et al., 1979. Review and Recommendations of Dose Conversion Factors and Environmental Transport Parameters for Pb-210 and Ra-226, NUREG/CR-0574. Oak Ridge National Laboratory.

McMahon, T. A. and Denison, P. J., 1979. "Empirical Atmospheric Deposition Parameters - A Survey", Atmospheric Environment, Vol. 13, pp.571-585.

Momeni, M., Yuan, Y. and Zielen, A. J., May, 1979. "The Uranium Dispersion and Dosimetriy (UDAD) Code," NUREG/CR-0553, ANL/ES-72. Argonne National Laboratory.

Moore, R. E., 1975. AIRDOS - A Computer Code for Estimating Population and Individual Doses Resulting from Atmospheric Releases of Radionuclides from Nuclear Facilities, ORNL-TM-4687. Oak Ridge National Laboratory.

Moore, R. E., April, 1977. The AIRDOS-II Computer Code for Estimating Radiation Doses to Man from Airborne Radionculides in Areas Surrounding Nuclear Facilities, ORNL-5245. Oak Ridge National Laboratory.

Sagendorf, J. F. and Dickson, C. R., 1976. "Diffusion Under Low Windspeed, Inversion Conditions", Preprints of the Third Symposium on Atmospheric Turbulence, Diffusion and Air Quality, October 19-22, 1976. Raleigh, N.C. American Meteorological Society, Boston.

Schreckhise, R. G., March, 1980. Simulation of the Long Term Accumulation of Radiocontaminants in Crop Plants, PNL-2636. Battelle-Pacific Northwest Laboratory.

Schwendiman, L. C., et al., June, 1980. A Field and Modeling Study of Windblown Particles From a Uranium Mill Tailings Pile, NUREG/CR-1407. Battelle-Pacific Northwest Laboratory

Sears, M. B., et al., May, 1976. Correlation of Radioactive Waste Treatment Costs and the Environmental Impact of Waste Effluents in the Nuclear Fuel Cycle for use in Establishing "As Low As Practicable" Guides - Milling of Uranium Ores, ORNL-TM-4903, Vol. 1. Oak Ridge National Laboratory.

Sehmel, G. A. and Hodgson, W. H., September, 1976. "Predicted Dry Deposition Velocities", Atmospheric-Surface Exchange of Particulate and Gaseous Pollutants, CONF-740921.

Shaeffer, D. L., August, 1979. A Model Evaluation Methodology Applicable to Environmental Assessment Models, ORNL-5507. Oak Ridge National Laboratory.

Slade, D. H., July, 1969. Meteorology and Atomic Energy, TID-24190. United States Atomic Energy Commission.

Start, G., Dickson, C., and Wendell, L. 1975. "Diffusion in a Canyon within Rough Mountainous Terrain", Journal of Applied Meteorology, Vol. 143.

Start, G., Ricks, N. R., and Dickson, C. R., 1976. "Effluent Dilutions over Mountainous Terrain", Preprints of Third Symposium on Atmospheric Turbulence, Diffusion, and Air Quality, Oct. 19-22, 1976. Raleigh, N. C. American Meteorological Society, Boston.

Turner, D. B., 1970. Workbook of Atmospheric Dispersion Estimates. U.S. Environmental Protection Agency, Research Triangle Park, N. C.

Turner, D. B., May, 1979. "Atmospheric Dispersion Modeling, A Critical Review," Journal of the Air Pollution Control Association, Vol. 29, p. 5.

United States Atomic Energy Commission., July, 1973. Final Environmental Statement Concerning Proposed Rule Making Action: 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. Volumes I and II, WASH-1258. Washington, D.C.

United States Environmental Protection Agency, 1973. Environmental Analysis of the Uranium Fuel Cycle, Part I - Fuel Supply, EPA-520/9-73-003B.

United States Environmental Protection Agency, 1976. Environmental Analysis of the Uranium Fuel Cycle, Part IV - Supplementary Analysis - 1976, EPA-520/4-76-017.

United States Environmental Protection Agency, June, 1979. AIRDOS-EPA: A Computerized Methodology for Estmating Environmental Concentrations and Dose to Man from Airborne Releases of Radionuclides, ORNL-5532. Oak Ridge National Laboratory.

United States Environmental Protection Agency, August, 1979. Radiological Impact Caused by Emissions of Radionuclides Into Air in the United States, Preliminary Report, EPA-520/7-79-006.

United States Nuclear Regulatory Commission, 1977. Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I, (Revision 1). Office of Standards Development.

United States Nuclear Regulatory Commission, April, 1979. Draft Generic Environmental Impact Statement on Uranium Milling, NUREG-0511. Washington, D. C.

United States Nuclear Regulatory Commission, May, 1980. MILDOS Computer Code User's Manual."

Van der Hoven, I., July, 1969. "Deposition of Particles and Gases", Meteorology and Atomic Energy, TID-24190. D. H. Slade, Ed.

Wilson, R. B., Start, G. E., Dickson, C. R., and Ricks, N. R., 1976. "Diffusion Under Low Windspeed Conditions Near Oak Ridge, Tennessee, Preprints of the Third Symposium on Atmospheric Turbulence, Diffusion and Air Quality, October 19-22, 1976. Raleigh, N. C. American Meterological Society, Boston.

Appendix A
MODEL MILL ANALYSIS DATA SOURCES

Data used in the model mill analyses were derived from several sources. Input data categories and sources are presented in the following pages along with data values used if the same for all runs. Case-specific values have been omitted.

The primary sources were the data input tabulations used by the EPA during their AIRDOS-II analyses for the RICERAUS document. When data unique to the AIRDOS-EPA Code were required those values were taken from the AIRDOS-EPA documentation (USEPA, 1979a). Dose conversion factors were taken (as recommended in the AIRDOS-EPA documentation) from a recent work entitled "Estimates of Internal Dose Equivalent to 22 Target Organs for Radionuclides Occurring in Routine Releases from Nuclear Fuel Cycle Facilities" (Killough, et al., 1979), and one entitled "Dose-Rate Conversion Factors for External Exposure to Photon and Electron Radiation from Radionuclides Occurring in Routine Releases from Nuclear Fuel Cycle Facilities" (Kocher, 1979). Where pulished data were not available, values used were those provided us by EPA.

Keys to source codes are:

AII	AIRDOS-II Data Sets
AE	AIRDOS-EPA Documentation
KI	Killough, et. al., 1979
KO	Kocher, 1980

Sources: All All

RELEASE RATES FOR RADIONUCLIDES

STACK	NUCLIDE	RELEASE RATE (CURIES/YEAR)
1	U-238	
1	U-234	
1	TH-230	
1	RA-226	
1	PB-214	
1	BI-214	
1	PB-210	
1	PO-210	

Sources: As Marked Individually

METEOROLOGICAL AND PLANT INFORMATION SUPPLIED TO PROGRAM----

AVERAGE AIR TEMPERATURE (DEG K)	282.0	All
AVERAGE VERTICAL TEMPERATURE GRADIENT OF THE AIR (DEG K/METER)		
IN STABILITY CLASS E	0.0728	All
IN STABILITY CLASS F	0.1090	All
IN STABILITY CLASS G	0.1455	All
RAINFALL RATE (CM/YEAR)	20.00	All
HEIGHT OF LID (METERS)	800	All
NUMBER OF STACKS IN THE PLANT		All

STACK INFORMATION--

	STACK NUMBER						
	1	2	3	4	5	6	
HEIGHT (METERS)							AE
DIAMETER (METERS)							All
EFFLUENT VELOCITY (METERS/SEC)							All
RATE OF HEAT EMISSION (CAL/SECOND)							All
DIAMETER OF AREA SOURCE (METERS)							All

Sources: As Marked By Column

PLUME DEPLETION AND DEPOSITION PARAMETERS

NUCLIDE	GRAVITATIONAL FALL VELOCITY (METERS/SEC)	DEPOSITION VELOCITY (METERS/SEC)	SCAVENGING COEFFICIENT (1/SEC)	EFFECTIVE DECAY CONSTANT IN PLUME (PER DAY)
	All	All	All	AE Table 13
U-238				
U-234				
TH-230				
RA-226				
PB-214				
BI-214				
PB-210				
PO-210				

Sources: All All

FREQUENCY OF ATMOSPHERIC STABILITY CLASSES FOR EACH DIRECTION

SECTOR	FRACTION OF TIME IN EACH STABILITY CLASS						
	A	B	C	D	E	F	G
1	0.0277	0.0653	0.1118	0.2731	0.1517	0.3705	0.0000
2	0.0169	0.0555	0.0852	0.3901	0.1569	0.2954	0.0000
3	0.0367	0.1338	0.1667	0.3783	0.0887	0.1959	0.0000
4	0.0179	0.1259	0.1877	0.4097	0.0661	0.1926	0.0000
5	0.0650	0.2801	0.1804	0.2975	0.0295	0.1474	0.0000
6	0.1381	0.0410	0.2127	0.1866	0.0410	0.3806	0.0000
7	0.0875	0.2602	0.0852	0.1832	0.0665	0.3174	0.0000
8	0.0754	0.1447	0.1156	0.3106	0.0452	0.3085	0.0000
9	0.0464	0.1383	0.1320	0.2285	0.1295	0.3254	0.0000
10	0.0290	0.1021	0.1406	0.2746	0.1637	0.2899	0.0000
11	0.0103	0.0722	0.1104	0.1905	0.2485	0.3682	0.0000
12	0.0188	0.0387	0.0695	0.2171	0.3169	0.3391	0.0000
13	0.0111	0.0827	0.0998	0.3827	0.1368	0.2869	0.0000
14	0.0238	0.0680	0.1257	0.4770	0.1423	0.1633	0.0000
15	0.0486	0.1099	0.1260	0.4649	0.0564	0.1943	0.0000
16	0.0438	0.1148	0.1547	0.4117	0.0758	0.1992	0.0000

Sources: All All

FREQUENCIES OF WIND DIRECTIONS AND RECIPROCAL-AVERAGED WIND SPEEDS

WIND TOWARD	FREQUENCY	WIND SPEEDS FOR EACH STABILITY CLASS (METERS/SEC)						
		A	B	C	D	E	F	G
1	0.027	0.98	1.28	1.83	2.65	3.55	0.93	0.00
2	0.044	0.77	0.98	2.34	3.86	3.43	1.01	0.00
3	0.112	0.96	1.19	2.53	3.62	3.52	0.96	0.00
4	0.083	0.92	1.26	2.73	3.84	3.47	0.99	0.00
5	0.012	0.77	1.13	1.89	2.09	2.97	0.81	0.00
6	0.003	0.77	4.38	4.38	1.77	4.38	1.01	0.00
7	0.009	0.77	0.99	1.15	1.29	3.09	0.90	0.00
8	0.010	0.77	1.35	1.73	3.04	3.74	0.92	0.00
9	0.056	0.88	1.06	2.05	3.51	3.87	0.97	0.00
10	0.129	0.89	1.02	2.25	4.33	4.13	1.08	0.00
11	0.182	0.88	0.98	2.07	3.46	4.12	1.02	0.00
12	0.139	0.95	1.17	2.34	4.56	4.09	1.09	0.00
13	0.068	0.98	1.11	2.44	5.24	3.87	1.03	0.00
14	0.063	0.92	1.27	3.20	5.88	4.08	1.08	0.00
15	0.038	0.84	1.18	2.51	4.48	3.58	0.97	0.00
16	0.026	0.90	1.58	3.04	3.80	3.40	0.95	0.00

WIND DIRECTIONS ARE NUMBERED COUNTERCLOCKWISE STARTING AT 1 FOR DUE NORTH

Sources: All All

FREQUENCIES OF WIND DIRECTIONS AND TRUE-AVERAGE WIND SPEEDS

WIND TOWARD	FREQUENCY	WIND SPEEDS FOR EACH STABILITY CLASS (METERS/SEC)						
		A	B	C	D	E	F	G
1	0.027	1.32	2.18	3.37	4.87	3.78	1.20	0.00
2	0.044	0.77	1.52	3.56	5.74	3.67	1.37	0.00
3	0.112	1.27	1.95	3.74	5.72	3.75	1.28	0.00
4	0.083	1.18	2.09	4.14	5.84	3.70	1.34	0.00
5	0.012	0.77	1.79	2.95	3.98	3.16	0.89	0.00
6	0.003	0.77	4.38	4.38	4.01	4.38	1.37	0.00
7	0.009	0.77	1.41	1.61	2.60	3.80	1.15	0.00
8	0.010	0.77	2.35	3.16	4.91	3.94	1.18	0.00
9	0.056	1.09	1.77	3.25	5.13	4.04	1.29	0.00
10	0.129	1.10	1.54	3.51	5.74	4.22	1.50	0.00
11	0.182	1.10	1.53	3.14	5.31	4.22	1.39	0.00
12	0.139	1.25	1.96	3.38	6.24	4.19	1.52	0.00
13	0.068	1.32	1.73	3.82	6.69	4.04	1.42	0.00
14	0.063	1.18	2.18	5.22	7.46	4.19	1.50	0.00
15	0.038	0.99	1.94	3.98	6.67	3.80	1.29	0.00
16	0.026	1.14	2.66	4.75	6.13	3.63	1.26	0.00

WIND DIRECTIONS ARE NUMBERED COUNTERCLOCKWISE STARTING AT 1 FOR DUE NORTH

Sources: All All

SUMMARY OF AREA SURROUNDING PLANT

AREA		NO. MEAT ANIMALS	NO. MILK CATTLE	FOOD CROPS (SQUARE METERS)	WATER AREA	POPULATION
SECTOR	DISTANCE					
1	1	0	0	0.000E+00	0	0.0
1	2	0	0	0.540E+02	0	0.0
1	3	0	0	0.760E+02	0	0.0
1	4	1	0	0.217E+03	0	0.0
1	5	2	0	0.694E+03	0	0.0
1	6	4	0	0.136E+04	0	0.0
1	7	6	0	0.190E+04	0	0.0
1	8	16	0	0.542E+04	0	0.0
1	9	23	1	0.759E+04	0	0.0
1	10	65	2	0.217E+05	0	0.0
1	11	208	6	0.694E+05	0	0.0
1	12	405	11	0.135E+06	0	0.0
1	13	568	16	0.190E+06	0	0.0
1	14	1622	45	0.542E+05	0	0.0
1	15	2271	63	0.759E+06	0	14.0
1	16	0	0	0.000E+00	0	0.0
1	17	0	0	0.000E+00	0	0.0
1	18	0	0	0.000E+00	0	0.0
1	19	0	0	0.000E+00	0	0.0
1	20	0	0	0.000E+00	0	0.0
2	1	0	0	0.000E+00	0	0.0
2	2	0	0	0.540E+02	0	0.0
2	3	0	0	0.760E+02	0	0.0
2	4	1	0	0.217E+03	0	0.0
2	5	2	0	0.694E+03	0	0.0
2	6	4	0	0.136E+04	0	0.0
2	7	6	0	0.190E+04	0	0.0
2	8	16	0	0.542E+04	0	0.0
2	9	23	1	0.759E+04	0	0.0
2	10	65	2	0.217E+05	0	0.0
2	11	208	6	0.694E+05	0	0.0
2	12	405	11	0.135E+06	0	0.0
2	13	568	16	0.190E+06	0	0.0
2	14	1622	45	0.542E+05	0	1076.0
2	15	2271	63	0.759E+06	0	0.0
2	16	0	0	0.000E+00	0	0.0
2	17	0	0	0.000E+00	0	0.0
2	18	0	0	0.000E+00	0	0.0
2	19	0	0	0.000E+00	0	0.0
2	20	0	0	0.000E+00	0	0.0
3	1	0	0	0.000E+00	0	0.0
3	2	0	0	0.540E+02	0	0.0
3	3	0	0	0.760E+02	0	0.0
3	4	1	0	0.217E+03	0	0.0

6	3	0	0	0.760E+02	0	0.0
6	4	1	0	0.217E+03	0	0.0
6	5	2	0	0.694E+03	0	0.0
6	6	4	0	0.136E+04	0	0.0
6	7	6	0	0.190E+04	0	0.0
6	8	16	0	0.542E+04	0	0.0
6	9	23	1	0.759E+04	0	0.0
6	10	65	2	0.217E+05	0	0.0
6	11	208	6	0.694E+05	0	0.0
6	12	405	11	0.135E+06	0	0.0
6	13	568	16	0.190E+06	0	0.0
6	14	1622	45	0.542E+06	0	0.0
6	15	2271	63	0.759E+05	0	382.0
6	16	0	0	0.000E+00	0	0.0
6	17	0	0	0.000E+00	0	0.0
6	18	0	0	0.000E+00	0	0.0
6	19	0	0	0.000E+00	0	0.0
6	20	0	0	0.000E+00	0	0.0
7	1	0	0	0.000E+00	0	0.0
7	2	0	0	0.540E+02	0	0.0
7	3	0	0	0.760E+02	0	0.0
7	4	1	0	0.217E+03	0	0.0
7	5	2	0	0.694E+03	0	0.0
7	6	4	0	0.136E+04	0	0.0
7	7	6	0	0.190E+04	0	0.0
7	8	16	0	0.542E+04	0	0.0
7	9	23	1	0.759E+04	0	0.0
7	10	65	2	0.217E+05	0	0.0
7	11	208	6	0.694E+05	0	953.0
7	12	405	11	0.135E+06	0	0.0
7	13	568	16	0.190E+06	0	0.0
7	14	1622	45	0.542E+06	0	0.0
7	15	2271	63	0.759E+06	0	897.0
7	16	0	0	0.000E+00	0	0.0
7	17	0	0	0.000E+00	0	0.0
7	18	0	0	0.000E+00	0	0.0
7	19	0	0	0.000E+00	0	0.0
7	20	0	0	0.000E+00	0	0.0
8	1	0	0	0.000E+00	0	0.0
8	2	0	0	0.540E+02	0	0.0
8	3	0	0	0.760E+02	0	0.0
8	4	1	0	0.217E+03	0	0.0
8	5	2	0	0.694E+03	0	0.0
8	6	4	0	0.136E+04	0	0.0
8	7	6	0	0.190E+04	0	0.0
8	8	16	0	0.542E+04	0	0.0
8	9	23	1	0.759E+04	0	0.0
8	10	65	2	0.217E+05	0	0.0
8	11	208	6	0.694E+05	0	693.0
8	12	405	11	0.135E+06	0	1492.0
8	13	568	16	0.190E+06	0	681.0
8	14	1622	45	0.542E+05	0	0.0
8	15	2271	63	0.759E+06	0	411.0
8	16	0	0	0.000E+00	0	0.0
8	17	0	0	0.000E+00	0	0.0
8	18	0	0	0.000E+03	0	0.0
8	19	0	0	0.000E+03	0	0.0
8	20	0	0	0.000E+00	0	0.0

9	1	0	0	0.000E+00	0	0.0
9	2	0	0	0.540E+02	0	0.0
9	3	0	0	0.760E+02	0	0.0
9	4	1	0	0.217E+03	0	0.0
9	5	2	0	0.694E+03	0	0.0
9	6	4	0	0.136E+04	0	0.0
9	7	6	0	0.190E+04	0	0.0
9	8	16	0	0.542E+04	0	0.0
9	9	23	1	0.759E+04	0	0.0
9	10	65	2	0.217E+05	0	0.0
9	11	208	6	0.694E+05	0	0.0
9	12	405	11	0.135E+06	0	8768.0
9	13	568	16	0.190E+06	0	0.0
9	14	1622	45	0.542E+06	0	0.0
9	15	2271	63	0.759E+06	0	0.0
9	16	0	0	0.000E+00	0	0.0
9	17	0	0	0.000E+00	0	0.0
9	18	0	0	0.000E+00	0	0.0
9	19	0	0	0.000E+00	0	0.0
9	20	0	0	0.000E+00	0	0.0
10	1	0	0	0.000E+00	0	0.0
10	2	0	0	0.540E+02	0	0.0
10	3	0	0	0.760E+02	0	0.0
10	4	1	0	0.217E+03	0	0.0
10	5	2	0	0.694E+03	0	0.0
10	6	4	0	0.136E+04	0	0.0
10	7	6	0	0.190E+04	0	0.0
10	8	16	0	0.542E+04	0	0.0
10	9	23	1	0.759E+04	0	0.0
10	10	65	2	0.217E+05	0	0.0
10	11	208	6	0.694E+05	0	0.0
10	12	405	11	0.135E+06	0	0.0
10	13	568	16	0.190E+06	0	0.0
10	[illegible]	1622	45	0.542E+05	0	1826.0
10	[illegible]	2271	63	0.759E+06	0	1160.0
10	16	0	0	0.000E+00	0	0.0
10	17	0	0	0.000E+00	0	0.0
10	18	0	0	0.000E+00	0	0.0
10	19	0	0	0.000E+00	0	0.0
10	20	0	0	0.000E+00	0	0.0
11	1	0	0	0.000E+00	0	0.0
11	2	0	0	0.540E+02	0	0.0
11	3	0	0	0.760E+02	0	0.0
11	4	1	0	0.217E+03	0	0.0
11	5	2	0	0.694E+03	0	0.0
11	6	4	0	0.136E+04	0	0.0
11	7	6	0	0.190E+04	0	0.0
11	8	16	0	0.542E+04	0	0.0
11	9	23	1	0.759E+04	0	0.0
11	10	65	2	0.217E+05	0	0.0
11	11	208	6	0.694E+05	0	0.0
11	12	405	11	0.135E+06	0	1182.0
11	13	568	16	0.190E+06	0	0.0
11	14	1622	45	0.542E+05	0	628.0
11	15	2271	63	0.759E+06	0	0.0
11	16	0	0	0.000E+00	0	0.0
11	17	0	0	0.000E+00	0	0.0
11	18	0	0	0.000E+00	0	0.0

11	19	0	0	0.000E+00	0	0.0
11	20	0	0	0.000E+00	0	0.0
12	1	0	0	0.000E+00	0	0.0
12	2	0	0	0.540E+02	0	0.0
12	3	0	0	0.760E+02	0	0.0
12	4	1	0	0.217E+03	0	0.0
12	5	2	0	0.694E+03	0	0.0
12	6	4	0	0.136E+04	0	0.0
12	7	6	0	0.190E+04	0	0.0
12	8	16	0	0.542E+04	0	0.0
12	9	23	1	0.759E+04	0	0.0
12	10	65	2	0.217E+05	0	0.0
12	11	208	6	0.694E+05	0	0.0
12	12	405	11	0.135E+06	0	0.0
12	13	568	16	0.190E+06	0	0.0
12	14	1622	45	0.542E+05	0	1128.0
12	15	2271	63	0.759E+06	0	684.0
12	16	0	0	0.000E+00	0	0.0
12	17	0	0	0.000E+00	0	0.0
12	18	0	0	0.000E+00	0	0.0
12	19	0	0	0.000E+00	0	0.0
12	20	0	0	0.000E+00	0	0.0
13	1	0	0	0.000E+00	0	0.0
13	2	0	0	0.540E+02	0	0.0
13	3	0	0	0.760E+02	0	0.0
13	4	1	0	0.217E+03	0	0.0
13	5	2	0	0.694E+03	0	0.0
13	6	4	0	0.136E+04	0	0.0
13	7	6	0	0.190E+04	0	0.0
13	8	16	0	0.542E+04	0	0.0
13	9	23	1	0.759E+04	0	0.0
13	10	65	2	0.217E+05	0	0.0
13	11	208	6	0.694E+05	0	0.0
13	12	405	11	0.135E+06	0	0.0
13	13	568	16	0.190E+06	0	0.0
13	14	1622	45	0.542E+06	0	0.0
13	15	2271	63	0.759E+06	0	0.0
13	16	0	0	0.000E+00	0	0.0
13	17	0	0	0.000E+00	0	0.0
13	18	0	0	0.000E+00	0	0.0
13	19	0	0	0.000E+00	0	0.0
13	20	0	0	0.000E+00	0	0.0
14	1	0	0	0.000E+00	0	0.0
14	2	0	0	0.540E+02	0	0.0
14	3	0	0	0.760E+02	0	0.0
14	4	1	0	0.217E+03	0	0.0
14	5	2	0	0.694E+03	0	0.0
14	6	4	0	0.136E+04	0	0.0
14	7	6	0	0.190E+04	0	0.0
14	8	16	0	0.542E+04	0	0.0
14	9	23	1	0.759E+04	0	0.0
14	10	65	2	0.217E+05	0	0.0
14	11	208	6	0.694E+05	0	0.0
14	12	405	11	0.135E+06	0	399.0
14	13	568	16	0.190E+06	0	0.0
14	14	1622	45	0.542E+06	0	0.0
14	15	2271	63	0.759E+06	0	2383.0
14	16	0	0	0.000E+00	0	0.0

POOR ORIGINAL

14	17	[illegible]	[illegible]	[illegible]	0	0.0
14	18	0	0	0.000E+03	0	0.0
14	19	0	0	0.000E+00	0	0.0
14	20	0	0	0.000E+00	0	0.0
15	1	0	0	0.000E+00	0	0.0
15	2	0	0	0.540E+02	0	0.0
15	3	0	0	0.760E+02	0	0.0
15	4	1	0	0.217E+03	0	0.0
15	5	2	0	0.694E+03	0	0.0
15	6	4	0	0.136E+04	0	0.0
15	7	6	0	0.190E+04	0	0.0
15	8	16	0	0.542E+04	0	0.0
15	9	23	1	0.759E+04	0	0.0
15	10	65	2	0.217E+05	0	0.0
15	11	208	6	0.694E+05	0	0.0
15	12	405	11	0.135E+06	0	0.0
15	13	568	16	0.190E+06	0	0.0
15	14	1622	45	0.542E+06	0	0.0
15	15	2271	63	0.759E+06	0	0.0
15	16	0	0	0.000E+00	0	0.0
15	17	0	0	0.000E+00	0	0.0
15	18	0	0	0.000E+00	0	0.0
15	19	0	0	0.000E+00	0	0.0
15	20	0	0	0.000E+00	0	0.0
16	1	0	0	0.000E+00	0	0.0
16	2	0	0	0.540E+02	0	0.0
16	3	0	0	0.760E+02	0	0.0
16	4	1	0	0.217E+03	0	0.0
16	5	2	0	0.694E+03	0	0.0
16	6	4	0	0.136E+04	0	0.0
16	7	6	0	0.190E+04	0	0.0
16	8	16	0	0.542E+04	0	0.0
16	9	23	1	0.759E+04	0	0.0
16	10	65	2	0.217E+05	0	0.0
16	11	208	6	0.694E+05	0	0.0
16	12	405	11	0.135E+06	0	0.0
16	13	568	16	0.190E+06	0	0.0
16	14	1622	45	0.542E+06	0	0.0
16	15	2271	63	0.759E+06	0	1207.0
16	16	0	0	0.000E+00	0	0.0
16	17	0	0	0.000E+00	0	0.0
16	18	0	0	0.000E+00	0	0.0
16	19	0	0	0.000E+00	0	0.0
16	20	0	0	0.000E+00	0	0.0
17	1	0	0	0.000E+00	0	0.0
17	2	0	0	0.000E+00	0	0.0
17	3	0	0	0.000E+00	0	0.0
17	4	0	0	0.000E+00	0	0.0
17	5	0	0	0.000E+00	0	0.0
17	6	0	0	0.000E+00	0	0.0
17	7	0	0	0.000E+00	0	0.0
17	8	0	0	0.000E+00	0	0.0
17	9	0	0	0.000E+00	0	0.0
17	10	0	0	0.000E+03	0	0.0
17	11	0	0	0.000E+00	0	0.0
17	12	0	0	0.000E+00	0	0.0
17	13	0	0	0.000E+00	0	0.0
17	14	0	0	0.000E+03	0	0.0

17	15	0	0	0.000E+00	0	0.0
17	16	0	0	0.000E+00	0	0.0
17	17	0	0	0.000E+00	0	0.0
17	18	0	0	0.000E+00	0	0.0
17	19	0	0	0.000E+00	0	0.0
17	20	0	0	0.000E+00	0	0.0
18	1	0	0	0.000E+00	0	0.0
18	2	0	0	0.000E+00	0	0.0
18	3	0	0	0.000E+00	0	0.0
18	4	0	0	0.000E+00	0	0.0
18	5	0	0	0.000E+00	0	0.0
18	6	0	0	0.000E+00	0	0.0
18	7	0	0	0.000E+00	0	0.0
18	8	0	0	0.000E+00	0	0.0
18	9	0	0	0.000E+00	0	0.0
18	10	0	0	0.000E+00	0	0.0
18	11	0	0	0.000E+00	0	0.0
18	12	0	0	0.000E+00	0	0.0
18	13	0	0	0.000E+00	0	0.0
18	14	0	0	0.000E+00	0	0.0
18	15	0	0	0.000E+00	0	0.0
18	16	0	0	0.000E+00	0	0.0
18	17	0	0	0.000E+00	0	0.0
18	18	0	0	0.000E+00	0	0.0
18	19	0	0	0.000E+00	0	0.0
18	20	0	0	0.000E+00	0	0.0
19	1	0	0	0.000E+00	0	0.0
19	2	0	0	0.000E+00	0	0.0
19	3	0	0	0.000E+00	0	0.0
19	4	0	0	0.000E+00	0	0.0
19	5	0	0	0.000E+00	0	0.0
19	6	0	0	0.000E+00	0	0.0
19	7	0	0	0.000E+00	0	0.0
19	8	0	0	0.000E+00	0	0.0
19	9	0	0	0.000E+00	0	0.0
19	10	0	0	0.000E+00	0	0.0
19	11	0	0	0.000E+00	0	0.0
19	12	0	0	0.000E+00	0	0.0
19	13	0	0	0.000E+00	0	0.0
19	14	0	0	0.000E+00	0	0.0
19	15	0	0	0.000E+00	0	0.0
19	16	0	0	0.000E+00	0	0.0
19	17	0	0	0.000E+00	0	0.0
19	18	0	0	0.000E+00	0	0.0
19	19	0	0	0.000E+00	0	0.0
19	20	0	0	0.000E+00	0	0.0
20	1	0	0	0.000E+00	0	0.0
20	2	0	0	0.000E+00	0	0.0
20	3	0	0	0.000E+00	0	0.0
20	4	0	0	0.000E+00	0	0.0
20	5	0	0	0.000E+00	0	0.0
20	6	0	0	0.000E+00	0	0.0
20	7	0	0	0.000E+00	0	0.0
20	8	0	0	0.000E+00	0	0.0
20	9	0	0	0.000E+00	0	0.0
20	10	0	0	0.000E+00	0	0.0
20	11	0	0	0.000E+00	0	0.0
20	12	0	0	0.000E+00	0	0.0

20	13	0	0	0.000E+00	0	0.0
20	14	0	0	0.000E+00	0	0.0
20	15	0	0	0.000E+00	0	0.0
20	16	0	0	0.000E+00	0	0.0
20	17	0	0	0.000E+00	0	0.0
20	18	0	0	0.000E+00	0	0.0
20	19	0	0	0.000E+00	0	0.0
20	20	0	0	0.000E+00	0	0.0

FOR WATER AREAS--0= NONE OR MINIMAL AND 1= MAJOR WATER AREA PRESENT

Sources: As Marked Individually

LIST OF INPUT VALUES FOR RADIONUCLIDE-INDEPENDENTVARIABLES

NUMBER OF NUCLIDES CONSIDERED	8	
TIME DELAY--INGESTION OF PASTURE GRASS BY ANIMALS (HR)	0.0000E+00	AE Table 14
TIME DELAY--INGESTION OF STORED FEED BY ANIMALS (HR)	0.2160E+04	AE Table 14
TIME DELAY--INGESTION OF LEAFY VEGETABLES BY MAN (HR)	0.3360E+03	AE Table 14
TIME DELAY--INGESTION OF PRODUCE BY MAN (HR)	0.3360E+03	AE Table 14
REMOVAL RATE CONSTANT FOR PHYSICAL LOSS BY WEATHERING (PER HOUR)	0.2100E-02	AE Table 14
PERIOD OF EXPOSURE DURING GROWING SEASON--PASTURE GRASS (HR)	0.7200E+03	AE Table 14
PERIOD OF EXPOSURE DURING GROWING SEASON--CROPS OR LEAFY VEGETABLES (HR)	0.1440E+04	AE Table 14
AGRICULTURAL PRODUCTIVITY BY UNIT AREA (GRASS-COW-MILK-MAN PATHWAY (KG/SQ. METER))	0.2800E+00	AE Table 8
AGRICULTURAL PRODUCTIVITY BY UNIT AREA (PRODUCE OR LEAFY VEG INGESTED BY MAN (KG/SQ. METER))	0.7160E+00	AE Sample
FRACTION OF YEAR ANIMALS GRAZE ON PASTURE	0.4000E+00	AE Table 14
FRACTION OF DAILY FEED THAT IS PASTURE GRASS WHEN ANIMAL GRAZES ON PASTURE	0.4300E+00	AE Table 14
CONSUMPTION RATE OF CONTAMINATED FEED OR FORAGE BY AN ANIMAL IN KG/DAY (DRY WEIGHT)	0.1560E+02	AE Table 14
TRANSPORT TIME FROM ANIMAL FEED-MILK-MAN (DAY)	0.2000E+01	AE Sample[1]
RATE OF INGESTION OF PRODUCE BY MAN (KG/YR)	0.1760E+03	AE Table 15
RATE OF INGESTION OF MILK BY MAN (LITERS/YR)	0.1120E+03	AE Table 15
RATE OF INGESTION OF MEAT BY MAN (KG/YR)	0.9400E+02	AE Table 15
RATE OF INGESTION OF LEAFY VEGETABLES BY MAN (KG/YR)	0.1800E+02	AE Table 15
AVERAGE TIME FROM SLAUGHTER OF MEAT ANIMAL TO CONSUMPTION (DAY)	0.2000E+02	AE Table 14
FRACTION OF PRODUCE INGESTED GROWN IN GARDEN OF INTEREST	0.1000E+01	AE Sample Run
FRACTION OF LEAFY VEGETABLES GROWN IN GARDEN OF INTEREST	0.1000E+01	AE Sample Run
PERIOD OF LONG-TERM BUILDUP FOR ACTIVITY IN SOIL (YEARS)	0.1000E+03	AE Table 14[2]
EFFECTIVE SURFACE DENSITY OF SOIL (KG/SQ. M, DRY WEIGHT) (ASSUMES 15 CM PLOW LAYER)	0.2150E+03	AE Table 14
VEGETABLE INGESTION RATIO-IMMEDIATE SURROUNDING AREA/TOTAL WITHIN AREA	0.7000E+00	All
MEAT INGESTION RATIO-IMMEDIATE SURROUNDING AREA/TOTAL WITHIN AREA	0.4420E+00	All
MILK INGESTION RATIO-IMMEDIATE SURROUNDING AREA/TOTAL WITHIN AREA	0.3990E+00	All

MINIMUM FRACTIONS OF FOOD TYPES FROM OUTSIDE AREALISTED BELOW ARE ACTUAL FIXED VALUES

MINIMUM FRACTION VEGETABLES INGESTED FROM OUTSIDE AREA	0.0000E+00	All

MINIMUM FRACTION MEAT INGESTED FROM OUTSIDE AREA	0.0000E+00	All	
MINIMUM FRACTION MILK INGESTED FROM OUTSIDE AREA	0.0000E+00	All	
INHALATION RATE OF MAN (CUBIC CENTIMETERS/HR)	0.9167E+06	AE	Sample
BUILDUP TIME FOR RADIONUCLIDES DEPOSITED ON GROUND AND WATER (DAYS)	0.3652E+05	All	
DILUTION FACTOR FOR WATER FOR SWIMMING (CM)	0.1524E+03	All	
FRACTION OF TIME SPENT SWIMMING	0.0000E+00	All	
MUSCLE MASS OF ANIMAL AT SLAUGHTER (KG)	0.2000E+03	All	
FRACTION OF ANIMAL HERD SLAUGHTERED PER DAY	0.3810E-02	All	
MILK PRODUCTION OF COW (LITERS/DAY)	0.1100E+02	All	
FALLOUT INTERCEPTION FRACTION-VEGETABLES	0.2000E+00	AE	Section 5.2.1
FALLOUT INTERCEPTION FRACTION-PASTURE	0.5700E+00	AE	Section 5.2.2
FRACTION OF RADIOACTIVITY RETAINED ON LEAFY VEGETABLES AND PRODUCE AFTER WASHING	0.1000E+01	AE	Sample[3]

[1] Value given in AE Table 14 is 4 days and is referenced to NRC Regulatory Guide 1.109. Reg. Guide 1.109 presents a value of 2 days as does the AE Sample run. The Table 14 value is assumed to be a mistake and the 2 day value was used.

[2] Value taken from AE Table 14. Also consistent with 100 year value used for buildup time for radionuclides deposited on ground and water.

[3] Value from AE Sample run. NRC accepted value is .5 (Draft Regulatory Guide)

Sources: As Marked Individually

LIST OF INPUT DATA FOR NUCLIDES

RADIOACTIVE DECAY CONSTANT (PER DAY)	All	Runs
ENVIRONMENTAL DECAY CONSTANT--SURFACE (PER DAY)	All	Runs
ENVIRONMENTAL DECAY CONSTANT--WATER (PER DAY)	All	Runs
AVERAGE FRACTION OF ANIMAL'S DAILY INTAKE OF NUCLIDE WHICH APPEARS IN EACH L OF MILK (DAYS/L)	AE	Table 11
FRACTION OF ANIMAL'S DAILY INTAKE OF NUCLIDE WHICH APPEARS IN EACH KG OF FLESH (DAYS/KG)	AE	Table 12
CONCENTRATION FACTOR FOR UPTAKE OF NUCLIDE FROM SOIL FOR PASTURE AND FORAGE (IN PCI/KG DRY WEIGHT PER PCI/KG DRY SOIL)	AE	Table 9[1]
CONCENTRATION FACTOR FOR UPTAKE OF NUCLIDE FROM SOIL BY EDIBLE PARTS OF CROPS (IN PCI/KG WET WEIGHT PER PCI/KG DRY SOIL)	AE	Table 10[1]
GI UPTAKE FRACTION (INHALATION)	AE	Killough
GI UPTAKE FRACTION (INGESTION)	AE	Killough
PARTICLE SIZE (MICRONS)	All	
SOLUBILITY CLASS	All[2]	

DOSE CONVERSION FACTORS

ORGAN	INHALATION (REMS/MICROCURIE) KILLOUGH[1]	INGESTION (REMS/MICROCURIE) KILLOUGH	SUBMERSION IN AIR (REMS-CUBIC CM/ MICROCURIE-HR) KOCHER	SURFACE EXPOSURE (REMS-SQUARE CM/ MICROCURIE-HR) KOCHER	SUBMERSION IN WATER (REMS-CUBIC CM/ MICROCURIE-HR) KOCHER
TOT.BODY					
S WALL					
LLI WALL					
LUNGS					
KIDNEYS					
LIVER					
OVARIES					
R MAR					
ENDOST					
TESTES					
THYROID					

[1] All values taken from referenced table except those for Bismuth-214. Bi-214 values taken from a sample AIRDOS-EPA run provided by EPA personnel which was stated to have the latest values being used by EPA.

[2] Y solubility class assumed except when dose conversion factor unavailable from Killough (Radium-226, Lead-214, Bismuth-214, Lead-210, and Polonium-210 compounds all assumed W by Killough).

APPENDIX A-2

DOSE, HEALTH EFFECT, AND COST-EFFECTIVENESS CALCULATIONS RELATIVE TO A PETITION TO REOPEN THE RECORD ON 40 CFR-190

September 19, 1980

TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

The EPA development of the 40 CFR-190 regulation started with a rather simple analysis published in 1973, EPA-73.[1] This analysis was substantially altered in a supplement published in 1976, EPA-76.[2] The 1976 version was used as the basis for the regulation.

This analysis provides a detailed examination of the doses and risks to the maximally exposed individual, the doses and risks to the regional population, and the cost-effectiveness of the controls proposed by EPA. The procedures used by EPA in EPA 76 and in a later document [3] designated as RI-79 have been followed as closely as possible. This does not mean that the American Mining Congress (AMC) necessarily agrees with these procedures, but it is most straightford to examine the situation with EPA's own methodology and avoid the additional complications of debating calculation procedures. Three basic cases are compared; the 1976 source model based on 1976 exposure and cost estimates, the same 1976 sources combined with present (1979-80) technology and costs, and the most recent EPA model (RI-79) also using present technology and costs. The health risk factors used by EPA are also reviewed and the implications of the levels of risk found are examined.

[1] Environmental Analysis of the Uranium Fuel Cycle, Part 1, Fuel Supply, EPA 520/9-73-00313.

[2] Environmental Analysis of the Uranium Fuel Cycle, Part IV, Supplementary Analysis - 1976, EPA 520/4-76-017.

[3] Radiological Impact Caused by Emissions of Radionuclides Into Air in the United States, EPA 520/7-79-006. August 1979.

1973 EPA CASE (EPA-73)

This case used rather crude dosimetry calculations based on source terms estimated from the Highland Mill. Apparently no contribution was included from dust blown from the tailings pile and several other potential sources were omitted. A waterborne pathway with discharge to a nearby river was also assumed as a source and was found to be the cause of about 90% of the health effects estimated.

The source terms used and details of the dosimetry and health effects calculations are shown in Tables I and II to identify the methodology used. Since this case was superseded by the 1976 model which was substantially different, details of the 1973 model mill were not pursued further.

SOURCE TERMS - REGULATORY ANALYSIS

1976 EPA Approximation (EPA-76)

In their revised analysis in 1976 (EPA-76), the EPA adjusted the source terms from the 1973 model to allow specifically for a modest contribution from tailings and dropped the water pathway completely. The source terms chosen by the EPA with the tailings contribution adjusted slightly to match the totals actually used in the calculations are shown in Table III.

The same dosimetry and health effect factors given for the earlier 1973 were used by the EPA to calculate the impacts here. The regional population of 55,000 was also unchanged.

1979 Case (RI-79)

In 1979 the EPA published a justification for listing of radionuclides as a hazardous air pollutant under Section 112 of the Clean Air Act (RI-79). The milling portion of this listing was based on a model mill in a New Mexico geological and meteorological location with a surrounding population of 36,000 people. The milling source terms used here were the same as the totals for the 1976 case except that the Th-230 and Ra-226 terms had each been reduced by 5 mCi/year and Pb-210 and Po-210 had been added at 5 mCi/year. The "less than 10μ" tailings contribution was increased by a factor of about 4, however, and a "greater than 10μ" tailings component that totaled 123 mCi/year was added. Details, including radon which is not considered in this analysis, are shown in Table III.

AMC ANALYSIS OF HEALTH EFFECTS AND COST EFFECTIVENESS

Cases Examined

Health effects to the maximally exposed individual and to the general population in the region at the various levels of control suggested by EPA and the cost effectiveness of these levels of control have been examined in detail for five specific cases as follows:

1. 1976 EPA Approximation (Base Case)

This case used the EPA-76 source terms (See Table III), the same 30-year dose commitments as used by EPA as the basis for the total health effects, the same regional population of 55,000, and also the 1974 EPA costs and health risk factors. The results provide a comparison basis for the other cases and also show what EPA would have seen if the milling operation had been examined in its entirety rather than been mixed in an undefined way with the overall fuel cycle.

2. 1976 Sources - AIRDOS EPA - Radon Daughters Included

The total source terms here were the same as the base case but were adjusted to include radon daughters in the particulate blown from the mill and tailings. (The AIRDOS-EPA code cannot be operated without the inclusion of radon daughters in the source terms). The latest EPA procedure for dispersion and dosimetry, AIRDOS-EPA was used to calculate doses to the total body and to the specific organs. The factors used to obtain health effects were essentially the same as used by EPA in the RI-79 listing. The New Mexico regional population of 36,000 from RI-79 was also used and the 1976 EPA costs were adjusted upward by a factor of 1.55 to represent 1980 costs. The results show how the 1976 base case would look if calculated to present conditions by the present methods.

3. 1976 Sources - AIRDOS EPA - Radon Daughters Excluded

This is the same as Case 2 except that the effect of the radon daughters have been subtracted out. The difference between the two cases shows the effect of the radon daughters.

4. RI-79 Sources - AIRDOS EPA - Radon Daughters Included

This case uses the source terms from RI-79. (See Table III) All other conditions are the same as Case 2.

5. RI-79 Sources - AIRDOS EPA - Radon Daughters Excluded

This is the same as Case 4 except that the impact of the radon daughters has been dropped out.

In the development of these cases a detailed calculation which combined the RI-79 input terms and assumptions with the later AIRDOS-EPA procedures was made for Case 4. The doses for the other cases based on present technology, i.e., Cases 2, 3 and 5, were found by ratio. Details are provided in Appendix A-1.

In their analysis the EPA postulated a series of controls in the order of decreasing cost-effectiveness. These controls, together with corresponding efficiency attained in each step are shown in Table IV. All of the reanalysis done here uses the same sequence of controls at the same assumed efficiencies.

Impact on the Regional Population

The annual doses to the regional population for each of the eight levels of control defined by the EPA have been calculated for the five cases just described. The results are summarized by organ in Table 5.

In the 1976 analysis, (EPA-76) a value of 30 times the annual dose was used to estimate the lifetime risk since the mill was shut down at the end of 30 years and only minimal additional doses would result. In the RI-79 analysis, however, the exposure was calculated for a highly hypothetical 100th year of operation and this exposure was taken to be present for 70 years, i.e., the lifetime exposure was found as 70 times the 100th year exposure. Since the 1976 approach seems more realistic and to avoid further complications in the analysis, all lifetime doses have been approximated as 30 times the annual dose obtained from the AIRDOS-EPA calculations. Note that this is still the 100th year dose, however. Health effect factors essentially the same as used by EPA in RI-79 were then applied to these organ doses to estimate the annual risk to the general population (See Table XVI for specific factors).

The results of these calculations are summarized in Table VI. The key point shown is that the lifetime risks range from about 0.07 to 0.4 per million persons exposed for the assumed present base level of control, A1, B1. This is substantially less than the level EPA has proposed as sufficiently hazardous to require reporting of a hazardous substance spill under the Clean Water Act [4]. While the AMC does not necessarily endorse a level of lifetime risk as low as $1/10^6$ as appropriate, there is clearly no justification for the addition of any controls on the basis of risk to the regional population at the still lower level of 0.07 to 0.4 per million.

Cost-Effectiveness of the Proposed Levels of Control

The incremental health effects for each successive level of control were obtained from Table VI and were combined with the corresponding incremental costs to move to each successive level to obtain the cost-effectiveness of each added control, i.e., the incremental cost per incremental health effect averted. The costs used, expressed as present worth as done in EPA-76, are summarized in Table VII. Note that the cost of the orifice scrubber on the ore handling facilities, A1, is not included since it is assumed by EPA to be current technology. The net costs of the wet impingement scrubber and the low energy venturi scrubber on the yellowcake operations B1 and B2, are also taken to be zero by EPA on the basis that the value of the recovered yellowcake at least covers the cost of recovery.

In 1976, EPA concluded from their analysis of the entire fuel cycle that a level of cost-effectiveness of approximately $250,000 to $500,000 was a reasonable guideline for the addition of controls. On a 1980 basis, this would correspond to

[4] Proposed Amendment to 40 CFR-117, Determination of Reportable Quantities of Hazardous Substances, 45FR 46097.

about $390,000-$775,000, i.e., $400,000-$800,000. This general level is supported in an extensive analysis by Cohen [5] published in 1980 and will be used as a benchmark in this discussion.

The results of the cost-effectiveness calculations are listed in Table VIII. It is immediately evident that for the base case (1976-EPA Approximation) all of the controls beyond A1, B2 (which were claimed to be self-liquidating) exceed the 0.25-0.5 million dollar per level criteria just described by a factor of about 250 to 14,000. They clearly fail to be cost-effective by the EPA's own criteria by a tremendous margin.

It is also evident that the change in dosimetry to AIRDOS-EPA substantially increases the number of calculated health effects for the same source terms (compare Cases 1 and 2). The inclusion of additional organs and pathways also alters the relative effectiveness of the various types of controls. Since the basic objective here was the evaluation of the order of magnitude of the cost per health effect averted and since none of the controls beyond A1:B2 were cost effective by a large margin, no attempt has been made to optimize the order of addition.

The higher costs for 1980 do not compensate for the change in health effects so that there is an apparent improvement in cost-effectiveness at each specific level of control. It will be shown subsequently, however, that the new dosimetry code changes the level of control required to meet the 25 mrem requirement from A2:B3 to the much more stringent A4:B4:C2. This increases the cost per health effect averted from $133 million to $1.2 billion.

The RI-79 case differs from the 1976 cases in that the source terms due to tailings have been increased substantially. (See Table III) This results

[5] Cohen, B.L., Society's Valuation of Life Saving in Radiation Protection and Other Contexts, 38 Health Physics, Jan. 1980, Pgs. 33-51.

(compare Cases 2 and 4) in an increase in the absolute level of health effects but little change in the incremental values for the ore and yellowcake controls. The health effects decrease sharply when chemical control of tailings, C2, is introduced so the cost-effectiveness of this step becomes better but still is very poor. Once complete tailings control (C2) is added there is little further difference between Cases 2 and 4.

There is another consideration that needs to be examined here. It is well recognized that the estimation of cost-effectiveness for the control of the discharge of long-lived radionuclides is a controversial subject. The conclusions reached are largely a function of the integration period used.

Since the present case includes only particulates there will be no further source releases after the mill is shut down and the tailings disposal is completed. The effects will gradually decrease as a result of weathering and radioactive decay.

As mentioned previously, in the RI-79 analysis the EPA did not estimate the impacts for the 20th year at the close of typical mill operation or even for the 30th year after shutdown but for an assumed 100th year of operation. The lifetime health effects in Table VI, therefore, are in fact the result of a hyopthetical hundredth year of mill operation multiplied by 30 to conform to the earlier EPA approach. They thus represent an extremely conservative estimate of a 100-year population dose commitment, i.e., the health effects for a 100-year integration period. Even if the integration period were extended to 1,000 years, i.e., the calculated 100-year health effects were multiplied by 10, the cost-effectiveness

of the proposed controls would still exceed the criteria level by a factor of at least about 2 and for most controls by far more than this. It is thus clear that the proposed controls in all reasonable cases exceed the EPA criteria for an appropriate level of cost-effectiveness by a large amount.

Impact on the Maximally Exposed Individual

Annual Doses

The annual doses to the maximally exposed individual at the various proposed levels of control have been calculated and are summarized for the five cases being examined here in Table IX. The control level that would be needed to meet the 25 mrem level in 40 CFR-190 is indicated for each case.

It is immediately evident from Table IX that the inclusion or the exclusion of the radon daughters has a relatively modest impact so it will not be considered further. It is also evident that the change in the dosimetry code to AIRDOS-EPA has made an extreme change in the level of control that would be required for the same model mill with the same source terms. The critical organ has shifted from the lung to the endostial tissue. The level of control has changed from a low energy venturi scrubber on the ore handling facilities plus a high energy venturi scrubber on the yellowcake processing (A2, B3) to highest proposed level of control on all sources, A4, B4, C2. The RI-79 case shows higher exposure levels until tailings controls are added but the conclusion are the same. A change in dosimetry only thus presents an entirely different picture of what would be needed for compliance with the 25 mrem level than was presented by the EPA in their 1976 justification.

The problem is complicated further by the fact that the EPA is providing the justification for the regulation but it will be enforced by the NRC using a substantially different code currently designated as Mildos. Mildos evolved in about August 1980 from UDAD-II and is itself in transition.

The similarities and differences between these codes are described in detail in Appendix A-1. They emphasize different organs, different pathways, and use different dose conversion factors. The disparities are illustrated in Table X which compares the individual doses for RI-79 source terms calculated by AIRDOS-EPA and by the present version of the NRC Mildos code.

Note particularly the endostial tissue dose where AIRDOS-EPA shows an exposure of 2262 mrem/ at the maximum exposure (A_1 B_1 control level), while Mildos does not even present this as an important organ. Doses to the two organs common to both codes, liver and kidney, differ by a factor of about 20 and 3 respectively. The organs "lung" and "average lung" which may not be the same in the two codes differ by about a factor of 2.

The present situation for the application of the 40 CFR-190 standard to mills is thus one of complete chaos. The 25 mrem above background level cannot be measured directly by any technology now available, but must be calculated using a dispersion and dosimetry code. In reality, therefore, the standard should include both a specified exposure level and the code used to calculate this level. Otherwise, the specification of a level only has little meaning and compliance becomes an arbitrary function of the code selected by the enforcing agency.

Also, the 25 mrem level was justified by the EPA using a 1976 model and 1976 dosimetry. Both the model and the dosimetry have been changed substantially. There has never been an assessment of the potential impact, which is clearly much greater than the original 1976 EPA assessment, using present technology. The problem is not made any easier by the continuing changes in the EPA dosimetry code.

On the compliance side, the code by which the NRC will determine what controls must be installed has only become available in the last several months and it too is changing steadily. There has thus been no way for the EPA or the regulated industry to assess the overall impact of the regulation nor for the

individual licensees to make a reliable determination of what equipment is necessary to meet the standard. This situation urgently needs to be remedied before the regulation goes into effect.

Health Risks

The health risks to the maximally exposed individual have been calculated for the doses given in Table IX by the use of the same health effect factors and assumptions used previously to estimate risks to the general population. The results are shown in Table X for the five cases being examined. For convenience in comparison with literature values from various sources the results are presented in three different units: lifetime risk in units of health effects per million persons exposed, annual rate of risk in units of health effects per million persons exposed per year, and as the days of life expectancy lost averaged over the entire population. This latter approach is taken from Cohen.[6]

Depending on the source terms assumed for the model and the health risk factors used, i.e., 1976 or 1979, the results range from 2.2 to 8 average days of life expectancy lost for the assumed present level of control A_1, B_1, from 0.3 to 4.8 for the A2, B3 level indicated by the 1976 EPA analysis, and from 0.003 to 0.04 for the A4, B4, C2 level suggested as needed by the AIRDOS-EPA calculations. It is clear that the change in the level of control that results from the emphasis on different organs in the new dosimetry code also significantly alters the level of risk that corresponds to the 25 mrem requirement.

Before examining the significance of these levels of risk it is important to recall another problem in the manner in which the AIRDOS-EPA was applied: As noted previously, among a number of assumptions that can be questioned in the EPA RI-79 dosimetry calculations which have been used as a model for this analysis

[6] Cohen, B.L., Lee, I.S., A Catalogue of Risks, Health Physics, Vol. 36, June 1979, pgs. 701-722.

two are of particular note:

1. The annual impact from the mill (which normally operates only about 20 years) was calculated as if it were the 100th year of continuous operation.

2. The maximally exposed individual lives his entire life 500-600 meters downwind from the mill, raises all his own vegetables, and consumes them unwashed.

These two factors multiply and have impacted on the results just presented. A calculation was made using the more reasonable factors 0.25 instead of 1 to account for the radionuclides remaining after the vegetables are washed and the 20th year of mill operation instead of the 100th. These changes reduced the 1976 source case from 3.8 days to 2.7 days and the RI-79 source case from 8.0 to 4.5 days. These values refer to the base case controls A1, B1 and would be reduced further as each level of control is added. The key point is that the risks indicated from the models, without additional controls are basically of the order of 2-4 days of life expectancy lost. The implications of this level of risk are examined in the next section.

RISK CONSIDERATIONS

Risk is an inherent aspect of life itself. In a very real sense living is a process of trading certain risks for the benefits involved in an activity. Sometimes we make these balancing judgments and accept certain risks consciously; often our consent is involuntary or unknown to us.

Many of our activities today involve benefits and risks to a broad segment of our population. In such instances we increasingly have to come to rely on

governments to perform the necessary risk-benefit balancing. Obviously, in these instances, as well as in individual choice situations, there is no such thing as zero risk. For questions involving either societal benefits or societal risks, the responsibility of government is to provide the greatest common benefit with the least common risk recognizing that, as always, we have only limited resources of time, money, manpower and materials. In the final analysis, it is not only the government's duty to carry out the balancing of risks and benefits but also to fully explain its decisions and reasoning so that it can be evaluated by those it governs.

In order to put the risks due to uranium milling into perspective it is useful to note first that the radioactive materials that are released by this activity also occur naturally throughout the world. The general population is thus subject to a substantive exposure from these natural sources. The incremental increase in exposure that results from milling operations is extremely small relative to the natural background and cannot be detected reliably by any measuring technique available today. Any correspond increase in risk also cannot be measured or distinguished from that due to the natural background. The regulation thus addresses both increases in exposure and increases in risk which are indistinguishable from those already present due to the natural background concentrations of the radionuclides under consideration.

The EPA stated in their analysis that the risks from releases of particulate radionuclides from uranium milling were "small" to even the maximally exposed individual. This conclusion is entirely consistant with the situation just described. "Small", however, is a relative term that can have different interpretations. To add further perspective to the term it is useful to compare it with other risks that occur commonly in everyday life.

Table XII provides an extensive listing of a wide variety of risks expressed as the average days of life expectancy lost. Selected values to highlight the value of 2-4 days from uranium milling at the present level of control, for new mills, A1, B1, assumed by the EPA are shown below:

COMPARISON OF RISKS-MAXIMALLY EXPOSED INDIVIDUAL

Source of Risk	Days of Life Expectancy Lost
Accidents in Home	95
Drowning	41
Falls	39
Coffee	6
Oral Contraceptives	5
All Catastrophies Combined	3.5
One Transcontinental Flight Per Year	2.5
Maximally Exposed Individual	2-4
Diet Drinks	2
Living in a Brick vs Wood House (Radon)	0.8

As the table shows, the risk to the maximally exposed individual is at the same general level as the risk from living in a brick rather than a wood house (radon), diet drinks, one transcontinental flight per year, all natural catastrophies combined, oral contraceptives, and coffee. It is about ten times smaller than the risk from falls and drowning and thirty times smaller than the risk of accidents in the home. It should also be noted that most of the risks just described apply to large

segments of the population. The number of maximally exposed persons, i.e., those who live their entire lives and raise all of their own food at a distance of 500-600 meters downwind from a mill, is clearly limited to a miniscule fraction of the population if such a person exists at all. This comparison shows that it is most appropriate to reexamine the EPA conclusions that the very small number of maximally exposed individuals are subject to an "unreasonable risk" or that an "extreme maldistribution of risk" exists.

The issue of the selection of the level of risk which is acceptable to society in a particular situation is clearly a societal not a technical decision. The type of information just presented is essential for a fully informed decision and should be an integral part of any rulemaking.

HEALTH RISK FACTORS

1973 EPA Analysis (EPA-73)

In this analysis the EPA considered the health effects to four types of organs; lung, bone, bone marrow and total soft tissue other than bone. The health effect factors used in EPA-73 are shown in Table XIII.

Bone apparently includes both tabecular bone and bone surfaces and the corresponding health effect was given as cancer of the skeleton. It is not clear whether this is related to the "endostial tissue" organ factor which appears in subsequent reports.

Doses were estimated for all of these factors and the health effects were calculated for all three of the categories, i.e., mortality, non-fatal events, and genetic effects. Only the fatal cancers were used in the cost-effectiveness calculations.

1976 EPA Approximation (EPA-76)

The water pathway was assumed not to be significant in the EPA-76 version of the model mill so only the airborne pathway to the lungs was used. The health effect factor for the lung was unchanged from the EPA 1973 analysis but an adjustment was made to reduce the dose-conversion factor for the lungs by about 50% to take into account new information on solubility.

1979 EPA Analysis (RI-79)

The AIRDOS-II Code was used here and doses to the ten organs and the total body listed in the left hand column of Table XIV could be calculated. The available health risk factors, however, did not correspond exactly to the calculated doses so several adjustments were necessary. These factors as given in Table B-1, Page B-2 of RI-79 are shown in the center column of the table. The adjusted factors actually used in the risk calculations are given in the right hand column. It should be noted that the total health effect for a particular exposure was found by summing the product of the dose and the health effect factor for each individual organ impacted. The "total body" factor was not used in the calculation.

1979 Draft GEIS (NRC) [7]

The organs and doses calculated by the latest NRC Code, MILDOS, were compared with AIRDOS-EPA in Table X. The most recent NRC risk factors available are those for the predecessor code UDAD II. These are listed in Table XIII to further illustrate the extensive differences between the approaches being used by the two agencies.

[7] Draft Generic Environmental Impact Statement on Uranium Milling, NUREG-0511, Vol. II.

Selection of Health Risk Factors for the AMC Analysis

When AIRDOS-II evolved to AIRDOS-EPA the procedure still calculated doses to 10 organs and the total body but several of the organs had changed so that risk factors were not available. Of particular importance was the introduction of endostial tissue with extremely high estimated dosages.

Dr. G. Hoyt Whipple, the AMC consultant, discussed the problem informally with EPA to obtain guidance on the appropriate health risk factors and learned that they are now moving towards a code which calculates doses to eighteen organs and the total body. The code and corresponding risk factors are, however, not yet available and Dr. Whipple's best estimate of how the risk factors might eventually look is shown below:

Organ	Projected EPA-1980 Male	Female
Red Bone Marrow (Lukemia)	24	24
Lung	24	24
Thyroid	6	6
Endostial Tissue	6	6
Stomach Wall	12	12
Small Intestine Wall	12	12
Upper Large Intestines	12	12
Lower Large Intestine Wall	12	12
Kidney	12	12
Liver	12	12
Pancreas	12	12
Bladder Wall	12	12
Spleen	12	12
Skin	1	1
Breast	-	30
Uterus	-	12
Ovaries	-	12
Testes	12	-
Total Body	181	223

Since it was necessary to have factors for the specific organs used in AIRDOS-EPA a combination of the factors from RI-79 and the Whipple estimate were selected for this analysis. These factors are compared in Table XVI with factors used previously by the EPA. Note particularly that the lung and bone marrow values are essentially the same as RI-79 and the total of all of the factors is moderately higher than the EPA reference, i.e., 141 is 161. These values have been used for all risk calculations presented in this report except for the EPA-76 base case where the EPA lung factor of $50/10^6$ rem was retained. It should be noted that the AMC does not necessarily accept the validity of these factors but the present petition is not the appropriate place to contest this issue.

TABLE 4

1973 - EPA CASE (EPA-73)[17]

DOSE ESTIMATES - MODEL FACILITY - CURRENT BEST TECHNOLOGY[1]

AIRBORNE PATHWAY

Radionuclicle	Source Term[2] (Ci/Yr)	$(\bar{\chi}/Q)_3$max.[3] (s/m³)	Critical Organ	Dose Conversion Factor[4] (mrem/yr)/(pCi/m³)	Maximum Exposure at Boundry[5] (mrem/yr)	80 km Dispersion Factor C(a)[7]	Average Exposure Dose Within 80 km (mrem/yr)[8]	Persons Exposed[9]	Aggregate Somatic Organ Dose[10] Person rem/yr/facility yr
U (Total)	0.1	6×10^{-6}	Lung	1.0×10^{4}	1.9×10^{2}	2.3×10^{-4}	4.4×10^{-2}	5.5×10^{4}	2.4×10^{0}
Ra-226	0.06	"	Lung	1.1×10^{4}	1.3×10^{2} (6)	"	2.9×10^{-2}	"	1.6×10^{0}
Th-230	0.06	"	Lung	1.1×10^{4}	1.3×10^{2} (6)	"	2.9×10^{-2}	"	1.6×10^{0}
					4.5×10^{2} (6)		10.2×10^{-2}		5.6×10^{0}

WATERBORNE PATHWAY

Radionuclicle	Source Term[2] (Ci/Yr)	$(\bar{\chi}/Q)R$ (pCi/l)/(pCi/sec)	Critical Organ	Dose Conversion Factor[12] (mrem/yr)/(pCi/Liter)	Note (13)	C(W)[14]	Average Exposure Dose from 300 km of River (mrem/yr)[15]	Note (9)	Note (16)
U (Total)	0.1	$20\times4\times10^{-6}$ (11)	Bone	9	2.2×10^{0}	0.1	2.2×10^{-1}	4.4×10^{-1}	1×10^{1}
			Soft Tissue	0.9	2.2×10^{-1}	"	2.2×10^{-2}	"	1×10^{0}
Ra-226	0.06	"	Bone	12	1.8×10^{0}	"	1.8×10^{-1}	"	8.1×10^{0}
			Soft Tissue	0.4	6.2×10^{-2}	"	6.1×10^{-3}	"	2.7×10^{-1}
Th-230	3.5	"	Bone	1	8.9×10^{0}	"	8.9×10^{-1}	"	3.9×10^{1}
			Soft Tissue	-	-	-	-	-	-
				Bone	12.9×10^{0}		Bone 1.3×10^{0}		Bone 5.7×10^{1}
				Soft Tissue	2.8×10^{-1}		Soft Tissue 0.3×10^{-1}		Soft Tissue 1.3×10^{0}

1. Adapted from Tables A-12 and A-13 to show the sources of the various factors used and to demonstrate the calculation procedure.
2. Table 2-5, Page 34.
3. Table A-2, Page A-6.
4. Table A-4, Page A-9 and Table A-5, Page A-10.
5. Calculated as $\frac{Ci}{Yr} \times \frac{1\ yr}{3.15\times10^{7}\ sec} \times \frac{10^{12}\ pCi}{pCi} \times \frac{pCi/m^3}{pCi/sec} \times \frac{mrem/yr}{pCi/m^3}$ = mrem/yr e.g. $(0.1)[\frac{1}{(3.15)10^{7}}]\ (10^{12})(6\times10^{-6})(1.0\times10^{4}) = 1.905\times10^{2}$
6. These values should be $(0.6)(1.904\times10^{2}) = 1.14\times10^{2}$ not 1.3×10^{2}. Total is 4.2×10^{2}, a difference of about 7%.
7. See Page A-4. This is the average factor for 50 power reactor sites. This value was selected for fuel supply facilities.
8. Calculated as: [C(a)] (Maximum Exposure of Boundry); Error noted in (6) continues here and through the remainder of the calculation.
9. From Table A-3, Page A-7.
10. Calculated as: (Average exposure dose within 80 km) (Persons Exposed); Note also the change in units from person mrem to person rem.
11. Table A-13 gives 1×10^{-6} times the factor of 20 to compensate for lower river flow. This appears to be in error. Note also that unity in Table A-2 are $(pCi/m^3)(pCi/sec)$ and in Table A-13 the same numerical value is shown as $pCi/\ell)|(pCi/sec)$.
12. From Table A-7, Page A-13.
13. Calculated as: $(0.1\ \frac{pCi}{yr})\ (\frac{1\ yr}{3.15\times10^{7}\ sec})\ (\frac{10^{12}\ pCi}{Ci})\ (\frac{20\times4\times10^{-6}\ \frac{pCi|\ell}{pCi|sec}}{})\ (\frac{9\ mrem\ yr}{pCi|\ell})$ = 2.3×10^{0} (Value of 2.2×10^{0} reported in Table A-13.)
14. From Table A-2, Page A-6. Assumes a 300 km length of river. Appears to be totally arbitrary.
15. Calculated as: [C(W)] [Maximum exposure at boundary].
16. Calculated as: (Average exposure dose from 300 km of river) (Persons Exposed): Note person mrem to person rem conversion.
17. Environmental Analysis of the Uranium Fuel Cycle, Part I, Fuel Supply, EPA 520/9-73-00313.

1973 - EPA CASE[8]

HEALTH EFFECT ESTIMATES - MODEL FACILITY - CURRENT BEST TECHNOLOGY[1]

Critical Organ	Aggregate Somatic Dose[2] (Person Rem/Facility-Yr)	Health Effect Factors[3] /10^6	Genetic Correction[4]	Health Effects: Mortalities[6]	Health Effects: Non-Fatal Cancers	Health Effects: Genetic Events	Pathway	Total Effects Per Exposure Yr (Effects/Facility-Yr)	Total Effects Per 30 Yr Exposure (Effects/Facility-30 Yr)
Lung	5.6×10^{0}	50/0/0	-	2.8×10^{-4}	0	0	Air	2.8×10^{-4}	8.4×10^{-3}
Bone	5.7×10^{1}	16/16/0	-	9.1×10^{-4}	9.1×10^{-4}	0	Water		
Bone Marrow	(5.7×10^{1})[5]	11/0/0[5]	-	6.3×10^{-4}	0	0	Water	3.1×10^{-3}	9.2×10^{-2}
Soft Tissue	1.3×10^{0}	150/150/300	-/-/0.5	2.0×10^{-4}	2.0×10^{-4}	2.0×10^{-4}[4]	Water		
				20.2×10^{-4}	11.1×10^{-4}	2.0×10^{-4}		3.4×10^{-3}	10.0×10^{-2}

(1) Adapted from Table A-14 to show the sources of the various factors used and to demonstrate the calculation procedure.

(2) Totals from Table I of this report (indicated by boxes).

(3) From Table A-11, Page A-18. Shown in order as mortalities, non-fatal cancers, genetic events.

(4) Genetic correction factor is based on 20 years of mill operation with a doubling time of 40 years, ∴ factor of 0.5.

(5) H.E.F. for above marrow was (leukemia) multiplied by 0.2 to give the value of $11/10^6$ shown. This is because dose to bone marrow is taken as 20% of the bone dose. It would seem to make more sense to reduce the bone dose and leave the H.E.F. alone but the end result is the same.

(6) Calculated as: $\frac{(5.6)(50)}{10^6} = 2.8 \times 10^{-4}$ etc.

(7) Calculated as: (30)(Health Effects/Facility-Yr.)

(8) Environmental Analysis of the Uranium Fuel Cycle, Part I, Fuel Supply, EPA 520/9-73-00313.

TABLE III

SOURCE TERMS FOR 1976 AND 1979 EPA ANALYSES

EPA-76 APPROXIMATION

Sources (mCi/year)[1]

Radionuclide	Ore Pile and Crusher	Yellow Cake	<10μ Tails	Total
U-238	4.5	85.0	0.5	90
U-234	4.5	85.0	0.5	90
Ra-226	4.5	0.2	5.3	10
Th-230	4.5	4.7	5.8	15
Totals	18.0	174.9	12.1	205

Ri 1979 ANALYSIS

Sources (mCi/year)[2]

Radionuclide	Milling	Tailings Disposal Area	
		0-10μ m	10-80μ m
U-238	90	0.6	1.5
U-234	90	0.6	1.5
Th-230	10	12	30
Ra-226	5	12	30
Pb-210	5	12	30
Po-210	5	12	30
Rn-222	120,000	-	2.7×10^6
Ex. Radon	205	49.2	123

(1) Environmental Analysis of the Uranium Fuel Cycle, Part IV, Supplemental Analysis, (EPA 520/4-76-017), Tables 5.0-1 and 6.0-1, pages 20 and 24.

(2) Radiological Impact Caused by Emissions of Radionuclides Into Air in the United States (EPA 520/7-79-000). Table 4.2-4, Page 4.2-9.

TABLE IV

SUMMARY OF CONTROL METHODS AND CORRESPONDING EFFLUENT REDUCTIONS (1)

Control Method	Assumed Effluent Reduction (%)
A. Gaseous (Crusher and Fine Ore Bins)	
1. Orifice Scrubber (2)	93.6
2. Wet Impingement Scrubber	97.9
3. Low Energy Venturi Scrubber	99.5
4. Bag Filters	99.9
B. Gaseous (Yellowcake Drying and Packaging)	
1. Wet Impingement Scrubber (2)(3)	97.9
2. Low Energy Venturi Scrubber (3)	99.5
3. High Energy Venturi Scrubber	99.9
4. High Energy Venturi Scrubber + HEPA Filters	>99.9
C. Liquids, Solids, and Windblown Particulate Matter	
1. Clay Core Dam Retention System with Seepage Return and 0.6 Meters (160 Acre Tailings Pile)	-
2. Chemical Control of Windblown Dust from Tailings and Pond Beach	100.00
3. Asphalt Liner for Tailings Pond (160 Acre Tailings Pile)	100.00

1. Environmental Analysis of the Uranium Fuel Cycle, Part IV, Supplementary Analysis - 1976, EPA 520/4-76-017, Table 8.1-1, Page 29.

2. Assumed current level of control for new mills.

3. Costs for B1 and B2 are assumed to be more than compensated for by the value of the product recovered.

TABLE V

DOSE TO THE REGIONAL POPULATION[1]

(Person rem/yr)

CONTROLS[2]	TOTAL BODY	MARROW	LUNGS	ENDOSTEAL TISSUES	STOMACH WALL	LOWER LARGE INTESTINE WALL	THYROID	LIVER	KIDNEYS	TESTES	OVARIES
1. 1976 EPA APPROXIMATION[3]											
A1,B1	-	-	2.5	-	-	-	-	-	-	-	-
A1,B2	-	-	0.91	-	-	-	-	-	-	-	-
A1,B3	-	-	0.43	-	-	-	-	-	-	-	-
A2,B3	-	-	0.30	-	-	-	-	-	-	-	-
A2,B3,C2	-	-	0.19	-	-	-	-	-	-	-	-
A2,B4,C2	-	-	0.075	-	-	-	-	-	-	-	-
A3,B4,C2	-	-	0.019	-	-	-	-	-	-	-	-
A4,B4,C2	-	-	0.004	-	-	-	-	-	-	-	-
2. 1976 SOURCES - AIRDOS EPA[4] - RADON DAUGHTERS INCLUDED											
A1,B1	1.7890	1.9400	2.0200	19.5820	0.1158	0.2175	0.2111	0.6540	0.3358	0.1439	0.1405
A1,B2	1.6328	1.8158	0.7230	18.1210	0.1118	0.1511	0.1876	0.4360	0.2765	0.1120	0.1096
A1,B3	1.5938	1.7848	0.4014	17.7560	0.1108	0.1346	0.1818	0.3817	0.2617	0.1040	0.1019
A2,B3	1.0198	1.1448	0.2667	11.7530	0.0726	0.0878	0.1180	0.1347	0.0890	0.0356	0.0383
A2,B3,C2	0.29180	0.32380	0.14770	3.2284	0.01900	0.02730	0.03290	0.13470	0.08900	0.03460	0.03330
A2,B4,C2	0.28300	0.31680	0.07440	3.1455	0.01882	0.02350	0.03150	0.12240	0.08570	0.03380	0.03160
A3,B4,C2	0.06780	0.07540	0.02380	0.75020	0.00442	0.00590	0.00750	0.03010	0.02060	0.00810	0.00760
A4,B4,C2	0.01470	0.01610	0.01130	0.16120	0.00092	0.00150	0.00160	0.00730	0.00450	0.00180	0.00170
3. 1976 SOURCES - AIRDOS EPA[4] - RADON DAUGHTERS EXCLUDED											
A1,B1	1.4430	1.7760	1.8857	19.1630	0.0040	0.1178	0.0757	0.8030	0.1745	0.1076	0.1059
A1,B2	1.2929	1.6548	0.5979	17.7260	0.0020	0.0532	0.0546	0.5889	0.1221	0.0779	0.0770
A1,B3	1.2555	1.6246	0.2768	17.3460	0.0015	0.0371	0.0493	0.5355	0.1090	0.0705	0.0698
A2,B3	0.8025	1.0397	0.1850	11.1250	0.0009	0.0239	0.0316	0.3546	0.0713	0.0457	0.0452
A2,B3,C2	0.23254	0.29572	0.12633	3.1563	0.00042	0.01054	0.01007	0.10259	0.02188	0.01408	0.01393
A2,B4,C2	0.22403	0.28885	0.05332	3.0739	0.00030	0.00688	0.00888	0.09045	0.01801	0.01240	0.01229
A3,B4,C2	0.05367	0.06886	0.01880	0.73379	0.00008	0.00194	0.00220	0.02241	0.00472	0.00307	0.00304
A4,B4,C2	0.01176	0.01473	0.01030	0.15781	0.00003	0.00072	0.00056	0.00567	0.00123	0.00078	0.00077
4. 1979 SOURCES (RI-79) - AIRDOS EPA[4] - RADON DAUGHTERS INCLUDED											
A1,B1	3.14	3.45	2.16	34.6	0.197	0.314	0.352	1.53	0.962	0.385	0.361
A1,B2	2.98	3.32	0.870	33.1	0.193	0.248	0.328	1.31	0.902	0.353	0.330
A1,B3	2.94	3.29	0.548	32.8	0.192	0.231	0.322	1.25	0.887	0.345	0.332
A2,B3	2.37	2.65	0.413	26.4	0.154	0.185	0.258	1.01	0.714	0.277	0.259
A2,B3,C2	0.292	0.323	0.148	3.25	0.019	0.0273	0.0329	0 .135	0.0890	0.0356	0.033
A2,B4,C2	0.283	0.316	0.0744	3.15	0.019	0.0235	0.0315	0.1227	0.0857	0.0338	0.0316
A3,B4,C2	0.0678	0.0754	0.0238	0.750	0.0044	0.0059	0.0075	0.0301	0.0206	0.0081	0.0076
A4,B4,C2	0.0147	0.0161	0.0113	0.161	0.0009	0.0015	0.0016	0.0073	0.0045	0.0018	0.0017
5. 1979 SOURCES (RI-79) - AIRDOS EPA[4] - RADON DAUGHTERS EXCLUDED											
A1,B1	2.5120	3.1650	1.9431	33.910	0.0048	0.1422	0.1159	0.1870	0.2561	0.1627	0.1606
A1,B2	2.3619	3.0438	0.6553	32.401	0.0028	0.0776	0.0948	0.9729	0.2037	0.1330	0.1317
A1,B3	2.3245	3.0136	0.3342	32.021	0.0023	0.0615	0.0895	0.9195	0.1906	0.1256	0.1245
A2,B3	1.8715	2.4287	0.2424	25.800	0.0017	0.0484	0.0718	0.7386	0.1529	0.1008	0.0999
A2,B3,C2	0.23254	0.29572	0.12633	3.1563	0.00042	0.01054	0.01007	0.10259	0.02188	0.01408	0.01393
A2,B4,C2	0.22403	0.28885	0.05332	3.0739	0.00030	0.00688	0.00888	0.09045	0.01891	0.01240	0.01229
A3,B4,C2	0.05367	0.06886	0.01880	0.73379	0.00008	0.00194	0.00220	0.02241	0.00472	0.00307	0.00304
A4,B4,C2	0.01176	0.01473	0.01030	0.15781	0.00003	0.00072	0.00056	0.00567	0.00123	0.00078	0.00077

(1) For Case 1 the regional population is 55,000. For all other cases it is 36,000.

(2) Levels of control as defined in Table 8.1-1, page 29 of "Environmental Analysis of the Uranium Fuel Cycle (EPA 520/4-76-017), Part IV Supplemental Analysis.

(3) Dispersion estimated from $(\bar{\chi}/Q)_{max}$ by application of a constant factor $C_a = 2.3 \times 10^{-4}$.

(4) All AIRDOS-EPA based calculations are from Appendix A-1.

TABLE VI

ESTIMATED REGIONAL POPULATION HEALTH EFFECTS AND RISKS

Controls	Health Effects Per Year[1]	Health Effects Cumulative 30 Years[2]	Lifetime Health Effects (10^6 Exposed)[3]
1. 1976 - EPA APPROXIMATION[4]			
A1;B1	0.000125	0.00375	0.068
A1;B2	0.000046	0.00138	0.025
A1;B3	0.000022	0.00066	0.012
A2;B3	0.000015	0.00045	0.0082
A2;B3;C2	0.0000095	0.00029	0.0052
A2;B4;C2	0.0000038	0.00011	0.0021
A3;B4;C2	0.00000095	0.000029	0.00052
A4;B4;C2	0.00000020	0.000006	0.00011
2. 1976 - SOURCES - AIRDOS EPA - RADON DAUGHTERS INCLUDED[5]			
A1;B1	0.000298	0.00894	0.25
A1;B2	0.000226	0.00677	0.19
A1;B3	0.000208	0.00625	0.17
A2;B3	0.000133	0.00400	0.11
A2;B3;C2	0.0000507	0.00152	0.042
A2;B4;C2	0.0000421	0.00127	0.035
A3;B4;C2	0.0000094	0.000283	0.0078
A4;B4;C2	0.0000023	0.000069	0.0019
3. 1976 - SOURCES - AIRDOS EPA - RADON DAUGHTERS EXCLUDED[5]			
A1;B1	0.000278	0.00833	0.23
A1;B2	0.000207	0.00621	0.17
A1;B3	0.000190	0.00571	0.15
A2;B3	0.000122	0.00367	0.10
A2;B3;C2	0.0000379	0.00114	0.032
A2;B4;C2	0.0000339	0.00102	0.028
A3;B4;C2	0.0000084	0.00025	0.0070
A4;B4;C2	0.0000021	0.000063	0.0018
4. 1979 - (RI-79) - AIRDOS EPA - RADON DAUGHTERS INCLUDED[5]			
A1;B1	0.000479	0.01437	0.40
A1;B2	0.0004082	0.012246	0.34
A1;B3	0.000391	0.0117	0.32
A2;B3	0.000312	0.00937	0.26
A2;B3;C2	0.000048	0.00144	0.040
A2;B4;C2	0.000039	0.00116	0.033
A3;B4;C2	0.0000094	0.000283	0.0078
A4;B4;C2	0.0000023	0.000069	0.0019
5. 1979 - (RI-79) - AIRDOS EPA - RADON DAUGHTERS EXCLUDED[5]			
A1;B1	0.00043	0.01294	0.36
A1;B2	0.00036	0.01083	0.30
A1;B3	0.00034	0.01020	0.28
A2;B3	0.000276	0.00828	0.23
A2;B3;C2	0.000038	0.00114	0.032
A2;B4;C2	0.000035	0.00105	0.029
A3;B4;C2	0.0000085	0.000255	0.0071
A4;B4;C2	0.0000019	0.000057	0.0016

1. Number of health effects committed as a consequence of the emissions in a year.
2. Annual health effects time 30 years. Since the assumption is made that virtually the entire dose is committed over 30 years this has been taken as the lifetime health effect.
3. 30-year cumulative HE expressed as HE (lifetime) per million persons exposed. For example - $\frac{(0.00375)(10^6)}{55{,}000} = 0.068$.
4. Based on a regional population of 55,000.
5. Based on a regional population of 36,000.

TABLE VII

CONTROL COSTS USED TO CALCULATE COST-EFFECTIVENESS[1]

Controls	1974 Dollars[1]	ΔPW (1974)	ΔPW (1980)[4]
A1,B1[2][3]	172,000	172,000	266,600
A1,B2[2]	172,000	0	0
A1,B3	262,000	90,000	139,500
A2,B3	290,000	28,000	43,400
A2,B3,C2	432,000	142,000	220,100
A2,B4,C2	561,000	129,000	199,950
A3,B4,C2	701,000	140,000	217,000
A4,B4,C2	867,000	166,000	257,300

1. Dollars per facility. Environmental Analysis of the Uranium Fuel Cycle, Part IV, Supplemental Analysis - 1976, EPA 520/4-76-017, Table 9.0-1.

2. Costs for control options B1 and B2 are not included, since they are more than compensated for by the value of the product recovered.

3. Assumed current levels of controls for new mills.

4. 1980 dollars obtained from 1974 dollars by a factor of 1.553. Chem. Eng. Plant Cost Index, 1980.

TABLE VIII

COST-EFFECTIVENESS[1] OF VARIOUS LEVELS OF CONTROL

Controls	Lifetime Health Effects[3]	Cost Effectiveness (Millions of Dollars/Present Worth)[2] Per (Health Effect Averted)[3]
1. 1976 - EPA APPROXIMATION		
A1;B1	0.00375	-[4]
A1;B2	0.00138	0
A1;B3	0.00066	125
A2;B3	0.00045	133
A2;B3;C2	0.00029	888
A2;B4;C2	0.00011	717
A3;B4;C2	0.000029	1728
A4;B4;C2	0.000006	7217
2. 1976 - SOURCES - AIRDOS - EPA - RADON DAUGHTERS INCLUDED		
A1;B1	0.00894	-[5]
A1;B2	0.00677	0
A1;B3	0.00625	268
A2;B3	0.00400	19
A2;B3;C2	0.00152	89
A2;B4;C2	0.00127	800
A3;B4;C2	0.000283	220
A4;B4;C2	0.000069	1202
3. 1976 - SOURCES - AIRDOS - EPA - RADON DAUGHTERS EXCLUDED		
A1;B1	0.00833	-[5]
A1;B2	0.00621	0
A1;B3	0.00571	279
A2;B3	0.00367	21
A2;B3;C2	0.00114	87
A2;B4;C2	0.00102	1667
A3;B4;C2	0.00025	281
A4;B4;C2	0.000063	1429
4. 1979 - (RI-79) - AIRDOS - EPA - RADON DAUGHTERS INCLUDED		
A1;B1	0.01437	-[5]
A1;B2		0
A1;B3	0.0117	255
A2;B3	0.00937	19
A2;B3;C2	0.00144	28
A2;B4;C2	0.00116	714
A3;B4;C2	0.000283	247
A4;B4;C2	0.000069	1202
5. 1979 - (RI-79) - AIRDOS - EPA - RADON DAUGHTERS EXCLUDED		
A1;B1	0.01294	-[5]
A1;B2	0.01083	0
A1;B3	0.01020	221
A2;B3	0.00826	23
A2;B3;C2	0.00114	21
A2;B4;C2	0.00105	2222
A3;B4;C2	0.000255	272
A4;B4;C2	0.000057	1299

1. Calculated as the incremental cost (present worth) for each successive level of control divided by the incremental health effects averted by the next control level.
2. From Table VI.
3. From Table VII.
4. 1976 Dollars.
5. 1980 Dollars.

TABLE IX

MAXIMUM DOSE TO INDIVIDUAL

(Persons mrem/Year)[1]

CONTROLS[2]	TOTAL BODY	RED MARROW	LUNGS	ENDOSTEAL TISSUES	STOMACH WALL	LOWER LARGE INTESTINE WALL	THYROID	LIVER	KIDNEYS	TESTES	OVARIES
1. 1976 EPA APPROXIMATION[3]											
A1,B1	-	-	200	-	-	-	-	-	-	-	-
A1,B2	-	-	73	-	-	-	-	-	-	-	-
A1,B3	-	-	34	-	-	-	-	-	-	-	-
A2,B3[5]	-	-	24[5]	-	-	-	-	-	-	-	-
A2,B3,C2	-	-	15	-	-	-	-	-	-	-	-
A2,B4,C2	-	-	6	-	-	-	-	-	-	-	-
A3,B4,C2	-	-	1.5	-	-	-	-	-	-	-	-
A4,B4,C2	-	-	0.3	-	-	-	-	-	-	-	-
2. 1976 SOURCES - AIRDOS EPA[4] - RADON DAUGHTERS INCLUDED											
A1,B1	99.4	104.6	224.3	1034.0	9.6	15.3	14.9	64.7	32.3	16.4	15.1
A1,B2	86.5	95.5	75.7	925.8	9.3	10.9	13.2	48.0	27.8	13.9	12.8
A1,B3	83.3	93.2	38.7	898.8	9.2	9.9	12.7	43.8	26.8	13.3	12.2
A2,B3	45.0	50.5	23.3	487.8	5.7	5.4	6.9	24.3	14.2	7.2	6.6
A2,B3,C2	19.61	21.68	16.92	208.83	2.83	2.48	3.00	10.65	6.45	3.16	2.91
A2,B4,C2	18.88	21.16	8.50	202.68	2.81	2.24	2.90	9.70	6.20	3.03	2.77
A3,B4,C2	4.53	5.04	2.73	48.48	0.50	0.55	0.69	2.37	1.49	0.73	0.67
A4,B4,C2[5]	0.99	1.08	1.30	10.43[5]	0.10	0.13	0.15	0.57	0.33	0.16	0.15
3. 1976 SOURCES - AIRDOS EPA[4] - RADON DAUGHTERS EXCLUDED											
A1,B1	78.2	92.0	214.0	1007.0	0.3	7.1	4.5	51.8	10.9	6.6	6.4
A1,B2	65.8	83.2	65.4	899.6	0.1	3.0	2.9	35.4	7.0	4.3	4.3
A1,B3	62.7	81.0	28.4	872.8	0.1	1.9	2.5	31.3	6.1	3.9	3.7
A2,B3	34.0	43.8	17.8	474.1	0.0	1.1	1.4	17.7	3.4	2.1	2.1
A2,B3,C2	14.91	18.84	14.57	203.12	0.03	0.67	0.66	7.76	1.56	0.97	0.95
A2,B4,C2	14.20	18.34	6.15	197.03	0.02	0.43	0.57	6.84	1.34	0.85	0.83
A3,B4,C2	3.42	4.38	2.17	47.09	0.01	0.12	0.14	1.69	0.34	0.21	0.21
A4,B4,C2[5]	0.76	0.94	1.19	10.20[5]	0.00	0.05	0.04	0.43	0.09	0.05	0.05
4. 1979 SOURCES (RI-79) - AIRDOS EPA[4] - RADON DAUGHTERS INCLUDED											
A1,B1	216	235	242	2262.0	23.1	29.0	33.2	114	69.2	34.9	32.1
A1,B2	203	226	93.3	2153.0	22.7	24.6	31.4	97.4	64.8	32.5	29.8
A1,B3	200	224	56.2	2126.0	22.6	23.5	31.0	93.2	63.7	31.9	29.2
A2,B3	162	181	40.9	1716.0	19.1	19.0	25.1	73.8	51.1	25.8	23.6
A2,B3,C2	19.6	2 .6	16.9	209.0	2.83	2.49	3.00	10.7	6.45	3.17	2.91
A2,B4,C2	18.9	21.1	8.50	203.0	2.81	2.24	2.90	9.70	6.20	3.03	2.78
A3,B4,C2	4.53	5.03	2.73	48.5	0.496	0.550	.694	2.37	1.49	0.727	0.668
A4,B4,C2	0.994	1.08	1.30	10.5	0.103	0.134	0.151	0.570	0.327	0.161	0.149
5. 1979 SOURCES (RI-79) - AIRDOS EPA[4] - RADON DAUGHTERS EXCLUDED											
A1,B1	164.9	204.7	217.3	2196.0	0.4	9.2	7.8	82.9	17.6	11.1	10.8
A1,B2	152.5	195.9	68.7	2088.6	0.2	5.0	6.2	66.5	13.7	8.9	8.7
A1,B3	149.4	193.7	31.6	2061.8	0.2	4.0	5.8	62.4	12.7	8.3	8.2
A2,B3	120.7	156.5	21.0	1663.1	0.1	3.2	4.7	48.8	10.0	6.6	6.5
A2,B3,C2	14.91	18.84	14.57	203.12	0.03	0.67	0.66	7.76	1.56	0.97	0.95
A2,B4,C2	14.20	18.34	6.15	197.03	0.02	0.43	0.57	6.84	1.34	0.85	0.83
A3,B4,C2	3.42	4.38	2.17	47.09	0.01	0.12	0.14	1.69	0.34	0.21	0.21
A4,B4,C2	0.76	0.94	1.19	10.20	0.00	0.05	0.04	0.43	0.09	0.05	0.05

(1) Individual subjected to maximum dose as most recently defined by EPA is a person living 500 meters from the source. For this analysis, as in prior EPA AIRDOS-II analyses, distances of 570 meters from the tailings and 503 meters from milling operations were selected for use. Emissions of radon and its daughters not considered.

(2) Levels of control as defined in Table 8.1-1, page 29 of "Environmental Analysis of the Uranium Fuel Cycle (EPA 520/4-76-017), Part IV Supplemental Analysis.

(3) Dispersion estimated by an average $(\bar{\chi}/Q)_{max}$. Lung was designated as the critical organ and lung dose only was considered.

(4) All AIRDOS-EPA based calculations are from Appendix A-1.

(5) Indicates level of control needed to meet the 40 CFR-190 25 mrem standard.

TABLE X

RISKS TO THE MAXIMALLY EXPOSED INDIVIDUAL[1]

Controls[2]	Lifetime Risk[4] (HE/10^6)	Annual Rate of Risk[5] (HE/10^6/Year)	Average Days of Life Expectancy Lost[6] - (Days)
0. EPA 1976 APPROXIMATION - RADON DAUGHTERS INCLUDED			
A1,B1	-	-	-
A1,B2	-	-	-
A1,B3	-	-	-
A2,B3	-	-	-
A2,B3,C2	-	-	-
A2,B4,C2	-	-	-
A3,B4,C2	-	-	-
A4,B4,C2	-	-	-
2. 1976 SOURCES (EPA-76) AIRDOS EPA[3] - RADON DAUGHTERS INCLUDED[8]			
A1,B1	640	9.3	4.8
A1,B2	420	6.0	3.1
A1,B3	360	5.1	2.6
A2,B3	200	2.86	1.5
A2,B3,C2	95	1.36	0.7
A2,B4,C2	82	1.17	0.6
A3,B4,C2	20	0.29	0.15
A4,B4,C2	5.3	0.08	0.04
4. 1979 SOURCES (RI-79) AIRDOS EPA - RADON DAUGHTERS INCLUDED[8]			
A1,B1	1100	15.6	8.0
A1,B2	870	12.5	6.4
A1,B3	820	11.7	6.0
A2,B3	660	9.4	4.8
A2,B3,C2	95	1.35	0.7
A2,B4,C2	82	1.17	0.6
A3,B4,C2	20	0.29	0.15
A4,B4,C2	5.3	0.076	0.04

Lifetime Risk[4] (HE/10^6)	Annual Rate of Risk[5] (HE/10^6/Year)	Average Days of Life Expectancy Lost[6] - (Days)
1. RADON DAUGHTERS EXCLUDED[7]		
300	4.3	2.2
110	1.56	0.8
51	0.73	0.4
36	0.51	0.3
23	0.32	0.16
9	0.13	0.07
2.3	0.032	0.02
0.5	0.006	0.003
3. RADON DAUGHTERS EXCLUDED[8]		
650	9.3	4.8
360	5.1	2.6
310	4.4	2.2
170	2.41	1.2
81	1.16	0.6
69	0.98	0.5
17	0.25	0.13
4.7	0.067	0.03
5. RADON DAUGHTERS EXCLUDED[8]		
1070	15.3	7.8
730	10.4	5.3
700	10.0	5.1
520	7.4	3.8
81	1.16	0.6
69	0.98	0.5
17	0.25	0.13
4.6	0.067	0.03

(1) Individual subjected to maximum dose as most recently defined by EPA is a person living 500 meters from the source. For this analysis, as in prior EPA AIRDOS-II analyses, distances of 570 meters from the tailings and 503 meters from milling operations were selected for use. Emissions of radon and its daughters not considered.

(2) Levels of control as defined in Table 8.1-1, page 29 of "Environmental Analysis of the Uranium Fuel Cycle (EPA 520/4-76-017), Part IV Supplemental Analysis.

(3) All AIRDOS-EPA calculations are based on doses given in Appendix A-1 .

(4) Lifetime risk of cancer as a result of 30 years discharge from the source. Since only a minimal further discharge after shutdown was assumed in the 1976 analysis this becomes the total lifetime risk of cancer due to this source.

(5) Average annual rate of risk calculated as lifetime risks per million divided by a life expectancy of 70 years. Expressed as health effects/per million/per year.

(6) Based on 20 years of life expectancy lost per health effect.

(7) Only lung dose included on the basis that it was the critical organ. Health effect factor = 50 HE/10^6 rem.

(8) Health effect factors used for the same 10 organs listed in Table XVI as follows: red marrow and lungs 40/10^6 rem; endostial tissue and thyroid 6/10^6 rem; all others 12/10^6 rem.

TABLE XI

COMPARISON OF AIRDOS-EPA TO MILDOS - MAXIMALLY EXPOSED INDIVIDUAL (1)(2)

AIRDOS-EPA

Total Body	Red Marrow	Lungs	Endostial Tissue	Stomach Wall	Lower Large Intestine Wall	Thyroid	Liver	Kidneys	Testes	Ovaries	
216	235	242	2262	23.1	29.0	33.2	114	69.2	34.9	32.1	-

MILDOS

Whole Body		Average Lung					Liver	Kidneys			Bone
6.07	-	132	-	-	-	-	5.11	19.5	-	-	78.1

(1) Calculations from Attachment 1.

(2) RI-79 Source Terms; A, B, Control Level. (Orifice scrubber on Crusher and Fine Ore Bins and Wet Impingement Scrubber on Yellowcake Facilities)

TABLE XII

LOSS OF LIFE EXPECTANCY DUE TO VARIOUS CAUSES[1]

CAUSE	Days
Being Unmarried - Male	3500
Cigarette Smoking - Male	2250
Heart Disease	2100
Being Unmarried - Female	1600
Being 30% Overweight	1300
Cancer	980
20% Overweight	900
<8th Grade Education	850
Cigarette Smoking - Female	800
Low Socioeconomic Status	700
Stroke	520
Living In Unfavorable State	500
Army In Vietnam	400
Cigar Smoking	330
Dangerous Job - Accidents	300
Pipe Smoking	220
Increasing Food Intake 100 Calories/Day	210
Motor Vehicle Accidents	207
Pneumonia - Influenza	141
Alcohol (U.S. Average)	130
Accidents in Home	95
Suicide	95
Diabetes	95
Being Murdered (Homicide)	90
Legal Drug Misuse	90
Average Job - Accidents	74
Drowning	41
Falls	39
Accidents to Pedestrians	37
Safest Jobs - Accidents	30
Fire - Burns	27
Illicit Drugs (U.S. Average)	18
Poison (Solid, Liquid)	17
Suffocation	13
Firearms Accidents	11
Natural Radiation (BEIR)	8
Medical X-Rays	6
Poisonous Gases	7
Coffee	6
Oral Contraceptives	5
Accidents to Pedacycles	5
All Catastrophes Combined	3.5
Frequent Airline Passenger[2] (Radiation Only)	2.5
One Transcontinental Flight Per Year (Radiation+Accident)[2]	2.5
Maximally Exposed Individual[3]	2-4
Diet Drinks	2
Person in Room With A Smoker[2]	1.5
Living in a Brick vs Wood House[2]	0.8

(1) Source unless otherwise noted: "A Catalog of Risks", B.L. Cohen, I.S. Lee, Health Physics, Vol. 36, June 1979, p. 701-722.

(2) Adapted from Richard Wilson, direct testimony presented on OSHA Docket No. H-090, Proposed Regulations for Identification, Calssification, and Regulation of Toxic Substances Posing a Potential Occupational Carcinogenic Risk. Conversion values to life expectancy lost used were 20 years for cancer and 30 years for accidents.

(3) Risk corrected to conditions at 20th year of plant operation and washing of home grown vegetables before eating.

TABLE XIII

. EPA - 1973 RISK FACTORS[1]

Organ	Organs and Factors Used to Calculate Risk[2] (H.E./10^6 Person-Rem)
Lung	50/0/0
Bone[4]	16/10/0
Bone Marrow	54/0/0[3]
Total Soft Tissue Organs Other Than Bone	150/150/300
TOTAL	270/165/300

[1] Environmental Analysis of the Uranium Fuel Cycle, Part 1, Fuel Supply, EPA 520/9-73-00313.

[2] Table A-11, Page A-18. Factors given as events per 10^6 rem aggregate dose in the order of mortality, non-fatal cancers and genetic effects. Only the lungs were used in EPA-76.

[3] It was stated in Table A-14, Page A-22, that the bone marrow dose is 20% of the bone dose. In the calculation of health effects in Table A-14, the H.E.F. for bone marrow was reduced to 20% and applied to the whole bone dose instead of adjusting the dose and applying the proper factor. The end result is the same.

[4] Apparently includes tabecular bone and bone surfaces.

TABLE XIV

RI-79 RISK FACTORS[1]

AIRDOS-II[1]	(Fatal Cancers per 10^6 Person-Rem) Factors[2]	Organs and Factors Actually Used To Calculate Risk[3]
Lung	40+0.021/person-WL-Y	40
Bone	-	30[4]
Kidney	-	10 (From "Other")
Thyroid	1	1
Liver	-	10 (From "Other")
G.I. Tract	20	-
Testes	-	-
Ovaries	-	-
Spleen	-	-
Muscle	-	-
[2](Red Bone Marrow)[2]	40	-[4]
[2](Breast Ave. for Both Sexes)	40	(Other Soft Tissue) 50[5]
[2](Stomach)	20	-(Dose Not Calculated)
[2](Up to 4 Others at 10 Each)	40	-
	Σ = 201	Σ 141
Total Body	200	

[1] Radiological Impact Caused by Emissions of Radionuclides Into Air in the United States, EPA 520/7-79-006, August 1979 (RI-79). AIRDOS-II calculated doses and applied dose conversion factors to these 10 organs and total body as listed.

[2] As listed in Table B-1, Page B-2, RI-79.

[3] The factors shown here were used with the specific organs and the results were summed to calculate the total health risks. The total body risk was not included as part of this calculation.

[4] See Page B-1, RI-79. Includes both bone (as one of the four "other") and red marrow as a composite of $40/10^6$ for bone marrow and $10/10^6$ for bone, i.e., $0.5 \times 40/10^6 + 10/10^6 = 30/10^6$. This factor was applied to the calculated bone dose.

[5] Includes $40/10^6$ for breast plus one other organ at $10/10^6$.

TABLE XV

DRAFT GEIS - RISK FACTORS

(NRC - 1979)[1]

Organ	Risk Estimates[2]
Lung (Pulmonary and Bronchial Epithelium)	72
Bone	6
Bone Marrow(Leukemia)	32
Other[3]	120
Total	230

(1) Draft Generic Environmental Impact Statement on Uranium Milling, NUREG-0511, Volume II, Page G59.

(2) Fatal health effects/year/10^6 man-rem/year.

(3) Appears to mean everything not accounted for via lung and bone.

FACTORS FOR HEALTH RISK CALCULATIONS

Airdos - EPA - Organs Calculated	Organs and Factors Used in Health Risk Calculations (Fatal HE/10^6 Person-Rem)			
	EPA - 1973[1]	EPA - 1976[2]	RI-79[3]	AMC Petition
Bone (Red Marrow)	54/0/0	-	30[4]	40
Lungs	50/0/0	50/0/0	40	40
Endostial Tissue[5]	16/16/0 (Bone)	-	-	6
Stomach Wall	-	-	-	12
Lower Large Intestine Wall	-	-	-	12
Thyroid	-	-	1	6
Liver	-	-	10	12
Kidneys	-	-	10	12
Testes (Cancer)	-	-	-	12
Ovaries (Cancer)	-	-	-	12
	150/300/300 (Soft Tissue)	-	50[5] Soft Tissue	-
Totals	270/165/300	50/0/0	141	164

(1) Environmental Analysis of the Uranium Fuel Cycle, Part I - Fuel Supply (EPA 520/9-73-003-B), Page A-22. Values given are for fatal cancers, non-fatal cancers and genetic effects where applicable.

(2) Environmental Analysis of the Uranium Fuel Cycle, Part IV - Supplementary Analysis - 1976 (EPA 520/4-76-017).

(3) Radiological Impact Caused by Emissions of Radionuclides into Air in the United States, Preliminary Report (EPA 520/7-79-006), Table 4.2-5, Pages 4.2-11.

(4) Composite of red bone marrow at $40/10^6$ and bone at $10/10^6$, i.e., $(0.5)(40)/10^6 + 10/10^6 = 30/10^6$ Applied to calculated bone dose.

(5) Includes breast at $40/10^6$ plus one other soft tissue organ.

APPENDIX A-3

RADIOLOGICAL ASPECTS OF THE EPA FINAL ENVIRONMENTAL STATEMENT AND 40 CFR 190 REGULATIONS WITH RESPECT TO URANIUM MILLING

Dr. G. Hoyt Whipple

Prepared for the American Mining Congress

September 12, 1980

ABSTRACT

This report reviews available information on the Environmental Protection Agency positions on individual radiation dose limits, dose conversion factors and risk factors as they apply to the Final Environmental Statement on Environmental Radiation Protection Requirements for Normal Operations of Activities in the Uranium Fuel Cycle and the requirements set forth in EPA's 40 CFR 190 regulations, as these requirements relate to uranium milling. It is concluded that EPA has not provided quantitative, objective justification for the choice of the 25 mrem per year individual limit. Dose conversion factors, and to a lesser extent, risk factors are at present in such a state of disagreement that it is by no means clear what factors should be applied in enforcing the requirements.

It thus seems very clear that the values used by EPA in the studies the Agency cites in support of its standards are at best questionable. In view of this, and the above, there would appear to be no rational basis for putting the proposed standard into effect.

TABLE OF CONTENTS

LIST OF TABLES

RADIOLOGICAL ASPECTS OF THE EPA FINAL ENVIRONMENTAL STATEMENT AND 40 CFR 190 REGULATIONS WITH RESPECT TO URANIUM MILLING

I. INTRODUCTION

A. PURPOSE

This report examines the radiological bases for radiation protection standards proposed by the Environmental Protection Agency in the Final Environmental Statement, Environmental Radiation Protection Requirements for Normal Operations of Activities in the Uranium Fuel Cycle (EPA 76) as these requirements apply to uranium milling under EPA's 40 CFR 190 regulations. The report specifically considers three matters: 1) the 25 mrem per year standard, 2) dose conversion factors relating the radiation dose experienced by body organs to quantities of radioactive material inhaled or ingested, and 3) risk factors which relate the radiation dose to the chance of additional health effects.

B. SCOPE

The report addresses the principal features of the three matters mentioned above and centers attention on the radionuclides and exposure pathways which produce the largest doses.

The report relies primarily on published technical literature. Comparisons are made between the concepts and values used by EPA in developing, proposing and promulgating the 25 mrem standard, and the corresponding concepts and values which appear in the scientific literature. These comparisons reveal some serious deficiencies and inconsistencies in EPA's position and in the standard.

II. THE 25 MREM STANDARD

A. JUSTIFICATION

Nowhere in the 1976 FEIS, or in any of its published supporting documents does EPA explicitly justify the radiation limits in the 40 CFR 190 standard, i.e., 75 mrem per year to the thyroid and 25 mrem per year to the total body and to all other organs and tissues. The figure of 25 mrem per year is presented with the implication that judgment, cost-effectiveness analysis, and controls readily available to the industry have all been considered carefully prior to its formulation. However, nowhere is there any explanation sufficiently quantitative to support 25 mrem, as opposed to say 50 or 100 mrem per year.

The Federal Register notice proposing the standards, dated May 29, 1975, page 23421, third column, states:

"The proposed standards for annual whole body dose to any individual limits the combined internal and external dose equivalent ... from all operations of the fuel cycle to 25 millirems. Such a limit is readily satisfied at all sites ... by levels of control that are cost-effective for the reduction of potential risk achieved; is in accord with the capabilities of controls anticipated by the AEC ... ; and, on the basis of present operating experience at existing sites, can be readily achieved in practice. ..."

The following two quotations are as close as the FEIS comes to explaining the choice of 25 mrem per year.

"If the data in the cost versus health effect curves in Figure 3 are plotted as differential curves, as shown in Figure 4, a display of the rate of aversion of health effects per unit cost versus cumulative cost is obtained. An examination of these curves in conjunction with Figure 3 shows that near a cumulative present worth cost of about three million dollars per gigawatt of power capacity for the entire fuel cycle for the PWR case (about eight million dollars for the BWR case), a breakpoint occurs between efficient and inefficient control options. At this point the rate of reducing potential health effects is roughly one per half-million dollars. In the region beyond this point, the differential curve continues to descend rapidly to very low rates of cost-effectiveness ... and an insignificant further reduction in health effects is obtainable even for large additional control expenditures." (EPA 76, Vol. I, p. 48)

"...the approach to setting standards for maximum individual dose was to weigh the cost-effectiveness of individual dose reduction and the cost of control relative to total capital cost, in order to arrive at a judgment whether or not it was possible, at reasonable cost, to reduce these few individual exposures to the same general levels that are achievable for large populations for other sources of environmental radiation exposure from the uranium fuel cycle." (EPA 76, Vol. I, p. 26)

These statements scarcely enable an interested observer to comprehend how the limit of 25 mrem per year was reached for the proposed standard.

B. OTHER CONSIDERATIONS

EPA's position with respect to limits on dose commitments to populations (expressed in person-rems) is stated as follows (EPA 76, Vol. I, pp. A-7 to A-8):

> "... The Agency believes that future changes and refinements in models, and thus the person-rem assessments upon which these standards are based, will occur on a continuing basis. The standards are therefore not proposed directly in terms of person-rems, but future reviews of their adequacy will reflect any changes in model-based assessments of population dose. Standards have also not been proposed directly in terms of person-rems because the regulatory implementation of such a requirement does not appear to be administratively feasible for the fuel cycle under existing widely varying geographical and demographic conditions and for doses that may, in some instances, be delivered over indeterminately long periods of time. ..."

It appears from the quotation above that EPA intends to consider limits on person-rem when the models and administrative procedures have developed sufficiently. Once the problems identified in this report and the petition to which it is appended have been solved, this may be within EPA's reach. Alternatively, perhaps this eventuality can be deflected by regarding the 25 mrem per year individual limit as a threshold, or de minimis level, below which the integration of person-rems is of no moment. Absent the imposition of this, or a similar cutoff, the assumption of a linear,

non-threshold relationship between radiation dosage and excess health effects would suggest society should make the massive expenditures necessary to attempt to eliminate any risk whatsoever. Clearly the elimination of all risk is neither feasible nor cost-effective. Unfortunately as indicated in the following comment and response, EPA seems to fail to grasp the fact that our society's resources are limited and should not be squandered in this fashion. (EPA 76, Vol. II, pp. 59-60):

> "Comment 126: The economic resources required to satisfy these standards could be more effectively spent to reduce health impact in areas other than nuclear power. ...
>
> "Response: It will probably always be true that, for any given social expenditure, an alternative choice can be found that would yield a greater return. However, it will usually also be found that the resources involved are not transferable. In any case, the possibility that greener fields may exist elsewhere for health effects reduction does not absolve the Agency from ensuring that appropriate measures be taken by the uranium fuel cycle. In no case does the agency believe that the costs that would be incurred to satisfy these standards represent an unreasonable use of the Nation's resources."

III. DOSE CONVERSION FACTORS

A. BACKGROUND

That fraction of the radioactive material initially deposited in an organ which is present at some later time is called the retention function (See Attachment at p. A-5) and is dependent on time after deposition and the effective half-life. For many chemical elements, it is found that biological elimination can be

described adequately by a simple exponential function of the same form given for radioactive decay. Among the few elements which cannot be satisfactorily represented by a simple exponential elimination function is radium. The ICRP (ICRP 72) has developed a thorough and complex model for radium transfer within the body which involves both exponential and power functions of time after deposition.

The ICRP (ICRP 66) has developed a model for the deposition, retention and transfer of radioactive material in inhaled aerosols. This model appears to have been used in the calculation of all the inhalation dose conversion factors cited in this report. Table 1 (p. 7) gives the constants used in the ICRP lung clearance model.

For four of the elements of interest in this report, the ICRP Task Group on Lung Dynamics (ICRP 66, pp. 201 - 202) has given recommended values for the slow phase clearance half-life (T_b). These values are given in Table 2 (p.9).

Inhalation dose conversion factors are functions of several characteristics of the aerosols involved: 1) particle size distribution, 2) solubility in lung fluid, described by the three classes, D, W and Y, and 3) the retention function which is controlled by the clearance half-life, T_b, and is closely related to the solubility class.

Table 1. Constants Used in the ICRP Lung Clearance Model (ICRP 66, page 193)

Depos. in respir. region	Trans-ferred to	Class D		Class W		Class Y	
		T_b	F	T_b	F	T_b	F
N-P	blood	4 m	0.50	4 m	0.10	4 m	0.01
	G-I	4 m	0.50	4 m	0.90	4 m	0.99
T-B	blood	10 m	0.50	10 m	0.10	10 m	0.01
	G-I	10 m	0.50	10 m	0.90	10 m	0.99
P	blood	30 m	0.80	90 d	0.15	360 d	0.05
	G-I	-	-	24 h	0.40	24 h	0.40
	G-I	-	-	90 d	0.40	360 d	0.40
	lymph	30 m	0.20	90 d	0.05	360 d	0.15
Lymph	blood	30 m	1.00	90 d	1.00	360 d	0.10
	-	-	-	-	-	∞	0.90

T_b = biological half-life
F = fraction transferred
N-P= nasopharyngeal
T-B= tracheobronchial
G-I= gastro-intestinal tract
P = pulmonary
m = minutes
h = hours
d = days

The sources from which the dose conversion factors given in Tables 4a through 9b (pp. 14 - 26) are drawn are, in all cases, for particle size distributions with an activity median aerodynamic diameter (AMAD) of 1 um. The selection of this small size produces larger dose commitments than would a larger sized aerosol.

The findings of Kalkwarf (1979) with respect to solubility of airborne material from uranium mines and mills are summarized in Table 3 (p.10). Comparison of the ICRP recommended classifications in Table 2 with the experimental classifications in Table 3 shows excellent agreement for thorium, fair agreement for radium, except that Kalkwarf found 10% of Class D component in both ore and tailings dust, and rather poor agreement for uranium and polonium. Kalkawarf found generally higher solubilities for uranium, and lower solubilities for polonium than those recommended by the ICRP Task Group.

Age is one factor which affects the relation between the quantity of a given radionuclide inhaled or ingested and the resulting organ doses. The ICRP has used a 50-year individual dose commitment period for workers (ICRP 78a at p. 78b). This means that when an individual inhales or ingests a given quantity of radioactive material at a particular time, the doses delivered to the organs of his body are summed over time thereafter until either the material has been completely removed from his body, or a period of 50 years has elapsed. As far as the references used

Table 2. Clearance Half-Times for the Slow Phase (ICRP 66, pp. 201-202)

Chemical Element	Chemical Form	Clearance Half-Time, T_b, days		Class
		Single Exposure	Multiple Exposures	
Polonium	Hydroxide	30	30	W
Uranium	Oxides	120-150	380	Y
Thorium	Dioxide	500	-	Y
Radium	Sulfate	180	-	Y

Table 3. Solubility Classification for Airborne Products from Uranium Ores and Tailings Piles in Simulated Lung Fluid (Kalkwarf 79, p. 3)

Product	Isotope	Class D	Class W	Class Y
Uranium-ore dust	U-235	-	100%	-
	U-238	-	100%	-
	Ra-226	10%	-	90%
	Th-230	-	-	100%
	Pb-210	-	-	100%
	Po-210	-	-	100%
Tailings-pile dust	Ra-226	10%	-	90%
	Th-230	-	-	100%
	Pb-210	-	-	100%
	Po-210	-	-	100%
Uranium octoxide	—	-	-	100%
Uranium tetrafluoride	—	-	-	100%
Yellow-cake dust	U-235 U-238	60%	40%	-
Ammonium diuranate	—	100%	-	-

in this report indicate, all have used a 50-year period in the dose conversion factors. Inasmuch as the average life expectancy is about 70 years, a 50-year individual dose commitment period seems appropriate. Finally, the quality factor (See Attachment at p. A-9) used in this report is Q = 20 based on ICRP 78a.

B. COMPARISON OF DOSE CONVERSION FACTORS

The following six pairs of tables (pp. 15 - 26) give the latest available inhalation and ingestion dose conversion factors for uranium-238, uranium-234, thorium-230, radium-226, polonium-210 and lead-210. Radon, of course, is excluded from consideration.

The data in the first several rows of each table give the bases on which the dose conversion factors were calculated. A question mark indicates it to be probable that the information was not given in the reference from which the tabulated dose conversion factors were obtained. In some cases the required information is probably given in the reference cited by the sources used here, but unavailablility of documents prevented inclusion of this information in the tables.

First, it should be noted that the dose conversion factors used by Impact, Ltd. in their computer runs, which are those recommended by the EPA for use with AIRDOS-EPA, are those designated ORNL in the following tables.

The dose conversion factors given by NRC are essentially equal to those given by EPA-2 (See p. 14) for uranium-238, uranium-234 and thorium-230, but not for radium-226, lead-210 or polonium-210. The dose conversion factors given by ORNL are approximately equal to those given by ICRP for uranium-238, uranium-234 and thorium-230 by inhalation, for polonium-210 by inhalation and ingestion, and for radium-226 in the lung and gonads. However, the ORNL factors are 5 to 10 times greater than the ICRP factors for thorium-230 by ingestion, and for radium-226 to endosteal tissue by inhalation and ingestion, and to red marrow by ingestion. ICRP has not yet published factors for lead-210.

Finally, it should be noted that there is no apparent agreement between EPA-1 and EPA-2 (See p. 14) for the three isotopes for which both references give dose conversion factors (radium-226, polonium-210 and lead-210).

The chaotic lack of agreement evident in Tables 4a through 9b makes it difficult to predict which set of dose conversion factors will ultimately be determined to be correct. EPA personnel are presently indicating that some months will pass before a decision is reached.

To some extent the differences in the tabulated dose conversion factors result from different choices of the factors

which enter into the calculations. It seems natural to accord the ICRP factors more respect than the others. However, the fact that the ICRP factors rest on calculations made at the Oak Ridge National Laboratory makes the lack of agreement with the ORNL factors puzzling.

At the very least, the disagreement evident in Tables 4a through 9b calls for delay in enforcing the 40 CFR 190 standard until these disagreements have been resolved in a clear and reasonable manner.

DOSE CONVERSION FACTORS: Key to Tables 4a through 9b.

References:

ICRP: ICRP Publication 30, Supplement to Part 1 (ICRP 78b), pp. 378, 364, 365, 322, 323, 289, 272.

ORNL: Dunning, et al. NUREG/CR-0150, Vol II (Dunning, et al. 79), pp. 497, 498, 483, 484.

NRC: Draft Generic Environmental Impact Statement on Uranium Milling (NRC 79), Vol. II, pp. G-42, G-48.

EPA-1: AIRDOS-EPA (Moore, et al. 79), pp. 216-218.

EPA-2: Preliminary Report: Radiological Impact Caused by Emissions of Radionuclides into Air in the United States (EPA 79), pp. A-31, A-33.

Key to Abbreviations

Period, yr: the period in years over which the dose equivalent commitment is integrated

Q(alpha): the quality factor taken for alpha particles

N: the modifying factor for alpha particles

AMAD, um: the activity median aerodynamic diameter of the radioactive aerosol in um.

Class: the degree of solubility of the aerosol in lung fluid; D half-tme of 0 to 10 days, W 11 to 100 days, and Y greater then 100 days.

f_1: the fraction transferred from the gastro-intestinal tract to the blood.

T. body: total body

St. wall: wall of the stomach

LLI wall: wall of the lower large intestine

Red marr.: the red bone marrow, where the formed blood elements are produced.

Endosteal: the endosteal tissue to a depth of 10 um from the surface of mineral bone.

Table 4a. Inhalation Dose Conversion Factors; rem/uCi, for Uranium-238

	ICRP	ICRP	ICRP	ORNL	ORNL	ORNL	NRC	EPA-2
Period,yr	50	50	50	50	50	50	50	50
Q(alpha)	20	20	20	20	20	20	?	?
N	1	1	1	5(bone)	5(bone)	5(bone)	?	?
AMAD,um	1	1	1	1	1	1	1*	1
Class	D	W	Y	D	W	Y	Y	Y
f_1	0.05	0.05	0.002	0.05	0.05	0.002	?	?
Organ								
T. body	-	-	-	29.	9.6	17	0.206	0.21
St. wall	-	-	-	0.0151	0.007	0.009	-	0.030
LLI wall	-	-	-	0.041	0.11	0.28	-	0.030
Lungs	1.04	51.8	1,000	0.83	49.	480.	360.	390.
Kidneys	14.8	-	-	15.	4.4	1.5	0.79	0.82
Liver	-	-	-	10.	3.0	1.1	0	-
Ovaries	-	-	-	10.	3.0	1.0	-	-
Testes	-	-	-	10.	3.0	1.0	-	-
Red marr.	2.44	-	-	11.	3.2	1.1	-	-
Endosteal	36.3	-	-	28.	8.4	2.9	3.5	3.6
Thyroid	-	-	-	9.9	3.0	1.0	-	-

* ρ = 2.4 gm/cm^3

Table 4b. Ingestion Dose Conversion Factors, rem/uCi, for Uranium-238

	ICRP	ICRP	ORNL	ORNL	NRC	EPA-2
Period, yr	50	50	50	50	50	50
Q(alpha)	20	20	20	20	?	?
N	1	1	5 (bone)	5(bone)	?	?
f_1	0.05	0.002	0.05	0.002	?	?
Organ						
T. body	-	-	3.0	0.12	0.045	0.045
St. wall	-	-	0.005	0.004	-	0.15
LLI wall	-	0.17	0.16	0.17	-	0.15
Lungs	-	-	0.002	0.000	-	0.045
Kidneys	1.52	0.063	1.5	0.060	0.175	0.17
Liver	-	-	1.0	0.041	0	-
Ovaries	-	-	1.0	0.041	-	-
Testes	-	-	1.0	0.041	-	-
Red marr.	0.252	0.010	1.1	0.044	-	-
Endosteal	3.7	0.148	2.8	0.11	0.767	0.76
Thyroid	-	-	-	-	-	-

Table 5a. Inhalation Dose Conversion Factors, rem/uCi, for Uranium-234

	ICRP	ICRP	ICRP	ORNL	ORNL	ORNL	NRC	EPA-2
Period,yr	50	50	50	50	50	50	50	50
Q(alpha)	20	20	20	20	20	20	?	?
N	1	1	1	5(bone)	5(bone)	5(bone)	?	?
AMAD,um	1	1	1	1	1	1	1*	1
Class	D	W	Y	D	W	Y	Y	Y
f_1	0.05	0.05	0.002	0.05	0.05	0.002	?	?
Organ								
T. body	-	-	-	33.	11.	19.	0.23	0.24
St. wall	-	-	-	0.016	0.007	0.004	-	0.034
LLI wall	-	-	-	0.043	0.095	0.11	-	0.034
Lungs	1.18	59.2	1,110.	0.94	55.	536.	410.	450.
Kidneys	16.7	-	-	16.	4.9	1.7	0.90	0.94
Liver	-	-	-	11.	3.4	1.2	0	-
Ovaries	-	-	-	11.	3.4	1.2	-	-
Testes	-	-	-	11.	3.4	1.2	-	-
Red marr.	2.59	-	-	12.	3.6	1.3	-	-
Endosteal	40.7	-	-	34.	10.	3.5	3.8	3.9
Thyroid	-	-	-	11.	3.4	1.2	-	-

* ρ = 2.4 gm/cm^3

Table 5b. Ingestion Dose Conversion Factors, rem/uCi, for Uranium-234

	ICRP	ICRP	ORNL	ORNL	NRC	EPA-2
Period, yr	50	50	50	50	50	50
Q(alpha)	20	20	20	20	?	?
N	1	1	5(bone)	5(bone)	?	?
f_1	0.05	0.002	0.05	0.002	?	?
Organ						
T. body	-	-	3.4	0.14	0.052	0.051
St. wall	-	-	0.006	0.004	-	0.065
LLI wall	-	0.18	0.17	0.18	-	0.065
Lungs	-	-	0.002	0.000	-	0.051
Kidneys	1.74	0.070	1.7	0.067	0.20	0.20
Liver	-	-	1.1	0.046	0	-
Ovaries	-	-	1.1	0.046	-	-
Testes	-	-	1.1	0.046	-	-
Red marr.	0.27	0.011	1.2	0.046	-	-
Endosteal	4.07	0.17	3.5	0.14	0.84	0.83
Thyroid	-	-	1.1	0.046	-	-

Table 6a. Inhalation Dose Conversion Factors, rem/uCi, for Thorium-230

	ICRP	ICRP	ORNL	ORNL	NRC	EPA-2
Period, yr	50	50	50	50	50	50
Q(alpha)	20	20	20	20	?	?
N	1	1	5(bone)	5(bone)	?	?
AMAD, um	1	1	1	1	1*	1
Class	W	Y	W	Y	Y	Y
f_1	0.0002	0.0002	0.001	0.001	?	?
Organ						
T. body	-	-	347.	155.	20.7	25.
St. wall	-	-	0.003	0.003	-	0.033
LLI wall	-	-	0.93	0.10	-	0.033
Lungs	-	1,110.	54.	526.	401.	440.
Kidneys	-	-	233.	94.	208.	250.
Liver	-	-	1,800.	730.	42.7	52.
Ovaries	-	-	91.	37.	-	-
Testes	-	-	91.	37.	-	-
Red marr.	630.	260.	690.	280.	-	-
Endosteal	8,150.	3,220.	10,600.	4,260.	741.	830.
Thyroid	-	-	13.	5.4	-	-

* ρ = 2.4 gm/cm^3

Table 6b. Ingestion Dose Conversion Factors, rem/uCi, for Thorium-230

	ICRP	ORNL	NRC	EPA-2
Period, yr	50	50	50	50
Q(alpha)	20	20	?	?
N	1	S(bone)	?	?
f_1	0.0002	0.001	?	?
Organ				
T. body	-	2.8	0.057	0.057
St. wall	-	0.004	-	0.065
LLI wall	-	0.18	-	0.065
Lungs	-	0.000	-	-
Kidneys	-	1.9	0.565	0.56
Liver	-	15.	0.117	0.12
Ovaries	-	0.75	-	-
Testes	-	0.75	-	-
Red marr.	1.07	5.7	-	-
Endosteal	13.3	87.	2.06	2.0
Thyroid	-	0.11	-	-

Table 7a. Inhalation Dose Conversion Factors, rem/uCi, for Radium-226

	ICRP	ORNL	NRC	EPA-1	EPA-2
Period, yr	50	50	50	50	50
Q(alpha)	20	20	?	?	?
N	1	1	?	?	?
AMAD, um	1	1	1*	1	1
Class	W	W	W	W	Y
f_1	0.2	0.2		0.2	?
Organ					
T. body	-	19	4.23	9.01	2.0
St. wall	-	0.004	-	0.003	0.024
LLI wall	-	0.18	-	0.18	0.024
Lungs	59.3	56.	50.3	55.7	1,000.
Kidneys	-	0.66	0.149	0.662	-
Liver	-	0.66	0.005	0.662	-
Ovaries	-	0.67	-	0.664	-
Testes	-	0.66	-	0.664	-
Red marr.	-	23.	-	1.92	-
Endosteal	28.1	227.	42.3	9.90	200.
Thyroid	-	0.66	-	0.664	-

* ρ = 2.4 gm/cm^3

Table 7b. Ingestion Dose Conversion Factors, rem/uCi, for Radium-226

	ICRP	ORNL	NRC	EPA-1	EPA-2
Period, yr	50	50	50	50	50
Q(alpha)	20	20	?	?	?
N	1	1	?	?	?
f_1	0.2	0.2	?	0.2	?
Organ					
T. body	-	16.	4.60	7.26	0.10
St. wall	-	0.005	-	0.004	0.065
LLI wall	-	0.33	-	0.333	0.065
Lungs	-	0.002	-	0.001	-
Kidneys	-	0.59	0.163	0.590	0.30
Liver	-	0.59	0.006	0.590	0.30
Ovaries	0.34	0.59	-	0.592	-
Testes	0.34	0.59	-	0.591	-
Red marr.	2.2	20.	-	1.71	-
Endosteal	25.	202.	46.0	8.82	10.
Thyroid	-	.59	-	0.591	-

Table 8a. Inhalation Dose Conversion Factors, rem/uCi, for Polonium-210

	ICRP	ICRP	ORNL	ORNL	NRC	EPA-1	EPA-2
Period, yr	50	50	50	50	50	50	50
Q(alpha)	20	20	20	20	?	?	?
N	1	1	5(bone)	5(bone)	?	?	?
AMAD, um	1	1	1	1	1*	1	1
Class	D	W	D	W	W	W	Y
f_1	0.1	0.1	0.1	0.1		0.1	?
Organ							
T. body	-	-	2.8	1.6	0.192	1.56	0.051
St. wall	-	-	0.001	0.002	-	0.002	0.03
LLI wall	-	-	0.029	0.088	-	0.088	0.03
Lungs	-	48.1	1.0	46.	18.4	45.8	110.
Kidneys	44.4	14.4	46	14.	5.78	14.4	1.6
Liver	8.15	-	8.0	2.5	1.72	2.48	0.47
Ovaries	-	-	2.6	0.80	-	0.803	-
Testes	-	-	2.6	0.80	-	0.803	-
Red marr.	-	-	2.6	0.81	-	0.855	-
Endosteal	-	-	1.2	0.37	0.783	0.374	0.22
Thyroid	-	-	2.6	0.80	-	0.803	-
Spleen	81.5	24.8	80.	25.	-	-	-

* $\rho = 2.4$ gm/cm^3

Table 8b. Ingestion Dose Conversion Factors, rem/uCi, for Polonium-210

	ICRP	ORNL	NRC	EPA-1	EPA-2
Period, yr	50	50	50	50	50
Q(alpha)	20	20	?	?	?
N	1	5(bone)	?	?	?
f_1	0.1	0.1	?	0.1	?
Organ					
T. body	-	0.56	0.086	0.562	0.29
St. wall	-	0.005	-	0.005	0.065
LLI wall	-	0.18	-	0.179	0.065
Lungs	-	0.000	-	0.000	0.086
Kidneys	9.26	9.3	2.52	9.32	4.8
Liver	1.63	1.6	0.756	1.61	0.82
Ovaries	-	0.52	-	0.521	-
Testes	-	0.52	-	0.521	-
Red marr.	-	0.53	-	0.554	-
Endosteal	-	0.24	0.356	0.242	1.3
Thyroid	-	0.52	-	0.521	-
Spleen	16.3	16.	-	-	-

Table 9a. Inhalation Dose Conversion Factors, rem/μCi, for Lead-210

	ORNL	NRC	EPA-1	EPA-2
Period, yr	50	50	50	50
Q(alpha)	20	?	?	?
N	5(bone)	?	?	?
AMAD, um	1	1*	1	1
Class	W	W	W	Y
f_1	0.08	?	0.08	?
Organ				
T. body	15.	1.03	15.	0.56
St. wall	0.001	-	0.001	0.001
LLI wall	0.047	-	0.047	0.001
Lungs	6.2	4.21	6.18	370.
Kidneys	3.3	26.5	7.54	14.
Liver	3.1	8.13	3.09	4.5
Ovaries	0.67	-	0.120	-
Testes	0.67	-	0.120	-
Red marr.	1.4	-	2.94	-
Endosteal	20.	31.9	19.5	17.
Thyroid	0.67	-	0.120	-

* ρ = 2.4 gm/cm^3

Table 9b. Ingestion Dose Conversion Factors, rem/uCi, for Lead-210

	ORNL	NRC	EPA-1	EPA-2
Period, yr	50	50	50	50
Q(alpha)	20	?	?	?
N	5(bone)	?	?	?
f_1	0.08	?	0.08	?
Organ				
T. body	7.4	0.544	7.33	3.3
St. wall	0.000	-	0.000	0.010
LLI wall	0.020	-	0.020	0.010
Lungs	0.000	-	0.000	0.52
Kidneys	0.94	12.3	3.03	0.46
Liver	1.4	4.37	1.44	0.64
Ovaries	0.30	-	0.030	-
Testes	0.30	-	0.030	-
Red marr.	0.64	-	1.42	-
Endosteal	9.6	15.3	9.64	45.
Thyroid	0.30	-	0.030	-

IV. RISK FACTORS

Radiation risk factors may be expressed in several ways: 1) as the chance that a radiation-induced health effect will arise per year of life, 2) as the chance that a radiation-induced health effect will cause death per year of life, 3) as the chance that a radiation-induced health effect will arise in the years of life after irradiation, and 4) as the chance that a radiation-induced health effect will cause death in the years of normal life expectancy after irradiation. The first two are based on per year of life after irradiation; the last two are based on all the years of normal life expectancy after irradiation. The first and third give the chances that health effects (fatal and non-fatal) will be induced; the second and fourth give the changes that a fatal health effect will be induced.

Few, if any, of the epidemiological studies on which radiation risk factors are based encompass the entire lives of all the individuals exposed. As a consequence, it is necessary to adopt a model which projects from the available data the risk for the years of life remaining to the exposed individuals. The model usually takes the form of a latent period following exposure during which the risk is zero, followed by a plateau during which the risk is taken to be constant. The plateau may be assigned a finite duration, usually 30 years, or assumed to persist for the remainder of the normal life expectancy.

Radiation risk factors may be estimated on the assumption that the risk has a constant, absolute value throughout the plateau (the so-called absolute risk model), or on the assumption that the risk is a constant fraction of the spontaneous incidence of cancers of the same type (the so-called relative risk model). Since the spontaneous incidence of most cancers increases with age, the relative risk model predicts that the risk of radiation-induced cancer also increases with age. Figure V-4 in the 1980 BEIR Report (BEIR 80, p. 220) illustrates these models well.

In several instances where radiation-induced cancer data are available for two countries in which the spontaneous incidence of cancers is quite different, the radiation-induced rates do not appear to reflect the differences in spontaneous rates. This observation argues against the relative risk model. ICRP and UNSCEAR (see Table 11, p. 32) have elected to use the absolute risk model; BEIR 72 and BEIR 80 use both models, but

> "It should be noted that, if epidemiologic follow-up through the entire lifetime is complete, both models will give the same result for lifetime risk." (BEIR 80, p. 37)

Table 10 (p. 31) summarizes radiation risk factors from four recently published sources. The first two columns are from the 1972 BEIR Report (BEIR 72) for absolute and relative risk models. The next two columns are estimates adopted by EPA in 1973 from the BEIR 1972 Report; the first of these two columns is for the induction of fatal cancer, the second column is for

cancers which do not prove to be fatal. The reason for including both fatal and non-fatal factors in Table 10, under EPA 1973, is that when the EPA refers to "health effects", it is not clear whether only fatal cancers, or both fatal and non-fatal cancers are included.

Table 11 is a comparison of the lifetime risk factors for radiation-induced fatal cancers per million person-rem given by BEIR 1972, UNSCEAR 1977 and BEIR 1980 (BEIR 80, p. 195). It should be noted that BEIR 1980 gives risk estimates based on three dose-effect relations: a linear-quadratic model (which the Committee favors for low LET radiation), a pure quadratic model (which the Committee believes gives the lower bound of risk for low LET radiation), and a pure linear model (which the Committee believes to give the best estimate of risk for high LET radiation). All the data given here from the BEIR 1980 report are for the pure linear model.

Table 11 indicates quite good agreement among the risk estimates given by both the absolute and relative risk models. The ICRP 1977 risk estimate, based on the absolute risk model, is also in good agreement with the corresponding risk estimates of Table 11.

Table 12 gives the BEIR 1980 risks of fatal cancer, according to the linear model, for a single exposure of 10 rad of low LET radiation, and for a continuous exposure of 1 rad per year of

low LET radiation. Since the linear model is used to obtain these risks, the BEIR 80 Committee would indicate them to be the best estimates for 10 rem and 1 rem per year of high LET radiation. For the same reason, these risks will scale linearly with dose, i.e., a single 0.1 rem exposure will produce 0.1/10 = 0.01 of the excess fatalities given in Table 12 for a single 10 rad exposure.

The BEIR 1980 report gives risk estimates over a considerable range for each of the major types of cancer, depending on the model used to obtain the estimate. Even for the high LET alpha particles, the risk factors cover a range of about 5 (see Table 11). Also this report gives risk estimates for, at most, 12 plus "other" sites. In these circumstances the shape of the risk schedule finally adopted by EPA cannot be anticipated with any confidence.

Table 13 gives estimates from the BEIR 1980 report for risk of cancer incidence and cancer mortality for 12 cancer sites, and "other" sites. The data given in Table 13 are said to have been "derived from Appendix A" (BEIR 80 p. 248), however, this derivation is by no means clear. Taking the data of Table 13 at face value, one finds that the risk of fatal cancer (the I x R columns) is greatest and approximately equal for red bone marrow, the female breast and the lung. Note in Table 10 that UNSCEAR and ICRP accorded the female breast a fatal risk more than twice as great as that for bone marrow and lung. Bone has

Table 10. Radiation Risk Factors, life-time risk per million person-rem.

Organ irrad.	BEIR 1972 Absolute	BEIR 1972 Relative	EPA 1973 Fatal	EPA 1973 Non-fatal	UNSCEAR 1977	ICRP 1977
Female breast	-	-	-	-	50	75
Red marrow(1)	26	37	54	0	20	20
Lung	-	-	50	0	25-50	20
Bone	-	-	16	16	2-5	5
Thyroid	-	-	-	-	10	5
All others	61-74	122-417	150	150	-	50(2)
Total	87-100	159-454	270	166	100	100(3)
Gonads(4)	50 (300)		(300)		20-30 (165)	40 (200)

BEIR 72: p. 169, Table 3-1; p. 57, Table 4.
EPA 73: p. A-18, Table A-1.
UNSCEAR 77: pp. 6,9, 413, 414.
ICRP 77: pp. 10-12.

1) irradiation of red bone marrow increases the incidence of leukemia.
2) 10 for each of up to 5 of the most highly irradiated organs, other than those listed.
3) the sum for the individual organs = 125, but ICRP estimates the total risk to be 100.
4) the open numbers give the risk of genetic defect in the first generation; the numbers in parentheses give the risk for all future generations, including the first.

Table 11. Comparison of Risk Factors, Lifetime Excess Deaths per Million Person-rem (BEIR 80, p. 195).

Source	Single 10 rad Exposure		Continuous 1 rad per year	
	Absolute model	Relative model	Absolute model	Relative model
BEIR 80, linear model	167	501	158	430
BEIR 72	117	621	115	568
UNSCEAR 77	75 to 175 (absolute model)			

Table 12. Lifetime Risk of Fatal Cancer per Million of U.S. Population for Two Types of Exposure, Linear Model (BEIR 80, pp. 193, 256, 259).

	Single 10 rad Exposure		1 rad per Year for Life		BEIR 80
	Male	Female	Male	Female	page
Leukemia + bone cancer:					256
normal expectation	9,860	8,018	10,600	9,050	
excess	566	384	3,568	2,709	
Cancers other than leukemia and bone:					259
normal expectation	170,400	139,400	165,700	149,200	
excess:					
absolute risk	919	1,473	5,827	10,400	
relative risk	4,226	4,852	24,210	30,540	
All forms of Cancer:					193
normal expectation	163,800		167,300		
absolute risk	1,671		11,250		
relative risk	5,014		30,520		

Table 13. Risk of Cancer Incidence and Mortality per Million Persons per Year per rem (BEIR 80, p. 250, except as noted.)

Site	Male			Female		
	I[1]	R[2]	IxR[3]	I	R	IxR
Red marrow[4]	2.239	1.00	2.24	2.239	1.00	2.24
Bone[5]	0.05	1.00	0.05	0.05	1.00	0.05
Thyroid	2.20	0.18	0.40	5.80	0.20	1.16
Breast	-	-	-	5.82	0.39	2.27
Lung	3.64	0.83	3.02	3.94	0.75	2.96
Esophagus	0.26	1.00	0.26	0.28	1.00	0.28
Stomach	1.53	0.75	1.15	1.68	0.78	1.31
Intestine	1.02	0.52	0.53	1.12	0.55	0.62
Liver	0.70	1.00	0.70	0.70	1.00	0.70
Pancreas	0.90	0.91	0.82	0.99	0.90	0.89
Urinary	0.81	0.37	0.30	0.88	0.46	0.41
Lymphoma	0.27	0.73	0.20	0.27	0.75	0.20
Other sites	1.52	-	0.99	1.64	-	0.82
All sites	15.14	-	10.66	25.41	-	13.91

1) I = incidence of cancer, cancers per million persons per year per rem, age-weighted average.
2) R = ratio of mortality to incidence
3) I x R = fatal cancers per million persons per year per rem.
4) irradiation of red bone marrow increases the incidence of leukemia; values of I and R from p. 256
5) values of I and R from p. 256

a fatal risk, according to BEIR 80, far less than the thyroid, or any other organs in Table 13. It seems inappropriate that 40 CFR 190 allows 75 mrem per year to the thyroid, but 25 mrem per year to the bone as one of the "all other organs". In fact, six of the organs in Table 13 (bone, esophagus, intestine, liver, urinary and lymphoma) have fatal risk factors, one-third or less that of red bone marrow and might better be accorded the 75 mrem per year limit than the thyroid.

V. CONCLUSIONS

A. THE STANDARD OF 25 MREM PER YEAR

EPA has not provided quantitative, objective justification for the choice of the 25 mrem per year limit. On the basis of relative radiosensitivity, the limit of 25 mrem per year for all organs other than the thyroid is not appropriate.

B. DOSE CONVERSION FACTORS

EPA has not published the dose conversion factors to be used in putting the proposed standard into effect. Differences greater than a factor of 10 exist among the dose conversion factors published by ICRP, NRC, ORNL and EPA. The proposed standard should not be put into effect until a set of dose conversion factors has been proposed by EPA and has been reviewed by the parties affected.

C. RISK FACTORS

The recent publication of the 1980 BEIR Report should be considered by EPA in connection with the 40 CFR 190 standard. The 1980 BEIR risk factors have a range of a factor of 3, even when limited to the linear model the

this Committee indiates to be most appropriate for high LET radiation. This range and the as yet unpublished selection of organs to be used by the EPA give rise to considerable uncertainty. The proposed standard should not be put into effect until a set of radiation risk factors has been proposed by the EPA and has been reviewed by all of the parties affected.

D. OTHER CONSIDERATIONS

In addition to the uncertainties in dose conversion factors and radiation risk factors discussed above, large uncertainties are also associated with source terms (including particle size distribution and solubility), dispersion factors, uptake and transfer factors, and public use of air, land, water and produce. It is premature to put the standard into effect until the principal uncertainties have been resolved.

VI. REFERENCES

BIER 72: National Academy of Sciences, National Research Council, The Effects on Populations of Exposure to Low Levels of Ionizing Radiation. Report of the Advisory Committee on the Biological Effects of Ionizing Radiations, Washington, D.C. November 1972.

BEIR 80: National Academy of Sciences, The Effects on Populations of Exposure to Low Levels of Ionizing Radiation. Committee on the Biological Effects of Ionizing Radiation, Washington, D.C. 1980.

Dunning, et al. 79: Dunning, D.E., Jr. Bernard, S.R., Et al., Estimates of Internal Dose Equivalent to 22 Target Organs for Radionuclides Occurring in Routine Releases from Nuclear Fuel-Cycle Facilities. Vol. 11, NUREG/CR-0150-V.2, November 1979 (ORNL/NUREG/TM-190/V2).

EPA 73: EPA, Environmental Analysis of the Uranium Fuel Cycle, Part I Fuel Supply. EPA-520/9-73-003-B, October 1973.

EPA 75: EPA, Radiation Protection for Nuclear Power Operations, Proposed Standards (Part II). Federal Register, Thursday, May 29, 1975, Vol 40, No 104, pp. 23420-23425.

EPA 76: EPA, Final Environmental Statement 40 CFR 190, Environmental Radiation Protection Requirements for Normal Operations of Activities in the Uranium Fuel Cycle. EPA ORP 520/4-76-016, November 1976, Vols I and II.

EPA 79: EPA, Radiological Impact Caused by Emissions of Radionuclides into Air in the United States, Preliminary Report. EPA-520/7-79-006, August 1979.

ICRP 66: ICRP, Deposition and Retention Models for Internal Dosimetry of the Human Respiratory Tract. Health Physics 12: 173-207, 1966, Task Group on Lung Dynamics, P. E. Morrow, Chairman.

ICRP 72: ICRP, Alkaline Earth Metabolism in Adult Man. ICRP Pub 20, adopted May 1972.

ICRP 77: ICRP, Recommendations of the International Commission on Radiological Protection. ICRP Pub 26, adopted January 1977.

ICRP 78a: ICRP, Limites for Intakes of Radionuclides by Workers. ICRP Pub 30, Part 1, adopted July 1978.

Kalkwarf 79: Kalkwarf, D. R., Solubility Classification of Airborne Products from Uranium Ores and Tailings Piles. US NRC, NUREG/CR-0530, PNL-2870 RE, January 1979.

Moore, et al. 79: Moore, R. E. Base, C. F. III, et al., AIRDOS-EPA: A Computerized Methodology for Estimating Environmental Concentrations and Dose to Man from Airborne Releases of Radionuclides. US EPA ORP, EPA 520/1-79-009, December 1979 (ORNL-5532, June 1979).

NRC 79: NRC, Draft Generic Environmental Impact Statement on Uranium Milling. US NRC NUREG-0511, April 1979, Vols I and II.

UNSCEAR 77: United Nations Scientific Committee on the Effects of Atomic Radiation, Sources and Effects of Ionizing Radiation, United Nations, New York 1977.

ATTACHMENT

RADIOLOGICAL ASPECTS OF THE EPA FINAL ENVIRONMENTAL STATEMENT 40 CFR 190 REGULATIONS COVERING URANIUM MILLING

G. HOYT WHIPPLE

I. DOSE CONVERSION FACTORS

Dose conversion factors are usually expressed as the 50-year dose equivalent commitment, in rem, to a specified organ, or to the total body, per uCi (microcurie) inhaled or ingested. In a few of the references cited in the dose conversion factors in this text, the dose conversion factor for inhalation is given in terms of mrem/year per pCi/m^3. In such cases, these factors have been converted to rem per uCi inhaled using the ICRP average daily air intake for Reference Adult Man and Reference Adult Woman of 22 m^3/day = 8030 m^3/year (ICRP 74, p. 346). Then

$$\frac{\text{mrem/year}}{pCi/m^3} \times 0.125 = \text{rem/uCi}.$$

The ICRP is switching over to the International System of Units (SI) and now expresses dose conversion factors as Sv/Bq, where

1 Sv (sievert) = 100 rem

1 Bq (becquerel) = 2.7×10^{-11} Ci = 2.7×10^{-5} uCi.

Then, (Sv/Bq) x 3.7×10^6 = rem/uCi.

A. INGESTION

Ingestion of radioactive material occurs when this

material is present in water, food, and in the mucus elevated from the respiratory tract and swallowed. When ingested radioactive material is in a chemical form highly insoluble in the digestive tract, this material passes through the body without being assimilated and is excreted in the feces. In such cases, the only body organs irradiated are the stomach, small intestine, and large intestine. However, when the ingested radioactive material is soluble, or rendered soluble by digestive agents, this material is transferred through the wall of the small intestine in the blood.

Few materials are completely soluble or completely insoluble in the digestive tract. The solubility of any given radioactive material is determined by the chemical compound in which the material occurs and can vary considerably from one compound to another of a given radionuclide. The solubility, or availability, of a radionuclide is set by consideration of the chemical forms in which it is likely to be encountered, and is expressed as "f_1, the fraction of the ingested compound of the element which is absorbed into the blood" (ICRP 78b, p. 20). It is noted that the conventional values of f_1 may be either greater or lesser than the actual fraction absorbed if the chemical form is more or less soluble than the compound for which f_1 was selected.

Radionuclide	Class	f_1
U-238	Y	0.002
U-234	Y	0.002
Th-230	Y	0.001
Ra-226	W	0.2
Pb-210	W	0.08
Po-210	W	0.1

Once in the blood, the absorbed radioactive material is distributed within the body according to the metabolic dictates for the chemical form in which the radionuclide occurs. The distribution of a radionuclide in a given chemical form is described by a series of terms which give the fractional transfer from the blood to each of a number of organs. The symbol usually used for these transfer fractions is f_2'. In general, this fraction has a different value for each organ and for each chemical ient.

Given that a fractic f_1, of the ingested radioactive material, QuCi, is transferred from the gastrointestional tract to the blood, and that a fraction, f_2', of this absorbed activity is transferred from the blood to a specific organ, there is at some short time after ingestion a quantity, $Qf_1f_2' = q(0)$, of the radionuclide in this organ. The quantity $q(0)$ can leave the organ in two ways: by radioactive decay, and by biological elimination, or transfer to another organ .

Radioactive decay proceeds in an exponential manner:

$$q(t) = q(0)\ e^{-0.693\ t/T_p}$$

where $q(t)$ = quantity of radioactive material in the organ at time = t days, uCi

$q(0)$ = quantity of radioactive material in the organ at time = 0 days, uCi

T_p = radioactive half-life of the isotope, days

For many chemical elements it is found that biological eliminiation can be described satisfactorily by a simple exponential function of the same form given for radioactive decay. For radioactive isotopes of these elements the quantity of radioactivity in an organ as a function of time after ingestion is given by:

$$q(t) = q(0)\ e^{-0.693\ t/T}$$

where T = effective half-life days

$$= (T_p \times T_b)/(T_p + T_b)$$

T_b = apparent biological half-life of elimination, days

The term <u>retention function</u> is given to the fraction of material initially deposited in the organ that remains at some time, t days, after this deposition, i.e.:

$$R(t) = q(t)/q(0)$$

The retention function, R(t), is, clearly, a function of time after deposition and of the radioactive and biological half-lives.

B. INHALATION

The ICRP (ICRP 66) has developed a model for the deposition, retention, and transfer of radioactive material in inhaled aerosols. This model appears to have been used in the calculation of all the inhalation dose conversion factors cited in this report. The model considers the activity median aerodynamic diameter (AMAD) and the solubility of the aerosol in lung fluid.

Table A1 (p. A-7) (ICRP 66, p. 183) indicates the tendency of smaller particles to deposit deep in the respiratory tract, and of larger particles to be deposited preferentially in the upper portions of the respiratory tract, whence, it will be evident in a moment, they are rapidly removed.

Solubility in lung fluid is divided into three classes (ICRP 66, p. 195): Class D, which dissolves with a half-life of 0 to 10 days; Class W, which dissolves with a half-life of 11 to 100 days; and Class Y, which dissolves with a half-life of greater than 100 days.

All material, regardless of solubility, is removed in a matter of minutes from both the nasopharyngeal (N-P) and tracheobronchial (T-B) regions of the respiratory tract. As

TABLE A1. The Fraction of Inhaled Material Deposited in Various Regions of the Respiratory Tract (ICRP 66, p. 183)

AMAD	N-P	T-B	P	Total
1	0.24	0.04	0.26	0.54
10	0.81	0.07	0.10	0.98

AMAD = activity median aerodynamic diameter, um
N-P = nasopharynx
T-B = trachea and bronchial tree
P = pulmonary region, consisting of respiratory bronchioles, alveolar ducts, atria, alveoli and alveolar sacs

the material becomes less soluble, smaller and smaller fractions of it are transferred to the blood. Only in the respiratory tract (region P) does the degree of solubility have a marked effect on the retention of half-life (biological half-life, T_b). The ICRP model indicates that 60% of the Class Y material deposited in the pulmonary region will be removed with a half-life of 360 days; the remaining 40% is removed with a half-life of 24 days by macrophages to the ciliary-mucus transport system and then to the gastrointestinal tract.

High solubility leads to rapid removal, short term retention time, low lung dose and high doses to other organs, such as bone; low solubility leads to the reverse. Polonium and uranium appear to deliver only small fractions of the total dose to any organ, so the disparities between Tables 2 and 3 of this text will have little influence on the overall doses. The 10% Class D component for radium observed by Kalkwarf in ore and tailings dust may have a marked influence on the bone doses, however.

C. OTHER FACTORS

Among the other factors which affect the relation between the quantity of a given radionuclide inhaled or ingested and the resulting organ doses are: age, dose commitment period and quality factor.

Data for the Reference Man (ICRP 74) permit the calculation of dose conversion factors for infant, child, teenager and adult. Although some of the sources from which Tables 4a through 9b of the text were compiled give factors for ages in addition to those for the adult, only the factors for the adult have been tabulated. The average person spends more of his life as an adult than as a member of any other age group, so this choice is appropriate.

The quality factor (indicated by Q in the tables) is the factor by which the physical dose in rads is multiplied to obtain the dose equivalent in rem. For beta particles, electrons, gamma rays and X rays, it has been, and remains, common practice to use Q = 1. For alpha particles, which are of principal importance in this report, there has been some dithering between Q = 10 and Q = 20. The latest recommendation on this matter (ICRP 78a) is Q = 20 for alpha particles.

In addition to the quality factor, the ICRP has introduced a "modifying factor," N, which is intended to allow for any other modifications that anyone may think of. In the latest recommendation (ICRP 78a), N has been taken equal to 1 for all cases. However, it is not always clear what value of N has been assumed by some authors in calculating dose conversion factors. Dunning, et a. 79, p. 9, state:

> ". . . the alpha dose to the target 'BONE' in the tables assumes a volume distribution and contains the N-factor 5 except when the isotope

taken into the body is radium. . ." in which case N = 1 for each alpha emitter in the chain.

This suggests that while bone doses from ingested and inhaled radium should be the same for ICRP and ORNL (Dunning), bone doses for ingested and inhaled thorium might be as much as 5 times greater in the ORNL factors than in the ICRP factors. While this expectation is realized approximately for thorium (see text, Table 6b), it is far off for radium (see text, Table 7b).

APPENDIX

ICRP 74: ICRP, Report of the Task Group on Reference Man. ICRP Publication 23, adopted October 1974

ICRP 78b: ICRP, Limits for Intakes of Radionuclides by Workers. ICRP Publication 30, Supplement to Part I, adopted July, 1978.

APPENDIX A-4

1980 AMC SURVEY OF COSTS TO CONTROL AIRBORNE RADIONUCLIDE EMISSIONS FROM URANIUM MILLS

APPENDIX A-4

1980 AMC SURVEY OF COSTS TO CONTROL AIRBORNE RADIONUCLIDE EMISSIONS FROM URANIUM MILLS

AMC has recently completed an industry-wide survey designed to update and better define the actual costs required to install and operate emissions controls at uranium mills. The survey specifically addresses the costs of control technologies considered by EPA in its analysis of the 25 millirem standard. The results of the survey are shown in Attachment 1 of this appendix. These values and values from recently published literature are the basis for the figures in Table 2 of the petition.

Survey Method

AMC distributed a questionnaire to member uranium companies requesting information about costs to control five sources of radionuclide emissions from uranium mills:

- ore haul roads
- ore storage pads
- ore crushing and storage
- yellowcake drying and packaging
- airborne particulate from tailings beaches

The AMC questionnaire is shown in Attachment 2. The actual number and the names of the companies that responded to the survey as well as to the questions that a given company answered were kept confidential. The results were compiled by an independent law firm to protect the information submitted by the individual mills.

Calculations

Attachment 1 shows the results of the AMC cost survey. The alpha-numeric designation from FCA 1976, (Table 8.1-1 at 29) is indicated for each emission control type where applicable. The results shown represent an average of responses from at least three mill operators, unless noted otherwise.

Survey results are presented in terms of the equivalent present value for the EPA 1976 model mill ($ 1980). This was done to facilitate comparison with cost estimates developed by EPA for its 1976 analysis of the 40 CFR 190 standard (FCA 1976, Tables 8.1-1 and 9.0-1 at 29 and 35).

The calculations converting the survey results to equivalent present value for the EPA 1976 model mill were performed at the law firm using the same methods used in Sears et al. (1975) and the NRC-GEIS (1978). These methods, described below --

(1) Adjust survey results to account for differences in emission control device capacities between the survey mills and the EPA model mill;

(2) Convert survey capital costs to 1980 dollars; and

(3) Convert capital and annual operating costs to

Capacity: Capital cost information from the survey was scaled to reflect the capacity of EPA model mill emissions control equipment using the scaling factor "X 0.6" (Sears, et al. 1975)(NRC-GEIS). Operating costs were scaled directly (i.e., operating costs to sprinkle a 10 acre ore storage pad were assumed to be twice those of sprinkling a 5 acre pad).

Inflation: Survey results on capital costs (and EPA cost estimates shown in Table 2 of AMC's Petition) were converted to 1980 dollars by multiplying them by factors taken from the "Chemical Engineering Plant Cost Index" for 1980. No inflation adjustment was necessary for survey information on operating costs, because respondents provided this information in 1979-80 dollars.

Present Value: Present value was calculated from capital and annual operating costs using the same formula used by EPA (FCA 1976, Table 8.1-1 at 29): Present Value = Capital Cost + (Annual Cost x 9.818).

Table 2 of the Petition compares AMC survey results with EPA's 1976 estimates of costs to control emissions from the model mill. AMC's values in Table 2 were developed by summing the appropriate combination of control costs listed in Attachment 1. The costs

of water spraying ore haul roads and ore storage pads inside the NRC licensed area are included in the cost for each control combination. Cost estimates from recently published literature (i.e., Sears, 1975 and NRC-GEIS) were used where costs for a particular control technology (e.g., one crusher orifice scrubber) were not available from the AMC survey.

TABLE 1

PARTICULATE EMISSIONS CONTROL COSTS FOR URANIUM MILLS (1980)(1)

Source Term	Control Type(2)	Present Value for (3)(4) EPA 76 Model Mill (1980 $)
Ore Haul Roads	Water Spraying	$286,704
Ore Storage Area	Water Spraying	38,323
Ore Crusher and Storage	Bag Filters (A4)	151,313
	Wet Impingement Scrubber (A2)	207,265
	Low-Energy Venturi (A3)	903,216 (1 mill)
Yellowcake Drying & Packaging	Wet Impingement Scrubber (B1)	423,427
	High Energy Venturi (B3)	399,176
	Wet Orifice Scrubber	134,269 (1 mill)
	Low Energy Venturi (B2)	62,363 (1 mill)
Windblown Tailings	Chemical Stabilization (C2)	835,810 (2 mills)
	Water Spray	150,024 (2 mills)
	Water Spray/Chemical Stabilization	330,038 (1 mill)

1) See text for details of survey and calculation methods.

2) Alpha-numeric designations from EPA 76 where applicable.

3) Results represent average of at least three responses unless otherwise indicated.

4) EPA 76 Model Mill Control Capacities: Ore Haul Roads = not given (assume 10 acres); Ore Storage Area = not given (EPA 79 assumes 2.5 acres); Ore Crusher and Storage = 27,000 cfm; Yellowcake Drying and Packaging = 6,000 cfm; Tailings Area = not given (EPA 79 assumes 37.5 acres dry).

AMERICAN
MINING
CONGRESS
FOUNDED 1897
RING BUILDING
WASHINGTON
D.C. 20036
202 861 2800
TWX 710 822 0126
J. ALLEN OVERTON, JR.
PRESIDENT

AMC RADIOACTIVE DUST CONTROL COST DATA SHEET

INSTRUCTIONS

Please answer the following questions with respect to the various control points at your facility. If you have any questions, call Larry A. Boggs at AMC, (202-861-2876).

Return the completed questionnaire by fastest available means to Anthony J. Thompson of Hamel, Park, McCabe & Saunders, 1776 F Street, N.W., Washington, D.C. 20006. Telecopier use is available. The firm's telecopier numbers are: (202)785-1244 (automatic) or (202)785-1234 ext. 213 (manual). If a telecopier is used, a confirming copy should be sent by regular mail. An envelope addressed to Mr. Thompson is enclosed for this purpose.

All information will be kept CONFIDENTIAL. Only Hamel, Park, McCabe & Saunders, as counsel for the AMC, will have access to data with respect to individual companies and facilities. The AMC will receive only aggregate data.

QUESTIONNAIRE

1. Name of Facility _____.

2. Location of Facility _____.

3. Name(s) and telephone number(s) of person(s) completing this questionnaire _____

_____

_____

4. Capacity of mill (tons ore/day) _____.

5. Cost Information by Control Point. In the following radioactive dust source categories associated with your uranium mill and associated areas, please provide the requested information to the best of your ability. (The information requested with respect to ore haulage roads and ore storage areas should include only those within a mill's restricted area, i.e., the area defined in the operator's license.) Please do not guess at these numbers -- include information that you have available or can generate in a reproducible fashion. We are not seeking documentation of how numbers were derived; we simply want to be sure that, if necessary later, you would be able to show how you got the numbers presented.

A. Surface Haulage Roads Radioactive Dust Control

1. Control technique (i.e., none, water spraying, chemical spraying, windbreak, combinations of above (specify), or other (specify)). (NOTE: if a combination of control types is employed, provide answers separately for each type of control used). _____

_____

_____

2. Acreage to which control(s) are applied _____

_____acres.

3. Capital cost(s) of control equipment used, _____ dollars; number of years over which capital costs depreciated, _____years.

4. Annual operating and maintenance costs of control(s).

_____dollars.

5. Year of cost data: for capital cost(s) _____

_____year(s); for operating costs _____

_____(give most recent typical year).

ALL INFORMATION WILL BE KEPT CONFIDENTIAL

B. Ore Storage Areas Radioactive Dust Control

1. Control technique (i.e., none, water spraying, chemical spraying, windbreak, combination of above (specify), other (specify)). (NOTE: if a combination of control types is employed, provide answers separately for each type of control used). _____

_____

_____.

2. Acreage to which control(s) are applied _____

_____.

3. Capital cost(s) of control equipment used, _____ dollars; number of years over which capital cost(s) depreciated, _____ years.

4. Annual operating and maintenance costs of control(s) _____ dollars.

5. Year of cost data: for capital cost(s) _____ _____ year(s); for operating costs _____ _____ (give most recent typical year).

ALL INFORMATION WILL BE KEPT CONFIDENTIAL

C. Ore Crusher Radioactive Dust Control

1. Control type (i.e., none, orifice scrubber, wet impingement scrubber, low energy venturi scrubber, bag filters, combination of above (specify), or other (specify)). (NOTE: if a combination of control types is employed, provide answers separately for each type of control used). _____

_____

_____

2. Capacity of control device _____

_____

_____cubic feet per minute (cfm).

3. Capital cost(s) of control device(s) used,_____

_____ dollars; number of years over which capital cost(s) depreciated,

_____years.

4. Annual operating and maintenance costs _____

_____dollars.

5. Year of cost data: for capital cost(s) _____

_____year(s); for operating costs_____

_____(give most recent typical year).

6. Percentage efficiency of control device(s) _____

_____%. (indicate whether based on actual operating experience or design limitations, if not yet operating. Check one of following: ( ) operating experience or ( ) design limitations).

7. Annual operating costs v. efficiency (percent of control data, if available. (The answers to this question should reflect the efficiency/cost relationship for different ways of operating the installed control system).

ALL INFORMATION WILL BE KEPT CONFIDENTIAL

D. Yellowcake Dryer Radioactive Dust Control

1. Control type (i.e., none, wet impingement scrubber, low energy venturi scrubber, high energy venturi scrubber, high energy venturi scrubber and HEPA filters or other (specify)).

_____

_____.

2. Capacity of control device _____

_____cubic feet per minute (cfm).

3. Average annual release _____lbs U_3O_8 (if available).

4. Capital cost(s) of control device(s) _____

_____dollars; number of years over which capital cost(s) depreciated, _____ years.

5. Annual operating costs, _____dollars.

6. Year of cost data: for capital cost(s) _____

_____ year(s); for operating costs _____

_____(give most recent typical year).

7. Percentage efficiency of control device(s) _____

_____%.
(Indicate whether based on actual operating experience or design limitations, if not yet operating. Check one of the following: ( ) operating experience or ( ) design limitations).

8. Annual operating costs v. efficiency (percent of control) data, if available. (The answers should reflect the efficiency/cost relationship for different ways of operating the installed control system). _____

_____

_____

_____

ALL INFORMATION WILL BE KEPT CONFIDENTIAL

E. Tailings Radioactive Dust Control

1. Control technique (i.e., none, spray dry beach with water, chemical stabilization, combination of above (specify) or other (specify)). (NOTE: if a combination of control types is employed, provide answers separately for each type of control used). _____

_____

_____

2. Area of dry beach or area to which control(s) is (are) applied _____acres.

3. Capital cost(s) for control type(s), _____ _____dollars; number of years over which capital cost(s) depreciated, _____years.

4. Annual operating costs, _____dollars.

5. Year(s) of cost data: for capital cost(s) _____

_____year(s); for operating costs_____

_____(give most recent typical year.

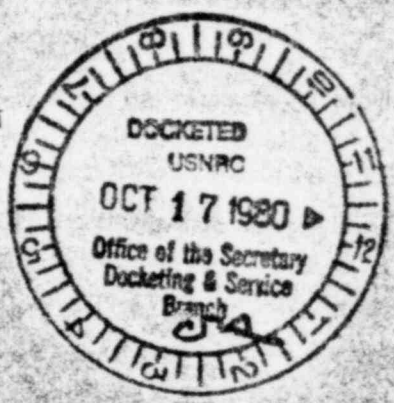
ALL INFORMATION WILL BE KEPT CONFIDENTIAL

BEFORE THE
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

DOCKET NO. _____

IN RE ENVIRONMENTAL RADIATION
PROTECTION STANDARDS FOR NUCLEAR POWER
OPERATIONS, 40 C.F.R. 190

APPENDIX B IN SUPPORT OF THE
AMERICAN MINING CONGRESS' PETITION
FOR RECONSIDERATION AND REVISION



Edward McCabe
Anthony J. Thompson
Hamel, Park, McCabe & Saunders
Suite 400
1776 F Street, N.W.
Washington, D.C. 20006

Counsel for the American
Mining Congress

OF COUNSEL:

Larry A. Boggs
Senior Counsel
American Mining Congress
1920 N Street, N.W.
Washington, D.C. 20036

APPENDIX B

TABLE OF CONTENTS

ENVIRONMENTAL PROTECTION AGENCY

[40 CFR Part 190]

[FRL 376-1]

ENVIRONMENTAL RADIATION PROTECTION FOR NUCLEAR POWER OPERATIONS

Proposed Standards

Reorganization Plan No. 3, which became effective on December 2, 1970, transferred to the Administrator of the Environmental Protection Agency the functions of the former Atomic Energy Commission to establish ". . . generally applicable environmental standards for the protection of the general environment from radioactive material." The Plan defined these standards as "limits on radiation exposures or levels, or concentrations or quantities of radioactive material outside the boundaries of locations under the control of persons possessing or using radioactive material." On May 10, 1974, the Agency published an advance notice of its intent to propose standards under this authority for the uranium fuel cycle and invited public participation in the formulation of this proposed rule.

The Agency has reviewed and considered the comments received in response to that notice and proposes herein environmental radiation standards which would assure protection of the general public from unnecessary radiation exposures and radioactive materials in the general environment resulting from the normal operations of facilities comprising the uranium fuel cycle. Nuclear power generation based on recycled plutonium or on thorium is excluded from these standards because sufficient operating data and experience concerning fuel cycles utilizing these fuels are not yet available. Before any of these developing technologies becomes of potential significance to public health the need for additional generally applicable standards will be considered.

The environmental radiation standards proposed in this notice supplement existing Federal Radiation Protection Guideline limiting maximum exposure of the general public [FR Docs. 60-4539 and 61-9402] by providing more explicit public health and environmental protection from potential effects of radioactive effluents from the uranium fuel cycle during normal operation. Numerically the proposed standards are below current Federal Radiation Protection Guides. The Agency is not, at this time, proposing revisions in existing Federal Radiation Protection Guidance for the general public because of its belief that a detailed examination of each major activity contributing to public radiation exposure is required before revision of this general guidance should be considered. Existing Federal Radiation Protection Guidance for workers in the fuel cycle is also not affected by these proposed standards. In addition, since these standards are proposed under authority derived from the Atomic Energy Act of 1954, as amended, they do not apply to radioactive materials and exposures in the general environment that are the result of effluents from mining operations because that Act does not provide authority over such effluents. Finally, since there are no planned releases from existing radioactive waste disposal sites and these sites primarily serve sources of waste other than uranium fuel cycle operations, these standards do not apply to such sites. The Agency has each of these areas of concern under continuing study.

It is the intent of the Agency to maintain a continuing review of the appropriateness of these environmental radiation standards and to formally review them at least every five years, and to revise them, if necessary, on the basis of information that develops in the interval.

Interagency relationships. Reorganization Plan No. 3 transferred to the Environmental Protection Agency (EPA) the broad guidance responsibilities of the former Federal Radiation Council and also transferred from the former Atomic Energy Commission (AEC) the more explicit responsibility to establish generally applicable radiation standards for the environment. However, the responsibility for the implementation and enforcement of both this guidance and these standards lies, in most cases, in agencies other than EPA as a part of their normal regulatory functions. For nuclear power operations, this responsibility, which had been vested in the AEC, is now vested in the Nuclear Regulatory Commission (NRC), which will exercise the responsibility for implementation of these generally applicable standards through the issuance and enforcement of regulations, regulatory guides, licenses, and other requirements for individual facilities.

Basic considerations. The Agency has concluded that environmental radiation standards for nuclear power industry operations should include consideration of: 1) the total radiation dose to populations, 2) the maximum dose to individuals, 3) the risk of health effects attributable to these doses, including the future risks arising from the release of long-lived radionuclides to the environment, and 4) the effectiveness and costs of the technology available to mitigate these risks through effluent control. The Agency also recognizes the findings of the recent study of the biological effects of low levels of ionizing radiation by the Advisory Committee on the Biological Effects of Ionizing Radiation (BEIR Committee) of the National Academy of Sciences—National Research Council. Two of the principal conclusions of the BEIR Committee were: 1) that current societal needs appear to be achievable ". . . with far lower average exposure and lower genetic and somatic risk than permitted by the current Radiation Protection Guide. [Thus,] to this extent, the current Guide is unnecessarily high . . ." and 2) that "Guidance for the nuclear power industry should be established on the basis of cost-benefit analysis, particularly taking into account the total biological and environmental risks of the various options available and the cost-effectiveness of reducing these risks."

For the purpose of setting radiation protection standards the most prudent basis for relating radiation dose to its possible impact on public health continues to be to assume that a potential for health effects due to ionizing radiation exists at all levels of exposure and that at the low levels of exposure characteristic of environmental levels of radiation the number of these effects will be directly proportional to the dose of radiation received (a linear non-threshold dose-effect relationship). Even under these assumptions, the range of estimates of the health risks associated with a given level of exposure derived from existing scientific data is broad. It is recognized that sufficient data are not now available to either prove or disprove these assumptions, nor is there any reasonable prospect of demonstrating their validity at the low levels of expected exposure with any high degree of certainty. However, the Agency believes that acceptance of the above prudent assumptions, even with the existence of large uncertainties, provides a sound basis for developing environmental radiation standards which provides reasonable protection of the public health and do so in a manner most meaningful for public understanding of the potential impact of the nuclear power industry. Standards developed on this basis are believed to also protect the overall ecosystem, since there is no evidence that there is any biological species sensitive enough to warrant a greater level of protection than that adequate for man.

Radiological protection of the public from nuclear power industry operations has been based to date on guidance which has had as its primary focus the general limitation of dose to the most exposed individual, rather than limitation of the total population dose from any specific type of activity. The proposed expanded development of the nuclear power industry requires, however, the use of a broader environmental perspective that more specifically considers the potential radiological impact on human populations of radioactive effluents from this industry, rather than just that on the most exposed individual. A number of long-lived radionuclides are now discharged from various fuel cycle operations which carry a potential for buildup of environmental levels and irreversible commitments for exposure of populations that may persist for tens, hundreds, or thousands of years. The extent of the cumulative population doses which may occur over the years following release of such radionuclides is related to their radioactive decay times, the details of their dispersion through environmental media, the period over which they remain in the biosphere, and their exposure (both internal and external) of individuals in populations. The cumulative dose resulting from releases to the environment of such materials can be termed an "environmental dose commit-

ment," and quantitatively expressed in terms of the number of person-rems of dose committed. The proposed standards are based, to the extent that present knowledge permits, on such projections of the migration of radioactive effluents through the biosphere and estimates of the sum of potential doses to present and future populations during that migration.

Since potential effects from radiation exposure are assumed to occur at any level of exposure, it is not possible to specify solely on a health basis an acceptable level of radiation exposure for either individuals or populations; it is necessary to balance the health risks associated with any level of exposure against the costs of achieving that level. In developing the proposed standards, EPA has carefully considered, in addition to potential health effects, the available information on the effectiveness and costs of various means of reducing radioactive effluents, and therefore potential health effects, from fuel cycle operations. This consideration has included the findings of the AEC and the NRC with respect to practicability of effluent controls, as well as EPA's own continuing cognizance of the development, operating experience, and costs of control technology. Such an examination made it possible to propose the standards at levels consistent with the capabilities of control technology and at a cost judged by the Agency to be acceptable to society, as well as reasonable for the risk reduction achieved. Thus, the standards generally represent the lowest radiation levels at which the Agency has determined that the costs of control are justified by the reduction in health risk. The Agency has selected the cost-effectiveness approach as that best designed to strike a balance between the need to reduce health risks to the general population and the need for nuclear power. Such a balance is necessary in part because there is no sure way to guarantee absolute protection of public health from the effects of a nonthreshold pollutant, such as radiation, other than by prohibiting outright any emissions. The Agency believes that such a course would not be in the best interests of society.

The total population impact associated with a particular level of effluent control is best assessed in terms of dose commitments to populations measured in person-rems, which are then converted into estimates of potential health impact. However, the environmental models used for deriving these assessments, while useful for making estimates of potential health impact, are not considered to be so well-defined as to allow standards for populations to be expressed directly in terms requiring their explicit use. The Agency believes that future changes and refinements in models, and thus in the person-rem assessments upon which these standards are based, will occur on a continuing basis. The standards are therefore not proposed directly in terms of person-rems, but future reviews of their adequacy will reflect any changes in model-based assessments of population dose. Standards have also not been proposed directly in terms of person-rems because the regulatory implementation of such a requirement does not appear to be administratively feasible for the fuel cycle under existing widely varying geophysical and demographic conditions and for doses that may, in some instances, be delivered over indeterminately long periods of time. The proposed standards are expressed in terms of 1) limits on individual doses to members of the public and 2) on quantities of certain long-lived radioactive materials in the general environment. On the basis of its assessments of the health risks associated with projected annual population doses and environmental dose commitments, the Agency has concluded that these two types of standards are the most appropriate choice of criteria to provide effective limitation of the potential health impact on populations of short-lived and long-lived radioactive materials, respectively.

Even though adequate protection of populations considered as a whole may be assured by standards based upon the above consideration of health risks and control costs, it may not always be the case that adequate protection is assured on this basis to some individuals in these populations who reside close to the site boundaries of nuclear facilities, because of the distribution characteristics of certain effluents. Such a situation is possible in the case of thyroid doses due to releases of radioiodines from reactors and fuel reprocessing facilities. Although the risk from such doses to nearby individuals is quite small, it is inequitable to permit doses to specific individuals that may be substantially higher than those to other members of the population from other radionuclides. Additional protection for these individuals should be provided when technology or other procedures are available for minimizing any additional potential risk at a reasonable cost. The standards proposed to limit doses to individuals reflect this additional requirement where it is appropriate to do so.

Technical considerations. It is convenient to consider effects of radioactive materials introduced into the environment by the uranium fuel cycle in three categories. Prior to the occurrence of nuclear fission at the reactor only naturally occurring radioactive materials are present in fuel cycle operations. This first category of materials consists principally of uranium, thorium, radium, and radon with its daughter products. Radioactive materials introduced to the environment from facilities for milling, chemical conversion, isotopic enrichment, and fabrication of fuel from uranium which has not been recycled are limited to these naturally occurring radionuclides. As a result of the power-producing fission process at the reactor a large number of new radionuclides are created as fission or activation products. These may be introduced into the general environment principally by reactors or at fuel reprocessing and are conveniently categorized as either long-lived or short-lived fission and activation products, depending upon whether their half-lives are greater than or less than one year. Although naturally occurring radionuclides are of some concern, it is these fission and activation products which are of greatest concern from the point of view of controlling radiation doses to the public due to nuclear power operations.

Standards are proposed for the fuel cycle in two major categories. The proposed standards would limit: 1) the annual dose equivalent to the whole body to 25 millirems, to the thyroid to 75 millirems, and to any other organ to 25 millirems; and 2) the quantities of krypton-85, iodine-129, and certain long-lived transuranic radionuclides released to the environment per gigawatt-year of power produced by the entire fuel cycle to 50,000 curies, 5 millicuries, and 0.5 millicuries, respectively. The first standards are designed to limit population and individual exposures near fuel cycle operations due to short-lived fission-produced materials and naturally occurring materials, and due to transportation of any radioactive materials, while the second specifically addresses potential population exposure and buildup of environmental burdens of long-lived materials.

The proposed standard for annual whole body dose to any individual limits the combined internal and external dose equivalent from gaseous and liquid effluents as well as exposure to gamma and neutron radiation originating from all operations of the fuel cycle to 25 millirems. Such a limit is readily satisfied at all sites for which fuel cycle facilities are presently projected through the year 1985 (including any potential overlap of doses from adjacent sites) by levels of control that are cost-effective for the reduction of potential risk achieved; is in accord with the capabilities of controls anticipated by the AEC for all sites for which Environmental Statements have been filed; and, on the basis of present operating experience at existing sites, can be readily achieved in practice. The combined effect of any combinations of operations at the same location that are foreseeable for the next decade or so was also examined and is judged to be small, so that the proposed standards can readily be satisfied by use of levels of control that are similar to those required for single operations. It should be noted that this proposed standard for maximum whole body dose, which is higher than that proposed by the AEC as guidance for design objectives for light-water-cooled reactors, differs from those objectives in that it applies to the total dose received from the fuel cycle as a whole and from all pathways, including gamma radiation from onsite locations. It is also not a design objective, but a standard which limits doses to the public under conditions of actual normal operation.

The appropriate level for a standard limiting the maximum annual total dose to the thyroid of individuals is not easy

to determine. A standard for maximum total thyroid dose based on considerations limited to the same criteria as for maximum whole body dose (cost-effectiveness of reduction of total population impact and achievability) would permit unacceptably high doses to individuals near some site boundaries. The proposed standard of 75 millirems per year to the thyroid has therefore been chosen to reflect a level of biological risk comparable, to the extent that current capability for risk estimation permits, to that represented by the standard for dose to the whole body. The effluent controls required to achieve this limit have been examined extensively by EPA, AEC, and the industry, particularly in regard to the AEC's proposed Appendix I to 10 CFR 50 for light-water-cooled reactors, and, in the view of the Agency, this level of maximum annual individual dose to the thyroid can be achieved at reasonable effort and cost.

The principal potential doses to internal organs other than the thyroid are to the lung via inhalation of airborne particulates and to bone due to ingestion via water and other pathways of the naturally occurring materials processed in the several components of the fuel cycle required to convert uranium ore into reactor fuel. The impact on populations due to effluents from these operations is generally quite small (due to their predominately remote locations and lack of widespread dispersion), however, significant lung doses are possible to individuals near to these operations, particularly in the case of mills and conversion facilities. The use of well-established, efficient, and inexpensive technology for the retention and control of particulate effluents can readily achieve the levels of control required to meet the proposed standard of 25 millirems per year for limiting dose equivalent to the internal organs (other than thyroid) of individuals.

Environmental radiation exposures from transportation operations are due to direct radiation. Although average radiation doses to individuals in the general public from transportation activities are very small, situations in which individuals could receive higher doses may reasonably be postulated. It is recognized that exposures due to transportation of radioactive materials are difficult to assess and regulate because as shipments move in general commerce between sites the exposed population is constantly changing. Transportation activities should be conducted with every effort made to maintain doses to individuals as low as reasonably achievable, consistent with technical and economic feasibility. In any case, the maximum dose to any member of the general public due to uranium fuel cycle operations, including those due to shipments of radioactive materials, should not exceed the proposed standard of 25 millirems per year to the whole body of an individual. The Agency will continue to examine potential exposures due to transportation of radioactive materials with a view to further action, if necessary.

Among the variety of long-lived radionuclides produced in the fuel cycle, tritium, carbon-14, krypton-85, iodine-129, plutonium, and certain other long-lived transuranic radionuclides are of particular significance as environmental pollutants. Environmental pathways of tritium, carbon-14, and krypton-85 are worldwide. Even though the balance of the above radionuclides may not rapidly become widely dispersed, they are significant because of their potential for extreme persistence in environmental pathways, possibly for thousands of years for plutonium and other transuranics, and for even longer periods for iodine-129.

Because of their high toxicity and long half-lives, the cumulative impact of releases of plutonium and other transuranics to the environment could be large. However, due to very large uncertainties concerning their environmental behavior over long periods of time, as well as a lack of definitive information concerning the relationship between exposure to these materials and health effects, the limits of this potential impact cannot be more than roughly estimated. Therefore prudence dictates that the environmental burden of these materials be minimized to the lowest levels reasonably achievable. Similarly, although its toxicity is less than that of the alpha-emitting transuranics, in view of the extreme persistence of iodine-129 (half-life 17 million years) and great uncertainty concerning its environmental behavior, environmental releases of this isotope should be also maintained at the lowest level reasonably achievable. The prevention of unlimited discharges of krypton-85 to the environment from fuel cycle operations is of high priority because of its potential for significant long-term public health impact over the entire world. Finally, carbon-14 and tritium, both of which rapidly enter worldwide pathways as gaseous radioactive materials, are of particular concern because carbon and hydrogen are principal constituents of the chemical structures of all life forms.

These long-lived radionuclides should only be discharged to the environment after careful consideration of the tradeoffs between the societal benefits of the power generated, the current and projected health risks to populations, and the costs and effectiveness of methods available to limit their release. Since the anticipated maximum dose to any single individual from any of these materials is very small, the primary concern is the cumulative risk to population groups over long periods of time. For this reason, it is not of primary importance where or when in the fuel cycle any such materials are released, since the committed impact will be similar. What is important is to assure that any permitted discharge has been offset by a beneficial product, i.e., a quantity of electricity, and that every reasonable effort has been made to minimize it. It is also important to assure that society is not burdened with unreasonable expenditures to minimize these risks in order to gain the necessary benefits of electric power. Fortunately the vast majority of potential health effects due to release of these radionuclides can be avoided at a reasonable cost. The Agency estimates the cost of implementing the proposed standards for these long-lived radioactive materials to be less than $100,000 per potential case of cancer, leukemia, or serious genetic effect averted (less than $75 per person-rem). In view of the above considerations, the Agency believes that the proposed standards, which limit the number of curies of certain of these radionuclides released to the general environment for each gigawatt-year of electricity produced by the fuel cycle, represent the most reasonable means of providing required protection of the general environment for present and future generations. The standards will assure that any environmental burdens of long-lived radioactive materials accumulate only as the necessary result of the generation of an offsetting quantity of electrical energy.

The proposed standards for long-lived materials fall into two categories: those which can be achieved using currently available methods for control of environmental releases, and those that require use of methods that have been demonstrated on a laboratory or larger scale, but have not yet achieved routine use. In the former case, exemplified by the standard of 0.5 millicuries per gigawatt-year for plutonium and other long-lived alpha-emitting transuranics, the standard limits the environmental burden to the lowest level reasonably achievable using currently available control methods. In the latter case, that of the proposed standard of 50,000 curies per gigawatt-year for krypton-85 and 5 millicuries per gigawatt-year for iodine-129, these limiting levels of environmental burdens are not those achievable by best demonstrated performance, but instead by minimum performance reasonably anticipated from introduction of these new systems into commercial operations. As experience is gained with the ability of the industry to limit fuel cycle releases of these materials to the environment, it may be appropriate to reconsider the standards limiting the maximum environmental burdens of these particular radionuclides.

Similarly, as knowledge becomes available concerning the practicability of limiting environmental releases of tritium and carbon-14, the appropriate levels of maximum environmental burdens of these radionuclides due to fuel cycle operations will be carefully considered by the Agency. However, the knowledge base now available is inadequate for such a determination, and no standards are presently proposed for these radionuclides. The potential for a long-term impact due to carbon-14 released from fuel cycle operations was not recognized until the Agency considered environmental dose commitments from the industry in the course of developing these standards; thus consideration of methods for limit-

ing its release to the general environment are only now beginning. Tritium levels in the general environment from fuel cycle operations are not expected to become significant until the late 1980's, and development programs are in existence for control of releases of this radionuclide from its principal source, fuel reprocessing operations. The Agency believes that the development and installation of controls to minimize environmental burdens of both carbon-14 and tritium are important objectives, and will carefully follow the development of new knowledge concerning both the impact and controllability of these radionuclides.

To allow adequate time for implementing the standards for krypton-85 and iodine-129 control, including the necessary testing and analysis required prior to licensing of these control systems, the effective date is proposed as January 1, 1983. Implementation by this date would result in control of these releases before any substantial potential health impact from these materials due to uranium fuel cycle operations can occur and would, in the judgment of the Agency, provide adequate protection of public health thereafter.

The proposed standard for maximum dose to organs excludes radon and its daughter products. Radon is released as a short-lived (3.8 days half-life) inert gas, mainly from tailings piles at mills, and produces its principal potential impact through deposition of its daughter products in the lung. There exists considerable uncertainty about the public health impact of existing levels of radon in the atmosphere, as well as over the best method for management of new sources of radon created by man's activities, which remove this naturally occurring material and its precursors from beneath the earth's protective crust. Radon levels in the general environment are substantial and are dominated by natural sources, except in the immediate vicinity of man-made sources. Exposures from radon and its daughters have previously been the subject of Federal Radiation Protection Guidance, in the case of underground uranium miners (FR Doc. 71-7819 and FR Doc. 71-9697), and of guidance from the Surgeon General, in the case of public exposure due to the use of uranium mill tailings in or under structures occupied by members of the general public ("Use of Uranium Mill Tailings for Construction Purposes," hearings before the Subcommittee on Raw Materials of the Joint Committee on Atomic Energy, October 28-29, 1971, pp. 226-233). The Agency has concluded that the problems associated with radon emissions are sufficiently different from those of other radioactive materials associated with the fuel cycle to warrant separate consideration, and has undertaken an independent assessment of manmade sources of radon emissions and their management.

Implementation of the standards. These proposed standards are expected to be implemented for the various components of the uranium fuel cycle, operating under normal conditions, by the Nuclear Regulatory Commission. The mechanisms by which these standards are achieved will be a matter between the NRC and the industries that are licensed to carry out various uranium fuel cycle operations, but, in general, will be based on regulations and guides for the design and operation of the various facilities. The Agency is confident that these proposed standards can be effectively implemented by such procedures.

Current rules and regulations applicable to fuel cycle operations generally contain provisions which have the effect of limiting doses to individuals, thus implementation of the proposed standards for maximum doses to individuals should be straightforward. Protection of the public from the environmental accumulation of long-lived radioactive materials may require some changes in regulatory requirements. For example, this standard limit environmental accumulations of certain radionuclides associated with the generation of a gigawatt-year of electrical energy, which is generated only at the power reactor. Since other operations in the cycle which do not generate power are more likely to discharge such materials, it may be necessary for the regulatory agency to make an appropriate allocation to each facility and to determine the emission rates required to satisfy the standard for the entire fuel cycle. This is especially the case for a radionuclide like krypton-85 which can be released either at reactors, during fuel storage, or during fuel reprocessing. The standards do not specify the time, location, or concentration of emissions of long-lived radionuclides. Once a given quantity of electrical power has been generated the specified amount of the radionuclide may be released at any time and at any rate or location that does not exceed the individual dose limitations. Demonstration of compliance with the standard requires only that the total quantity of electricity generated after the effective date of the standards be recorded to determine the maximum quantity of these long-lived radionuclides that may eventually be released.

The Agency recognizes that implementation of the standards for krypton-85 and iodine-129 by the proposed effective date of January 1, 1983, will require successful demonstration of control technology for commercial use that is now in advanced stages of development. The Agency, as stated above, intends to review all of these standards in at least five year intervals. If substantial difficulty should develop for implementing the standards for krypton-85 and iodine-129 with respect to the proposed levels, facility safety, or cost, the Agency will give these factors careful and appropriate consideration prior to the effective date.

With respect to operations associated with the supply of electrical power it is important not only to set standards which will provide satisfactory public health protection, consistent with technical and economic feasibility, but also to minimize societal impacts which may occur as the result of temporary interruptions in these fuel cycle operations that are necessary to assure the orderly delivery of electric power. Such a two-fold objective requires consideration of the question whether to impose stricter standards which achieve lower levels of radiation exposure and environmental burdens of long-lived radioactive materials, but which may force temporary shutdowns which may not be justified on a risk-benefit basis for such periods; or to establish more liberal standards which decrease the possibility of such shutdowns, but may be overly permissive with respect to public exposure and long-term environmental releases. The Agency has attempted to avoid this dilemma by proposing standards that are not permissive with respect to either public exposures or long-term environmental releases and at the same time providing a variance which allows the standards to be temporarily exceeded under unusual conditions. The use of such variances by the regulatory agency will depend to a large degree upon their value judgments concerning the necessity of the fuel cycle operation concerned to a region, overall facility safety, and the possible impact on public health. The proposed variance provides that temporary increases above the standards for normal operations are allowable when the public interest is served, such as to maintain a dependable source of continuous power or during a power crisis. The Agency anticipates that the need to use such variances will be infrequent and of short duration, and that the overall impact on population and individual radiation doses from the operations of the entire fuel cycle will be minimal.

With respect to regulatory implementation of the flexibility provided by this proposed variance provision, the Agency has carefully examined the guidance for design objectives and limiting conditions for operation of light-water-cooled nuclear power reactors as set forth recently by the NRC in Appendix I to 10 CFR 50. It is the view of the Agency that this guidance for reactors will provide an appropriate and satisfactory implementation of these proposed environmental radiation standards for the uranium fuel cycle with respect to light-water-cooled nuclear reactors utilizing uranium fuel. The various monitoring and reporting procedures required by the AEC in the past and supplemented by Appendix I are expected to provide continuing information sufficient to determine that these standards are being satisfied during the course of normal operations of the fuel cycle.

Although the Agency has attempted to limit the effect of radioactive discharges from the fuel cycle on populations and on individuals through these proposed standards, it has not attempted to specify constraints on the selection of sites for fuel cycle facilities, even though the Agency recognizes that siting is an important factor which affects the potential health impact of most planned releases from operations in the fuel cycle. The standards were developed, however, on the assumption that sound siting practices will continue to be promoted

as in the past and that facility planners will utilize remote sites with low population densities to the maximum extent feasible.

The Agency has also considered the need for special provisions for single sites containing large numbers of facilities, of single or mixed types, as exemplified by the "nuclear park" concept. Present construction projections by utilities indicate that no such sites are likely to be operational during the next ten years. In view of the need to accumulate operating experience for the new large individual facilities now under construction and the intent of the Agency to review these standards at reasonable intervals in the future, it is considered premature and unnecessary to predicate these standards on any siting configurations postulated for the next decade and beyond. The Agency will consider changes in these standards based on such considerations when they are needed and justified by experience.

It is the conclusion of the Agency that implementation of the proposed standards for normal operations of the nuclear power industry based on the uranium fuel cycle will provide society protection of its environment and the health of its citizens and that this protection is obtained without placing unreasonable financial burdens upon society. In this context, these standards are responsive to the President's energy messages of June 4, 1971, and April 18, 1973, which challenged the Nation to the twin objectives of developing sufficient new energy resources while providing adequate protection for public health and the environment.

Request for comments. Notice is hereby given that pursuant to the Atomic Energy Act of 1954, as amended, and Reorganization Plan No. 3 of 1970 (FR Doc. 70-13374), adoption of Part 190 of Title 40 of the Code of Federal Regulations is proposed as set forth below. All interested persons who wish to submit comments or suggestions in connection with this proposed rulemaking are invited to send them to the Director, Criteria and Standards Division (AW-560), Office of Radiation Programs, Environmental Protection Agency, Washington, D.C. 20460, on or before July 28, 1975. Within this same time period, interested parties are also invited to indicate their desire to participate in a public hearing on the proposed rulemaking to be scheduled after the comment period ends. Comments and suggestions received after July 28, 1975 period will be considered if it is practical to do so, but such assurance can only be given for comments filed within the period specified. Single copies of a Draft Environmental Statement for the proposed standards and a technical report entitled "Environmental Analysis of the Uranium Fuel Cycle" are available upon request at the above address. The above-mentioned technical documents and comments received in response to this notice, as well as comments received in response to the Agency's advance notice of this proposed rulemaking published on May 10, 1974, and the Agency's response to these comments, constitute part of the background for this rulemaking and may be examined in the Agency's Freedom of Information Office, 401 M Street, SW., Washington, D.C. 20460.

Dated: May 23, 1975.

RUSSELL E. TRAIN,
Administrator.

A new Part 190 is proposed to be added to Title 40, Code of Federal Regulations, as follows:

PART 190—ENVIRONMENTAL RADIATION PROTECTION STANDARDS FOR NUCLEAR POWER OPERATIONS

Subpart A—General Provisions

Sec.
190.01 Applicability.
190.02 Definitions.

Subpart B—Environmental Standards for the Uranium Fuel Cycle

190.10 Standards for normal operations.
190.11 Variance for unusual operations.
190.12 Effective date.

AUTHORITY: Atomic Energy Act of 1954, as amended; and Reorganization Plan No. 3 of 1970.

Subpart A—General Provisions

§ 190.01 Applicability.

The provisions of this part apply to radiation doses received by members of the public in the general environment and to radioactive materials introduced into the general environment as the result of operations which are part of a nuclear fuel cycle.

§ 190.02 Definitions.

(a) "Nuclear fuel cycle" means the operations defined to be associated with the production of electrical power for public use by any fuel cycle through utilization of nuclear energy.

(b) "Uranium fuel cycle" means all facilities conducting 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 using uranium fuel, reprocessing of spent uranium fuel, and transportation of any radioactive material in support of these operations, to the extent that these support commercial electrical power production utilizing nuclear energy, but excludes mining operations and the reuse of recovered non-uranium fissile products of the cycle.

(c) "General environment" means the total terrestrial, atmospheric and aquatic environments outside sites upon which any operation which is part of a nuclear fuel cycle is conducted.

(d) "Site" means any location, contained within a boundary across which ingress or egress of members of the general public is controlled by the person conducting activities therein, on which is conducted one or more operations covered by this part.

(e) "Radiation" means any or all of the following: alpha, beta, gamma, or x rays; neutrons; and high-energy electrons, protons, or other atomic particles; but not sound or radio waves, nor visible, infrared, or ultraviolet light.

(f) "Radioactive material" means any material which emits radiation.

(g) "Uranium ore" is any ore which contains one-twentieth of one percent (0.05 percent) or more of uranium by weight.

(h) "Curie" (Ci) means that quantity of radioactive material producing 37 billion nuclear transformations per second. (One millicurie (mCi)=0.001 Ci.)

(i) "Dose equivalent" means the product of absorbed dose and appropriate factors to account for differences in biological effectiveness due to the quality of radiation and its spatial distribution in the body. The unit of dose equivalent is the "rem." (One millirem (mrem) =0.001 rem.)

(j) "Organ" means any human organ exclusive of the dermis, the epidermis, or the cornea.

(k) "Gigawatt-year" refers to the quantity of electrical energy produced at the busbar of a generating station. A gigawatt is equal to one billion watts. A gigawatt-year is equivalent to the amount of energy output represented by an average electric power level of one gigawatt sustained for one year.

(l) "Member of the public" means any individual that can receive a radiation dose in the general environment, whether he may or may not also be exposed to radiation in an occupation associated with a nuclear fuel cycle. However, an individual is not considered a member of the public during any period in which he is engaged in carrying out any operation which is part of a nuclear fuel cycle.

(m) "Regulatory agency" means the government agency responsible for issuing regulations governing the use of sources of radiation or radioactive materials or emissions therefrom and carrying out inspection and enforcement activities to assure compliance with such regulations.

Subpart B—Environmental Standards for the Uranium Fuel Cycle

§ 190.10 Standards for normal operations.

(a) The annual dose equivalent shall not exceed 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public as the result of exposure to planned discharges of radioactive materials, radon and its daughters excepted, to the general environment from uranium fuel cycle operations and radiation from these operations.

(b) The total quantity of radioactive materials entering the general environment from the entire uranium fuel cycle, per gigawatt-year of electrical energy produced by the fuel cycle, shall contain less than 50,000 curies of krypton-85, 5

millicuries of iodine-129, and 0.5 millicuries combined of plutonium-239 and other alpha-emitting transuranic radionuclides with half-lifes greater than one year.

§ 190.11 Variance for unusual operations.

The standards specified in § 190.10 may be exceeded if:

(a) The regulatory agency has granted a variance based upon its determination that a temporary and unusual operating condition exists and continued operation is necessary to protect the overall societal interest with respect to the orderly delivery of electrical power, and

(b) Information delineating the nature and basis of the variance is made a matter of public record.

§ 190.12 Effective date.

(a) The standards in this Subpart, excepting those for krypton-85 and iodine-129, shall be effective 24 months from the promulgation date of this rule.

(b) The standards for krypton-85 and iodine-129 shall be effective January 1, 1983.

[FR Doc.75-14017 Filed 5-28-75;8:45 am]

THURSDAY, JANUARY 13, 1977

PART VII

ENVIRONMENTAL PROTECTION AGENCY

■

RADIATION PROTECTION PROGRAMS

Environmental Radiation Protection Standards for Nuclear Power Operations

Title 40—Protection of Environment

CHAPTER I—ENVIRONMENTAL PROTECTION AGENCY

SUBCHAPTER F—RADIATION PROTECTION PROGRAMS

[FRL 059 6]

PART 190—ENVIRONMENTAL RADIATION PROTECTION STANDARDS FOR NUCLEAR POWER OPERATIONS

On May 10, 1974, the Environmental Protection Agency (EPA) published an advance notice of intent to propose environmental radiation protection standards for the uranium fuel cycle (39 FR 16906) and invited public participation. On May 29, 1975, EPA proposed regulations setting forth such standards (40 FR 23420) pursuant to the Atomic Energy Act, as amended, and Reorganization Plan No. 3 of 1970 (35 FR 15623). Numerous written comments were received, and a public hearing was held on March 8–10, 1976 (41 FR 1124 and 41 FR 5349).[1]

These regulations setting forth environmental radiation standards are hereby promulgated in final form. The standards specify the levels below which normal operations of the uranium fuel cycle are determined to be environmentally acceptable. A number of changes have been made in the proposed regulations in response to comments received. These changes modify and clarify the areas of applicability of the standards and their effective dates, and expand the conditions under which variances may be granted. The numerical levels of the standards have been retained as proposed.

The Agency has benefited from extensive public participation during the course of the development of these regulations. Sixteen comment letters were received in response to the Agency's May 10, 1974, notice of intent to propose standards, and 82 comment letters following the publication of proposed regulations on May 29, 1975. Letters were received from a broad cross-section of representatives of the general public, the industry, professional groups, the States, and Federal agencies. In addition, 17 parties participated in three days of public hearings and, in many cases, submitted extensive additional written testimony. In all, the contributed record comprises over 3500 pages. Comment letters, a transcript of the public hearing, and all submitted testimony are available for viewing and copying in the Agency's Public Information Reference Unit, Room 2922, U.S. Environmental Protection Agency, 401 M Street SW., Washington, D.C. 20460. The Agency has considered all of this record in reaching its conclusions for these final regulations.

At the time these standards were proposed, EPA released a Draft Environmental Statement and solicited public comments. A Final Environmental Statement is being made available concurrently with the promulgation of these standards. This statement contains the comments received on both the proposed standards and the draft statement, and EPA's response to these comments. Single copies of the Final Environmental Statement and an additional document containing EPA's detailed responses to testimony received in connection with the public hearing are available from the Director, Criteria and Standards Division (AW–460), Office of Radiation Programs, Environmental Protection Agency, Washington, D.C. 20460. Persons interested in a summary discussion of the background, rationale, interpretation, and significance of these standards should consult the notice proposing these regulations and, for greater detail, the Final Environmental Statement.

Major Issues Raised During Review

Three major issues were raised by commenters. These were: (1) concern that procedures for implementation of the standards would be unnecessarily conservative or costly, (2) disagreement over the need for and cost-effectiveness of control of environmental releases of krypton-85 and other long-lived radionuclides, and (3) disagreement over the form of the relationship between effects on health and radiation dose assumed in deriving these standards.

A large number of commenters expressed the view that implementation would lead to more restrictive control of effluents than intended due to the use of unnecessarily conservative models for source terms, control capability, and environmental transport, and due to requirements for unreasonably large margins between normal operating levels and the standards, especially at sites containing a number of facilities. The authority to regulate fuel cycle facilities under these standards resides in the Nuclear Regulatory Commission (NRC), or, in some cases, the States, under agreements with NRC. The standards have been expressed in terms of the dose to members of the public, rather than to hypothetical receptors, in order to encourage the use of realistic models by the regulatory agency. In addition, the Agency has made its intent regarding realistic implementation clear, as, for example, in the discussion of these matters in the Final Environmental Statement and will continue to do so if necessary as implementation proceeds, to assure that unnecessary conservatism does not occur.

In this regard, the NRC has recently issued a revised set of regulatory guides for light-water-cooled reactors which implement their announced intent to use the most realistic models available when adequate experimental data exist to permit a prudent and scientific determination. These models are intended for use in implementing the recently-issued Appendix I to 10 CFR Part 50, which defines design and operating criteria for single reactor units. EPA has examined Appendix I and the accompanying regulatory guides and agrees that they provide the basis for realistic implementation of these standards for single reactor units. The existence of these requirements, coupled with the realization that most existing reactor licenses are for no more than one or two units on a site, makes it unnecessary, in the Agency's judgment, to reexamine the license conditions of these licensees for compatibility with these standards, unless the nearest neighboring site covered by this standard is within ten miles. In these latter cases small adjustments may be necessary. However, in the vast majority of situations, the sum of all reasonably postulable contributions from sources other than the immediate site will be small compared to these standards and should be ignored in assessing compliance. It would not be reasonable to attempt to incorporate into compliance assessment doses which are small fractions of the uncertainties associated with the determination of doses from the primary source of exposure. The Agency has also concluded that, except under highly improbable circumstances, conformance to these criteria should provide reasonable assurance of compliance with these standards for up to five units on a site. This conclusion is based, among other considerations, upon realistic consideration of anticipated site sizes and the relative location of individual units, as well as the stochastic nature of effluent releases.

A number of commenters, including the NRC, also noted that shutdown of nuclear facilities for minor deviations from the standards would not be reasonable. The Agency agrees, and notes that the use of such an extreme measure is not required under present compliance procedures for licenses issued pursuant to the Atomic Energy Act, and that these regulations do not add such a requirement. A graded scale of action is an appropriate regulatory response for achieving conformance. This may include, for example, requirements for corrective actions, appropriate penalties, and, in extreme cases, cessation of operations. The Agency is confident that the NRC will implement these standards in such a reasonable manner.

Some commenters expressed the view that it was not feasible to monitor con-

[1] In this connection the Agency received requests on behalf of Allied-General Nuclear Services (AGNS) on October 4 and December 2, 1976, for a supplemental hearing on certain aspects of this rulemaking, on the grounds that the Agency is, in part, relying upon information acquired subsequent to the public hearing which, in the view of AGNS, would be an essential basis for the rulemaking but is erroneous. The Agency has reviewed the materials submitted in support of this request and concluded that they would not provide a sufficient basis for altering its conclusions. A response to new matters addressed by this material has been appended to the Agency's commentary on testimony received in connection with the public hearing on these standards. In addition it is noted that the Agency has previously (40 FR 23420) made public its intent "* * * to maintain a continuing review of the appropriateness of these environmental standards * * * and to revise them, if necessary, on the basis of information that develops in the interval." In view of the above, the Agency has concluded that it is neither necessary nor appropriate to grant now the additional public hearing requested. We will, of course, welcome the submission of additional factual data on the matters concerned as it becomes available.

formance with these standards through the use of environmental measurements. The Agency agrees that routine monitoring based exclusively upon environmental measurements would not be a reasonable means for assuring conformance and the regulations do not contain such a requirement. Environmental objectives are generally best achieved through controls exercised at the source. For this reason effluent monitoring is generally preferable and such measurements, when combined with regulatory models for environmental transport, would provide quite adequate demonstration of conformance with the standards for the vast majority of situations, based upon existing experience. However, since varying degrees of conservatism and uncertainty exist in all environmental models, the Agency believes it will often be appropriate to supplement effluent monitoring with confirming environmental measurements, as is now the regulatory practice. In the case of light water reactors, models and monitoring requirements for demonstrating conformance with Appendix I of 10 CFR Part 50 are generally adequate for demonstrating conformance with these standards. Similar models and measurements would, in general, be appropriate for most other types of facilities.

In the special case of possible windblown effluents from mill tailings, the existence of operational measures (e.g., temporary or permanent stabilization) should normally be the criterion used for verifying compliance, in lieu of effluent and environmental monitoring, because of the difficulty associated with such measurements. It should be noted that doses resulting from exposure to radon and its daughters, which are discharged from a mill site (or result from material which has been discharged), are excluded, but that gamma radiation crossing site boundaries from any on-site source is covered.

In situations where members of the public are actually exposed, these standards, in effect, preempt those regulations which are based upon the Federal Radiation Protection Guides (25 FR 4402) insofar as exposure of the public is due to operations defined to be included in the uranium fuel cycle. For example, the dose limits in 10 CFR Part 20 would not be the limiting consideration regarding exposure of members of the public as a result of uranium fuel cycle operations. These standards do not, however, replace application of the Radiation Protection Guides to the regulation of sources not included within the scope of the uranium fuel cycle. Finally, the graded scale of actions established in 1961 (26 FR 9057) for use in implementing the Radiation Protection Guides do not apply to implementation of these standards, but would remain in effect for implementation of radiation protection guides for other radiation sources.

Several commenters expressed the view that a requirement for control of the unrestricted release of krypton to the environment from fuel cycle operations was: (a) beyond the jurisdiction of EPA, (b) unreasonably costly, (c) not achievable by 1983, the proposed implementation date (or, in the view of some commenters, was achievable prior to 1983), or (d) not a reasonable requirement of domestic industry until international agreements are achieved to restrict emissions from foreign sources.

The Agency has concluded that its jurisdiction is clear. Reorganization Plan No. 3 of 1970 specifically transferred to EPA from the Atomic Energy Commission the authority to establish standards for "* * * quantities of radioactive materials in the environment * * *" and attaches no conditions to this authority except a requirement that the standards apply outside the boundaries of licensees.

EPA has carefully reexamined the costs of control systems for krypton and has concluded that a substantial portion of the additional costs presented at the public hearings is correct. This analysis is reviewed in the Final Environmental Statement. However, in spite of these increased costs, the installation of controls for krypton-85 is believed to be justified by the public health benefits achievable. In today's dollars, the cost per unit radiation dose reduction at future reprocessing facilities will be $50–$75 per man-rem for whole body doses, and considerably less than this for doses to other organs. These values are more than an order of magnitude lower than limiting costs now specified in regulations governing the licensing of individual nuclear power reactors. It is recognized that the cost of retrofitting one facility which is expected to be in operation before 1983 will involve greater costs, and the regulatory agency is encouraged to explore means to minimize costs to this facility in its implementation of the standard for this pilot case.

Regarding the achievability of control over the release of krypton-85 to the environment by 1983, it is noted that this or similar control technology is already being offered commercially for nuclear reactors and fuel reprocessing facilities, and is currently being installed, or is on order, at several U.S. reactors and at a foreign fuel reprocessing facility by U.S. suppliers. The Agency, therefore, believes that 1983 is an achievable implementation date. However, a more accelerated schedule is not considered justified, in view of the small amount of reprocessing that will occur before that date and the present lack of operating experience with krypton controls.

Finally, we have examined arguments concerning the need for international agreement prior to the establishment of standards and do not find them persuasive. EPA fully supports the development of international agreements, and is presently participating in the development of international guidance for control of radioactive effluents from the fuel cycle under the auspices of the International Atomic Energy Agency. A number of countries are already committed to or are in the process of committing themselves to control of krypton releases. The Agency supports this trend and has concluded that the control of U.S. releases of krypton-85 is warranted on the basis of reducing its potential worldwide public health impact. In initiating a requirement for this control, the United States fulfills its responsibility, as the world's largest user of nuclear power, to provide leadership in this matter.

A number of commenters suggested that the proposed regulations should be amended to include standards for carbon-14 and, in some cases, other long-lived radionuclides. The Agency has studies of sources and controls for these materials underway and anticipates that proposals for appropriate environmental standards for carbon-14 can be made shortly, with consideration of proposals for other materials following at a later date. However, the knowledge base is not yet sufficient to permit incorporation into these standards now.

Comments were received reflecting many points of view on health effects issues. One group agreed with the Agency's primary reliance on risk estimates provided by the recent report to EPA of the National Academy of Sciences ("The Effects on Populations of Exposure to Low Levels of Ionization," Report of the Advisory Committee on the Biological Effects of Ionizing Radiation, NAS–NRC, 1972). These estimates are primarily based upon a linear interpolation between existing data on human populations and the assumption of no effects at zero dose. Another group believed this model is not sufficiently conservative to adequately protect public health, based upon several investigators' hypotheses concerning the shape of the dose-effect relationship at low doses. A third group believed these estimates to be too conservative at low doses and low dose-rates. Frequent reference was made by the third group to a report of the National Council on Radiation Protection and Measurements (Report No. 43) which implies that radiation standards should not be based upon numerical estimates of health effects, and a recent report of the Nuclear Regulatory Commission (NUREG–75/014) which presents, in addition to risk estimates based upon the National Academy of Sciences report, some lower risk estimates based upon a belief that dose-rate dependent phenomena exist for low linear energy transfer radiation (gamma rays and beta particles) which reduce the carcinogenic effect of radiation to levels lower than those predicted by the linear model. The Agency has examined the evidence for each of the above views and concluded that, while each may have validity under various assumptions or for various specific situations, the weight of currently available scientific evidence supports the continued use of a linear, nonthreshold model for deriving standards to protect public health.

Changes Made in the Proposed Regulations

A number of changes have been made in response to comments received on the proposed regulations. The following describes and provides the reasons for each of these changes:

1. Paragraph 190.02(b) has been changed to delete transportation as an operation covered by these standards and to specifically exclude waste disposal sites, which were previously not mentioned. The Agency is addressing the development of criteria and standards for management of radioactive wastes as a separate matter, as mentioned in the notice proposing these standards.

A number of commenters, including the NRC and the Department of Transportation, pointed out the difficulty of implementing these standards for transportation activities, particularly noting the problems near nuclear facilities. In such cases an apportionment of the dose limits would appear to be necessary in order to avoid unreasonably extensive monitoring requirements for members of the public. Since studies by both EPA and NRC show that most transportation-related doses are expected to remain at small fractions of these standards in any case, the implementation difficulty does not appear to warrant their inclusion in these standards limiting doses to individuals from uranium fuel cycle operations. The Agency will instead address this matter under its broad authority inherited from the former Federal Radiation Council, through the development of more general guidance to all Federal agencies concerning radiation exposure arising from the transportation of all types of radioactive materials, not just those from the uranium fuel cycle.

2. Paragraph 190.02(a) is changed to reflect the definition of "site" implied by Reorganization Plan No. 3 of 1970.

3. Paragraph 190.02(f) is changed by adding the word "spontaneously" to reflect the Agency's original intent.

4. Paragraph 190.02(g) is deleted and subsequent paragraphs in Section 190.02 are renumbered. This paragraph defined uranium ore as ore containing 0.05% or more uranium by weight. As pointed out by one commenter, it is not desirable to exclude ores containing less than this quantity of uranium, since future demand for ore may make the use of such ores economically feasible.

5. Section 190.11 has been broadened to permit a greater degree of discretion to the regulatory agency to develop and apply conditions for the granting of variances. As pointed out by a number of commenters, it is not reasonable to predicate the justification for variances solely on public need for orderly delivery of power. For example, a facility may have installed a control system which, in spite of good faith performance on the part of the supplier and the user, may fail to achieve operational capability on a timely basis, or, once installed may experience operational failure at some time, yet operation of the facility may not be essential to the "orderly delivery of electrical power." In addition, some portions of this standard are predicated upon the use of waste treatment systems not yet in general commercial use. Although in no case should operation continue if safety is compromised, it may easily be that excursions above these standards would occur in such cases to a degree that the added risk to the general public is small and the environmental effect is acceptable in comparison to the economic penalty that would be associated with cessation of operation or the anticipated public health and environmental impact of available alternative sources of power. For this reason, the variance provision has been broadened so that the regulatory agency may, if it deems it to be in the public interest, grant a variance in such situations. It should be noted, however, that the variance provision applies only to temporary and unusual situations. It is expected that continued operation under the variance provision will be predicated upon an approved plan to achieve compliance in an expeditious fashion, that is, in as short a time as is reasonably achievable.

The requirement for public documentation of variances has been clarified and extended to apply to this broadened provision. EPA will not review individual variances or compliance plans, which will be made public in accordance with the provisions of paragraph 190.11(b), but will maintain a general overview through periodic review of the use of this Section.

6. Section 190.12(a) has been changed to provide that the effective date for the standards limiting doses to individuals shall be December 1, 1979, for all operations except the milling of uranium ore, for which the effective date shall be December 1, 1980.

The NRC has carefully examined its existing programs for implementation of Appendix I at light-water-cooled reactors, and the feasibility of integrating implementation of these standards into that on-going process, as well as, in parallel, implementing these standards at other types of fuel cycle facilities through development and promulgation of new regulatory guides and individual license conditions. Finally, there are matters regarding reactors which will require generic treatment, such as the conditions required for compliance when there are multiple units on single sites. It is the conclusion of the NRC, and the Agency concurs, that the originally proposed two-year implementation period is insufficent and that three years will be required to complete this process. The NRC review of these matters regarding implementation has revealed that the case of mills is unique, since better information is required concerning a number of alternatives for stabilization of tailings—both as to their relative merit and the degree of periodic maintenance required. On June 3, 1976, the NRC published (41 FR 22430) a notice of intent to prepare a generic environmental statement on uranium milling operations. This effort will be completed in approximately two years, and includes field measurements with participation of both EPA and NRC personnel. In addition, the NRC issued proposed new effluent reporting requirements at mills on November 17, 1975 (40 FR 53230). In view of the above considerations, it is the jointly agreed upon conclusion of the Agency and NRC that a four-year implementation period is required at mills, rather than the three years provided for all other fuel cycle operations.

7. Section 190.12(b) has been changed to clarify the Agency's original intent that the standards specified in paragraph 190.10(b) apply to radioactive materials produced after the effective date.

The Agency anticipates that promulgation of these standards will serve, in addition to providing for necessary protection of public health, to alleviate some of the uncertainties associated with the design of environmental controls for fuel cycle facilities, and the consequent economic penalties, through stabilizing and providing direction to the process of development of standards and regulations. The economic and inflationary impacts of these regulations have been evaluated in accordance with Executive Order 11821 and it has been determined that an Inflation Impact Statement is not required. (The estimated annual cost of additional effluent controls required by these regulations is in no case greater than ten to twenty million dollars, which is significantly less than the one-hundred million dollar annual cost cut-off established as the minimum for which an Inflation Impact Statement is required.)

Notice is hereby given that pursuant to the Atomic Energy Act of 1954, as amended, and Reorganization Plan No. 3 of 1970 Title 40, Chapter I, of the Code of Federal Regulations is amended by adding a new Subchapter F and Part 190 as set forth below.

Dated: December 28, 1976.

RUSSELL E. TRAIN,
Administrator.

A new Subchapter F, consisting of Part 190, is added to 40 CFR Chapter I as follows:

SUBCHAPTER F—RADIATION PROTECTION PROGRAMS

PART 190—ENVIRONMENTAL RADIATION PROTECTION STANDARDS FOR NUCLEAR POWER OPERATIONS

Subpart A—General Provisions

Sec.

Subpart B—Environmental Standards for the Uranium Fuel Cycle

AUTHORITY: Atomic Energy Act of 1954, as amended; Reorganization Plan No. 3, of 1970.

Subpart A—General Provisions

§ 190.01 Applicability.

The provisions of this Part apply to radiation doses received by members of the public in the general environment and to radioactive materials introduced into the general environment as the result of operations which are part of a nuclear fuel cycle.

§ 190.02 Definitions.

(a) "Nuclear fuel cycle" means the operations defined to be associated with the

production of electrical power for public use by any fuel cycle through utilization of nuclear energy.

(b) "Uranium fuel cycle" 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 using uranium fuel, and reprocessing of spent uranium fuel, to the extent that these directly support the production of electrical power for public use utilizing nuclear energy, but excludes mining operations, operations at waste disposal sites, transportation of any radioactive material in support of these operations, and the reuse of recovered non-uranium special nuclear and by-product materials from the cycle.

(c) "General environment" means the total terrestrial, atmospheric and aquatic environments outside sites upon which any operation which is part of a nuclear fuel cycle is conducted.

(d) "Site" means the area contained within the boundary of a location under the control of persons possessing or using radioactive material on which is conducted one or more operations covered by this Part.

(e) "Radiation" means any or all of the following: alpha, beta, gamma, or X-rays; neutrons; and high-energy electrons, protons, or other atomic particles; but not sound or radio waves, nor visible, infrared, or ultraviolet light.

(f) "Radioactive material" means any material which spontoneously emits radiation.

(g) "Curie" (Ci) means that quantity of radioactive material producing 37 billion nuclear transformations per second. (One millicurie (mCi) =0.001 Ci.)

(h) "Dose equivalent" means the product of absorbed dose and appropriate factors to account for differences in biological effectiveness due to the quality of radiation and its spatial distribution in the body. The unit of dose equivalent is the "rem." (One millirem (mrem) = 0.001 rem.)

(i) "Organ" means any human organ exclusive of the dermis, the epidermis, or the cornea.

(j) "Gigawatt-year" refers to the quantity of electrical energy produced at the busbar of a generating station. A gigawatt is equal to one billion watts. A gigawatt-year is equivalent to the amount of energy output represented by an average electric power level of one gigawatt sustained for one year.

(k) "Member of the public" means any individual that can receive a radiation dose in the general environment, whether he may or may not also be exposed to radiation in an occupation associated with a nuclear fuel cycle. However, an individual is not considered a member of the public during any period in which he is engaged in carrying out any operation which is part of a nuclear fuel cycle.

(l) "Regulatory agency" means the the government agency responsible for issuing regulations governing the use of sources of radiation or radioactive materials or emissions therefrom and carrying out inspection and enforcement activities to assure compliance with such regulations.

Subpart B—Environmental Standards for the Uranium Fuel Cycle

§ 190.10 Standards for normal operations.

Operations covered by this Subpart shall be conducted in such a manner as to provide reasonable assurance that:

(a) The annual dose equivalent does not exceed 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public as the result of exposures to planned discharges of radioactive materials, radon and its daughters excepted, to the general environment from uranium fuel cycle operations and to radiation from these operations.

(b) The total quantity of radioactive materials entering the general environment from the entire uranium fuel cycle, per gigawatt-year of electrical energy produced by the fuel cycle, contains less than 50,000 curies of krypton-85, 5 millicuries of iodine-129, and 0.5 millicuries combined of plutonium-239 and other alpha-emitting transuranic radionuclides with half-lives greater than one year.

§ 190.11 Variances for unusual operations.

The standards specified in § 190.10 may be exceeded if:

(a) The regulatory agency has granted a variance based upon its determination that a temporary and unusual operating condition exists and continued operation is in the public interest, and

(b) Information is promptly made a matter of public record delineating the nature of unusual operating conditions, the degree to which this operation is expected to result in levels in excess of the standards, the basis of the variance, and the schedule for achieving conformance with the standards.

§ 190.12 Effective date.

(a) The standards in § 190.10(a) shall be effective December 1, 1979 except that for doses arising from operations associated with the milling of uranium ore the effective date shall be December 1, 1980.

(b) The standards in § 190.10(b) shall be effective December 1, 1979, except that the standards for krypton-85 and iodine-129 shall be effective January 1, 1983, for any such radioactive materials generated by the fission process after these dates.

[FR Doc.77-399 Filed 1-12-77;8:45 am]

9/40/73

00003

ENVIRONMENTAL PROTECTION AGENCY

40-CFR Part -

ENVIRONMENTAL RADIATION PROTECTION REQUIREMENTS FOR NORMAL OPERATIONS OF ACTIVITIES IN THE URANIUM FUEL CYCLE

Notice of Proposed Rulemaking

Reorganization Plan No. 3, which became effective on December 2, 1970, transferred certain functions from the Atomic Energy Commission to the Environmental Protection Agency "...to the extent that such functions of the Commission consist of establishing generally applicable environmental standards for the protection of the general environment from radioactive material. As used herein, standards mean limits on radiation exposures or levels, or concentrations or quantities of radioactive material, in the general environment outside the boundaries of locations under the control of persons possessing or using radioactive material." The Environmental Protection Agency proposes to issue standards under this authority to assure protection of the general public from radioactive effluents resulting from the normal operations of the uranium fuel cycle* which support the generation of electricity by light-water-cooled power reactors fueled with enriched uranium. Nuclear power generation based on recycled plutonium fuel, plutonium

---

*As used herein the uranium fuel cycle means all facilities or operations, including transportation, that are involved in the processing, fissioning, and reprocessing of uranium for the production of electrical power from the time uranium ore leaves the mine through the reprocessing of uranium after burnup in reactors and its eventual recycle back into fuel supply.

fuel, or thorium fuel are excluded from this consideration, as are mining operations, but future consideration of these activities is contemplated when appropriate.

A major national effort has been underway for more than a decade to develop light-water-cooled nuclear reactors using enriched uranium for fuel for the generation of electrical power. The current rapid growth of this energy source also mandates increases in associated activities and operations of the uranium fuel cycle. Increases are expected in the processing of uranium ore to supply fuel for the increasing generation of electricity by light-water-cooled nuclear power reactors. Similar increases will also be necessary in fuel reprocessing, waste disposal, and transportation requirements. The Agency believes that current radiation protection guides and regulations are not entirely adequate to control the impacts associated with these expanded activities for three principal reasons: 1) The concept of "as low as practicable" as enunciated by current guidance does not give adequate consideration to population dose, 2) the basis for exposure determinations should be expanded to include the long-term total population impact of the release of long-lived nuclides to the environment, and 3) a recent study by the National Academy of Sciences - National Research Council* concluded that current Federal guides for exposure of members of the general population as they apply to the nuclear power industry are "unnecessarily high."

---

*Report of the Committee on Biological Effects of Ionizing Radiation entitled "The Effects on Populations of Exposures to Low Levels of Ionizing Radiation" National Academy of Sciences, Washington, D.C. (November, 1972).

The standards proposed in this rulemaking are expected to provide environmental and public health protection from the potential effects of normal radioactive effluents from all operations within the total uranium fuel cycle which support the generation of electricity by light-water-cooled reactors fueled with enriched uranium. The standards under consideration have two principal objectives: 1) to provide standards specifically applicable to light-water-cooled nuclear power reactors and fuel reprocessing plants and 2) to provide standards to be achieved by all other components and operations in the balance of the uranium fuel cycle. Each of these standards is based, to the extent information is available, on an examination of the particular health risks, the technology available to mitigate these risks, and the costs of applying such technology to the operations involved.

It is the intention of the Agency, as recommended by its Environmental Radiation Exposure Advisory Committee, to review these standards periodically, in at least five-year intervals, and to revise them up or down as appropriate based on information that develops in the interval.

INTERAGENCY RELATIONSHIPS. Reorganization Plan No. 3 transferred to the Environmental Protection Agency the responsibility for establishing generally applicable environmental radiation standards for the protection of the general environment from radioactive materials. The Atomic Energy Commission remained responsible for the implementation and enforcement of the Agency's generally applicable standards. The standards proposed herein recognize this division of responsibilities by stating maximum exposure levels and quantities of radioactive materials

that categories of activities should satisfy in the general environment outside the site boundaries of sources; the implementation of these standards through the issuance and enforcement of licenses for individual facilities, including technical specifications at effluent points, is expected to be carried out by the Atomic Energy Commission. The regulatory activities which have been effectively carried out by the AEC in the past are expected to be equally as effective in assuring that these standards are met in the future.

The implementation of the standards proposed is not intended to alter the programs carried out by the States under agreements with the AEC. Implementation of these standards is compatible with the program activities the AEC has developed with its "Agreement States" insofar as these activities pertain to the various operations associated with the uranium fuel cycle.

Appropriate monitoring and inspection activities should be conducted to determine actual radiation exposures and discharges of radioactive materials. Sufficient reporting of these data through public channels should also take place to allow determination that normal, planned, controlled operations within the uranium fuel cycle have satisfied these standards.

BASIC STANDARDS APPROACH. Radiation protection standards for the nuclear power industry to date have been based primarily on the limitation of risk to the most exposed individual, rather than to the total population exposed. Furthermore, the current and proposed expanded development of the nuclear power industry, with its planned and potential releases of long-lived radionuclides, requires the development

of a broader environmental assessment that encompasses the entire radiological impact of these pollutants. Assessments of the potential impact represented by industries such as the nuclear power industry require projection of the migration of each radionuclide through the environment over long periods of time, and a determination of the potential dose to populations (measured in person-rems*) delivered and the associated health effects** expected to occur throughout this migration. These assessments must include all individual exposures, however small, so that all of the impact on society is assessed, and must be cognizant of the exposure of future generations implied by the essentially irreversible environmental commitments that result from the discharge of long-lived radioactive materials into the general environment.

The most prudent basis for relating radiation dose to its impact on public health continues to be that health effects due to exposure to ionizing radiation occur at all levels of exposure down to zero and that the number of these effects induced is directly proportional to the dose of radiation received (a linear, non-threshold cause-effect relationship). Although it is recognized that data are not available to either prove or disprove this assumption, the Agency believes that it provides the only sound basis for developing to protect public health. Within this framework, the only totally risk-free level of radiation exposure is zero; a standard set at any other level must be justified on

---

*Person-rem is the unit of total integrated exposure of all individuals exposed. For example, an exposure of 100 persons to 1 rem is 100 person-rems and an exposure of 1,000 persons to 0.1 rem is also 100 person-rems. For such a dose concept, dilution of the effluent does not change the potential health effect if the increase in population exposed is inversely proportional to the dilution factor.

**Health effect means lethal cancers, other non-lethal cancers, or serious genetic effects, such as mogolism and gross deformities.

the basis that the activity producing the radiation exposure provides sufficient offsetting benefits. The use of this radiation protection perspective for man is believed to provide also for the protection of the overall ecosystem since there is no present evidence that there is any biological species whose sensitivity is sufficiently high to warrant a greater level of protection than that adequate for man. This perspective and others on the risks due to exposures to ionizing radiation were recently analyzed quantitatively by the Committee on Biological Effects of Ionizing Radiation formed by the National Academy of Sciences - National Research Council. This study was conducted under joint sponsorship of the Environmental Protection Agency and the Department of Health, Education, and Welfare, and provided an important input to the development of these proposed standards.

The Agency believes that the first principle to be satisfied by activities producing radioactive effluents is that benefits should accrue to society from the activity in sufficient amounts to offset both the short- and long-term radiation risks involved. Although these risks can be quantified within reasonable limits of scientific uncertainty, benefits, whether described in social, health or economic terms, are very difficult to quantify and must usually be evaluated using somewhat arbitiary value judgments. With respect to electric power generated by the uranium fuel cycle, the Agency has concluded that the social, health, and economic benefits realized far outweigh the health risks presented by effluents resulting from the normal operations of this industry controlled at the levels proposed by these standards. This determination was reached after first assessing the total population

risk incurred, by determining, for all radioactive materials from the fuel cycle entering the general environment, the population exposure (in person-rems) delivered with consideration also given to the time the material persists in the environment. From these population exposure estimates, the projected health effects were calculated and the Such choices of standards corresponded to limits on total quantities of radioactive materials which enter the general environment or in some cases, limits on individual dose.

The second major perspective used by EPA in setting the proposed environmental radiation standards was to consider in some detail the effectiveness and associated costs of effluent control for each class of activity. Such an examination allowed the standards to be set at a level of radiation risk consistent with the capabilities of control technology and at a cost acceptable to the public and reasonable for the risk reduction achieved. The standards assume that the most cost-effective control technology available will be employed for each effluent stream. In order to bring about orderly achievement of the standards at reasonable cost, appropriate lead times are also given to those affected by the standards for changing processes and activities, or applying the control technology required to meet the standards.

After population protection has been assured by such consideration of risks and costs, a third requirement that must be satisfied is to assure that protection is provided to those individuals in the public who may receive unjustifiably high radiation doses close to the site boundaries of nuclear facilities. Such an occurrence is possible in a few situations in the uranium fuel cycle, such as exposure due to

releases of short-lived radioiodines and from shipments of radioactive materials. The risk to an individual from such exposures is, in most cases, quite small, but it is still basically unfair to impose such doses on specific individuals if they are substantially higher than those received by the average population. It is believed that such doses should be are limited where technology and other procedures are available such exposure reduction, and the cost can be justified.

CONSIDERATIONS FOR THE TOTAL URANIUM FUEL CYCLE. It has been projected that well over 300,000 MWe of generating capacity based on the uranium fuel economy will exist within the next 20 years. As indicated above, the prespective for radiation protection of the public from this growth should consider the effects of the chronic exposure of large populations. The major population exposures due to operations of the uranium fuel cycle are associated with: 1) near-term low-level radiation exposures resulting directly from effluents from the various operations of the uranium fuel cycle, and 2) increasing low-level radiation exposure which occurs as a result of the long-term accumulation of long-lived radioactive materials as general environmental contaminants.

Analysis of the environmental impact of the uranium fuel cycle indicates that a number of long-lived radionuclides are discharged as a result of planned operations within the cycle, with consequent buildup of environmental levels and commitments for population dose that may persist for tens, hundreds, or thousands of years. The extent of population doses which may occur as a result of such commitments are related to the physical half-life of the radionuclide, the extent of its

dispersion through envrionmental media, and the period over which it remains available in the environment so that it can interact with and expose humans and other species through air and water directly, by direct radiation, or by accumulation in and transferral through food chains. The population dose resulting from the dispersion of such long-lived materials into the environment can be termed an "environmental dose commitment." The Agency believes it is important to recognize this perspective of radiation risk in addition to the present one, which effectively considers only annual exposures of individuals from shorter-lived radionuclides, and to implement appropriate controls to minimize such long-term dose commitments. For this reason, the environmental analyses of the various operations in the fuel cycle have considered the potential for health effects due to long-lived radionuclides after their introduction into the general environment to the extent that present knowledge permits.

Because of the potential dose commitments involved, and in the interest of minimizing the degradation of the quality of environmental resources, it is important to keep the environmental burden of long-lived radionuclides at the lowest levels consistent with technical and economic feasibility. The Agency has, therefore, proposed environmental standards for the long-lived radionuclides of concern in the form of limits on the quantities discharged per year into the general environment.

In addition to constraints on quantity released for protection against environmental buildup, standards are also proposed to limit exposures to the whole body or organs of the individual due to short-

lived radioactive effluents. The standards proposed are consistent with limiting such exposures through the application of technology at an acceptable cost.

Whereas the Agency has attempted to minimize the total effect of radioactive discharges on populations in its development of these proposed standards, it has not attempted to specify siting constraints, even though siting is an important factor which also affects the population impact of all operations in the fuel cycle. It is expected that good siting practices will continue to be promoted and that facility planners will take advantage of the benefits of remote sites in their designs. In this regard, the Atomic Energy Commission's policy of low population density siting as practiced in the past should be continued.

Total population impact, particularly with reference to health effects, is best considered in terms of the total person-rem commitment over the entire population affected. The standards were based principally on a determination of the population impact of all operations in the uranium fuel cycle, even though actual limits are expressed in terms of quantities discharged and whole body or organ doses to individuals. Person-rem limits have not been specified in the standards because the implementation of such a requirement is difficult. The proposed standards are expressed as limits on quantities of radioactive material and individual doses outside the boundaries of classes of activity so as to facilitate their translation into regulatory controls.

It is the viewpoint of the Agency that adherance to the proposed standards by the nuclear power industry will insure levels of risk due to normal operations that are environmentally acceptable and that are worthy of public acceptance. In this context, these standards are responsive to the President's energy messages of June 4, 1971, and April 18, 1973, which challenged the Nation to develop sufficient new energy resources and at the same time to provide adequate protection for public health and for our environment.

CONSIDERATIONS FOR FUEL SUPPLY OPERATIONS. The principal activities involved in converting uranium ore into enriched uranium fuel for use in power reactors are milling, conversion, enrichment, fabrication, and transportation. With the exception of transportation, each of these operations involves environmental discharges of naturally-occurring uranium and daughter products which can result in radiation exposures of individual organs and the skeleton. The primary environmental radiation exposure from transportation operations is direct gamma radiation. Since the discharges, environmental pathways, and control techniques for uranium and its daughter products are common to all aspects of fuel supply operations except transportation, standards covering these operations as a group are proposed to limit the quantities of these materials discharged to the general environment and to minimize exposures to individuals. Through the application of cost effective control technology, doses to actual individuals or organs can be kept below 15 millirems per year and quantities discharged to the environment can be maintained below one curie per year, exclusive of radon-222.

Although radiation doses to individuals from transportation activities are small, on the average, instances where a few individuals may receive fairly high doses can easily be postulated. Exposures of individuals due to transportation of radioactive materials are difficult to regulate because as shipments move in general commerce between sites the exposed population is constantly changing. Transportation activities should be conducted with every effort made to maintain doses to individuals as low as possible consistent with technical and economic feasibility. In no case should doses to individuals due to shipments of radioactive materials exceed the general standard of 15 millirems per year. The Agency will continue to examine transportation with a view to further action in this area.

CONSIDERATIONS FOR LIGHT-WATER-COOLED POWER REACTORS. On June 9, 1971, the Atomic Energy Commission proposed (36 F. R. 1113) an Appendix I to 10 CFR Part 50 setting forth new design and operation guides for light-water-cooled power reactors. After a careful examination of current waste treatment technology for such plants, EPA concluded that the proposed design guides could be implemented so that design doses to individuals offsite would routinely be limited to less than 5 millirems per year, and that operational control measures could be taken to limit doses to the maximum exposed individual to within a range of 20-40 millirems per year under all conditions of normal operation. Under these circumstances, the Agency decided for the time being not to exercise its authority to establish generally applicable environmental radiation standards for light-water-cooled nuclear power reactors. This decision was publicly stated by the Agency on February 23, 1972, at the

rulemaking hearing on proposed Appendix I conducted by the Atomic Energy Commission. Continuing review of the environmental factors involved in the design and operation of light-water-cooled nuclear reactors, coupled with the need for comprehensive standards for the entire uranium-based fuel cycle, as well as specific standards for each component within the cycle, has led us to conclude that numerical standards for reactors should be included in this rulemaking.

As a result of our current analysis, we have concluded that nuclear power reactors can be designed and operated under most conditions at the design levels proposed by the AEC in Appendix I to 10 CFR 50. Accordingly, the Agency has specified a proposed annual dose limit for individuals in the general public of 5 millirems to the whole body and 15 millirems to the thyroid due to normal operations at a reactor site. The standard for discharges to the general aquatic environment is 5 curies per year and tritium entering the general environment is limited to 600 curies per year, for each 1000 megawatts of electrical generating capacity at the site.

With respect to light-water-cooled nuclear power reactors it is important: 1) to set standards which will result in radiation doses to the public which are at the lowest levels consistent with technical and economic feasibility, and 2) to maintain the benefit of a continuous uninterrupted supply of electric power to society during power energy crises, even though standards for normal situations might be exceeded. Such a two-fold objective raises the question whether to impose strict standards at the expense of possible shutdowns which are not justified on a risk-benefit basis during power shortages or to establish liberal

standards which would minimize the possibility of such shutdowns. The Agency has attempted to strike a balance between these two goals in the standards proposed by providing for operational variances which satisfy specified criteria in order to avoid closing down power reactors during periods of emergency power demand. The approach of granting operational variances depends to a large degree upon judgments concerning necessary power reserves, overall plant safety, and public health. EPA anticipates that its proposal in this area will be explored in detail during public hearings on these proposed standards.

The variance proposed is in order to allow orderly delivery of power during power-shortage conditions when operation of a given power reactor at emissions greater than normal is critical to the ability to meet an extraordinary power demand condition. The Atomic Energy Commission has effective regulatory mechanisms for controlling the daily operation of nuclear power plants, and the Agency believes the Commission will effectively carry out these proposed variance conditions in such a manner as to achieve good public health protection. An increase to three times the annual dose limit for normal operations is proposed provided a specified emergency demand situation exists and the reactor is otherwise safe to operate. Demand conditions satisfying these variance conditions are expected to occur only rarely, and then only for short periods once or twice annually. The variance is available only when the utility is unable to satisfy demand conditions through the purchase of other power and when normal AEC safety and occupational regulations are met, and then only to the extent that a demonstrable need for excessive emissions exists. When the variance is used a report

is required through normal public channels to the Federal agency which regulates the utility. These reports should document the rate and cause of the abnormal emissions, the power demand and reserve conditions which justified the operation, and the actions taken to minimize any increased doses to individuals in the general environment.

CONSIDERATIONS FOR FUEL REPROCESSING PLANTS. Although most radioactive products produced during fission are retained within reactor fuel elements, the processing of fuel elements destroys these barriers and a variety of radionuclides become available for release in potentially large amounts at fuel reprocessing sites. Krypton-85, tritium, plutonium, iodine-129, and possibly other long-lived radionuclides are of particular significance in that they have the potential to enter the general atmospheric and hydrological environments and expose large populations over long periods of time. Exposure due to releases of krypton-85 and tritium can be worldwide. Even though all of these radionuclides are amenable to control at plant sites so that individual exposures are small, the total population exposure in person-rems can be large because of their persistence in environmental pathways, for many decades in the case of krypton-85 and tritium, and possibly for hundreds of thousands of years for plutonium and the actinides, and millions of years for iodine-129.

Generally applicable environmental standards are proposed for fuel reprocessing plants because several are expected to be in operation during the next several years. However, in view of the environmental risks involved, the Agency is currently evaluating whether future fuel reprocessing ought to be limited until a viable plutonium-based power

industry exists. Important factors in this evaluation are: 1) uncertainties in the schedule on which reprocessing to supply plutonium recycled fuels and the plutonium-based fuel cycle are required and justified, 2) the true market value of plutonium, 3) the capability to supply sufficient virgin uranium economically, and 4) the degree to which the costs of dealing with remaining environmental aspects of the industry will affect the desirability of reprocessing fuel to recover uranium.

The Agency has performed a technical analysis of the environmental effects of normal effluents from fuel reprocessing, the efficiency of control technology available for effluent reduction, and the costs of such reduction. Four significant areas in which fuel reprocessing presents a significant environmental threat were identified. First, there will be worldwide exposure due to the gradual environmental buildup of krypton-85 from the U.S. fuel reprocessing industry. The worldwide impact of this radionuclide is considerable larger than the regional or national impact from this industry. Second, large doses to individuals may occur as a consequence of failure to apply currently available controls and reasonable fuel-cooling times, as a result of discharges of iodine-131 and other short-lived radionuclides. Third, unless currently available controls are rigorously applied, the environmental buildup from long-lived iodine-129, plutonium-239, and several other alpha-emitting transuranic isotopes could become substantial. And finally, there is no control currently available for tritium, the largest potential producer of health effects after krypton-85. The current design practice of eliminating liquid discharges from

the main process stream results ...tium being discharged to the atmosphere, rather than to the w... ...athway. Even though this may avoid release of other radioacti... ...erials, the impact of tritium releases to the atmosphere can, ... certain circumstances, result in considerably larger impact than ... the liquid discharge route.

The Agency has proposed envir... ...tal radiation standards for fuel reprocessing plants to control e... the four areas identified above. Because of their toxicity and per... ...nce, discharges of plutonium and other particulate alpha-emitting ... ...ides to the general environment should be as low as possible. Fo... ...tely, highly efficient means for the removal of plutonium and othe... ...tinides are available at low cost and are well developed. Standard... limit the number of curies of these nuclides released to the ge... ...l environment per year are proposed to limit the long-term buildup of ... ...e materials which should provide protection against potential healt... ...ffects over many generations.

Recently developed control tec... ...ques offer efficient methods of cost-effective supplementary contr... ...or the removal of radioiodines. At the levels of control achievabl... ...using these techniques it is possible to maintain annual doses ... infant thyroids below 15 millirems. Additional measures available for ... ...rol of iodine include fuel cooling prior to processing, site selectio... ...d access control, careful environmental monitoring, and acti... control of exposures via milk. On the basis of the availability of those and other control techniques and measures, therefore, it is propose... to limit the maximum annual dose to the whole body or any organ of any individual from fuel reprocessing activities to 15 millirems from a... ...dionuclides, including iodine-131.

The removal of krypton-85 from spent fuel reprocessing streams must be considered of high priority in terms of its potential for long-term public health impact over the entire world. A variety of highly efficient techniques are available to accomplish this, although no facility has yet installed such control. The Agency proposes that the amount of krypton-85 entering the general environment from fuel reprocessing be limited to less than one percent of the total inventory of krypton-85 in fuel received for processing. In order to allow the industry time to implement this standard, its effective date has been specified as 48 months after the effective date of this rulemaking. In view of the fact that systems have been offered by commercial vendors at performance levels sufficient to limit discharges to a fraction of a percent of the krypton-85 inventory in fuel received, the Agency will continue to examine the performance of this technology to determine how far below the proposed standard future required levels might be reasonably set. An exclusion from this standard for krypton-85 is proposed for the single operating plant in existence prior to this rulemaking, since it is of small capacity (1 metric ton of fuel per day processed) and retrofitting would constitute an unreasonable economic burden. If, however, that facility adds to or changes its processing capacity be more than 50 percent of its present capacity, it would be required to satisfy the proposed standard for krypton-85 after such modification.

No limit is proposed now for tritium entering the general environment from fuel reprocessing, since the availability of technology for controlling this discharge and its costs are uncertain at the

present time. Since tritium levels in the general environment are expected to become significant by the late 1980's, and tritium will present the largest potential population impact from the uranium fuel cycle after release of krypton-85 has been controlled, the Agency believes that final development and installation of controls to minimize the environmental buildup of tritium due to releases from uranium fuel reprocessing will then become essential. A future rulemaking is contemplated dealing with tritium releases from reprocessing plants built after 1978.

Current designs for new reprocessing plants propose no liquid effluents as a result of normal operations. This practice will usually result in minimum population impact from all radionuclides except, in some circumstances, tritium. This mode of operation is preferred, except in those instances where it can be demonstrated that radionuclide discharges in liquid effluents will result in lower total discharges or radiation doses to surrounding populations than would result if equivalent quantities were discharged via airborne effluents. This consideration is especially important for tritium discharges, since its population impact is governed primarily by the characteristics of sites with respect to population distribution and water use. For example, tritium discharges to the ocean from seacoast sites are expected to result in a lower total impact than atmospheric discharges at such sites.

Pursuant to the Atomic Energy Act of 1954, as amended, notice is hereby given that adoption of the following addition to 40 CFR Part — is contemplated. All interested persons who wish to submit comments or

suggestions in connection with this proposed rulemaking are invited to send them to the Office of Radiation Programs, Environmental Protection Agency, Washington, D.C. 20460, within 60 days after publication of this notice in the Federal Register. Within this same time period, interested parties are also invited to indicate their desire to participate in a public hearing on the proposed rulemaking to be conducted approximately 10 days after the comment period ends. Comments and suggestions received after the 60-day comment period will be considered if it is practical to do so, but such assurance can only be given for comments filed within the period specified. Comments and all technical support documents for this rulemaking may be examined in the Agency's Public Affairs Office, 4th and M Streets, S. W., Washington, D.C. 20460. Single copies of the Statement of Considerations and the technical report entitled "Environmental Analysis of the Uranium Fuel Cycle" are also available upon request at this same address.

John R. Quarles
Acting Administrator

Pre-Agh Are - Proposal

PART____

ENVIRONMENTAL RADIATION PROTECTION STANDARDS FOR NORMAL OPERATIONS OF ACTIVITIES IN THE URANIUM FUEL CYCLE

A new Part ____ is proposed to be added to Chapter ____, Title 40, Code of Federal Regulations as follows:

SUBPART A - GENERAL PROVISIONS

-.01 Applicability

The provisions of this Part apply to persons owning or operating facilities which are part of the Uranium Fuel Cycle.

-.02 Definitions

a) "Uranium fuel cycle" includes the operations of milling of uranium ore, conversion of uranium, enrichment of uranium, fabrication of enriched uranium, generation of electricity by a light-water-cooled nuclear power plant, reprocessing of spent reactor fuel, and transportation of any radioactive material in support of these operations, but excludes the reuse of recovered non-uranium fissile products produced in the cycle.

b) "General environment" means the total terresterial, atmospheric and aquatic environments outside the boundaries of locations under the control of persons processing or using radioactive material.

c) "Radiation" means any or all of the following: alpha rays, beta rays, gamma rays, X-rays, neutrons, high-speed electrons, high-speed protons, and other atomic particles; but not sound or radio waves, or visible, infrared, or ultraviolet light.

d) "Radioactive material" includes any such material which emits radiation.

e) "Uranium ore" is any ore which contains by weight one-twentieth of one percent (0.05%) or more of uranium.

f) "Curie (Ci) of Radioactive material" is equal to that amount of material that produces 37 billion nuclear transformations per second. One "millicurie" of radioactive material produces 37 million nuclear transformations per second.

g) "Dose" means the quantity of radiation absorbed, per unit of mass, by the body or by any designated portion of the body. When the regulations in this part specify a dose during a period of time, the dose means the total quantity of radiation absorbed, per unit of mass, by the body or by any designated portion of the body during such a period of time.

h) "Rem" is a measure of the dose of any ionizing radiation to the body tissue in terms of its estimated biological effect relative to a dose of one roentgen (r) of X-rays. (One millirem (mrem) = 0.001 rem.)

i) "Year" means any calendar year.

j) "Person" means (i) any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, Government agency, any State, any foreign government, any political subdivision of any such government or nations, or other entity and (ii) any legal successor, representative, agent, or agency of the foregoing.

k) "Individual" means any human being.

l) "Member of the public" means any individual that potentially could receive a radiation dose in the general environment whether he may or may not be also exposed to radiation in an occupation associated with the uranium fuel cycle.

m) "Facility" means any structure or combination of structures in which any operation as defined in paragraph -.02 a) as part of the uranium fuel cycle is conducted.

n) "Site" means any location under the exclusive control of a person wherein one or more operations or activities within the uranium fuel cycle are conducted.

o) "Site boundary" means the line inside of which the ingress or egress of members of the general public is controlled by the person conducting activities on the site.

p) "Power emergency" shall mean the occurrence or imminent occurrence as determined by the responsible power dispatcher of a power system in any part of the interconnected systems of a utility or utilities of abnormally low voltage, abnormally high or low frequency, or overload of tielines or generating equipment (i) of such magnitude as seriously to threaten the continuity of operations or the safety of equipment of electric utility systems or their customers, and (ii) which requires the taking of remedial measures within a time so short as reasonably to preclude effective consultation as to such measures among operators of the affected systems.

q) "Responsible power dispatcher" means the employee of the electric utility owner, (or of the Power Pool in which the electric utility is a participant) on duty at any given time at the Power Control Center of the electric utility (or of the Power Pool) then having immediate operating responsibility for analysis of operations and the security of the electric utility power system (or of the integrated power systems of the Pool participants).

-.03 Address

All requests, reports, submittals, and other communications to the Environmental Protection Agency should be addressed to the Director, Criteria and Standards Division, Office of Radiation Programs, Environmental Protection Agency, 4th & M Streets, S.W., Washington, D.C. 20460.

-.04 Availability of Information

Emmission data provided to, or otherwise obtained by, the Administrator in accordance with the provisions of this part shall be available to the public.

Any records, reports, or information, other than emission data, provided to, or otherwise obtained by, the Administrator in accordance with the provisions of this part shall be available to the public, except that upon a showing satisfactory to the Administrator by any person that such records, reports, or information, or particular part thereof (other than emission data), if made public, would divulge methods or processes

entitled to protection as trade secrets of such person, the Administrator will consider such records, reports, or information, or particular part thereof, confidential in accordance with the purposes of section 1905 of title 18 of the United States Code, except that such records, reports, or information or particular part thereof, may be disclosed to other officers, employees, or authorized representatives of the United States concerned with carrying out the provisions of the standards or when relevant in any proceeding pursuant to the standards.

SUBPART B - GENERAL STANDARDS FOR NORMAL URANIUM FUEL CYCLE OPERATIONS

-.10 Applicability

The provisions of this Subpart apply to all planned controlled discharges of radioactive material to the general environment and radiation doses to members of the public from any site containing any facility or operation which is part of the uranium fuel cycle.

-.11 Environmental Standards

a) For any site covered by this Subpart, the total quantity of uranium and its daughter products, except radon-222, entering the general environment shall be less than one curie per year for each separate facility, other than light-water-cooled reactors and fuel reprocessing plants, at the site.

b) For any site covered by this Subpart, regardless of the number of facilities located thereon, the annual dose to

the whole body or any organ of any exposed individual who is a member of the public shall be less than 15 millirem, or, if one or more light-water-cooled nuclear power reactors are located on the site, the limits allowed under SUBPART C, or, if one or more fuel reprocessing plants are located on the site, the limits allowed under SUBPART D, whichever is higher.

-.12 Effective Date

The standards for all activities covered by this Subpart shall take effect 12 months from the effective date of this rulemaking.

SUBPART C - SPECIFIC STANDARDS FOR PLANNED CONTROLLED DISCHARGES FROM LIGHT-WATER-COOLED NUCLEAR POWER REACTORS

-.20 Applicability

The provisions of this Subpart apply to planned, controlled discharges of radioactivity to the general environment and radiation doses to members of the public from single sites containing solely light-water-cooled nuclear power plants.

-.21 Environmental Standards

For any site covered by this Subpart regardless of the number of facilities located thereon:

a) The annual dose to the total body or any organ, excepting the thyroid, of any exposed individual who is a member of the public from all radionuclides released from the site, except radioiodine, shall be less than 5 millirems.

b) The annual dose to the thyroid of any exposed individual who is a member of the public shall be less than 15 millirems.

c) The total quantity of all radionuclides, excepting tritium, discharged to the general aquatic environment from a site shall be less than 5 curies per year for each 1000 megawatts of nuclear electrical generating capacity at the site.

d) The total quantity of tritium discharged from a light-water-reactor site shall be less than 600 curies per year for each 1000 megawatts of nuclear electrical generating capacity at the site.

-.22 Variances

When persons subject to this Subpart (or Subpart B) cannot meet the standards for light-water-cooled reactors and any portion of the power which could be generated by such a reactor is required to prevent a power emergency, a variance may be used subject to the following conditions:

a) Releases of radioactive materials are kept as low as possible.

b) The site to which the variance is applied utilizes it only so long as is necessary to meet the power emergency,

c) All power available from inside or outside the system has been utilized and/or purchased and appropriate load shedding has occurred,

d) The organ and whole body dose rate limits specified in Section____.21 a) and b) for individuals who are members of the public do not exceed an annual dose of 15 millirems for all radionuclides, excepting radioactive iodine, and an annual dose of 45 millirems to the thyroid from radioactive iodine.

e) Information upon which the variance is based be made a matter of public record concurrent with the use of the variance.

-.23 Effective Date

The standards for all sites containing activities covered by this Subpart shall take effect within 12 months of the effective date of this rulemaking.

SUBPART D - SPECIFIC STANDARDS FOR PLANNED CONTROLLED DISCHARGES FROM URANIUM FUEL REPROCESSING PLANTS

-.30 Applicability

The provisions of this Subpart apply to planned controlled discharges of radioactivity to the general environment and radiation doses to members of the public from single sites containing solely fuel reprocessing plants.

-.31 Environmental Standards

For any site covered by this Subpart

a) The total discharge to the general environment of radioactive material for each 1,500 metric tons of uranium fuel processed shall be less than one

millicurie of plutonium-239, one curie of other transuranic isotopes and 0.1 curies of iodine-129.

b) The total quantity of krypton-85 discharged to the general environment shall be less than one percent of the total inventory of krypton-85 in the fuel received for reprocessing.

c) The annual dose to the whole body or any organ of any exposed individual who is a member of the public shall be less than 15 millirems.

-.32 Effective Date

a) The effective date of the standards for all activities covered by this Subpart, excepting those for krypton-85, shall be 24 months from the effective date of this rulemaking.

b) The effective date for removal of 99 percent of the krypton-85 in the inventory received for reprocessing shall be 48 months from the effective date of this rulemaking for all plants exclusive of those of 300 tons per year capacity or less which commenced operation prior to January 1, 1970. If such plants are modified to increase the processing capacity to more than 450 tons per year, the standard of 99 percent removal of krypton-85 shall apply when the modification is complete.

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

October 19, 1973

MEMORANDUM FOR: THE PRESIDENT

FROM: Dixy Lee Ray

SUBJECT: AEC Position on Division of Responsibilities and Authorities Between the Atomic Energy Commission and the Environmental Protection Agency

Summary of AEC Position

AEC and EPA have certain related statutory responsibilities and authorities from the standpoint of radiation control. AEC's basic position with respect to the interface between those responsibilities and authorities is as follows:

a. AEC's and EPA's responsibilities and authorities should be coordinated in the overall public interest and in accordance with the President's direction to: "reduce excessive regulatory and administrative impediments which have delayed or prevented construction of energy-producing facilities; and streamline our governmental procedures for licensing and inspections, reduce overlapping jurisdictions and eliminate confusion generated by the government." Thus, these responsibilities and authorities should be complementary rather than duplicative.

b. EPA, rather than AEC, should establish generally applicable radiation standards for the protection of the general environment outside the boundaries of nuclear facilities or other activities licensed by the AEC under the Atomic Energy Act. Such generally applicable standards should be developed on the basis of a comparative-risk analysis and a general review of technology, should be based on normal conditions of operation rather than accidents, and should be in the nature of ambient standards rather than effluent or discharge limitations which are directly related to "hardware" and which are imposed by AEC as an integral part of its statutorily required and long-established licensing process.

c. AEC, rather than EPA, should specify the legal controls concerning radiation safety aspects of siting and design of nuclear facilities (such as nuclear electric power plants), operating procedures, and the limits on the small amounts of radioactive materials that may be emitted from nuclear facilities (and other

activities licensed by AEC) as a result of normal operations. In imposing such emission limits, AEC will implement and enforce, through its comprehensive program of licensing, standard-setting, inspection and enforcement, such generally applicable standards as are established by EPA in accordance with paragraph b. above.

AEC's position is based upon: (a) the text of Reorganization Plan No. 3; (b) the "legislative history" associated with the Plan; (c) the fact that AEC has already established a comprehensive program of licensing, standard-setting, inspection, and enforcement over nuclear facilities and activities (and must continue to carry out such a program in the exercise of its responsibilities under the Atomic Energy Act); (d) the fact that under that program the safety record of the nuclear industry has been outstanding; (e) AEC's demonstrated scientific competence and existing staff capabilities in the areas in question; and (f) the sound public policy that needless and wasteful duplication of effort should be avoided. The legal and policy support for the AEC position is set out in Attachment "A".

EPA's Proposed Fuel Cycle Standards

For the reasons stated below, the proposed EPA uranium fuel cycle standards (an analysis of which is contained in Attachment "B") are not in accord with the division of responsibilities and authorities described above. Moreover, they are not technically supportable in several respects and represent a wasteful, conflicting and unnecessary duplication of an AEC rulemaking proceeding which was initiated in 1971 and is now nearing completion. This AEC proceeding (which is described in greater detail in Attachment "C") involves a new Appendix I to 10 CFR Part 50 that would set forth design objectives and limiting conditions of operation to keep levels of radioactivity in effluents from light-water-cooled nuclear power reactors as low as practicable. A three-volume NEPA environmental impact statement was issued by AEC in connection with Appendix I. EPA participated in public hearings conducted by AEC on the Appendix. A copy of the testimony of Mr. David Dominick of EPA, supporting the AEC approach, is attached (Attachment "D").

Subpart C of the proposed EPA standards sets forth specific rather than generally applicable standards for planned controlled discharges from light-water-cooled nuclear power reactors. They would impose radionuclide release limits, dose limits and requirements for implementing such limits - matters that are specifically addressed in the AEC licensing and regulatory process.

The proposed EPA standards conflict and are inconsistent with the implementation approach in the AEC's Appendix I. EPA, since February 1972, was on record as supporting this AEC approach. The new standards proposed by EPA constitute a reversal of EPA's prior position. Further, the EPA standards include operating requirements related to power emergencies that are unrealistic and probably unworkable. Enforcement of such standards could

result in frequent shutdowns of nuclear power reactors without any significant contribution to the public health and safety or environmental protection. EPA does not propose to issue an environmental impact statement in connection with its proposed standards.

The requirements, in Subpart D of the EPA standards relating to the removal of krypton-85 from uranium fuel reprocessing plants, are beyond the state of the proven, practicable technology and, even if implemented, would reduce the average annual whole body exposure to the U.S. population by only 0.003 millirem by the Year 1980 and by 0.04 millirem by the Year 2000. This may be compared with the average annual exposure of the U.S. population from natural background radiation of about 125 millirems per year. It would be necessary for the industry to mount a heavily accelerated program to attempt to achieve the objectives proposed in the EPA standards within the time period permitted. We do not believe the requirements on krypton-85 removal can be justified on cost-effectiveness and health and safety bases at this time.

Implications of Proceeding with EPA's Proposed Standards

If the proposed EPA standards were adopted, AEC would be required by Reorganization Plan No. 3 to implement and enforce them.* Since they conflict with AEC's Appendix I, the AEC would need to assess the utility of continuing with its current rulemaking proceeding which, of course, would be disrupted by such a course of events. This proceeding has thus far involved several man-years of effort and the environmental impact statement alone is estimated to have cost $325,000.

In addition, there would be an impairment of AEC's ability to achieve the lowest practicable release of radioactive materials through a combination of appropriate siting factors, design requirements and operating procedures. This would be due to the fact that the proposed EPA standards are set at

---

* In the Federal Register notice which accompanied publication of proposed Appendix I on June 9, 1971, AEC included the following statement at the request of EPA: "EPA has under consideration generally applicable environmental standards for these types of power reactors. AEC has consulted EPA in the development of the guides on design objectives and limiting conditions for operation set forth below to control radioactivity in effluent releases. If the design objectives and operating limits established herein should prove to be incompatible with any generally applicable environmental standard hereafter established by EPA, the AEC will modify these objectives and limits as necessary."

This statement continues to reflect AEC policy. The disagreement with EPA relates to the type of generally applicable environmental standards that are appropriate for promulgation by EPA - not to AEC's responsibility to implement such standards.

such a level that implementation by AEC which gives credit to specific site characteristics and takes into account the need for reasonable operating flexibility, because of uncertainties in fuel element performance and rad-waste treatment performance, is not possible.

Implementation of the proposed EPA standards would have a significant impact on the nuclear industry. The AEC 1972 data on releases of radioactive material from 25 light-water-cooled operating power reactors indicate that 11 of the reactors, while meeting the AEC's Appendix I with its operating flexibility, would not have met EPA's curie limits for liquid releases which give no credit for site characteristics with respect to exposures. It appears that all of these reactors would have to make some modifications in their waste treatment systems within 12 months after the effective date of the regulation without any meaningful reduction in population doses. Some of these modifications would involve major changes in design of waste treatment systems and interruption of power reactor operation. In five cases the quantity limit on tritium could require replacing the fuel elements in the core of the reactor.

Implications of Not Proceeding with EPA's Proposed Standards

If EPA does not issue standards of the type proposed for the nuclear fuel cycle, AEC will complete its rulemaking proceeding on proposed Appendix I and continue to implement it in order to keep radiation exposures to the public as low as practicable. (As a practical matter, AEC has, since 1971, already implemented Appendix I guides in evaluating nuclear power plants.) Further, AEC has underway extensive studies on the remaining types of plants in the nuclear fuel cycle to develop data on technology, control measures and costs. This will provide a firm basis for rulemaking to assure that exposures from effluents from all plants in the fuel cycle are maintained at levels which are as low as practicable. In connection with such rulemaking, AEC would prepare NEPA environmental statements. EPA would have full opportunity to review such proposed regulations and environmental statements and to provide comments and recommendations to AEC.

We believe that from the standpoint of the nuclear industry - and, more importantly, from the overall public interest - a single Federal standard addressed to the matters dealt with above would avoid confusion and duplication of effort and would achieve the paramount objective of protection of the public health and safety.

From the standpoint of assuring adequate protection of public health and safety and the environment with respect to the operation of nuclear facilities, we do not believe that issuance of the EPA standards will make any significant contribution. AEC has estimated that by the Year 2000 the average whole body exposure to the U.S. population from commercial nuclear power facilities will be about 0.2 millirem per year. Similarly the Advisory Committee on the Biological Effects of Ionizing Radiation of the National Academy of Sciences estimated in the BEIR Report issued in November 1972 that the average whole

body dose to the U.S. population from normal operation of nuclear power reactors in the Year 2000 would be about 0.17 millirem. We are confident that by applying AEC's as low as practicable requirement in the licensing process to all nuclear facilities, the total exposure from such facilities in the Year 2000 will be a small fraction of the exposure from natural background radiation.

AEC Recommendation

EPA would develop generally applicable standards that would specify the annual radiation doses that could be received by a member of the public and the total population as a result of releases of radiation and radioactive materials to the environment from all sources of exposure or from classes of activities such as the entire light-water-cooled nuclear electric power plant fuel cycle, including uranium milling, conversion of uranium, fuel fabrication, generation of electricity, and fuel reprocessing. AEC would, in turn, implement such standards by establishing emission limits for individual activities in the fuel cycle, including operation of nuclear electric power plants. Further explanation of this recommendation is contained in Attachment "E".

Chairman

Attachments:

A - Basis for AEC Position Concerning Division of Responsibilities and Authorities between EPA and AEC

B - September 5, 1973 letter fm Commissioner Doub to Quarles w/ Technical Comments, w/Oct. 12, 1973 letter Rogers to Mills

C - Status of AEC Requirements for Control of Radioactive Materials in Power Reactor Effluents

D - Cy of Transcript of Statement of David D. Dominick, Asst. Admin. Office of Categorical Programs on Behalf of the EPA

E - Summary of AEC Position on Relative Responsibilities of EPA and AEC on Standards to Control Radioactivity in Effluents for Normal Operations w/Annex 1 - AEC Proposed Compromise EPA Generally applicable standard for the Protection of the General Environment for the Uranium Fuel Cycle

ATTACHMENT "A"

BASIS FOR AEC POSITION CONCERNING DIVISION OF RESPONSIBILITIES AND AUTHORITIES BETWEEN EPA AND AEC

The Atomic Energy Commission (AEC), created by the Atomic Energy Act of 1946 (amended in its entirety by the Atomic Energy Act of 1954), and the Environmental Protection Agency (EPA), created by Reorganization Plan No. 3 of 1970, have certain related statutory responsibilities and authorities under the Act and Plan from the standpoint of radiation control. In addition, both agencies have certain responsibilities and authorities concerning environmental matters under the National Environmental Policy Act of 1969 (NEPA), and EPA is vested with specific responsibilities concerning discharges into the waters of the United States under the Federal Water Pollution Control Act (FWPCA).

a. Authority over Radioactive Emissions from Nuclear Facilities

The peaceful use of atomic energy was the first technology to be subject to Federal control from its inception. Under the Atomic Energy Act, no person may construct or operate a nuclear facility (a facility which utilizes radioactive materials such as a nuclear electric power plant) or possess or use most radioactive materials except pursuant to an AEC permit or license. In addition, the Atomic Energy Act authorized AEC to promulgate regulations specifying design and siting requirements for nuclear facilities to protect against possible radiation hazards, including measures to protect against accidental releases of radioactive materials, and limits on the amounts of radioactive materials that may be released from nuclear

facilities, and other activities involving nuclear materials, as a result of normal operations.

Under the Act, the AEC established a comprehensive program of licensing of nuclear facilities and activities, standard-setting, regular inspections of licensed activities, and enforcement. Detailed regulations concerning siting, design, and other aspects of nuclear facilities and activities have been published in 10 CFR Chapter 1.

The Atomic Energy Act also established the Federal Radiation Council (FRC) whose function was to advise the President on radiation matters affecting health, and to provide recommendations to Federal agencies (including AEC) regarding the formulation of radiation standards. However FRC had no licensing or regulatory authority

Reorganization Plan No. 3 of 1970 grew out of recommendations of the President's Advisory Committee on Executive Reorganization, chaired by Mr. Roy L. Ash. The philosophy underlying the Plan was that it was not possible to bring together into one Federal agency all executive branch functions dealing with environmental protection and thereby create an environmental "czar". Rather, the central and guiding concept was to consolidate the general standard-setting functions of Federal agencies in the environmental protection field.

This underlying concept was reflected in the division of responsibilities in the radiation protection field. Under the Plan the following functions

with respect to radiation standards were transferred to the new EPA:

> "The functions of the Atomic Energy Commission under the Atomic Energy Act of 1954, as amended, administered through its Division of Radiation Protection Standards, to the extent that such functions of the Commission consist of establishing generally applicable environmental standards for the protection of the general environment from radioactive material. As used herein, standards mean limits on radiation exposures or levels, or concentrations or quantities of radioactive material, in the general environment outside the boundaries of locations under the control of persons possessing or using radioactive material."
>
> "All functions of the Federal Radiation Council...."

At the same time, the President's message transmitting the Plan to the Congress stated that "AEC would retain responsibility for the implementation and enforcement of radiation standards [promulgated by EPA] through its licensing authority".

Since the FRC had no licensing or regulatory authority, the only possible source for EPA responsibility and authority over radioactive materials under the Plan is the single function transferred from AEC. However as the Plan itself and the accompanying statement by the President make clear, the function transferred from AEC was confined to establishing <u>generally applicable</u> standards regarding limits on radiation exposures or levels or concentrations or quantities of radioactive materials <u>in the general environment outside the boundaries of locations under the control of persons possessing or using radioactive material</u> [such as persons licensed by AEC to operate nuclear electric power plants]. Clearly standards which are only applicable to areas beyond the control of persons possessing or using the

radioactive materials, are in the nature of ambient standards, and are not emission standards which would be directly applicable to the persons actually possessing or using the materials and areas within their control. It was specifically contemplated that implementing action would have to be taken to relate the general standards for the general environment to the persons actually operating nuclear facilities and possessing or using radioactive materials. As the President's message makes clear, this was to be the role of AEC.

There was substantial discussion during the House and Senate hearings on the Reorganization Plan regarding the respective functions of AEC and EPA. This "legislative history" confirms what common sense would indicate -- that emission limits on radioactive materials applicable to specific persons possessing or using the materials were regarded as an essential element of AEC's implementing role and not as an element of EPA's general environmental standard-setting function. Indeed establishment of such emission limits is an integral part of the safety review of the overall plant design and siting conducted by AEC. In the words of Mr. Ink of OMB, a principal Administration witness during the hearings, it is AEC which has "the competence and the know-how to see how a reactor is put together, and how it is designed, which, as you can appreciate, is a tremendously complex type of engineering and scientific undertaking. We have not tried to put into [EPA] that kind of scientific competence...."

Following enactment of the Federal Water Pollution Control Act Amendments

of 1972, EPA initially took the position that this legislation vested it with regulatory authority over discharges into United States waters of radioactive materials otherwise subject to regulation by the AEC. Subsequently, however, EPA adopted the position urged by the AEC that the term "pollutant", as used in that legislation, does not include radioactive materials subject to AEC regulation under the Atomic Energy Act.

However, despite the above, EPA proposes to establish specific limits for radioactive materials applicable to certain persons licensed by AEC, including persons licensed to operate nuclear electric power plants.* AEC believes this would go beyond the authority vested in EPA under the Reorganization Plan, and place EPA in an area where AEC rather than EPA has the scientific expertise and where AEC rather than EPA has established a comprehensive licensing and regulatory program.

In the past two years AEC has been conducting extensive rulemaking hearings, seeking in effect to establish more stringent and definitive limitations on the amounts of radioactive materials that may be released as a result of normal operation of individual nuclear electric power plants. The parties to this hearing were accorded full rights to present testimony and to cross-examine AEC expert witnesses and officials as to the basis for AEC's proposal. EPA made a statement at this hearing. EPA's proposal seeks to duplicate this AEC effort and, in the last analysis, supersede it by

* Proposed "Environmental Radiation Protection Requirements for Normal Operations of Activities in the Uranium Fuel Cycle", transmitted by EPA to AEC for comment on August 16, 1973.

initiating another rulemaking proceeding on the same subject under EPA auspices. Even apart from jurisdictional limitations discussed above, AEC believes that such an effort -- wastefully duplicative at best and, at worst, resulting in conflicting regulatory requirements by two Federal agencies -- would not be in the public interest.

Proposed Resolution

AEC proposes that EPA adopt generally applicable environmental radiation standards that would specify the annual radiation doses that could be received by a member of the public and the total population as a result of releases of radiation and radioactive materials to the environment from all sources of exposure or from classes of activities such as the entire light-water-cooled nuclear electric power plant fuel cycle, including uranium milling, conversion of uranium, fuel fabrication, generation of electricity, and fuel reprocessing. AEC would, in turn, implement such standards by establishing emission limits for individual activities in the fuel cycle, including operation of nuclear electric power plants.

b. Authority over Accident Prevention

In the past EPA has attempted to assert a kind of oversight authority over AEC accident protection functions. This position on the part of EPA is reflected, for example, in its insistence on direct participation in the Reactor Safety Study of accident probabilities and consequences currently being conducted by Professor Rasmussen of MIT under the Commission's auspices.

As indicated above, under the Atomic Energy Act AEC has been vested with broad authority over the design and siting of nuclear facilities to protect against accidental releases of radioactive materials. AEC's existing, comprehensive program for the licensing and regulation of such facilities is, of course, directed in large part to the prevention and control of nuclear accidents. At the time Reorganization Plan No. 3 of 1970 entered into effect, AEC's standard-setting functions in this regard were exercised primarily by its Division of Reactor Standards. The Division of Radiation Protection Standards, cited in the Plan in describing the functions transferred to EPA, exercised no functions in this area. The other entity cited in the Plan, the FRC, had no licensing or regulatory authority regarding protection against accidental releases of radioactive materials.

While AEC and EPA have been unable to agree as to the limits of their respective responsibilities and authorities in this area under Reorganization Plan No. 3, AEC and EPA have agreed upon the text of the radiation accident risk discussion to be included in environmental impact statements prepared by AEC, pursuant to NEPA, for nuclear electric power plants. A copy of this text is attached (Annex 1).

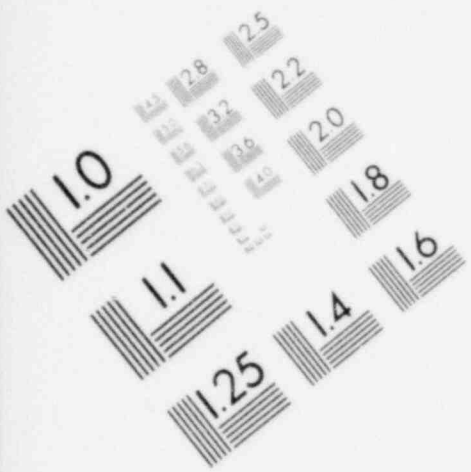
Proposed Resolution

AEC will continue to include the agreed upon discussion of radiation accident risk in its environmental impact statements. However, EPA should recognize that under the Reorganization Plan it has no legal authority concerning design and siting of nuclear facilities to protect against

accidental releases of radioactive materials.

c. Inspection of AEC Licensed Facilities

As indicated above, AEC has established a comprehensive program of regular inspections of persons licensed to possess and use radioactive materials and operate nuclear facilities. In the past there had been some disagreement between AEC and EPA regarding EPA's authority to inspect such licensed facilities. This has now been resolved by execution of a memorandum of understanding between the two agencies. A copy of this memorandum of understanding is attached (Annex 2). This memorandum of understanding recognizes that EPA has no independent legal authority to inspect AEC licensed facilities.



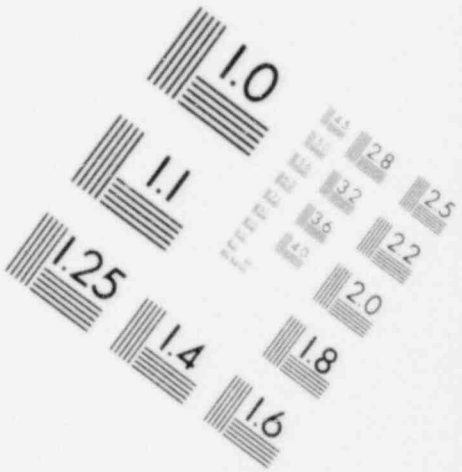
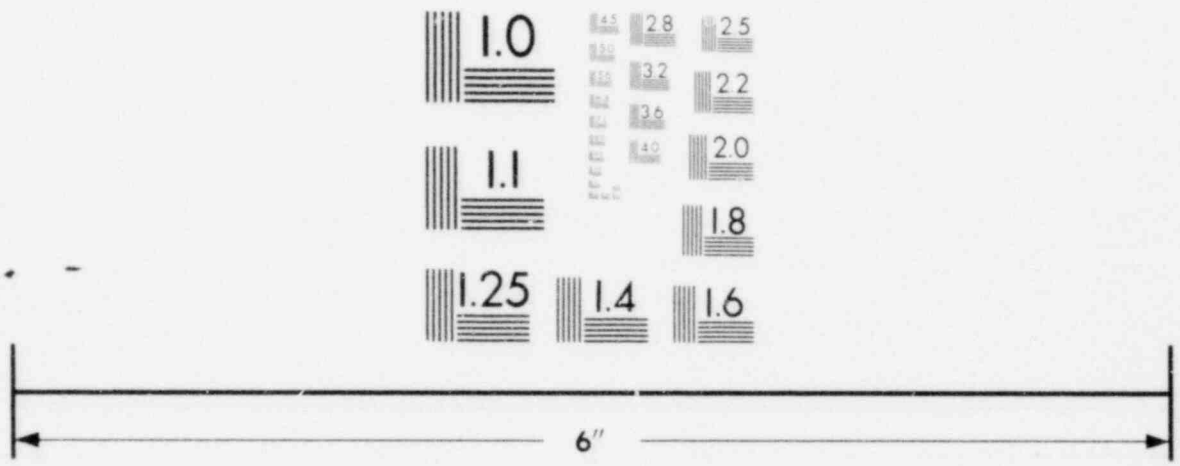
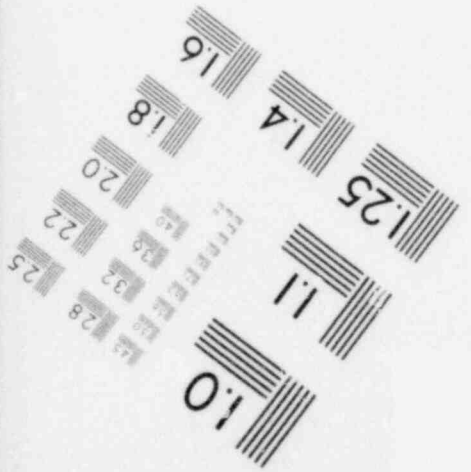
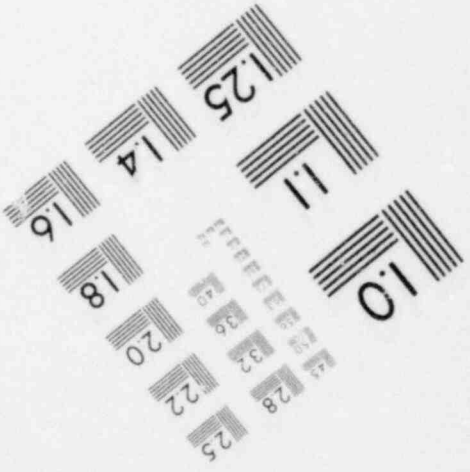


IMAGE EVALUATION TEST TARGET (MT-3)







ATTACHMENT "E"

SUMMARY OF AEC POSITION ON RELATIVE RESPONSIBILITIES OF EPA AND AEC ON STANDARDS TO CONTROL RADIOACTIVITY IN EFFLUENTS FOR NORMAL OPERATIONS

EPA generally applicable standards for the protection of the general environment should be ambient standards that establish acceptable upper limit environmental risks due to man-made radiation from all sources of exposure or from broad classes of sources of exposure. Such generally applicable standards would normally be in the form of radiation dose and dose commitment limits to individuals and populations. Such limits would be based on an acceptable level of risk taking into account the benefits derived from the nuclear power industry as compared with risks from alternative means of generating electrical power. The limits might also take into account a broad general consideration of the feasibility of meeting the standards based on the availability and cost of technology, uncertainties in the capability of performance of the technology and the need for operating flexibility. This latter consideration would be a generally applicable determination and would not represent a fine tuned cost-effective analysis of the "as low as practicable" level of radioactive materials in effluents from specific types of facilities based on design and operating parameters. Annex 1 is a draft model of a generally applicable standard for the fuel cycle.

The AEC under its authority to implement and enforce generally applicable environmental standards should maintain the authority to assure that generally applicable standards are met and to further achieve the lowest practicable releases of radioactive materials through a

combination of appropriate siting factors, design requirements for facilities and equipment, and operating procedures to assure operation in the public interest and to protect public health and safety. The implementation of the "as low as practicable" concept involves all of the same considerations of evaluation of specific designs of facilities to limit releases of radioactivity that are inherent in the licensing process. In the licensing process the AEC must, in addition to assuring that all plants operate within the generally applicable standards in the Commission's regulation, Part 20, establish "as low as practicable" effluent release limits on new types of facilities on a case-by-case basis. These limits are determined by examining in detail the design of the plant and operating procedures to achieve the objectives of "as low as practicable". This is the procedure that is presently followed for fuel reprocessing plants, fuel fabrication plants and other plants in the fuel cycle. As adequate experience is developed on a case-by-case basis numerical guides such as the AEC proposed Appendix I on design objectives and limiting conditions of operation for light-water-cooled power reactors are developed and issued on a generic basis. The AEC has underway a detailed study being conducted with the assistance of Oak Ridge National Laboratory to develop information on operating experience, the state of technology, cost of technology, and other information that will provide a solid basis for developing guides on "as low as practicable" levels of radioactivity in effluents for fuel cycle plants other than nuclear power reactors that are now covered by the proposed Appendix I.

Annex 1 to Attachment "E"

AEC PROPOSED COMPROMISE EPA
GENERALLY APPLICABLE STANDARD
FOR THE PROTECTION OF THE GENERAL ENVIRONMENT
FOR THE URANIUM FUEL CYCLE

A. The annual dose or dose commitment to a member of the public from radiation or radioactive materials released to the environment from the entire light-water-cooled nuclear power reactor fuel cycle should not exceed X millirems per year to the whole body, X millirems per year to the whole body, X millirems per year to the thyroid, X millirems to the skin, and X millirems to any other organ. (This would represent a dose limit not a design objective.)

B. The total annual population dose or dose commitment from radiation or radioactive materials released to the environment from the entire light-water-cooled nuclear power reactor fuel cycle should not exceed X person rems per year to the whole body. (The purpose of the person rem limit would be to deal with EPA's concern for population dose from both short-and long-lived radionuclides.)

The numerical values finally decided upon in the standards in (a) and (b) would be based on two considerations:

a. An acceptable level of risk taking into account the benefits derived from the nuclear power industry and in comparison with risk from alternative means of generating electrical power; and

b. A general consideration of the feasibility of meeting the numbers based on the technology and cost of technology available.

This latter consideration would be a broad determination and would not represent a fine tune cost-effectiveness analysis of what is "as low as practicable" for individual types of facilities. This would be reserved to AEC in implementing the generally applicable environmental standards. EPA standards would not include requirements on individual sites or facilities or any implementing requirements.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

00005

October 19, 1973

MEMORANDUM FOR: THE PRESIDENT

FROM: Russell E. Train

SUBJECT: AEC Opposition to EPA Radiation Standards

OFFICE OF THE ADMINISTRATOR

ISSUE: EPA has proposed standards for environmental releases of radioactivity from the nuclear power industry, based upon the authority transferred from AEC to EPA by Reorganization Plan #3. (TAB A) These standards are based on a balancing of health risks against the capabilities and costs of control technology, and therefore are related to classes of activity (e.g., reactors and fuel reprocessing). AEC objects to EPA's exercising its jurisdiction by issuing such standards and contends that EPA should set ambient standards that apply to the entire nuclear fuel cycle.

AUTHORITY: Reorganization Plan #3 of 1970 transferred to EPA the functions of the AEC to *"...establish generally applicable environmental standards for the protection of the general environment from radioactive material."* The Plan defined these standards to mean *"...limits on radiation exposures or levels, or concentrations or quantities of radioactive material, in the general environment outside the boundaries of locations under the control of persons possessing or using radioactive material."* Your message on the Plan established the EPA-AEC division of responsibilities as follows: *"...The Atomic Energy Commission's authority to set standards for the protection of the general environment from radioactive material would be transferred to the Environmental Protection Agency...AEC would retain responsibility for the implementation and enforcement of radiation standards through its licensing authority."*

There are no criteria for or constraints on *"generally applicable environmental standards"* set forth in Reorganization Plan #3 or in its legislative history.

THE PROPOSED STANDARDS: EPA's goal in developing standards for the nuclear power industry has been to implement your directive to develop our energy resources as rapidly as possible commensurate with a clean environment. EPA has balanced the short and long-term effects of planned releases on health against the costs of control and through these standards can assure, for these releases, that nuclear power is an environmentally acceptable means for achieving national energy goals. The EPA standards are proposed for public radiation exposures and quantities of long-lived radioactive materials in the environment outside AEC-licensed facilities. These kinds of limits are explicitly provided for by the above authority. The standards were determined to be reasonable by considering both the cost and technical feasibility of control technology. EPA cannot and should not set standards without such consideration for two reasons: 1) both agencies agree that it is prudent to assume that there is no threshold level for radiation effects in setting standards, that is, risk is proportional to dose all the way down to zero dose. Since there is no safe level of radiation, there is no logical way to set radiation standards other than to balance risks

against costs of control; and 2) the nuclear industry is too important to the nation's future power supply to ignore cost and technology considerations.

Since effluents, controls, and their costs differ for different classes of activity, EPA's proposed standards necessarily vary for different classes in the fuel cycle. However, the standards do not require the use of specific control mechanisms, types of equipment or siting conditions as is argued by AEC. EPA agrees that these are properly functions associated with implementation of standards. The implementation and enforcement of these standards at particular facilities (e.g., design, operating and monitoring requirements) are the responsibility of AEC. Therefore, EPA does not believe that these standards conflict in any way with AEC's responsibilities, and dual regulation of the industry is avoided.

Nevertheless, AEC argues that the establishment of standards for different classes of activity constitutes an *"implementation and enforcement"* function that only AEC can perform. However, if the AEC establishes standards of the type proposed by EPA, instead of EPA, it is not clear just what the AEC would be *"implementing and enforcing."* Apparently, to avoid this objection and the problems that would be associated with EPA not exercising the authority transferred in Reorganization Plan #3, the AEC recommends that EPA should set ambient standards applicable to the entire uranium fuel cycle. It is, therefore, AEC rather than EPA which is suggesting dual standards for the nuclear power industry. The AEC, not EPA, is suggesting that the nuclear fuel cycle should have to meet both source and ambient standards established by two different agencies.

PRACTICAL IMPLICATIONS OF PROCEEDING AS PROPOSED: Both agencies apparently agree that standards or guides should be set for each class of activity. This single EPA rulemaking would bring six major operations in the nuclear power fuel cycle, including reactors, to cost-effective levels of control comparable to those for reactors. AEC could then avoid its lengthy rulemaking procedures and needless duplication of work already done by EPA for the balance of the fuel cycle.

The AEC argues that EPA should not set these standards since AEC is developing guides for light-water reactors. EPA's standards are compatible with most of these guides. The conflict between EPA standards and AEC guides concerns the degree of operating flexibility available to AEC. EPA has already provided a variance above the standard to assure delivery of power during peak demand periods. AEC should provide information to justify the need for additional operating flexibility for older plants and to provide a margin in the absence of operating experience for large new plants. It should be noted that Appendix I was proposed by AEC after Reorganization Plan #3 and contrary to the advice of EPA. At the time Reorganization Plan #3 was signed, AEC had no standards for specific classes of activity.

Other implications of proceeding as proposed are: 1) control costs to industry are negligible but the benefit of having and meeting EPA standards, in terms of public acceptability, could be large, 2) EPA would carry out its charge under Reorganization Plan #3 for radiation as it does for other pollutants and in so doing, 3) EPA's standards would satisfy the directives of your recent energy messages to expedite the supply of energy while preserving a clean environment.

PRACTICAL IMPLICATIONS OF NOT PROCEEDING AS PROPOSED: If the standards are not issued as proposed: 1) the nuclear industry would be subjected to the uncertainty of not knowing when or what standards EPA might subsequently propose and would also have to wait for completion of the lengthy AEC processes for issuing five separate new regulatory guides for the balance of the fuel cycle; 2) EPA can anticipate increased pressure to establish similar standards under other less satisfactory authorities. EPA has already been challenged in court on its failure to control radioactive effluents under the 1972 Water Act; and 3) AEC's proposal to set ambient standards only is unworkable and would jeopardize EPA's environmental credibility. (TAB B)

ALTERNATIVES FOR RESOLUTION OF JURISDICTIONAL CONFLICT:

A. *Issue the standards as proposed, following normal interagency resolution of technical issues.*

This would resolve the issue in favor of EPA. Implementation at individual facilities or sites; specification of operating procedures, monitoring and reporting requirements; and enforcement of these standards would be vested in AEC.

B. *Modify the standards to specify variances to be exercised at the discretion of AEC in order to facilitate implementation for special reactor operating situations, following normal resolution of technical issues.*

This would give the AEC greater flexibility in establishing and enforcing limits at particular facilities. It will also permit AEC to introduce sufficient flexibility in applying EPA's standards to reactors when, in AEC's judgment, this is required to assure that the AEC's concerns about operational flexibility and alleged conflicts with Appendix I be satisfied. This alternative does, however, make the EPA standards less firm, although EPA would issue upper limits.

RECOMMENDATION: Alternative A. EPA believes that its proposed standards can be met without the need for additional operating flexibility beyond the variances for power emergencies presently provided in EPA's standards. The proposed standards are entirely within EPA's authority, were developed using the most rational approach available, can be met by industry cost-effectively, and would be beneficial to the rapid development of nuclear power.

_____ Approve _____ Disapprove _____ See Me

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

THE ADMINISTRATOR

Dear Mr. Fairbanks:

In accordance with the agreement reached at our meeting last Monday, namely that both AEC and EPA should address memoranda to the President on the subject of AEC's objection to EPA's exercise of its authority to set standards for the activities comprised in the uranium fuel cycle, I transmit herewith the required memorandum.

Consistent with the decision to address the jurisdictional issue first, and to reserve technical issues until the jurisdictional issue is settled, we have avoided dealing with what the precise numbers should be, exactly what sort of timetables are appropriate and similar technical issues. We have already provided you with the notice of proposed rule making that we propose to publish, together with the "quality of life" memorandum describing the proposal. You also have AEC's technical comments on the proposal and our response to those comments.

I feel that technical issues can and should be resolved by pursuing normal procedures, already established, for interagency review.

Sincerely yours,

Russell E. Train
Administrator

Mr. Richard Fairbanks
Room 100
Executive Office Building
Washington, D.C. 20500

TAB "A"

Language Relative to EPA Environmental Radiation Standards Authority

1. Reorganization Plan No. 3 of 1970.

"There are hereby transferred to the Administrator: ...

6) The functions of the Atomic Energy Commission under the Atomic Energy Act of 1954, as amended, administered through its Division of Radiation Protection Standards, to the extent that such functions of the Commission consist of establishing generally applicable environmental standards for the protection of the general environment from radioactive material. As used herein, standards mean limits on radiation exposures or levels, or concentrations or quantities of radioactive material, in the general environment outside the boundaries of locations under the control of persons possessing or using radioactive material."

7) "All functions of the Federal Radiation Council (42 U.S.C. 2021(h))."

2. The Message of the President Relative to Reorganization Plan Nos. 3 and 4 of 1970, July 9, 1970.

"Environmental radiation standards programs. -- The Atomic Energy Commission is now responsible for establishing environmental radiation standards and emission limits for radioactivity. Those standards have been based largely on broad guidelines recommended by the Federal Radiation Council. The Atomic Energy Commission's authority to set standards for the protection of the general environment from radioactive material would be transferred to the Environmental Protection Agency. The functions of the Federal Radiation Council would also be transferred. AEC would retain responsibility for the implementation and enforcement of radiation standards through its licensing authority."

3. AEC Federal Register Notice Proposing Appendix I Reactor Guidelines.

"EPA has under consideration generally applicable environmental standards for these types of power reactors. AEC has consulted EPA in the development of the guides on design objectives and limiting conditions for operation set forth below to control radioactivity in effluent releases. If the design objectives and operating limits established herein should prove to be incompatible with any generally applicable environmental standard hereafter established by EPA, the AEC will modify these objectives and limits as necessary."

Furthermore, the AEC apparently concedes, as EPA believes it must, that even ambient standards for the nuclear fuel cycle should take costs and achievability into account. In order to defend any ambient standard EPA developed, it would be necessary to show the releases estimated for each part of the fuel cycle. These estimates would undoubtedly be used by the public and the courts in evaluating AEC standards or guides for classes of activity. Thus little is gained and duplication is increased if EPA sets general ambient standards while the AEC sets standards for different classes of activity.

TAB "C"

EPA RESPONSE TO ARGUMENTS STATED IN AEC DRAFT PAPER

1. Nuclear safety. It is not at issue in the current controversy. The proposed standards relate entirely to what degree of control should be exercised over chronic emissions.

2. EPA has less competence than the AEC with respect to radioactive effluents. AEC's major expertise is in areas of designing and engineering plants themselves, which EPA does not duplicate nor does it need to for setting environmental standards. EPA has as much if not more expertise on effluent control technology which is usually separate (as it is in most industries) from the plants themselves. This knowledge plus environmental and health impact expertise combine to give EPA sufficient expertise to set environmental protection standards for radiation. Further, AEC continues to operate on a case-by-case basis which does not control the overall long-term health commitments of total releases of long-term nuclides. In all events EPA would work closely with AEC and draw upon its areas of special competence in the setting of standards.

3. Needless and wasteful duplication of effort. The work and effort on Appendix I and on the EPA standards is already spent, and cannot be retrieved. Both standards (EPA) and design and operating guides (AEC) are needed. Both steps should be carried forward. The work of both agencies should be made available for the benefit of the other in carrying out both of these tasks.

4. The standards are not correct and are inflexible. This memorandum to the President is not the place to discuss or try to resolve technical issues concerning the standards. Following the President's decision on this jurisdictional issue, the normal interagency review process will provide a forum for the resolution of these technical issues. EPA stands ready to discuss these with the AEC at any time and is confident that technical differences can be satisfactorily resolved.

5. Impact statements: AEC has been doing them and EPA has not promised to. Although EPA is not required to meet the formal impact statement requirements of NEPA in its regulatory activities EPA plans to issue an appropriate statement of environmental considerations in connection with the publication of these proposed regulations, and will, of course, comply with any other administrative or legal requirements for preparing impact statements or similar documents, including full public notice and hearing.

6. EPA has withdrawn support that Mr. Dominick offered with respect to Appendix I, and should therefore not set standards. Mr. Dominick's statement contained in the AEC Draft tabs rebuts this allegation.

EPA never promised not to set standards, in fact clearly indicated that it was considering doing so.

7. EPA's proposed standards are not "generally applicable" environmental standards. This is not correct. EPA does not propose to set standards facility by facility. It proposes to set them for categories of facilities. Even the AEC compromise proposal suggests EPA can set standards for a "system," that is, a category comprised of categories, rather than being limited to setting them for all sources. If one, therefore, accepts the premise that it is not possible to set a meaningful standard that applies across the board to all radiation sources, then the basic logic of EPA's proposed standards seems inescapable.

8. If EPA comes out with a standard, that will prevent AEC from going ahead with Appendix I and setting design and operating guidance based upon the "as low as practicable" concept. Both Appendix I type guidance and EPA ceiling limits are needed. Since EPA's numbers are upper limits, there is no reason why AEC cannot continue its "as low as practicable" concept if AEC wishes to do so. The nuclear industry would clearly benefit from the certainty provided by firmly established EPA standards.

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

00006

DEC 7 1973

MEMORANDUM FOR ADMINISTRATOR TRAIN
CHAIRMAN RAY

SUBJECT: Responsibility for setting radiation protection standards

FROM : Roy L. Ash

Thank you for providing position papers which outline the background and the current difference of views between your two agencies as to which should have the responsibility for issuing standards to define permissible limits on radioactivity that may be emitted from facilities in the nuclear power industry.

It is clear, as your paper indicates, that a decision is needed on this matter so that the nuclear power industry and the general public will know where the responsibility lies for developing (including public participation in development), promulgating and enforcing radiation protection standards for various types of facilities in the nuclear power industry. We must, in the national interest, avoid confusion in this area, particularly since nuclear power is expected to supply a growing share of the Nation's energy requirements; and it must be clear that we are assuring continued full protection of the public health and the environment from radiation hazards.

It is also clear from the information which you provided that:

. the area of responsibility now in controversy is intimately related to the direct regulatory responsibilities and capabilities of the Atomic Energy Commission, responsibilities about which there is no dispute.

. EPA has construed too broadly its responsibilities, as set forth in Reorganization Plan No. 3 of 1970, to set "generally applicable environmental standards for the protection of the general environment from radioactive material."

On behalf of the President, this memorandum is to advise you that the decision is that AEC should proceed with its plans for issuing uranium fuel cycle standards, taking into account the comments received from all sources, including EPA; that EPA should discontinue its preparations for issuing, now or

in the future, any standards for types of facilities; and that EPA should continue, under its current authority, to have responsibility for setting standards for the total amount of radiation in the general environment from all facilities combined in the uranium fuel cycle, i.e., an ambient standard which would have to reflect AEC's findings as to the practicability of emission controls.

EPA can continue to have a major impact upon standards for facilities set by AEC through EPA's review of proposed standards, during which EPA can bring to bear its knowledge and perspective derived from its responsibility for setting ambient radiation standards.

The President expects that AEC and EPA continue to work together to carry out the responsibilities as outlined above.

STAFF REPORT

CONSIDERATIONS RELATIVE TO SETTING ENVIRONMENTAL RADIATION STANDARDS AND CRITERIA

Criteria and Standards Division
OFFICE OF RADIATION PROGRAMS
ENVIRONMENTAL PROTECTION AGENCY

November 10, 1971
(Revised December 1, 1971)

BASIC STANDARDS STRATEGY

We believe that the primary ORP function is to insure that there is no undue hazard to the environment, the population, and occupational workers as a result of the use of radioactive materials or radiation-producing devices. In connection with the radiation protection criteria and standards aspect of this mission, EPA is operating under two authorities:

1. Establishing environmental radiation standards under the authority transferred from the AEC, and

2. Providing radiation protection guidance for Federal agencies under the functions transferred from the FRC.

While certain authorities have been transferred to EPA in regard to environmental standards and Federal guidance, we believe that EPA has a broader charter than a strict interpretation of these authorities may indicate. Any actual or potential risks to the environment from radiation should be within the purview of EPA. State and Federal agencies are both involved in the direct control of radioactive material, and it should be the role of EPA to see that these activities are consistent with a national program. The total actual and potential impact of radiation on the environment depends upon the adequacy of all the controls in effect. EPA should determine what these impacts are, what the sources of greatest exposures are, and use the appropriate tools to solve the specific problems. Medical exposures, for example, offer the

greatest potential for dose reduction. In cooperation with other agencies, such as HEW, we may find that the use of new equipment or procedures may cause a greater reduction in total exposure than any environmental limits we may set for the nuclear power industry. A plan for long-term waste management of radioactive material must be a part of EPA's overall concern with the environmental impact of the nuclear industry. As a part of this activity, we will be working with the Office of Solid Waste on the two-year study called for by the Waste Resources Act of 1970.

Other areas where EPA should be active is in regard to the potential effect of accidents from power plants and the associated criteria used in power plant siting.

A major effort during the coming years will be a continuation of the Special Studies activity initiated as a part of the two-year review of the basic radiation protection guidance. Information on all sources of exposure have been accumulated. We expect to establish a program of more orderly accumulation of these data along with projections of exposure in order to determine what areas should receive the greatest attention.

The activities described below relate specifically to those areas where effort will be applied during the coming months on appropriate standards or Federal guidance.

The overall strategy involves activities in three areas:

Activity 1: Environmental radiation standards for specific classes of activities

The major specific classes of activities for which we propose to issue environmental radiation standards include:

a. The production of electrical power by light-water-cooled reactors,

b. The reprocessing of nuclear fuel,

c. Residual radioactivity in natural gas, the production of which is stimulated by nuclear explosives, and

d. The breeder reactor.

In all of the above cases the approach will be to identify the total quantities of important radionuclides likely to be released under normal operating conditions, variations in their concentrations as a function of time and distance from the point of release, and their movement through critical pathways. We will then analyze the costs of reducing the releases of various radionuclides and relate these costs to reductions in human exposure. Standards will be quantitative in nature and expressed in terms of annual limitations on exposure to individuals and to potentially exposed populations. These limits will be derived from balancing cost against reduction in risk. This procedure will consider the application of available technology and will define the lowest

practicable levels of exposure. A specific example of our proposed approach is applied to light-water-cooled reactors is shown in Appendix A.[1/]

Activity 2: Review of scientific bases for radiation protection

One of EPA's important responsibilities in the area of radiation protection standards is to coordinate the completion of the various reviews (NAS, NCRP, and EPA Special Studies Group) of the basic guidance issued by FRC in 1960. The components of this activity are described in Appendix B. These reviews should be completed by mid-1972.

The guidance previously recommended by the FRC is expressed in terms of the radiation dose to occupational workers, the general public, and individuals in the general public. Other than excluding exposure for medical purposes and from natural background radiation, it is not related to classes of sources, but includes exposure from all sources. Secondary standards for concentrations of radioactive material in the environment have been derived by the FRC as Radiation Concentration Guides (RCG's) for selected radionuclides, based on the basic FRC guidance. Additional concentration guides have been derived from the FRC basic guidance by the AEC (10 CFR 20) and the PHS (Drinking Water Standards). The AEC

1/ Appendix A is submitted as an example, not for approval at this time.

standards (10 CFR 20) are applied to effluents, i.e., emission standards. Resulting exposure normally as been well below the FRC guides.

Our position with respect to the standards and guidance previously recommended by the FRC and approved by the President is that these are binding on all Federal agencies until they are revised by EPA. We anticipate that, at this time, exposure from all sources, in the absence of a specific EPA source standard, will remain well below the FRC guides and therefore we can wait until completion of the reviews to determine whether to adopt or revise the FRC guidance. In the review of FRC guidance EPA is also considering standards for occupational exposures.

We expect that planned operations normally will be conducted so that annual radioactive material releases to the environment from each operation, i.e., nuclear power plant, fuel reprocessing plant, or other specific activity, will result in a total does to the population that is less than resulting from variations in the natural background. This is estimated to be a maximum additional individual exposure in the range of 20 to 50 mrem per year and a maximum additional average exposure to the population which is in the range of 1/2 to 1/10 of the individual exposure. If estimated total exposures to individuals from all operations exceed these values, quantitative surveillance will be undertaken

with the objective of identifying the major sources of the radionuclides present and considering the need for the imposition of such additional controls as are required to assure that population exposures from all sources remain below the standards selected from the results of the review.

Activity 3: Guidance for evaluating Environmental Impact Statements

The Division of Technology Assessment needs policy guidance for evaluating Environmental Impact Statements, which is a priority obligation of ORP.

Implementation of the Calvert Cliffs decision regarding the application of the National Environmental Protection Act (NEPA) has introduced a very major change in the information required in Environmental Impact Statements. In particular, the requirements to evaluate the consequences of potential accidents leading to release of radioactive materials and quantitative benefit-risk/cost assessment on a facility-by-facility basis are important new requirements. (Appendix —, at ——).

In addition to the necessity for adequate evaluation of individual facilities the issues involved in the reviews are related to the basic controls over the nuclear industry, e.g., siting, potential exposures from accidents.

STATEMENT OF ROGER J. MATTSON

DIRECTOR, DIVISION OF SITING, HEALTH & SAFEGUARDS STANDARDS

U.S. NUCLEAR REGULATORY COMMISSION

PRESENTED BY

EPA HEARING ON PROPOSED 40 CFR PART 190

MARCH 8, 1976

Introduction

I am appearing in this hearing to present a statement on benalf of the Nuclear Regulatory Commission. The Commission has followed closely the development of the proposed 40 CFR Part 190 and has identified two general areas of interest. These are, first, the effectiveness of the proposed standard as an addition to the existing NRC program for regulatory control of radioactive materials in effluents, and second, the practicability of implementation of the proposed standard.

This brief statement today will summarize our views from the perspective of the agency responsible for implementing and enforcing radiation protection standards applicable to the nuclear power industry. Attachment A to this oral statement is a staff analysis which elaborates on the points which I will be addressing and a copy of our previous written comments on the proposed standard. We request that these attachments be incorporated in the record of this proceeding.

The Proposed Standard - An Overview

Our purpose today is to consider the advisability of imposing an additional set of radiation standards on that segment of the nuclear industry that processes and uses uranium for the production of electrical energy. It is important to realize that the nuclear power industry is closely regulated, and has been since it came into being, to provide assurance of the protection of people and the environment.

Under the Atomic Energy Act of 1954, the Atomic Energy Commission developed regulations within which the industry has been required to control its emissions of radioactive materials to levels below the radiation protection limits set on guidance from responsible government agencies with advice from eminent scientific authorities. These regulations contain the criteria to maintain radiation exposures at as low as reasonably achievable (ALARA) levels. The regulations were augmented less than one year ago when the NRC quantified the ALARA criteria contained in the regulations it inherited from AEC so that effluents of radioactive materials from uranium fueled power reactors are but a very small fraction of the existing radiation protection limits. Thus, we are not dealing with a source of pollution that has been allowed to defile the quality of the environment. Rather, we are dealing with a potential source of pollution that always has been required to be controlled before power production operations were allowed to begin. Furthermore, as this power production

technology has matured, it has had increasingly stringent effluent guidelines laid on because the responsible regulatory agency made public determinations that lower guidelines practicably could be achieved.

The questions before us then are, "Will the uranium fuel cycle standard proposed by the EPA improve the environmental protection now provided, and, if so, is the improvement worth the additional costs to the consumer which the standard entails?"

I want to make it clear at the outset that the NRC endorses the use of generally applicable environmental radiation standards which we can implement and enforce in the regulation of the nuclear power industry. AEC supported the transfer of the responsibility for such standards to EPA during the development of Reorganization Plan Number 3, and NRC staff has aided technical development efforts in that regard.

While we support the work by EPA on standards for radiation in the general ambient environment, we find that the proposed 40 CFR Part 190 is not an acceptable standard for reasons which we detail below. We view the proposed 40 CFR Part 190 as an unnecessary and costly overlay of the existing NRC program for assuring protection of public health and safety from exposure to low levels of radioactive material released in routine operations of facilities comprising the uranium fuel cycle. In simplest terms, we believe that the public interest would not be served by this proposed addition to the existing regulatory framework.

As we show in this statement and in the attached staff analysis, we believe there has been an incomplete analysis of the costs and benefits of the proposed 40 CFR Part 190. The Draft Environmental Impact Statement is deficient in important areas which are not corrected by the Supplementary Information issued on January 5, 1976. Even with these deficiencies, the partial cost analyses which were performed show that the benefits to be derived from the standard do not justify the costs of its implementation. In this regard, we believe that there has been serious underestimation of the real costs of compliance with the standard and an overestimation of potential benefits which would result. In addition, implementation incident to demonstrating compliance with the proposed 40 CFR Part 190 would require substantial modifications of the existing regulatory system for control of the design, operation, and surveillance of all facilities in the uranium fuel cycle. In addition to the modification of NRC rules, guides, standards and procedures which would be required to implement 40 CFR Part 190, implementation of the standard would potentially require re-examination of more than 120 nuclear facility licensing actions.

The proposed standard would require an implementation system which is counter to accepted and proven past practice for regulatory control of radioactive material in effluents. To understand the long term impact and burden portended by this problem, it is useful to briefly enumerate the principal features of the present NRC program for control of radioactive material in effluents. This program gives emphasis to the design of

effluent control systems and operational effluent monitoring and recognizes the extreme difficulty of environmental measurements. By these mechanisms a licensee is required to consider emission controls at an optimum time in the life of a facility, i.e., during its design, and to exercise operational controls at the optimum location; i.e., at the sources of radioactive materials. In addition, our existing system takes maximum advantage of a basic principle of engineering measurements by requiring the measurement of radioactive material at its source or in effluent streams where releases are controlled. At these locations the concentrations of radioactive material are orders of magnitude larger than the concentrations which occur after dilution in the general ambient environment. Further, the low environmental concentrations of man-made radioactive material are usually impossible to discern from the larger and variable radiation levels naturally occurring in the environment.

In contrast, the proposed approach in 40 CFR Part 190 emphasizes environmental monitoring, which, for the extremely low radiation levels of interest here, has been proven to be highly inaccurate even with the most sophisticated measurement devices. The inaccuracy of environmental monitoring for extremely low levels of radioactive materials cannot be remedied by costly development of instrumentation because the low levels of man-made radiation in the environment are small compared to levels of natural radiation. In addition, the inherent variability of climatic and other environmental conditions, including background radiation,

seriously detracts from the practicality of using environmental monitoring to demonstrate compliance with the proposed standard.

In addition to requiring substantially more environmental monitoring, implementation of the proposed 40 CFR Part 190 would require shutdown of facilities for noncompliance at emission levels very near those anticipated for normal operating conditions. Variances would be difficult if not impossible to apply in the case of fuel cycle facilities other than reactors and would require the demonstration of a public need for power. This basis for variance ignores larger cost-benefit considerations such as the costs to consumers of more than $250,000 per day for a 1000 MWe nuclear power plant for replacement fuels, such as coal or oil, or the incremental public health effects arising from shutdown of a nuclear plant and replacement with a high emission coal or oil fired plant. Furthermore, the substantially increased environmental monitoring would be required and the economic risks of forced shutdown would be present throughout the operating history of a facility. The long term costs and inefficiencies of this form of regulation are not justified for the proposed standards in view of the lack of any measurable increase in the protection of public health over that afforded by NRC's current regulatory framework.

The Proposed Standard - Specific Concerns

We have three kinds of specific concerns with the proposed standard; first, we believe that the analysis has not correctly assessed radioactive effluent control technology and the practicability of compliance with the proposed standard; second, we believe that the proposed standard would be impracticable to implement for technical and economic reasons for major components of the uranium fuel cycle; and third, we believe that it will be impossible to demonstrate, using environmental monitoring, either compliance or noncompliance at the low levels specified in the standard. We will enumerate these concerns. Supportive elaboration and technical data can be found in the attached staff analysis.

The criteria contained in the proposed standard cannot be traced to the technical analyses in the draft environmental impact statement or supporting documents. The numercial values for the criteria apparently were chosen as arbitrary limits and the feasibility of compliance was rationalized by comparison to effluent control values published by AEC and NRC in connection with the Appendix I rulemaking, in environmental impact statements, and in case-by-case licensing actions. There are two deficiencies in this approach. First the draft EIS provides no cost-benefit basis for the proposed numerical limits for doses to individuals. Thus, the EPA analysis is insufficient to demonstrate the practicability of the proposed standard. Second, some of the AEC and NRC environmental impact statements and licensing data used to

rationalize the feasibility of compliance with the numerical limits are now obsolete due to changes in design objectives to reflect issuance of Appendix I, accumulation of more recent operating data, and changes in our calculational models. The calculated doses to individuals as a result of these changes are still small in comparison to the present radiation limits in 10 CFR Part 20, but not small in comparison to the proposed standard. As a result of these changes, it will be more difficult to meet the proposed standard. Therefore, the data derived from AEC and NRC environmental statements are not sufficient to rationalize the practicability of the proposed standard. In summary, there is no basis in practicability for the proposed standard. Thus, there is an inadequate basis for introducing the new and costly operating limits that it contains.

The analysis underlying the proposed standard underestimates the considerable importance of commercial scale operating data in setting radiation limits very near the best expected performance capability of radioactive waste control systems. In the development of Appendix I we learned of the importance of such data in setting ALARA design objectives for light water reactors, which is the only component of the uranium fuel cycle for which adequate commercial operating data and experience exist for setting generic ALARA guidance. Despite the demonstrated nature of LWR effluent controls, our Appendix I numerical guidelines increased twice in the course of the rulemaking to account for changes in practicability assessments as more operating data became available.

By contrast, the proposed radiation limits, as they would apply to reprocessing plants and to tailings piles at operating uranium mills, have no basis in commercial scale operating data. There simply are insufficient data from which to judge the feasibility of the proposed standard. Since no cost/benefit basis has been provided for the selection of the numerical values, we must conclude that there is a high risk that compliance with the standard also would be impracticable for uranium mills and reprocessing plants. The Nuclear Regulatory Commission is, in fact, currently considering a staff recommendation to postpone rulemaking for generic ALARA numerical guidance for fuel cycle facilities other than reactors, due to the lack of commercial scale data. Furthermore, since the proposed standard does not allow for variance in the event of demonstrated impracticability on a case-by-case basis, implementation of the standard would create a high financial risk in the allocation of corporate resources to fuel cycle facilities because of the uncertain risk of shutdown of those facilities.

One of the important elements of the proposed standard - the limit on quantities of certain long-lived materials entering the general environment in proposed Section 190.10(b)--is not a generally applicable standard when considered along with the variance provisions of proposed Section 190.11. Considered together, these sections contemplate limits on quantities of certain radioactive materials entering the environment which are dependent on both the number and size of nuclear power reactors

and the particular circumstances that may be applicable to individual nuclear facilities. We believe that such a case-specific limit is not within the scope of EPA's authority under Reorganization Plan Number 3. Fuel reprocessing plants are the dominant source of these materials, so that the proposed standard will, in practice, be an effluent limit for these facilities.

The EPA has not correctly interpreted the practicability implications of NRC's final decision on Appendix I of 10 CFR Part 50 for light water reactors. We have elaborated on this point previously and we do so again in the attached staff analysis. Apparently the largest source of continued misunderstanding lies in the need to recognize that Appendix I allows designers of multi-unit LWR sites to select different racioactive waste treatment equipment for each reactor unit. For example, we would expect a multiple unit LWR station to operation, on occasions, at several times the Appendix I design objective values for a single reactor unit. This concept leads to doses to individuals which are small compared to current radiation protection limits, but doses that could be in excess of the proposed 40 CFR Part 190. Since Appendix I presents the considered practicability judgments of the NRC, we continue to underscore the conclusion that the proposed 40 CFR Part 190 is impracticable for stations having more than two large LWRs.

In the staff analysis we have provided considerable elaboration on other specific technical points. These include: 1) recent information on PWR fuel leakage rates and primary to secondary leakage in steam generators; 2) recent changes in NRC calculations of source terms for licensing actions; 3) specific points in critical review of the cost-effectiveness analysis; 4) an analysis of the cost-effectiveness of Kr-85 capture technology; 5) technical qualification of the ORNL reports written for NRC to characterize fuel cycle facility effluent control technology and cited in the EPA Supplementary Information; 6) an indication of the presently unavailable information which is prerequisite to specific generic controls on tailings piles for operating uranium mills; 7) a summary view of the technology for environmental monitoring and 8) an examination of the need for changes in standards at this time. The staff analysis also contains an elaboration of the procedural difficulties associated with implementation of the proposed standard which we have already summarized. Time does not allow for elaboration here of these somewhat complex and detailed concerns. They are, however, important parts of the basis for our judgment that, on balance, the proposed standard is not generally applicable, is not practicable, is costly, and is an unnecessary overlay of the existing NRC program which regulates quantities of radioactive material in effluents from uranium fuel cycle facilities to extremely low levels.

This hearing panel is familiar with the existing NRC program for control of radioactive material in effluents, and we will not take valuable time to discuss its principal features. A brief summary is provided as Attachment B to this testimony for completeness.

Recommendations

We have stated our support, in principle, for generally applicable radiation standards for the ambient environment. We have also shown why the NRC recommends that the proposed 40 CFR Part 190 not be issued in effective form.

We have reexamined the statutory authorities and the expert recommendations of the NCRP, NAS, and FRC which underlie EPA's responsibilities. The material studied in this review is discussed in the attached staff analysis. We concluded from this review that generally applicable standards are desirable, and revisions of such standards should be based on considerations of the following:

1) the expenditure by society of large resources to reduce radiation risks further than the levels at which they are presently controlled at the expense of greater risks to society that may go unattended; [For example, we need to know what resources should be required for controlling risks from the uranium fuel cycle so that balanced health

and safety protection is provided against all hazardous pollutants arising from the production of electrical energy. The BEIR Committee of the National Academy of Sciences also has identified this need in its 1972 report.]

2) justification of radiation limits, standards, or guidelines on a cost/benefit basis to ensure even-handedness and uniformity in application of national resources to abatement of radioactive and other environmental pollutants;

3) assessments of the broad questions of acceptability of risk; [The BEIR Committee also has identified this need. Because of a lack of Federal policy guidance from EPA in this area, the NRC has proceeded to establish a precendent by ordering rulemaking proceedings to formulate an acceptable monetary value for the worth of population exposure reductions.]

4) development of broad methodology for cost/benefit analysis for all pollutants so that radiation limits for the general population can be based on balanced choices concerning acceptability of risks; allocation of national resources; and the use of uncertain, potentially highly conservative, health indicators such as the linear, nonthreshold radiation dose-effects hypothesis;

5) more definitive operating data from commercial uranium fuel cycle facilities to more completely characterize the interaction of these very low levels of radioactive material with man and the environment and to further improve and validate the realism of calculational models for more efficient regulation of radioactive materials in effluents; [The EPA has recently exercised needed leadership in this regard by initiating, under its FRC authorities, a comprehensive annual report on radiation control in the United States. The NRC is cooperating fully in providing its input to this broad inter-governmental effort. Also, EPA and NRC staffs jointly are giving increased attention to efficient use of monitoring data for model verification.] and

6) the need for timely initiation of international discussions on krypton control.

In closing, the NRC believes that the proposed standard should not be issued in effective form. That does not mean that the considerable effort expended in its development has not been worthwhile. EPA's work has forced critical re-evaluations of the existing NRC program, of industry's performance, and of the nation's needs. It is only because of these critical re-evaluations that we can recommend today with conviction that the presently proposed standard is not needed. And we are able to identify what more is needed, as explained above.

The re-evaluations also have served to identify the need for increased cooperative efforts by EPA, NRC, ERDA, and the power production industry to obtain commercial scale operating data (1) to more realistically characterize the environmental impact of nuclear operations at these very low levels of radiation, (2) to develop and validate more realistic predictive models, and (3) to provide the data base necessary for future reconsideration of generally applicable standards. The NRC is prepared to renew its active support of the Environmental Protection Agency in addressing the considerations outlined above.

We thank you for the opportunity of appearing in this hearing to present the NRC's additional views on the proposed standards. If the hearing panel has questions, we are prepared to respond.

back into the retention pond thus eliminating release to the offsite environment. In that situation where either an underlying impermeable geological formation is not existent or is not continuous, vertical seepage may occur to the underlying ground water formation. Wells may be drilled downstream of the retention system into the subsurface formations where seepage will collect, and this water is pumped back to the retention system. Such a system requires specific favorable subsurface conditions. In both cases, these control costs are small compared to the cost of the clay core dam retention system (1).

Impoundment of solids is being accomplished in older mills merely by construction of a dike with natural materials and filling the diked area with slurried tailings. When full, the height of the dike is increased with dried tailings to accommodate even more waste material. Process liquids which overflow the tailings dike or seep through the dike are sometimes routed through a treatment system and discharged to the environment. The diking procedure which is less costly initially, creates an above-ground pile of tailings which is difficult and costly to stabilize. While the mill is operating, this type of pile is also subject to wind and water erosion. Field studies at tailings piles after mill shut-down have shown high gamma radiation levels in the vicinity of such piles, elevated radium-226 levels in water supplies, and high airborne levels of thorium-230 and radium-226 due to wind blown tailings (14,15,16,17). For these reasons, new mills are not likely to be built using this type of solid waste control.

Stabiliza[illegible]on of tailings piles requires grading of the tailings area [illegible]ssen side slopes, establishing drainage diversion, covering with nonradioactive material, and revegetating the area. In semiarid regions it may be necessary to initially irrigate the pile to achieve vegetation growth. Other types of stabilization may also be feasible. One method involves the covering of the tailings with large aggregate gravel from a river bottom. Silt fines which accompany the river gravel will blow away in a short time leaving what is effectively a wind-proof rip rap, thus significantly reducing or eliminating migration of the tailings outside the controlled area. The costs of such stabilization has recently been estimated (6) at $350/acre-ft for earth, and $2,000/acre-ft for rock. The cost associated with stabilizing a diked surface pile is significantly higher and probably less effective because of difficulties faced in grading, covering, and revegetating the potentially steep side slopes.

Uranium mill tailings piles are long half-life, low-level radioactive wastes. As such, they will require perpetual care. This will include occasional inspection and maintenance to insure integrity of the stabilizing cover, fencing, and of the warning signs around the pile. An annuity should be included as part of the cost of the control technology to pay for this care. The maintenance associated with perpetual care of a stabilized dike system would probably be higher than that for the depression fill system, since there is tendency toward collapse of side slopes and possibly inadequate drainage of precipition from the pile.

9.0 Effluent Control Technology for the Model Mill

Typical current effluent control systems were assumed for the model mill. They were:

a. Ore Crusher and Ore Bin Dust - Orifice Scrubber.

b. Yellowcake Dryer and Packaging Dust - Wet Impingement Scrubber.

c. Liquid and Solid Waste - Clay-core dam retention system (160 acres) with seepage return and exposed beach. To be stabilized with 2 feet of earth cover and 6 inches of rock cover.

The radiological impact of total airborne effluent versus successively more effective control systems for a model uranium mill are listed in table 9.0-1. Each improvement in control is the most cost-effective available at that level of control.

The output of the model plant using base case controls is 1,140 MT U_3O_8 of which approximately 1% is recovered by the wet impingement dust collector system during drying and packaging operations (6). The value of 11,00 kilograms (24,000 lbs) of recovered yellowcake more than compensates for the cost of this control system. The low energy venturi scrubber is 1.6% more efficient that the wet impingement scrubber and will recover an estimated additional 200 kilograms (440 lbs) of yellowcake per year. The value of this additional recovered yellowcake is approximately equal to the increased annual operating costs of the low energy venturi scrubber as compared to the wet impinger. The present worth of these systems are, therefore, not included as a control cost for the model mill.

Table 9.0-1

Radiological Impact of Airborne Effluents versus Control Costs for a Model Uranium Mill

Controls	Source Term[a]	Maximum Lung Dose to an Individual[b]	Present Worth
(Table 8.1)	(mCi/yr)	(mrem/yr)	(1974 $/facility)
None	>20,000	>20,000	0
A1; B1[c][d]	205	200	172,000
A1; B2[d]	75	[illegible]	[illegible]
A1; B3	35	34	262,000
A2; B3	25	24	290,000
A2; B3; C2	15	15	432,000
A2; B4; C2	6	6	561,000
A3; B4; C2	1.5	1.5	701,000
A4; B4; C2	0.3	0.3	867,000
C1[c]	0	0	2,750,000

(a) Alpha emitting radionuclides as insoluble, respirable particulate matter.
(b) For the assumed worst case of an individual permanently occupying a location exhibiting a χ/Q of 6×10^{-6} s/m^3.
(c) Assumed current level of controls for new mills.
(d) Costs for control [illegible]

10.0 Retrofitting Control Technology to Operating Uranium Mill

The cost and practicality of retrofitting control technology systems to an operating uranium mill was not included in Reference (6). The cost is judged to be approximately the same order of magnitude as the cost to install the same control system in a new mill.

The cost and practicality of retrofitting control measures to operational tailings piles that do not use clay core dam impoundment technologies must be considered on an individual basis.

REFERENCES

1. U.S. ENVIRONMENTAL PROTECTION AGENCY. Environmental Analysis of the Uranium Fuel Cycle, Part I - Fuel Supply, EPA-520/9-73-003-B, Office of Radiation Programs, Environmental Protection Agency, Washington, D.C. 20460 (October 1973).

2. U.S. ENVIRONMENTAL PROTECTION AGENCY, Environmental Analysis of the Uranium Fuel Cycle, Part II - Nuclear Power Reactors, EPA-520/9-73-003-C, Office of Radiation Programs, Environmental Protection Agency, Washington, D.C. 20460 (November 1973).

3. U.S. ENVIRONMENTAL PROTECTION AGENCY. Environmental Analysis of the Uranium Fuel Cycle, Part III - Nuclear Fuel Reprocessing, EPA-520/9-73-003-D, Office of Radiation Programs, Environmental Protection Agency, Washington, D.C. 20460 (October 1973).

4. U.S. ENVIRONMENTAL PROTECTION AGENCY, Environmental Radiation Protection for Nuclear Power Operations, 10 CFR Part 190, Federal Register, Vol. 40 No. 109 (Thursday, May 29, 1975).

5. U.S. ATOMIC ENERGY COMMISSION. Draft Environmental Statement Related to the Utah International, Inc. Shirley Basin Uranium Mill, Shirley Basin, Wyoming, Docket No. 40-6622, Fuels and Materials Directorate of Licensing, U.S. Atomic Energy Commission, (June 1974).

6. SEARS, M.B. et.al. "Correlation of Radioactive Waste Treatment Costs and the Environmental Impact of Waste Effluents in the Nuclear Fuel Cycle for Use in Establishing 'as Low as Practicable' Guides - Milling of Uranium Ores," ORNL-TM-4903, Two Volumns, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37830 (May 1975).

7. TEKNEKRON, INC. "Scopping Assessment of the Environmental Health Risk Associated with Accidents in the LWR Supporting Fuel Cycle - Draft Report" - EPA Contract No. 68-01-2237, Teknekron, Inc. Washington, D.C. 20036 (September 2, 1975).

8. "Controlling the Radiation Hazard from Uranium Mill Tailings" Report of the Congress by the Comptroller General of the United States RED-75-365 (May 21, 1975).

9. HUMBLE OIL AND REFINING COMPANY. Applicant's Environmental Report, Highland Uranium Mill, Converse County, Wyoming. Minerals Department, P.O. Box 2180, Houston, Texas 77001 (July 1971).

10. HUMBLE OIL AND REFINING COMPANY. Supplement to Applicant's Environmental Report, Highland Uranium Mill, Converse County, Wyoming. Minerals Department, P.O. Box 2180, Houston, Texas 77001 (January 1972).

11. U.S. ENVIRONMENTAL PROTECTION AGENCY. Evaluation of the Impact of the Mines Development, Inc. Mill on Water Quality Conditions in the Cheyenne River. EPA Region VIII, Denver, Colorado 80203 (September 1971).

12. U.S. ENVIRONMENTAL PROTECTION AGENCY. Interim Primary Drinking Water Regulations - 40 CFR Part 141 - Federal Register, Volume 40, No. 158 (Thursday, August 14, 1975).

13. U.S. ATOMIC ENERGY COMMISSION. Draft Detailed Statement on the Environmental Considerations Related to the Proposed Issuance of a License to the Rio Algom Corporation for the Humeca Uranium Mill, Docket No. 40-8084. Fuels and Materials Directorate of Licensing, U.S. Atomic Energy Commission, Washington, D.C. 20545 (December 1972).

14. SNELLING, R. N. and SHEARER, S. D., Jr. Environmental Survey of Uranium Mill Tailings Pile, Tuba City, Arizona. Radiological Health Data and Report 10:475-487 (November 1969).

15. SNELLING, R. N. Environmental Survey of Uranium Mill Tailings Pile, Monument Valley, Arizona. Radiological Health Data and Report 11:511-517 (October 1970).

16. SNELLING, R. N. Environmental Survey of Uranium Mill Tailings Pile, Mexican Hat, Utah. Radiological Health Data and Report 12:17-28 (January 1971).

17. U.S. ENVIRONMENTAL PROTECTION AGENCY. Radium-226, Uranium, and Other Radiological Data from Water Quality Surveillance Stations Located in the Colorado River Basin of Colorado, Utah, New Mexico, and Arizona, January 1961 through June 1972. 8SA/TIB-24, EPA Region VIII, Denver, Colorado (July 1973).

18. International Commission on Radiological Protection, The Metabolism of Compounds of Plutonium and Other Actinides, Adopted May 1972, ICRP Publication 19, Pergammon Press, New York (1972).

GPO 901-190

Enclosure 2

SEP 15 1975

Honorable Russell E. Train
Administrator
U. S. Environmental Protection Agency
Washington, D.C. 20460

Dear Mr. Train:

This is in reply to the notice in the Federal Register, Volume 40 Number 104, May 29, 1975, wherein the Environmental Protection Agency proposed Environmental Protection Standards for the Uranium Fuel Cycle (40 CFR Part 190), and to the letter (Rowe to Muller, June 2, 1975) requesting comments on the Draft Environmental Impact Statement for the rulemaking action.

The NRC strongly supports EPA's mission to develop generally applicable environmental radiation standards. We believe the national interest and our regulatory program would benefit by a numerical expression of safe limits on radioactivity in the ambient environment within which radioactive emissions from the facilities in the uranium fuel cycle could be regulated. Such standards should be developed with full consideration given to the balancing of resource expenditures for health protection for the uranium fuel cycle versus similar expenditures for control of other activities which affect the public health aspects of the environment.

Existing Federal regulations and current regulatory practices provide assurance that for normal operation the uranium fuel cycle facilities will be designed and operated in a manner which limits to as low as reasonably achievable the levels of release of radioactive material and exposures to radiation. In view of the demonstrated effectiveness of the existing regulatory program, we do not believe there is a need for further restrictions for these facilities at this time. Furthermore, any small changes in radiation exposure which might be effected by the proposed EPA standards do not justify the considerable costs associated with the standards. The apparent lack of cost effectiveness should be examined in perspective to reductions which might be afforded by expenditures for control of more significant environmental problems. We believe that EPA's broad responsibilities for pollution abatement and the diverse expertise represented by the EPA staff would permit examination of these trade-offs.

We find that the EPA proposed standards are in reality a "fine tuning" of existing effluent regulations. To demonstrate why this is objectionable, consider the relationship between the EPA proposed standard and the NRC

10 CFR Part 50, Appendix I. The numerical guidelines in Appendix I were derived from a thorough consideration of the costs and environmental effects of radioactive effluents which were presented during a public rulemaking hearing. EPA's proposed standards specify environmental radiation levels for activities in the uranium fuel cycle. Yet, when applied to only one kind of facility within the fuel cycle, light water power reactors, the levels specified by EPA are in the same range as the the guidelines of Appendix I. Furthermore, the EPA proposed standards differ in specific details and are not consistent with Appendix I. The EPA Notice of Proposed Rulemaking states that Appendix I "will provide an appropriate and satisfactory implementation" of these standards for light-water-cooled nuclear power reactors. The NRC staff does not agree that compliance with Appendix I necessarily would provide compliance with the EPA proposed standards. For instance, for a multiple reactor site it would be possible for the emissions to be within the Appendix I levels and in excess of the EPA proposed standards. The EPA proposed standards also would require the scheduled application of technologies which have not been demonstrated on a commercial scale for removing and retaining radioactive iodine and krypton for long term decay and for stabilizing mill tailing piles.

Implementation of the EPA proposed standards would require a substantive effort to modify the NRC's regulations in order to remove these discrepancies, and it would not change significantly the overall environmental impact. Although the proposed standard would require a system for implementation which would be similar in concept to the existing NRC system for regulating effluents, there would be significant differences in the details of implementation which would impose a significant administrative burden on the NRC. It would be particularly difficult to develop a mechanism to demonstrate conformance with the emission limits stated in curies per unit of energy generated.

Thus, we believe that the proposed standard requires further work. The NRC staff believes that EPA's generally applicable environmental radiation standards should provide an upper limit for radiation exposures, predicated upon restricting the potential health impact from all sources of radiation exposure. The Nuclear Regulatory Commission would require its licensees to operate within such limits and further restrict effluent releases and radiation exposures in a cost-effective manner to be as low as reasonably achievable. Several alternative approaches appear available to the EPA. The limits could be raised to reflect the concerns expressed above and in the NRC staff comments which are attached. Another possible approach would be that the Federal Radiation Council (FRC) radiation protection guides for doses to individuals be supplemented to limit doses from the nuclear fuel cycle facilities to a larger fraction of the present FRC limits than the factor of twenty reduction which is reflected in the EPA proposed standard. The fractional limits should be chosen on the basis

of a broad and balanced approach to resource expenditures for health protection. The NRC staff is prepared to initiate further work with your staff to develop an appropriate and balanced standard which would allow flexibility within which effluents could be regulated without undue interruptions of electric power sources and with consideration of the proper distribution of allowable discharges among the various types of facilities in the fuel cycle.

Sincerely,

(Signed) Lee V. Gossick

Lee V. Gossick
Executive Director for Operations

Enclosure: Staff Comments

SEE PREVIOUS YELLOW FOR CONCURRENCES

OFFICE ►					EDO
SURNAME ►					LVGossick
DATE ►					9-15-75

COMMENTS OF THE NUCLEAR REGULATORY COMMISSION STAFF

ON THE

EPA PROPOSED RULEMAKING ON ENVIRONMENTAL PROTECTION STANDARD

40 CFR PART 190

JULY 1975

1. Suitability of the EPA Proposed Standards with Respect to Statutory Authority

Under Reorganization Plan No. 3 the following functions, with respect to radiation standards, were transferred to EPA:

"The functions of the Atomic Energy Commission under the Atomic Energy Act of 1954, as amended, ... to the extent that such functions of the Commission consist of establishing generally applicable environmental standards for the protection of the general environment from radioactive material. As used herein, standards mean limits on radiation exposures or levels, or concentrations or quantities of radioactive material, in the environment outside the boundaries of locations under the control of persons possessing or using radioactive material."

In addition, a 1973 memorandum from the Director, OMB, to the Administrator of the EPA and the Chairman of the AEC clarified the responsibilities of the two Federal agencies by stating that:

"EPA should continue, under its current authority, to have responsibility for setting standards for the total amount of radiation in the general environment from all facilities combined in the uranium fuel cycle, i.e., an ambient standard which would have to reflect AEC's findings as to the practicability of emission controls."

The regulatory responsibilities of the AEC were transferred to the Nuclear Regulatory Commission (NRC) by the Energy Reorganization Act of 1974.

It is the view of the NRC staff that the portion of the EPA proposed standard which defines the annual dose equivalent for any member of the public is an appropriate "generally applicable standard" and within the EPA area of responsibility. The actual values proposed in the EPA standard do not adequately reflect NRC's findings as to practicability expressed in Appendix I which was published in the Federal Register on May 5, 1975, as discussed in Section 2, below.

The portion of the proposed standard which specifies limits on quantities of long-lived materials entering the environment is not, in our opinion, a generally applicable environmental standard. These limits which are expressed in curies per gigawatt-year of electric energy generation are, for nonelectrical purposes, discharge limitations for spent fuel reprocessing plants and, in our opinion, represent release limits for a specific type of facility. The proposed approach provides no real limit on the concentrations of these radionuclides in the environment. The use of environmental concentrations would provide a "generally applicable standard" for such long-lived radionuclides.

2. Comparison of the EPA Proposed Uranium Fuel Cycle Standard (40 CFR Part 190) with Appendix I, 10 CFR Part 50

Appendix I of 10 CFR Part 50, which provides numerical guidelines for design objectives and limiting conditions for operation to meet the criterion "as low as reasonably achievable" for radioactive material in light-water-cooled nuclear power reactor effluents, was issued as an NRC regulation on April 30, 1975, with notice in the Federal Register on May 5, 1975.

In addition to satisfying the design objective guidelines, additional radioactive waste treatment components are required by the regulation if the annual costs of those components are justified by reductions of the dose to the population within 50 miles of the reactor using the interim values of $1,000 per person-rem or $1000 per person-thyroid-rem as the basis for judging cost effectiveness.

The statement of considerations published in the Federal Register with the EPA proposed standard 40 CFR Part 190 states in part:

"It is the view of the Agency (EPA) that this guidance for reactors (Appendix I, 10 CFR Part 50) will provide an appropriate and satisfactory implementation of these (40 CFR Part 190) proposed environmental radiation standards for the uranium fuel cycle with respect to light-water-cooled nuclear reactors utilizing uranium fuel."

The NRC staff does not agree that the provisions of Appendix I would necessarily "provide an appropriate and satisfactory implementation" of the proposed 40 CFR Part 190 for LWR power stations. The reasons are several:

1. The design objective quantities of Appendix I and attendant doses for the three release modes under some circumstances could be additive.
2. The design objectives apply to each reactor on a site (not to the entire site) and can be multiplied by the number of reactors on the site for estimating the equivalent values for the site.
3. The flexibility provided in Appendix I for the limiting conditions for operation (in recognition of the uncertainties in the source

term estimates and in anticipated operational occurrences) would permit the design objective quantities to be exceeded under certain conditions.

4. Appendix I applies only to effluents from LWR power stations and does not apply to other radiation sources such as N-16 from the turbines, storage of radioactive material, or interaction of radiation from other nearby sites and radiation from other than LWRs on the same site.

For these reasons, a nuclear power station with only three LWR units designed and operated in accordance with Appendix I could result in the doses presented in Table I.

TABLE I. POTENTIAL ANNUAL DOSE RATES TO AN INDIVIDUAL NEAR A THREE-UNIT LWR STATION OPERATING WITHIN APPENDIX I, 10 CFR PART 50

Release Mode	Whole Body (mrem)	Organ (mrem)
Liquid Effluents	9	30
Gaseous Effluents	15	15
Iodine and Particulates	- -	45
Doses at "design objective" level	24	90
Proposed Standard (40 CFR Part 190)	25	75 (thyroid) 25 (other organs)

EPA'S ROLE IN THE CONTROL OF AIR-BORNE EFFLUENTS FROM FUEL CYCLE PLANTS

Allan C. B. Richardson
Assistant to the Director for Standards Development
Criteria & Standards Division
Office of Radiation Programs
U.S. Environmental Protection Agency

This paper will seek to accomplish two main objectives. First, it will provide an overview of Environmental Protection Agency (EPA) authorities that affect the regulation of radioactive materials, and, in particular, air-borne radioactive effluents. Second, it will discuss the background, content, and rationale for the development of EPA's proposed new environmental radiation standards for the nuclear power industry.

EPA AUTHORITIES FOR RADIATION AND RADIOACTIVE MATERIALS

EPA's principle authorities affecting air-borne radioactive effluents were inherited from other agencies under Reorganization Plan No. 3 of 1970, the plan which created EPA (1). Additional authorities were created later by statute that have only an indirect impact on air-borne effluents. The first authority inherited was that of the Atomic Energy Commission (AEC) to establish generally applicable environmental radiation standards under the Atomic Energy Act. Reorganization Plan No. 3 specifically transferred to EPA:

> The functions of the Atomic Energy Commission...to the extent that such functions of the Commission consist of establishing generally applicable environmental standards for the protection of the general environment from radioactive material. As used herein, standards mean limits on radiation exposures or levels, or concentrations or quantities of radioactive material, in the general environment outside the boundaries of locations under the control of persons possessing or using radioactive material.

The President's message transmitting Reorganization Plan No. 3 to Congress made it clear that AEC had the enforcement responsibility with respect to these standards.

Neither Reorganization Plan No. 3 and its legislative history nor the Atomic Energy Act specify the basis or the criteria EPA should use for establishing these standards. However, it has been and remains EPA policy that because of the presumed nonthreshold nature of the dose-effect relationship with respect to radiation exposure, any such standards should take into account the costs associated with achieving the level of protection attained. Since these costs will vary according to the source, the Agency believes that it is essential to relate any radiation standards to the source of the radiation. EPA's standards for the uranium fuel cycle are proposed under this authority and are discussed in greater detail below.

Through Reorganization Plan No. 3, EPA also inherited the functions of the former Federal Radiation Council (FRC). Under this authority (2):

> The Administrator shall advise the President with respect to radiation matters, directly or indirectly affecting health, including guidance for all Federal agencies in the formulation of radiation standards and in the establishment and execution of programs of cooperation with States.

EPA has not yet taken any action under this authority to provide overall Federal guidance for nuclear power operations for the reasons noted above regarding EPA's approach to setting generally applicable environmental radiation standards. That is, EPA is not presently planning to recommend, under this authority, a general "acceptable" level of radiation dose to the public unrelated to source, such as revised Federal Radiation Protection Guides. Because EPA has proposed standards for the uranium fuel cycle under the authority of the Atomic Energy Act, we do not believe it is

... to take action under Federal Guidance authority with respect to the fuel cycle. However, ... of developing recommendations in connection with medical uses of radiation ... exposures (4), clean-up criteria for plutonium (5), and protective action guides ... activity.

... specifically questions arise concerning how EPA's authority to make recommendations for ... medical radiation relates to the regulatory authorities which other agencies have ... areas. For example, the Nuclear Regulatory Commission (NRC) and the Occupational ... Health Administration (OSHA) have responsibilites with respect to regulating occupational ... the Department of Health, Education, and Welfare (DHEW) has major responsibilities with ... medical uses of radiation. EPA does not intend to intervene in the use of the regulatory ... authority that these agencies have in those respective areas. What the Agency does intend to do, ... is to provide uniform broad guidance for all government agencies with respect to these ... of exposures. We anticipate that we will be drawing upon the expertise of and information ... developed by agencies with specific responsibilities in the occupational and medical radiation areas ... developing such broad guidance, and that the general guidance that EPA provides will not be so ... restrictive as to interfere with the proper exercise of other agencies' statutory authorities. It ... should be noted that the Federal Radiation Council, from which EPA inherited this authority, was a ... cabinet level body composed of the heads of several different government agencies, including the ... HEW, the AEC, and the Departments of Defense, Commerce, and Labor. We believe that EPA's ... coordinating and general guidance role in these areas remains an important function for the Agency ... to provide on behalf of the Federal government as a whole.

EPA also has several specific authorities for the regulation of radioactive materials in water, which, since they only indirectly impact air-borne effluents, will be only briefly mentioned here. These include the Federal Water Pollution Control Act of 1972 (FWPCA), the Safe Drinking Water Act, and the Ocean Dumping Act.

The extent of EPA's responsibility under the FWPCA (6) was recently determined by the Supreme Court (7). The contested issue was whether or not EPA would be required to regulate, through the permit program required by FWPCA, those radioactive materials that are already regulated through licenses by the NRC. Both EPA and the NRC took the position that Congress did not intend for EPA to regulate such materials under FWPCA and that such regulation would constitute an unnecessary duplication. The Court upheld this view.

The issue arose because the FWPCA defines pollutants as specifically including, among other things, "radioactive materials," without any qualification in the Act itself. However, there is language in the House Report accompanying the House version of the bill that eventually became the FWPCA indicating clearly that the term "radioactive materials" was not intended to include those materials regulated by the AEC. Based on the House Report, EPA stated in its regulations setting up the national permit discharge elimination system that the term "radioactive materials" was not intended to include AEC-regulated materials. However, this interpretation was challenged by an environmental group, the Colorado Public Research Interest Group, in the U.S. District Court in Colorado. The District Court judge ruled in favor of the Government's position and held that EPA did not have authority to regulate such materials. However, the U.S. Court of Appeals for the Tenth Circuit unanimously reversed the District Court decision, primarily on the basis that the words of the Act were plain and unqualified, that is, that pollutants included "radioactive materials," and that legislative history was not important because there was no ambiguity in the statute itself. The Court of Appeals also felt that the legislative history was not clear. The Supreme Court reviewed the Tenth Circuit opinion last fall and on June 1 of this year ruled 8-0 in favor of the government's position. It should be noted that the controversy with respect to FWPCA involved only those materials subject to the Atomic Energy Act. Regulation of other radioactive materials, such as radium and accelerator-produced isotopes, remains clearly within EPA's authority.

In contrast to the FWPCA, EPA is authorized under the Safe Drinking Water Act (8) to set maximum contaminant levels for all kinds of radioactive materials, including those regulated by the NRC. In June of this year, the EPA issued interim primary drinking water regulations setting proposed maximum contaminant levels for radioactivity. As stated in the preamble to these interim regulations, the major impact will be ... water supplies containing naturally-occurring radioisotopes such as radium. EPA does not believe that these standards will result in a need to remove man-made radioactivity from public water systems, because ambient levels of man-made radioactivity are exceedingly small. These safe drinking water standards should therefore have negligible impact upon the nuclear power industry.

The Marine Protection, Research and Sanctuaries Act (9), more commonly known as the Ocean Dumping Act, prohibits the ocean dumping of any materials without an EPA permit. Dumping of any

radioactive wastes, including those regulated by the NRC, is included. Congress also specifically prohibited the dumping of radiological warfare agents and high level radioactive wastes under any circumstances. Effluent releases into the ocean from an outfall from a nuclear facility are not considered ocean dumping for purposes of the Ocean Dumping Act.

ENVIRONMENTAL RADIATION STANDARDS FOR THE URANIUM FUEL CYCLE

EPA's proposed standards will be discussed from three points of view. These are: 1) what is the historical perspective out of which these standards were developed; 2) what is the rationale upon which the standards are based; and, finally, 3) what specifically do the standards provide, and what is their anticipated impact on public health and on the industry.

1. HISTORICAL PERSPECTIVE

The 1960's, you will recall, were years of tumultuous change in general, and in the field of radiation protection, as in many other areas, the decade was marked by major public controversy. By 1960 public apprehension about radiation exposure had led President Eisenhower to create the Federal Radiation Council (10). The Council's first major task was to respond to public concern over fallout from atomic weapons testing. Their solution was to propose the Federal Radiation Guidance (11) we still operate under today - a series of numerical individual dose guides that represented their judgment of a negligible (or at least an acceptable) radiation risk to individuals, independent of the cause of the exposure. These numerical guides were coupled to two important additional pieces of guidance: first, that any exposure should be the result of a beneficial activity, and second, that it should be as far below the numerical guides "as practicable." This was most reasonable guidance, and, in retrospect, it is hard to conceive of a more appropriate set of recommendations for that time. Shortly after this guidance was promulgated, major releases to the atmosphere resulting from the U.S. weapons testing program ceased.

Since 1960, however, three events have occurred which have had important implications for radiation standards for nuclear power. First, the nuclear power industry, which was then in its early infancy, has now come of age and is becoming a significant factor in our electrical power economy. Second, at the end of the decade the National Environmental Policy Act (12) was enacted by Congress. That Act requires, as you know, detailed assessments of environmental impact - both immediate and long-term. These assessments can now be made with some degree of comprehensiveness for nuclear power, and the Act has provided much of the impetus for the more detailed and precise analyses of the sources, control, and environmental pathways of effluents now routinely carried out for all new nuclear facilities. These two developments have combined to produce an understanding, perhaps unparalleled in any other major industry, of the capabilities and costs of controls for radioactive effluents and of the environmental transport of these effluents.

The third factor has been our continuing progress in reducing the results of our extensive program of scientific research into the effects of radiation on health to a viable basis for public decision-making. By the end of the sixties, a new public controversy over radiation had emerged. Critics such as Gofman and Tamplin, and Sternglass, had called the old guidance into question. At the request of Senators Muskie and Gravel, the FRC commissioned the National Academy of Sciences to reexamine the scientific basis for existing Federal Radiation Guides, and to provide, in addition, the basis for numerical estimates of health risk, where possible. The Academy's report (13) was issued to EPA in late 1972, and while it did not support the extreme claims of the most vocal critics, it reaffirmed the use of the linear nonthreshold hypothesis in interpolating the dose-effect relationship as a prudent measure for the purpose of standards-setting, and it provided specific numerical estimates of radiation risk. In deriving its conclusions, the Academy fully recognized the many uncertainties that exist in our knowledge of the biological effects of radiation on populations at low dose. Finally, it recommended the establishment of guidance or standards for the nuclear power industry which include consideration of the cost-effectiveness of reducing public health risks.

In the meantime, the FRC had been abolished and its functions transferred to the newly created Environmental Protection Agency. And at the same time, the function of the former Atomic Energy Commission to establish environmental radiation standards under the Atomic Energy Act was also transferred to EPA. As described above, those standards were defined to include limits on dose, as well as concentration and quantity of radionuclides in the environment outside the boundaries of licensees. Not transferred, however, was the authority to implement these standards through license requirements, inspection, and enforcement. That responsibility remained with the AEC (14), and now resides in the NRC (15).

Having laid o[illegible] this bit of history, let us now ask "What are the existing radiation standards for nuclear power operations in 1976?" And the word "standards" means, in this context, numbers with some direct force of law, not recommendations or guidance. They are not the Federal Radiation Protection Guides. Those Guides are intended only as "...guidance to Federal agencies in the formulation of radiation standards." (See the above definition of the functions of the FRC.) They are also not such levels as those set out in Appendix I to Title 10, Part 50, of the Code of Federal Regulations (CFR) for light-water-cooled reactors. Those are regulatory guides only, and do not carry the force of law until translated into the technical specifications contained in each individual license to operate a facility. Further, these technical specifications only specify effluent levels at which corrective action must be initiated and reports made. They do not specify limiting levels for operation. They, also, are not true environmental radiation standards.

The only real environmental standards in existence are those enacted by the AEC in the 1960's under Section 161b of the Atomic Energy Act, and set forth in Appendix B, Table II, of 10 CFR 20. These standards are most simply characterized as a codification of the radionuclide concentrations in air and water directly corresponding (at standard intake levels) to the guidance provided by the 1960 Federal Radiation Protection Guides (e.g., 500 mrem/yr whole-body dose). These 10 CFR 20 limits thus do not reflect the 1960 Federal radiation guidance that exposures should be as far below the numerical guides "as practicable." Indeed, that Federal guidance did not become part of Title 10 of the Code of Federal Regulations until the day after EPA came into existence on December 2, 1970 (16). This is not to say that ALAP was not practiced before then, just that it was not a codified requirement, and is not yet reflected by environmental standards.

It is perhaps useful to reflect for a moment on the origin of the Federal Radiation Guides themselves, which paralleled the recommendations of the International Commission on Radiation Protection (ICRP) and the National Committee on Radiation Protection and Measurements (NCRP), and form the legal basis for the 10 CFR 20 limits. Historically, the starting point for all of these recommendations has been the control of doses to occupationally exposed radiation workers, so that "the risks of somatic effects (cancer) are comparable with or less than those of the majority of other trades and professions and would, therefore, be considered as not unacceptable" (17). Note that the consideration of risk acceptability was limited to occupational hazards. The ICRP recommended that occupational dose limits be arbitrarily reduced by a factor of ten when applied to individual members of the general population. The recommendations of the NCRP and the Federal Radiation Guides for individual members of the public were based on the same approach (18). They also contain a further reduction of a factor of three when a suitably large sample of the population is exposed. This radiation control philosophy is quite different from that of the Environmental Protection Agency, where public health protection of the general population, not workers occupationally exposed, is the starting point for its deliberations.

EPA's proposed new standards for the uranium fuel cycle (40 CFR 190) are proposed under the same authority used to establish the 10 CFR 20 standards. They will, when promulgated in final form, therefore, supercede these standards for the nuclear power industry. They are, in summary, true standards, not Federal guides, and also not regulatory guides.

2. RATIONALE FOR THE DEVELOPMENT OF ENVIRONMENTAL RADIATION STANDARDS

A prerequisite for any standards-setting rationale is an assumed relationship between cause and effect--in this case for the effects of exposure of human beings to ionizing radiation. Some of the more basic forms this relationship could take in the low dose region of interest to us in establishing standards for protection of the general population include: 1) the linear, nonthreshold relationship, 2) a threshold assumption for radiation effects, 3) a concave upwards relationship (that could result if repair mechanisms are important at low dose rates), and finally 4) a convex upwards relationship (which could result for the average response of a population if particularly radiation-sensitive individuals exist that are preferentially singled out by low doses uniformly applied to a population). Although there appear to be data available to support each of these viewpoints, we continue to base our judgments for standards on the linear nonthreshold dose-effect relationship (19). This decision stems from the need for reasonable prudence in matters affecting public health protection, especially in the absence of definitive scientific information, and reflects, as well, a consensus of the collective value judgments of experts in the field.

The rejection of a threshold relationship has basic significance for standards-setting, of course, and that is that there is no acceptable non-zero dose level based on elimination of health risk alone. Thus, at any level of exposure we must examine the benefits associated with an activity producing public radiation exposure and the cost-effectiveness of risk-reduction through effluent control. In carrying forward the process of developing standards based on this examination, we must proceed to make a series of decisions on judgmental issues. These include such matters as t[illegible]

propriate limiting level of spending for measures to reduce exposure, the equity of both the bsolute and relative distributions over the population of risks and finally, the implications of he distribution in time of these risks. The consideration of time is required because many uses of adioactive materials involve, in at least some degree, incurring long-term risks in order to cquire short-term benefits.

Before discussing each of these factors and developing a perspective on their various roles in he development of a framework for setting environmental standards, it must be emphasized that the bjectives should be of overriding importance in choosing a methodology to be used for standards-etting. The first is that as complete an assessment of the potential impact on public health must e made as possible, an assessment that reflects an up-to-date consensus of available knowledge. he second is that, in addition to explicitly assessing public health impact, the cost and ffectiveness of measures available to reduce or eliminate radioactive effluents must be carefully xamined. It would be irresponsible to set standards that impose unnecessary health risks on the ublic (unnecessary in the sense that exposures permitted can be avoided at a small or reasonable ost), and it would equally be irresponsible to set standards that impose unreasonable costs (unreasonable in the sense that control costs imposed by standards provide little or no health benefit to the public). Thus, the necessity to examine the economics of effluent control proceeds directly from the nature of the relationship assumed to exist between radiation dose and its effects on health. As pointed out above, it is true that if a threshold level were to exist it might then be possible to establish a level so as to avoid any public health impact. However, such a threshold cannot be assumed for the vast majority of radiation effects, and a standard set at any level other than zero must be justified on the basis that the activity provides offsetting benefits, and that all reasonable measures to minimize the risk due to radioactive effluents are required by the standards.

The health risk assessments made by EPA for deriving environmental radiation standards depart in two respects from practice common in the past. The first of these is the use of the concept of total population dose commitment in assessing the impact of an environmental release. We have defined the term "environmental dose commitment" for this total population dose commitment due to an environmental release (20). It differs from the UNSCEAR definition of dose commitment, which is, in a sense, a calculation of the limiting potential individual dose from an environmental level of radioactivity, and is not the total population dose due to a specific environmental release (21). Previous assessments of the impact of radioactive effluents from specific facilities have usually focused upon the calculation of radiation dose commitments to the hypothetical critical individual, who is generally found in the local population and whose exposure is usually incurred immediately following the release of an effluent. For short-lived radionuclides this may suffice to limit population impact, but when long-lived materials are involved this practice can lead to gross underestimates of the total impact of an environmental release. Instead of just local annual dose, the totality of doses to all populations over the lifetime of the radionuclide in the biosphere should be considered. The underlying assumption justifying the practice of assessing only the annual dose to local populations around nuclear facilities has usually been that maximum individual doses are of paramount concern and that doses to other than local populations and at times after the "first pass" of an effluent are so small as to be indistinguishable from those due to natural background radiation and are, therefore, ignorable. This point of view is not acceptable for use in deriving environmental standards because it not only neglects the implications of a nonthreshold hypothesis for radiation effects, but also the consideration that the radiation doses involved are due to avoidable man-made releases of materials and are not doses due to natural phenomena.

The second departure from usual practice is our use of explicit estimates of health effects, rather than the use of dose as the endpoint to be minimized by standards. It is perhaps obvious, in retrospect, that the proper focus for determination of the appropriate level for a standard to protect public health is its impact on health, but in the past minimization of dose has often served as a useful surrogate for this impact because of uncertainties about or a reluctance to accept the consequences of assumptions concerning the form of the relationship between dose and effect.

Before discussing in detail economic aspects such as the cost-effectiveness of risk reduction, it is useful to consider the various perspectives in which consideration of standards for radioactive effluents from the nuclear power industry can be placed. At least the following are possible:

1. The public health impact of each effluent stream of radioactive materials from each type of facility in the fuel cycle;

2. The combined impact on the various components of the fuel cycle required to support the production of a given quantity of electrical power; and,

3. The integrated impact of the entire fuel cycle due to the projected future growth of the industry through some future year, for example, the year 2000.

The first of these perspectives is required for assessing the effectiveness of control of particular effluent streams from specific types of facilities. It is particularly useful for regulatory purposes, such as the development of technical guides and regulations specifying "as low as practicable" design and operation of facilities.

The second viewpoint, which can be expressed as an assessment of the total impact of the industry for each unit of the beneficial end-product (electrical power) as a function of the level of effluent control, provides the perspective required for an assessment of the relationship of this benefit to the related environmental cost - in this case the potential public health impact.

Finally, although each of these perspectives can assist the forming of judgments as to the proper level of control and the acceptable impact of typical facilities or for a unit of output from the entire fuel cycle, only the third perspective provides an assessment of the potential overall impact of the entire industry. The magnitude of this impact can be either considerable or relatively small, depending upon the level of effluent control required by environmental standards. This third viewpoint will be most useful at the political level, where decisions must be made concerning the social acceptability of major alternative national courses of action for future energy supply. Of course, the overall potential radiological impact is only one small part of that consideration. The third perspective can also be useful to us as standards setters in the establishment of priorities.

The nuclear industry provides a useful example for the examination of the explicit use of cost-effectiveness of risk reduction in deriving standards. Figure 1 displays the general form that the cost-effectiveness of risk reduction function for a complex activity such as the entire uranium fuel cycle will take. Each point on the curve represents the addition of a new control over environmental releases. These are arranged in decreasing order of effectiveness. In the case of a large industry involving many different types of facilities, each with many types of effluents and many options for degree of control, this curve will actually approach the idealized smooth curve shown. The horizontal axis represents accumulated costs. These costs must be expressed as the present worth of all costs over the life expectancy of the controls, including both capital and operating expenses, and must also be normalized to a unit of benefit (in this case, a gigawatt-year of electricity), since different types of facilities have different quantitative relationships to the end product. The vertical axis is cost-effectiveness, expressed as the number of projected effects prevented per unit of present worth of expenditure. This number of projected effects must be carefully estimated -- ideally it should include all of the potential impact of each release over its entire projected time of residence in the biosphere, and also include all anticipated releases over the assumed lifetime of the control system concerned.

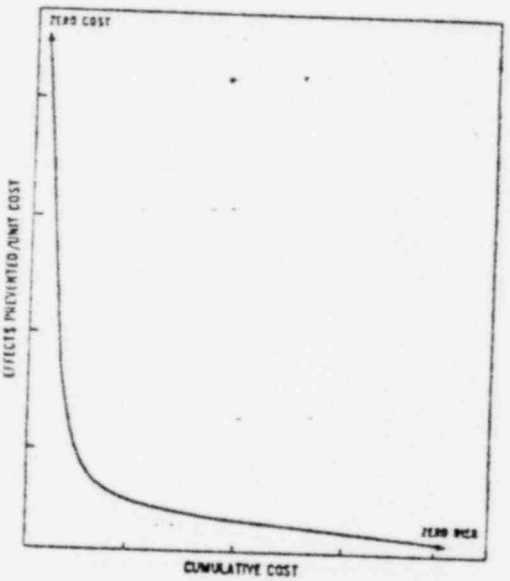


Figure 1. Idealized form of a typical cost-effectiveness of risk reduction function.

This sort of display (and its integral, which yields the total number of health effects prevented by any particular level of expenditure) gives a rather complete assessment of the total potential radiological impact of environmental releases from an activity. Its main deficiencies are: 1) a failure to display the distribution of that impact across the population and over time, and 2) a failure to relate the total impact of the activity to its benefits.

What does a display such as that in Figure 1 tell us about the choices for standards setting? There are two simple cases. These are no control, represented by the extreme upper left-hand end of the curve, and no risk, represented by the extreme lower right-hand end. In general, neither of these are reasonable possibilities. There are at least three more realistic choices. First, if one is given (from other considerations) an acceptable level of impact, one can require the imposition of controls starting at the left of the curve, until the impact is reduced to the desired level. A second alternative arises if the amount of expenditure available for control is predetermined. Then one simply imposes all controls to the left of that amount on the horizontal axis. Usually neither

these value judgments are available (or even appropriate) and a third alternative must be used - either explicitly or implicitly. This is to determine a maximum acceptable rate of spending for risk avoidance and require the imposition of all controls above that rate on the vertical axis. Although this procedure may seem distasteful, in actual practice it usually turns out to be the least so of the choices available. We have also found that in real situations a discrete break-point often occurs within the range of acceptable rates of expenditure that facilitates such decision-making. Based on recent U.S. experience this acceptable range appears to lie in the neighborhood of a few hundred thousand to about half a million dollars per health effect averted.

It is perhaps worth noting in passing that the proposed standards have not been based upon a cost-benefit evaluation of nuclear power relative to other technologies for the production of electricity, as has sometimes been suggested should be done. Even if such an evaluation were possible, and we do not believe that it can yet be successfully carried out, it would not provide an appropriate basis for standards setting. The Agency believes that, first, all sources of energy should be environmentally acceptable. In addition to a basic judgment on acceptability, the most important criterion for effluent control is that each source should minimize its impact on public health and the environment independently through the use of cost-effective levels of control. After attaining such environmental acceptability and internalizing the costs associated with minimization of public health and environmental impact, the marketplace is the proper place for determination of the extent of the use of each of the various energy sources, rather than to use imposed environmental clean-up costs as an arbitrary means of equalizing cost/benefit balances, or to use standards to arbitrarily equalize environmental impact. The Agency has rejected such methodologies as illogical and unsound.

3. THE PROPOSED STANDARDS

These standards (22) are proposed under general authority of the Atomic Energy Act and would override the existing environmental standards contained in Title 10, Part 20, of the Code of Federal Regulations for the nuclear power industry. In general they are lower than these existing standards by a factor of 20, and also provide additional protection against long-term exposures of human populations by long-lived materials. The proposed standards do not, however, alter existing Federal Radiation Protection Guides or Guidance--they are more properly regarded as implementing and supplementing the overall radiation protection provided for by that guidance.

The proposed standards are summarized in Figure 2. They apply to operations defined to be part of the commercial uranium fuel cycle. This includes 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 using uranium fuel, reprocessing of spent uranium fuel, and transportation of any radioactive material in support of these operations (to the extent that these support commercial electrical power production utilizing nuclear energy), but it excludes mining operations (since these are not covered under the Atomic Energy Act).

There are two types of limits. The first, which is expressed in terms of maximum dose to any real individual, is designed to provide protection of the individual and at the same time to assure that the exposure of nearby populations to short-lived materials will not exceed levels that can be achieved through the use of cost-effective levels of effluent control. The proposed maximum dose limits are 25 mrem/yr to the whole body or any organ except the thyroid, which is limited to 75 mrem/yr. Incidently, the dose to any organ means the total dose delivered to that organ, not just that from any single pathway or effluent. The proposed limit for the thyroid is larger than the others for two reasons: the greater difficulty (and therefore cost) of reducing iodine emissions (the principle source of thyroid exposure); and the lower level of severity of health effects due to thyroid exposure, compared to the other organs involved.

The second type of limit is designed to prevent the accumulation of long-lived radioactive materials in the environment. It is expressed in terms of the maximum total quantity of specific radioisotopes which may enter the general environment from the entire fuel cycle for each unit of electric power production. The proposed standards are based, to the extent that present knowledge permits, on projections of the migration of these radioactive effluents through the biosphere and estimates of the sum of potential doses to present and future populations during that migration, that is, the environmental dose commitment. The Agency believes that it is particularly important that release of such materials be properly limited, since they represent the largest source of potential exposure of human populations from fuel cycle operations.

The calculation of environmental dose commitments was terminated 100 years following release to the environment of each effluent considered. This was done because we do not believe that knowledge of environmental pathways is sufficient to permit credible assessments for more extended periods,

and because of the difficulty in making value judgments concerning doses received at more distant times. This inherently unsatisfactory situation is ameliorated, we believe, by the observation that for the two cases where this is of possible significance, iodine-129 and the transuranics, the controls required by the standards may be characterized as "best available technology" and the level of residual annual impact is extremely low. Concern has also been expressed that the consideration of environmental dose commitments, which generally involves large populations, small doses, and long periods of time, will lead to a never-ending series of increased control requirements. Our analysis convinces us that this is not the case--the most significant radionuclides have already been identified, and the indicated levels of cost-effective control are not only bounded, but appear to be readily achievable and reasonable in cost. Increases in population sizes would not change these conclusions significantly.

The quantity limits for long-lived materials are not specified on an annual basis, since they are normalized to total power production, which does not necessarily occur in the same year as fuel reprocessing, the operation principally affected by the quantity limits now being proposed. Standards are proposed for krypton-85, iodine-129, and alpha-emitting transuranics having half-lives greater than one year. However, as is pointed out in the draft environmental statement accompanying these proposed standards (23), two important radionuclides are missing from those included under these limits. These are tritium and carbon-14. These radionuclides are not unique to the reprocessing operation. Of the three that are included two have effective dates over six years hence. With the exception of plutonium and other transuranics, long-lived radionuclides have not received the attention we think they should get, and consequently control methods are not yet as well developed as they should be. It is principally for this reason that krypton-85 and iodine-129 requirements are postponed until 1983, and carbon-14 and tritium are not included. Although tritium control is under development, it is not yet at all clear whether or not it will be economic; and carbon-14 has just recently been recognized as an effluent of consequence. Although there is a paucity of data, it appears that carbon-14 effluents could contribute more population dose than all other effluents combined. Fortunately, the future control of carbon-14 appears to be a straightforward and inexpensive matter. Finally, the matter of radon-222 and its daughters remains unresolved by these proposed standards. An extensive evaluation of impact and costs of remedial measures at inactive tailings piles to control radon emanation is now being carried out jointly by the Energy Research and Development Administration and EPA under EPA funding.

The proposed standard contains a variance provision. This may be exercised by the NRC under conditions of "temporary and unusual" operation when continued operation is necessary to protect the overall societal interest with respect to the orderly delivery of electrical power. The correspondence of some of this language with that of Part IV of Appendix I to 10 CFR 50 is intentional, since EPA does not believe it would be appropriate to establish criteria which differ from those of NRC regarding "temporary and unusual" operating conditions. Reporting of the nature and basis of the variance is also required. This reporting would go beyond that now required by Appendix I, in that the extent of and reason for excess exposures and releases, as well as the basis and duration of the variance should be included, whereas Appendix I now requires only identification of the cause and proposed corrective action when Technical Specifications are exceeded. It should be noted in passing that exceeding Technical Specifications by small amounts need not necessarily result in a situation requiring a variance to permit continued operation, since in most instances Appendix I design criteria will be more restrictive than these generally applicable environmental standards.

In a few instances the standards would require the use of controls that are not cost-effective, based on consideration of total population exposure alone. This is because even though adequate protection of populations, considered as a whole, may be assured by standards based upon the balancing of total health risk and control costs, it may not always be the case that an equitable degree of protection is assured on this basis to individuals in those populations who reside close to the site boundaries of nuclear facilities, because of the distribution characteristics of certain effluents. Such situations are possible in the case of thyroid doses due to releases of radioiodines from reactors and lung doses due to particulates from mills. Although the absolute risk from such doses to nearby individuals is quite small the Agency believes that it is inequitable to permit doses to a few specific individuals that may be substantially higher than those to all other members of the population from other radionuclides. Additional protection for such individuals should be provided when this can be done at a reasonable cost. The standards proposed to limit doses to individuals reflect this additional judgmental consideration where it is considered appropriate to do so.

A few brief comments concerning implementation may be useful. First, it is not EPA's intent that the regulatory implementation of these standards involve an apportionment of the dose limits among the various fuel cycle operations. Although the standards for maximum dose apply to the total

contribution to any individual from the entire fuel cycle, in practice this will usually mean that each component of the fuel cycle must satisfy the same limits, since the vast majority of situations the sum of all possible contributions from all sources other than the immediate site will be small compared to these standards, and should be ignored in assessing compliance (as it now is regarding compliance with 10 CFR 20). It would not be reasonable to attempt to incorporate into compliance assessments doses which are small fractions of the uncertainties associated with doses from the primary source of exposure.

With regard to reactor sites, the Agency has reviewed Appendix I in its final form (which applies to single reactor units), and concluded that conformance to Appendix I by a planned reactor on a site containing up to five such facilities should constitute de facto demonostration to the NRC that a reasonable expectation exists that these standards can be satisfied in actual operation (unless a specific finding is made by EPA or NRC that extremely unusual combinations of liquid and air pathways of exposure are actually present and are expected to be simultaneously intercepted by real individuals). Additional guidance may be required in the future from NRC, as noted by the Commission in its opinion filed with 10 CFR 50, Appendix I, for sites containing larger numbers of facilities. In this regard, however, the NRC's very recently completed Nuclear Energy Center Site Survey (24) concluded that at least 20, and probably 40 reactor units would be expected to deliver maximum doses within the limits specified by these proposed standards using types of control currently required to meet Appendix I.

Finally, I would like to briefly comment on what we believe the implications of establishing these proposed standards will be. Perhaps I should start by making clear what these standards would not do. They do not constitute an Agency position on nuclear power--that would imply judgments on the adequacy of safeguards, ultimate disposal of radioactive wastes, decommissioning, and safety, in addition to planned environmental releases of radioactivity during normal operations. This rulemaking is limited to consideration of the last of these concerns only.

In this area the proposed standards would achieve some important objectives. They would insure that the maximum radiation impact on any individual due to all operations required to support the production of U.S. nuclear power is extremely small. Beyond this, they would, for the first time, establish standards to insure that this generation does not leave an unnecessary heritage of radiation exposure for indeterminate numbers of future generations. They would achieve this by requiring that releases of long-lived materials be controlled to the maximum practical extent, and not just to levels required to satisfy annual limits on individual exposure. It is recognized that these standards do not address all such materials, and the Agency will propose additional standards in this area when and if it appears reasonable to do so.

These proposed standards are important to the industry, as well as the public. They would establish, on the basis of a determination by the Federal agency responsible for the environment, environmentally acceptable levels for future operations of the uranium-based fuel cycle. Moreover, attainment of these proposed standards is based, with few exceptions, on the use of cost-effective levels of control. Thus, it is highly unlikely that future review of these standards will result in changes--not unless there are some remarkable breakthroughs in reducing the costs of controls, which currently appears highly unlikely. The Nation can, therefore, anticipate with reasonable confidence, I believe, a stabilization in meeting environmental requirements, at least as far as EPA is concerned.

REFERENCES

1. Reorganization Plan No. 3 of 1970, transmitted to Congress July 9, 1970, effective December 2, 1970, Sections 2(a)(6) and 2(a)(7).

2. Title 42, United States Code, Section 2021(h).

3. Background Report of Guidance for Diagnostic X-Ray Studies in Federal Health Care Facilities, Federal Register, 41, 10705, March 1, 1976.

4. Interagency Committee on Federal Guidance for Occupational Exposures to Ionizing Radiation, Federal Register, 40, 38187, August 27, 1975.

5. Plutonium and the Transuranium Elements, Contamination Limits, Federal Register, 39, 34076, September 23, 1974.

6. The Federal Water Pollution Control Act Amendments of 1972, Public Law 92-500, October 18, 1972.

7. Russell Train, Administrator of the Environmental Protection Agency, et al., versus Colorado Public Interest Research Group, Inc., et al., Supreme Court of the United States, No. 74-1227, June 1, 1976.

8. Safe Drinking Water Act, Public Law 93-523, December 16, 1974.

9. Marine Protection, Research, and Sanctuaries Act of 1972, Public Law 92-532, October 23, 1972.

10. Executive Order 10831, 1959.

11. Radiation Protection Guidance for Federal Agencies, Federal Register, 25, 4402, May 18, 1960, and 26, 9057, September 26, 1961.

12. The National Environmental Policy Act of 1969, Public Law 91-190, January 1, 1970.

13. The Effects on Populations of Exposure to Low Levels of Ionizing Radiation, Report of the Advisory Committee on the Biological Effects of Ionizing Radiation, National Academy of Sciences-National Research Council, November 1972.

14. Message of the President Relative to Reorganization Plans Nos. 3 and 4 of 1970, July 9, 1970.

15. Energy Reorganization Act of 1974, Public Law 93-438, October 11, 1974.

16. See Federal Register, 35, 18387, December 2, 1970.

17. Recommendations of the International Commission on Radiological Protection, ICRP Publication 6, Pergamon, Oxford, 1964.

18. Taylor, Lauriston S., The Origin and Significance of Radiation Dose Limits for the Population, U.S. Atomic Energy Commission, WASH-1336, August 1973.

19. Policy Statement: Relationship Between Dose and Effect, Office of Radiation Programs, U.S. Environmental Protection Agency, March 3, 1975.

20. Environmental Radiation Dose Commitment: An Application to the Nuclear Power Industry, U.S. Environmental Protection Agency, EPA-520/4-73-002, February 1974.

21. Richardson, Allan C.B., The Historical Development of Concepts of Radiation Dose Commitment, in "Symposium on Population Exposure," U.S. A.E.C., CONF-741018, October 1974.

22. Environmental Radiation Protection for Nuclear Power Operations, Environmental Protection Agency, Proposed Standards [40CFR Part 190], Federal Register, 40, 23420, May 29, 1975.

Environmental Radiation Protection Requirements for Normal Operations of Activities in the Uranium Fuel Cycle, Draft Environmental Statement, U.S. Environmental Protection Agency, May 1975.

Nuclear Energy Center Site Survey - 1975, U.S. Nuclear Regulatory Commission, NUREG-0001, January 1976.

PUBLIC HEARING ON PROPOSED ENVIRONMENTAL RADIATION STANDARDS FOR NUCLEAR POWER

INTRODUCTORY REMARKS

WILLIAM D. ROWE, PH.D.
DEPUTY ASSISTANT ADMINISTRATOR FOR RADIATION PROGRAMS
U.S. ENVIRONMENTAL PROTECTION AGENCY

Good morning. It is a great pleasure to welcome all of you to these public hearings. On May 29 of last year EPA proposed standards which would specify acceptable upper limits on normal releases of radioactive materials and public radiation exposures associated with operations of the nuclear power industry. Today, following a period of over nine months of public examination of this proposal, during which time we have received many written comments, we begin public hearings. Before turning these hearings over to our Presiding Officer, Mr. Denney, I would like to touch briefly on three aspects of this proposed rulemaking. First, what is the background from which these proposed standards have been developed? Second, what do we hope to achieve through these hearings and what do we anticipate to be the future steps leading to the final promulgation of these proposed standards? And finally, I will comment briefly on what we see at this point in time as the implications, both for the public and for the industry, of these proposed radiation standards for the nuclear production of electrical power.

I will begin by taking a brief step backward in time to the 1960's so that we can gain some perspective on where we stand today regarding environmental radiation standards for nuclear power and, hopefully, why we are there.

The 1960's, you will recall, were a time of tumultuous change and in the field of radiation protection, as in many other areas, the decade was marked by major public controversy. By 1960 public apprehension about radiation exposure had led President Eisenhower to create the Federal Radiation Council. The Council's first major task was to respond to public concern over fallout from atomic weapons testing. Their solution was to propose the Federal Radiation Guidance we still operate under today - a series of numerical individual dose guides that represented their judgment of a negligible (or at least an acceptable) radiation risk to individuals, independent of the cause of the exposure. These numerical guides were coupled to two important additional pieces of guidance: first, that any exposure should be the result of a beneficial activity, and second, that it should be as far below the numerical guides "as practicable." This was most reasonable guidance, and, in retrospect, it is hard to conceive of a more appropriate set of recommendations for that time. Shortly after this guidance was promulgated, major releases to the atmosphere resulting from the U.S. weapons testing program ceased.

Since 1960, however, three events have occurred which have important implications for radiation standards for nuclear power. First, the nuclear power industry, which was then in its early infancy, has now come of age and is becoming a significant factor in our electrical power economy. Second, at the end of the decade the National Environmental Policy Act was enacted by Congress. That Act requires, as you know, detailed assessments of environmental impact - both immediate and long-term. These assessments can now be made with some degree of

comprehensiveness for nuclear power, and the Act has provided much of the impetus for the more detailed and precise analyses of the sources, control, and environmental pathways of effluents now carried out. These two developments have combined to produce an understanding, perhaps unparalleled in any other major industry, of the capabilities and costs of controls for radioactive effluents and of the environmental transport of these effluents.

The third factor has been our continuing progress in reducing the results of our extensive program of scientific research into the effects of radiation on health to a viable basis for public decision-making. By the end of the decade of the sixties, a new public controversy over radiation had emerged. Critics such as Gofman and Tamplin, and Sternglass, had called the old guidance into question. At the request of Senators Muskie and Gravel, the FRC commissioned the National Academy of Sciences to reexamine the scientific basis for existing Federal Radiation Guides, and to provide, in addition, the basis for numerical estimates of health risk, where possible. The Academy's report was issued to EPA in late 1972, and while it did not support the extreme claims of the most vocal critics, it reaffirmed as a prudent measure the use of the linear nonthreshold hypothesis in interpolating the dose-effect relationship for standards-setting, and provided specific numerical estimates of radiation risk. In deriving its conclusions, the Academy fully recognized the many uncertainties that exist in our knowledge of the biological effects of radiation on populations at low dose. Finally, it recommended the establishment of guidance or standards for the nuclear power industry

which include consideration of the cost-effectiveness of reducing public health risks.

In the meantime, the Federal Radiation Council had been abolished and its functions transferred to the newly created Environmental Protection Agency. And at the same time, the function of the former Atomic Energy Commission to establish environmental radiation standards under the Atomic Energy Act was also transferred to EPA. Those standards were defined to include limits on dose, as well as concentration and quantity of radionuclides in the environment outside the boundaries of licensees. Not transferred, however, was the authority to implement these standards through license requirements, inspection, and enforcement. That responsibility remained with the AEC, and now resides in the NRC.

Having laid out this bit of history, let us now ask "What are the existing radiation standards for nuclear power in 1976." And by standards I mean numbers with some force of law, not recommendations or guidance. They are not the Federal Radiation Protection Guides. Those are intended only as "...guidance to Federal agencies in the formulation of radiation standards." (The quote is from Title 42 of the U.S. Code (Section 2021h) which lays out the charter of the former FRC.) They are also not the levels set out in Appendix I to 10 CFR 50. As you are aware, those are regulatory guides only, and do not carry the force of law until translated into the technical specifications contained in each individual license to operate a facility. Further, these technical specifications

only specify effluent levels at which corrective action must be initiated and reports made. They, also, are not environmental radiation standards.

The only real environmental standards in existence are those enacted by the AEC in the 1960's under Section 161b of the Atomic Energy Act, and set forth in Appendix B, Table II, of 10 CFR 20. These standards are most simply characterized as a codification of the radionuclide concentrations in air and water directly corresponding (at standard intake levels) to the guidance provided by the 1960 Federal Radiation Protection Guides (e.g., 500 mrem/yr whole body dose). These 10 CFR 20 limits thus do not reflect the 1960 Federal radiation guidance that exposures should be as far below the numerical guides "as practicable." Indeed, that Federal guidance did not become part of Title 10 until the day after EPA came into existence on December 2, 1970. I am, of course, not saying that ALAP was not practiced before then, just that it was not a codified requirement, and is not yet reflected by environmental standards.

It is perhaps useful to reflect for a moment on the origin of the Federal Radiation Guides themselves, which paralleled the recommendations of the ICRP and the NCRP. Historically, the starting point for all of these recommendations has been the control of doses to occupationally exposed radiation workers, so that "the risks of somatic effects (cancer) are comparable with or less than those of the majority of other trades and professions and would, therefore, be considered as not unacceptable" (ICRP Publication #6). Note that the consideration of risk acceptability was limited to occupational hazards. The ICRP recommended that

occupational dose limits be arbitrarily reduced by a factor of ten when applied to individual members of the general population. The recommendations of the NCRP and the FRC for individual members of the public were based on the same philosophy. They also recommended a further reduction of a factor of 3 when a suitably large sample of the population was exposed. This radiation control philosophy is different from that of the Environmental Protection Agency where public health protection of the general population, not workers occupationally exposed, is the starting point for its deliberations. In this case, a damage function (expressed in terms of health effects, not dose) must be balanced first against the public benefits of the activity causing the damage, and secondly, against the cost of reducing the damage for the same benefit. EPA has developed what it considers to be a prudent policy on dose-effect conversion which was published and distributed for comment a year ago. In the absence of scientific data to the contrary, EPA has adopted the linear dose-effect relationship as a prudent measure, in most cases, of the damage function. Use of this assumption does not acknowledge that such effects will actually occur, but it provides, we believe, a best estimate for regulatory purposes. If there is a bias, it must be to err on the side of public health protection. Furthermore, any policy so based must be uniformly and consistently applied, including to the case of doses at low levels acting in addition to background. This policy will, of course, continue to be reviewed as new scientific facts become available.

In summary, then, EPA's proposed new standards for the uranium fuel cycle will, when promulgated in final form, supercede current 10 CFR 20 standards for the nuclear power industry, and are proposed under the same authority. They are true standards, not Federal guides, and also not regulatory guides.

Well, so much for history. Since publicly proposing these standards early last summer, following internal review within relevant segments of the Federal government, we have received many thoughtful comments and suggestions from both industry and the public. A number of substantive issues appear to be emerging. These range from consideration of such practical matters as details of implementation to technical issues bearing on the absence of standards for some long-lived effluents and the costs of controls for some others (particularly for krypton-85), and to judgmental issues bearing on the most appropriate use of scientific information on the health risks of radiation. It is my hope that these hearings will be helpful in clarifying these and any other issues that emerge through the introduction of substantive new information to the record. The objective of these hearings is to help insure that the Agency will have the most complete and factual record available to assist it in reaching a reasonable final judgment.

I would like to emphasize that we are open to reconsideration of any part of the proposal based upon substantive information. To that end, I have requested that the Hearing Officer and the members of the panel be vigilant to clarify, through their questions to participants, the sources and bases of the information presented at this hearing and to separate

fact from judgment and opinion. While opinions are useful and often of great interest, the Agency's own final judgment must, in the last analysis, be based first upon the facts, when they are available, and only upon scientific value judgments and societal judgments in their absence. The panel will serve, then, to insure that as complete and factual a record as possible results from this hearing. It will not draw conclusions nor make recommendations. That responsibility rests with the Agency, which has, as you may be aware, an extensive formal internal review process for its rulemaking actions.

Following these hearings we will resolve any remaining issues, based upon the record of these hearings, on all information gathered prior to these hearings, and upon any additional inputs that are necessary and appropriate, and put this proposed rule into its final form. At the same time, a final environmental statement will be prepared. This statement will address all of the substantive comments raised during public review of these proposed standards. We have not yet determined what period of time will elapse between release of the FES and subsequent publication of the final rule. This will depend, to some extent, upon the remaining issues and the Agency's view of the definitiveness of their resolution. It is my hope that this entire process will be completed before fall.

Finally, I would like to briefly comment on what we believe the implications of establishing these proposed standards will be. Perhaps I should start by making clear what these standards would not do. They do not constitute an Agency position on nuclear power - that would imply judgments on the adequacy of safeguards, ultimate disposal of radioactive

wastes, decommissioning, and safety, in addition to planned environmental releases of radioactivity during normal operations. This rulemaking is limited to consideration of the last of these concerns only.

In this area I believe the proposed standards would achieve some important public objectives. They would insure that the maximum radiation impact on any individual due to all operations required to support the production of U.S. nuclear power is extremely small. Beyond this, they would, for the first time, establish standards to insure that we do not leave an unnecessary heritage of radiation exposure for indeterminate numbers of future generations. They would achieve this by requiring that releases of long-lived materials be controlled to the maximum practical extent, and not just to levels required to satisfy annual limits on individual exposure. I recognize that these standards do not address all such materials, and the Agency will propose additional standards in this area when and if it appears reasonable to do so.

These proposed standards are important to the industry, as well as the public. They would establish, on the basis of a determination by the Federal agency responsible for the environment, environmentally acceptable levels for all future operations of the entire uranium-based fuel cycle. Moreover, attainment of these proposed standards is based, with few exceptions, on the use of cost-effective levels of control. Thus it is highly unlikely that future review of these standards will result in changes - not unless there are some remarkable breakthroughs in reducing the costs of controls, which currently appears highly unlikely. We can, therefore, anticipate with reasonable confidence, I believe, a

stabilization in meeting environmental requirements, at least as far as EPA is concerned. I believe this would be a major step forward.

We hope, therefore, that since all stand to gain - the public, as well as the industry - we can work together through these hearings to insure the establishment of protective and fair environmental radiation standards for nuclear power. I am reminded of the closing statement in Administrator Train's message to the Agency on the occasion of its recent fifth anniversary. He said:

> "Finally, I must express my concern over the continuing tendency toward polarization of environmental issues. Perhaps in a society which relies as heavily as ours on the adversary process, this may be inevitable. On the other hand, shrill attacks from either side do little to contribute to real progress. I believe that we in EPA must ourselves do more to bring opposing viewpoints together in the course of program development. Environmental protection should be a purpose which unites our society rather than divides it. The control of pollution is sometimes viewed as an undesirable interference with the free market system. On the contrary, it should be seen as an essential self-discipline without which high levels of economic activity would be impossible."

I hope these thoughts can offer us some guidance as we undertake these hearings. Thank you.

ENVIRONMENTAL RADIATION PROTECTION FOR NUCLEAR POWER OPERATIONS

PROPOSED STANDARDS
[40 CFR 190]

SUPPLEMENTARY INFORMATION

JANUARY 5, 1976

PREFACE

As a result of the review of comments received on these proposed environmental radiation protection standards for normal operations of activities in the uranium fuel cycle, the Agency has identified a number of areas in which additional information would be desirable in order to provide a reasonable basis for discussion and comment on this proposed rulemaking at the public hearing scheduled for February 17, 1976. This material has been developed to supplement that contained in the notice proposing these standards (40 FR 23420), as well as the draft environmental statement and technical reports made available at that time. It does not constitute a complete response to comments, since the public record is still open. Modifications of the original proposal made as the result of comments received and a complete response to comments will be contained in the final environmental statment and notice of final rulemaking, which will reflect all the information received, including that developed at public hearings.

Three categories of additional information are contained in this Supplement. The first includes an extended discussion of the Agency's intent regarding implementation of these proposed standards, and further elucidation of the basis used by the Agency for assessing the potential health impact of exposure to ionizing radiation. The second consists of technical discussions of several areas not covered or addressed only briefly by the original material. This includes consideration of multiple reactors on a single site, the nuclear energy center concept, transuranic effluents resulting from recycled uranium, and nitrogen-16 skyshine doses and control at BWR's. Finally, in two areas, fuel

reprocessing and milling, considerable additional technical material has become available concerning control methods since the original documentation was prepared. Although the proposed standards reflected this information, the technical documents accompanying the proposal did not. Surveys based on this new information complete this collection of additional materials.

CONTENTS

SUPPLEMENT A

IMPLEMENTATION OF AND VERIFICATION OF COMPLIANCE WITH THE PROPOSED STANDARDS

IMPLEMENTATION OF AND VERIFICATION OF COMPLIANCE WITH THE PROPOSED STANDARDS

Introduction

As pointed out in the notice proposing these standards, the primary responsibility for implementing and assuring compliance with EPA standards for environmental radiation from nuclear power rests with the Nuclear Regulatory Commission (NRC) and, in certain cases, "Agreement States" operating within NRC regulations. Thus, although EPA must consider the practicality of implementing its standards, it would clearly be inappropriate for the Agency to specify the detailed procedures to be followed. On the other hand, it is important that the Agency clearly spell out what it would consider to be an appropriate implementation, as well as ones which are overly restrictive or inadequate, so as to provide guidance to the NRC for its development of the detailed regulations (and modifications of existing regulations) required. The following comments are intended in the sense of such guidance, as to the the Agency's intent, therefore, and should not be interpreted as literal dictates of the regulations required to implement these standards. That responsibility rests with the NRC, and will have to be worked out by the NRC through detailed interaction with the affected components of industry, with timely consultation by NRC with EPA as to the appropriateness of any proposed implementing regulations, particularly in the event that difficulties develop.

A similar situation obtains with respect to verification of compliance. Enforcement authorities reside in NRC, not EPA. EPA expects that the NRC will adequately assure compliance, and EPA's own "compliance" activities will consists principally of the review of the performance, as reported by NRC, of fuel cycle facilities and of any variances permitted by NRC. As required, EPA will in the future provide NRC with guidance on the adequacy of its compliance and variance posture with respect to these environmental standards.

Operational vs. Pre-Operational Application of the Standards

An important consideration relative to these standards is the NRC's continuing development of design and operating guidance, codified in 10CFR50, which implements the Federal Radiation Guidance that exposures of the public be maintained as low "as practicable" (25 FR 4402). The Commission has already issued such guidance for single light-water-cooled power reactors and has underway similar guidance for fuel reprocessing, milling, and fuel fabrication facilities. The Agency has determined that the guidance issued thus far for light-water-cooled reactors provides adequate assurance of compliance (unless the NRC finds that extreme extenuating circumstances exist for a specific site) for sites containing up to at least five such power reactors. Additional guidance may be required in the future, as noted by the Commission in its opinion filed with 10 CFR 50, Appendix I, for sites containing larger numbers of facilities.

These standards will supercede, for the nuclear power industry, the Federal Radiation Guides codified in 10 CFR 20 as limiting concentrations in air and water at unrestricted locations. Just as the development of the guidance expressed by Appendix I to 10 CFR 50 took place within the limitations specified by those standards, the development of future 10 CFR 50 guidance will now take place within the limits specified by these standards. However, it is not anticipated that the disparity between standards and guidance will, in general (but not always), be nearly so great as formerly. For example, at fuel reprocessing sites, a large portion of the thyroid individual dose standard could be taken up by new 10 CFR 50 guidance (whereas zero dose may be postulated through liquid pathways due to the absence of any liquid discharges). It is thus not the intent of the Agency that the standards for dose be "apportioned" to various operations of the fuel cycle. They apply equally and in full to doses from any operation or combination of operations in the cycle, and it is not anticipated that doses from multiple sites will be either common or significant. In the few instances where overlap of significance could occur this should be dealt with on a site-specific basis -- not generically through apportionment.

It is particularly important to recognize that the standards apply only to doses received by individuals and quantities of radioactive materials released to the environment from operating facilities. This situation is in contrast to design guidance set forth, for example, by Appendix I to 10 CFR 50 for light-water-cooled power reactors, which applies to pre-operational considerations, such as licensing for

construction of nuclear facilities. While such guidance is useful for providing the basis for concluding that such facilities can be expected to conform to standards which apply to actual operations, it is not a substitute for such standards.

Consideration of the adequacy of control measures at facilities during pre-operational stages with respect to these standards should be limited to a finding, either for specific sites, or on a generic basis, as appropriate, that the facility has provided or has available to it adequate means to provide reasonable assurance that these standards can be satisfied during actual operations. Such means may include the provision of cleanup controls on discharge streams, the ability to modify, if necessary, its mode of operation to mitigate environmental, discharges, or methods which interrupt exposure pathways in the environment. The important point is that the standards specify maximum doses to real individuals and maximum quantities of certain materials actually delivered or discharged to the environment, not the specific design parameters of individual facilities. Thus, for example, it is the Agency's view that conformance to Appendix I by a planned reactor or a site containing up to five such facilities (unless extremely unusual combinations of liquid and air pathways of exposure are actually present and are expected to be simultaneously intercepted by real individuals) should constitute de facto demonstration to the NRC that a reasonable expectation exists that these standards can be satisfied in actual operation. The Agency will, in the course of its continuing review of Environmental Statements, identify any situations for which it believes

that such an expectation has not been adequately justified. A more detailed exposition of some areas meriting in-depth discussion of the Agency's view of an adequate demonstration of reasonable expectation of compliance, such as for adjacent sites, minor releases of specifically limited radionuclides from fuel cycle facilities, doses from windblown material originating from mill sites, and transportation-related doses, is provided below.

Models for Operational Application of the Standards

a) Limits on doses to individuals.

Conformance to the standards should be measured using the most reasonable and, as required, realistic means available. Thus, in the case of dose to the thyroid, measurement of the radioiodine content of milk at the nearest farm, coupled with a determination of the milk consumption habits of the residents, would constitute a reasonable basis for a final determination of noncompliance. Conversely, calculations based on observed releases and meteorology should generally provide the basis for a routine finding of compliance. Sites failing this test would merit progressively more detailed study, leading finally to the above-described (or a comparable) determination of noncompliance (or compliance).

In the case of potential doses to the whole-body and other organs a similar sequence of compliance verification methods is available. The Agency believes that it may be presumed that existing models for

calculation of exposure fields due to gaseous and liquid releases, using measured data on quantities released, local meteorology, and stream-flow characteristics, are adequately conservative to serve as the basis for verification of compliance with these standards. If reason exists to believe, based on use of such source term measurements and models, that noncompliance may exist at a particular site, than more detailed field measurements may be employed (or, of course, the facility could reduce its emissions to achieve model-based compliance).

In a very few special situations when two or more sites are in close proximity, it may be necessary for the regulatory agency to make allowance for contributions from several sites in order to assure compliance with the standards at locations intermediate between such sites. For sites as close as a few miles from each other overlapping contributions of as much as 10 to 20% may be possible. The NRC should make the necessary adjustments in the individual technical specifications of facilities at such sites to provide reasonable assurance of compliance. However, in the vast majority of situations the sum of all reasonably possible contributions from all sources other than the immediately adjacent site will be small compared to these standards, and should be ignored in assessing compliance. It would not be reasonable to attempt to incorporate into compliance assessment doses which are small fractions of the uncertainties associated with determination of doses from the primary source of exposure.

A number of potential difficulties exist regarding implementation of the standards at mill sites. Gamma surveys in the vicinity of some

existing mill tailings piles show values ranging up to several hundred mrem/yr in situations where it is logical to assume that these elevated gamma radiation levels are the result of windblown tailings. Although the measurement of 25 mrem/yr increments in such dose rates is possible, rigorous measurement techniques would be required to identify locations where new depositions of windblown particulates elevate pre-existing local levels by 25 mrem/yr. Furthermore, because of the projected 20-year operational lifetime of a typical mill and the assumed additive impact of new depositions, 1/20 of 25 mrem/yr, or approximately one mrem/yr, would have to be measured if the standard were to be implemented by a regulation based on verification on an annual, incremental basis. This would be unreasonable, since one mrem/yr is small compared to uncertainties in natural gamma-ray background levels.

A recent engineering survey report developed for the Nuclear Regulatory Commission (ORNL-TM-4903, Volume 1) provides an estimation of the relative ratio of the respirable particles (<10μ) to larger particles (10-80μ) blown off the tailings beach of a well-managed tailings impoundment system. This ratio averages about one and varies from 0.4 to 1.4 depending on specifics of the milling process and other variables. It can be estimated, therefore, that one millicurie/yr of insoluble 0-10μ particles removed from a typical pile by wind could deliver a dose equivalent of approximately one mrem/yr to the lungs of a person living one kilometer downwind of the pile. At the same time, one millicurie/yr of 10-80μ particles might be deposited in a ring one-half to one kilometer from a pile, yielding a surface contamination level of about 3

nCi/m^2. This would result in a gamma-ray exposure level of about 10 μrem/yr. After 20 years of operations, each contributing to surface contamination at such a rate, this exposure might increase to as much as approximately 0.2 mrem/yr.

Accordingly, the critical exposure pathway for windblown tailings is most likely to be to the lungs through the direct inhalation of radioactive tailings; and if this source of exposure is controlled, direct whole-body gamma exposure from windblown tailings will also be controlled to a considerably greater degree.

It does not appear at this time to be practical to measure the annual release of radionuclides from operational tailings piles to the air pathway. However, it is practical and reasonable to reduce these releases to very small values (<1 mCi/yr) by application of control measures that will insure that maximum doses to individuals in the vicinity of tailings piles are well within the standards. These measures include back-filling of exposed tailings, keeping tailings under water, and spraying any tailings "beaches" that develop with chemical binders to prevent blowing. In practical terms, the standards should be implemented with regard to operational tailings piles by requiring proper and reasonable dust control measures and by permanent stabilization following termination of active milling operations.

It should be noted that the standards apply only to annual doses delivered as the result of discharges of radioactive materials beginning two years following the promulgation date. They do not apply to doses resulting from discharges before this date. Decontamination of areas

contaminated by windblown tailings from and management of tailings piles on previously abandoned mill sites are not covered by and are therefore not required by this standard.

At a fuel reprocessing or a multi-unit reactor site the number of shipments of radioactive materials per year in and out of the site could reach several thousand. However, even for this large of number of shipments, doses to nearby individuals under present Department of Transportation regulations would not reach one mrem/yr, if they are located, on the average, more than a few tens of meters from the shipping route, and if the vehicles involved remain in motion while in the vicinity of the site. Implementation of the standard does not require, therefore, modification of existing packaging and shielding requirements. It probably will be necessary, however, to reguire guaranteed non-stop shipments (a service which is presently obtainable from the transportation industry) to avoid buildup of doses to bystanders at habitual stopping places, or to provide restricted access areas for layovers. It should be noted that the standards do not apply to transportation personnel while they are engaged in handling shipments; such exposure is considered to fall in the category of occupational exposure.

b) Limits on quantities of specific radionuclides released.

Implementation of the nuclide-specific limits on releases of long-lived materials will require a determination by the NRC of the operating decontamination factors that must be achieved at locations that are the

principle potential sources of environmental releases of these materials. In order to make such a determination it will be necessary to characterize before 1983, except in the case of transuranics, the maximum average values of environmental releases of these materials from minor classes of sources to be permitted essentially unrestricted release (e.g., krypton-85, iodine-129, and transuranic releases from power reactors or fuel fabrication facilities). Following this, compliance should consist of verification that the appropriate decontamination factors are being realized through frequent inplant measurements at the principle potential sources reported on a routine basis.

Monitoring of the DF's achieved by inplant control systems for the three types of radionuclides specifically limited by the standards appears to be readily achievable using conventional monitoring techniques and analytical procedures, and such measurements appear to be provided for at the one facility approaching operational status. Flow-through ionization chambers are capable of measurements of krypton-85 at concentratons of less than 1 pCi/cm^3, a concentration 1000 times lower than that corresponding to the standard for a typical stack effluent volume. Similarly, x-ray spectrometry is capable of sensitivities of the order of 1 pCi for iodine-129; at 10% of the proposed limit a charcoal sample of stack effluent would accumulate, for a 10 minute sample of 0.2% of the stream, 1000 pCi. Finally, gas-flow proportional counters, using 24-hour filter samples (collected on 0.1% of the gas stream) would exhibit detection limits at least 1000 times smaller than activities

corresponding to the standard. Periodic confirmation of the isotopic distribution of transuranics would also be necessary.

It should not be necessary to routinely monitor minor releases of these materials from minor classes of sources, once these have been properly characterized as such, unless normal monitoring of general releases discloses that an unusual situation exists which indicates that normal "de minimus" releases of these materials may be being exceeded. Such an occurrence would, presumably, not constitute a "normal" release and investigation and correction would be warranted in any case.

c) The variance provision.

It is not anticipated that utilization of the variance provision of the standards is likely to be either required or appropriate for any facility other than a power reactor in the foreseeable future. That is not to say that it would be inappropriate to use the variance provision if circumstances warranted, but that such circumstances appear unlikely. On the other hand, it is quite possible that a power emergency, either local, regional, or national, could occur, and that continued production of power by a reactor experiencing higher than normal releases would be in the public interest.

In proposing these standards the Agency purposely did not specify detailed procedures to be followed to obtain a variance, since these should be developed by the NRC with opportunity provided for the views of the interested public and the industry to be heard. The Agency does, however, have some general views on the implementation of this provision.

First, the use of the variance should be predicated upon a demonstrable public need for power, and not on the needs of a utility, as, for example, the inconvenience of scheduling a repair to a control or a fuel reloading. Second, the granting of a variance should be publicly announced, with prior notification of the Agency, and include a brief preliminary assessment of the extent of the excess exposure and releases anticipated, the anticipated duration of the variance, the reason for the excess release, and the reason for granting the variance. Finally, after the variance has terminated, a final assessment of each of the above factors should be issued promptly.

In general it is anticipated, based upon past experience, that when a facility is approaching a condition in which excess releases are possible that normal monitoring and reporting of facility releases will provide more than adequate forewarning to permit timely consideration by NRC of the need for a variance. However, in order to provide for quick response in the case of a sudden power emergency, it may be desirable for the NRC to establish some basic criteria for semi-automatic invocation of a temporary variance under such circumstances. Such criteria would have to be limited, at a minimum, by considerations such as conformance with NRC's safety requirements and NRC occupational exposure limits, limitations which are not affected by these standards.

Implementing Regulations

A number of regulations or regulatory actions are affected by these standards, as the above discussion of implementation indicates. These include:

1) 10CFR20 - Modify, to reflect, by reference, that 40CFR190 supercedes for normal releases from uranium fuel cycle operations.

2) 10CFR50, Appendix I - Modify to indicate that additional requirements may be required for sites containing more than five light-water-cooled reactors, or, if the NRC so determines, in other special cases.

3) Review license conditions for fuel cycle facilities, other than light-water-cooled reactors conforming to Appendix I, for conformance to 40CFR190.

4) Determine whether any sites exist which are close enough to other sites to receive substantial contributions to dose from such sites, and make any necessary modifications of technical specifications in such cases (the Point Beach and Kewaunee sites appear to be the only such potential case presently in existence).

5) Determine the apportionment to be made for unrestricted release (relative to 40CFR190) of krypton-85, iodine-129, and alpha-emitting transuranics of half-life greater than one year at fuel cycle facilities not major sources of emissions of these nuclides, and determine the decontamination factors required at major sources.

6) Establish criteria, as required, for granting of variances under power emergency conditions, and for establishing public need for orderly delivery of electrical power.

7) Establish, where necessary, requirements on transportation of nuclear wastes and spent fuel to prevent layovers in areas to which public access is possible.

Several regulatory activities already required by existing NRC regulations or underway are also relevant to implementation of these standards. These include:

8) Continuing development of ALAP guidance for fuel cycle activities other than light-water-cooled reactors.

9) Definition of regulatory models for doses to individuals near fuel cycle operations.

10) Definition of "temporary and unusual operating conditions" for implementation of limiting conditions for operation under Appendix I to 10 CFR 50.

The most significant efforts required, of these that are not already required or committed, are items 3), 5), 6), and 7). These concern directly the implementation of the standards, the balance are either minor codifications of the standards into existing regulations, or represent reflection of the existance of these standards into existing ongoing efforts.

EPA Verification of Compliance

The Agency will assess compliance with these standards through its review of NRC implementing regulations, review of operating data supplied to the NRC by licensees, and review of any variances issued by NRC. Supporting activities will include the Agency's continuing review of draft and final environmental statements for all fuel cycle facilities, field studies at selected fuel cycle facilities, and assistance to the NRC, when necessary, through field measurements in cases of possible noncompliance.

Under general NEPA and FRC authorities, the Agency routinely reviews and comments on all NRC regulations, including 10 CFR 50 guidance and regulatory guides, pertaining to environmental releases and exposures of the public due to nuclear fuel cycle operations. In the future, this review will also include consideration of the implementation of these standards. This review will encompass, among others, the appropriateness of design basis assumptions, environmental transport models, dose conversion assumptions, environmental monitoring and reporting requirements, and, finally, operating compliance requirements. The Agency will not, however, routinely review technical specifications or other license requirements pertaining to individual licensees.

The Agency also maintains a continuing review of the state of the environment with respect to contamination by radionuclides and doses to the public, including contributions from fuel cycle sources. Beginning this year, the results of this review will be published annually. This report will depend, for fuel cycle sources, primarily upon data collected

by the NRC. The Agency has requested that the NRC supply this information in sufficient detail to permit reasonably detailed annual assessments of the exposures of members of the public and releases to the environment at fuel cycle facilities. Unfortunately, it will apparently be some time before data for all fuel cycle facilities can be made available in a suitable form.

EPA's review of draft and final impact statements for individual fuel cycle facilities will serve to allow EPA to identify to NRC situations in which it believes future compliance, when the facility is completed, may be questionable. However, such findings will remain advisory, as in the past, since responsibility for compliance with these standards during actual operations rests with the facility and the NRC.

EPA has for some years conducted special field studies in order to characterize the environmental releases, transport, and impact of radionuclides from fuel cycle facilities. These have included detailed general studies at pressurized and boiling water reactors, a fuel reprocessing facility, and at mill tailings piles. In addition, specialized studies of iodine pathways and of nitrogen-16 radiation at reactors have recently been carried out. These studies will continue in the future. They are of invaluable assistance in providing soundly based knowledge for assessing the behavior of environmental releases of radioactive materials, and in judging the adequacy of environmental models used for assessing compliance. The measurement capabilities developed for these studies may also prove useful and will be available

for situations in which the NRC needs assistance in field verification of compliance.

Timing of Implementation of the Standards

It is proposed that these standards become effective two years from the date of promulgation, with the exception of those for krypton-85 and iodine-129, which are proposed to become effective in 1983.

All existing reactors are now or will shortly be in compliance. In any case, it is considered reasonable to expect that any reactor facilities not now in compliance with Appendix I will be by 1978, three years after its issuance and the earliest possible implementation date for these standards. The question of timing of implementation of the standards is not significant, therefore, as it applies to reactors.

Only one fuel reprocessing facility is now likely to become operable by 1978, and, on the basis of its environmental statement and EPA's assessment of its projected control capabilities, this facility should be able to achieve compliance with the standards at that time. Future compliance with requirements for krypton and iodine releases will depend on the installation of additional controls by 1983. In this regard, it should be noted that the effective date of 1983 for this portion of the standard applies to any release of these nuclides after that date, not to nuclides produced in fuel irradiated after 1983.

Implementation of these standards at milling facilities will in many cases require the installation of updated dust collection equipment, and institution of dust control methods at tailings piles. This equipment is

commonly available in commerce. The standards do not apply retroactively to offsite windblown tailings, nor to tailings piles at sites no longer licensed. In a few instances large instabilized tailings piles may exist at sites with active licenses. The Agency has these special situations under study.

SUPPLEMENT B

DOSE-EFFECT ASSUMPTIONS USED AS THE BASIS OF THE PROPOSED STANDARDS

DOSE-EFFECT ASSUMPTIONS USED AS THE BASIS OF THE PROPOSED ENVIRONMENTAL RADIATION STANDARDS FOR THE URANIUM FUEL CYCLE

Many comments were received concerning the Agency's use of the linear nonthreshold dose response model for estimating the potential consequences of doses to populations. While a few commentors believed this model was insufficiently protective of public health, the majority of comments questioned the Agency's health effects estimates in the belief that they were overly conservative. These comments were confined to estimates of cancer risk; the Agency's use of a linear nonthreshold model to estimate genetic risks, perhaps the largest class of potential health effects, was not questioned. The Agency agrees that in certain cases a linear nonthreshold model could over- or under-estimate somatic health effects, and has adopted a policy of utilizing other dose-effect models where clinical data clearly indicate better risk estimates can be made using other assumptions. For example, the Agency has stated that it is highly probable that a threshold dose is required for the induction of skin cancer, and therefore such cancers were excluded from consideration in developing these standards(1).

No specific data was presented by commentors to indicate that any non-linear dose response model is applicable to exposures from the uranium fuel cycle. Rather, frequent reference was made to a statement by the NCRP(2) that extrapolation from the rising portion of dose-

incidence curves derived from data obtained at high doses and dose rates cannot be expected to provide realistic estimates of the actual risk of cancer from low level doses of low LET radiation. The Agency agrees that dose incidence curves must be interpreted with care, but believes much human data, such as that discribed in the NAS-BEIR Report (3), is useful for estimating radiation risks.

Three factors have been identified by the NCRP as influencing the validity of interpolation between zero dose and effects and existing data based on the linear nonthreshold hypothesis: dose, dose rate and the LET (linear energy transfer) of the radiation in question(2). For high LET radiations, such as alpha particle irradiation due to effluents from the Uranium Fuel Cycle, NCRP seems to accept the use of linear nonthreshold hypothesis. In the case of low LET radiation, such as from effluents emitting beta particles and gamma rays, the Agency accepts the fact that the epidemological basis for risk estimates is less straightforward and indeed discussed the uncertainties in its technical documents offered in support of these standards(1). The Agency is aware that for low LET radiations in-vitro cell killing experiments generally show reduced effects at low dose rates, indicating that repair of cell-killing damage may be taking place. The case for repair of precarcinogenic injury, however, is not nearly as clear-cut. Demonstrations of decreasing cancer induction at low dose rates have been confined to a few studies utilizing laboratory animals, most often mice. These

studies provide conflicting results depending on the species, pattern of irradiation and even the sex of the animals. The decreases in effects observed are in any case relatively small; about a factor of 2-5, but not several orders of magnitude as suggested by some commentors. It is important to note that the effect of dose rate on radiocarcinogensis in animals is not likely to provide an adequate predictor for human risk, since both the life span and the pattern of cancer induction following irradiation are different in man and animals. Nor is it necessary to limit consideration of this question to animal data. There is some cancer incidence data on the effect of dose rate on humans, unfortunately not cited in NCRP 40, which indicates that low dose rates may be equally or more carcinogenic, particularly for protracted exposures(3,4). Until unequivocal contradictory data on radiocarcinogenesis in humans is available that indicates protracted low dose rate exposures are less carcinogenic than acute exposure at high dose rates, the Agency considers allowance for reduced injury due to low dose rates too speculative to be made part of the basis for standards developed to protect public health. While the Agency does not overrule the possiblity that such data may become available in the future, it does not believe sufficient data exists now to warrant a revision in its somatic health effect estimates based on dose rates.

A separable question from dose rate effects is the question of interpolation from high doses to low doses. The point is often made that interpolation from high doses over-estimates risk if made from a

portion of the dose response curve where the number of cancers is in proportion to the square of the dose. However, as pointed out in the Agency's technical documents(1), interpolations from effects observed following high doses may also under-estimate the number of cancers induced because cell killing at high doses substantially reduces the number of cells at risk for radiocarcinogenic transformations.

There is growing evidence, as suggested in NCRP 43(2), that the Kellerer-Rossi model for initial radiation injury (not radiocarcinogenesis per se), which predicts a summation of linear and dose squared response, is useful for interpreting at least some radiation effects data. However, the available data in support of this model indicate that at doses less than about 100 rem the linear, not the dose squared, term dominates the predicted response. Most, but not all, of the health effect estimates given in the BEIR Report are based on data that include at least one point for doses less than 100 rems. Therefore, it is not considered likely that Agency estimates of radiation-induced cancer are greatly overestimated by the use of BEIR results. In a few cases it is possible to test for this effect directly by comparing the results of human experience at high and low doses(4). Such studies show little difference in effects per rem and may, in fact, indicate an increased effect at low doses, particularly in cases where the radiation exposure is protracted over relatively long periods of time. Again the linear nonthreshold hypothesis cannot be characterized as being overly conservative. The Agency recognizes that the interpolation of risk estimates

for humans from high to low doses is uncertain(5), but believes this is a more prudent public health policy than extrapolating laboratory data on short life span animals to man. None of the comments received indicated why the latter procedure would be preferable.

A number of comments were received expressing the view that the Agency had not recognized the NCRP comment cautioning, "...governmental policy-making agencies of the unreasonableness of interpreting or assuming 'upper limit' estimates of carcinogenic risks at low radiation levels, derived by linear extrapolation from data obtained at high doses and dose rates, as actual risks, and of basing unduly restrictive policies on such an interpretation or assumption"(2). The Agency agrees with the NCRP that only reasonable interpolations are warranted, and believes the proposed Uranium Fuel Cycle Standards are both prudent and reasonable. If there is any disagreement it is in the Agency's adoption of the NAS recommendation that linear interpolation be used as a "best" estimate(3) of risk, and not as an estimate on the "upper limit of risk," which seems to be the current philosophy of the NCRP. The Agency has based its health effects estimates on a continuing review of current scientific information, and it believes these estimates represent the most reasonable interpretation of the available data. It will, of course, review new scientific findings as soon as they become available.

Some commentors expressed the view that numerical estimates of radiation-related risks are of little use if they are not compared with

the risk from other environmental pollutants. While the Agency accepts that such comparisons, including a comparison with "natural background radiation," may place the radiation risk from man's activities in a perspective useful to the public, the Agency does not accept such comparisons as the primary basis for establishing radiation protection standards, since at best it could only result in equity between pollutants - not between costs and benefits. Having made an assessment of potential health risks the Agency believes it is more appropriate to select appropriate limits by means of a cost-effectiveness of health risk reduction methodology, rather than via comparative risk assessment.

A number of commentors noted that the reduction of very small risks even further is either not worthwhile or is not cost-effective. The Agency agrees that the risk to an individual from certain radioactive effluents may often be small. However, unless a threshold for radiocarcinogenesis can be demonstrated, the total risk is not necessarily small, but depends on the number of persons exposed. In developing the proposed standards careful consideration was given to the cost-effectiveness of various levels of risk reduction for the entire exposed population, not just for specified individuals. The standards proposed were chosen so as to avoid the imposition of any unreasonable costs for control. It is the Agency's conclusion that all of the costs incurred will be justified by the concomitant reduction of a potential risk to public health.

REFERENCES

(1) Environmental Analysis of the Uranium Fuel Cycle - Part III, Appendix C, U. S. Environmental Protection Agency, EPA-73-003-D, October 1973.

(2) NCRP Report No. 43, Review of the Current State of Radiation Protection Philosophy, National Council on Radiation Protection and Measurements, Washington, D.C., January 1975.

(3) The Effects on Populations of Exposure to Low Levels of Ionizing Radiation, Division of Medical Sciences, National Academy of Sciences, National Research Council, November 1972.

(4) Linearity vs. Nonlinearity of Dose Response for Radiation Carcinogenesis, Brown, J. M., review paper presented at the 20th Annual Meeting of the Health Physics Society, July 15, 1975.

(5) The Relationship Between Radiation and Effect, Policy Statement, U. S. Environmental Protection Agency, Office of Radiation Programs, March 1975.

SUPPLEMENT H

ENVIRONMENTAL ANALYSIS OF THE URANIUM FUEL CYCLE, PART I (FUEL SUPPLY): URANIUM MILLING - REVISED

CONTENTS

TABLES

CONTENTS (CONTINUED)

1.0 Introduction

The EPA recently completed a technical review (1) of the uranium milling industry as part of an overall analysis of the uranium fuel cycle (2) (3). This review included a description of the milling process, estimations of radioactive effluent releases, radiological impact, health effects impact, and the costs and effectiveness of control technologies for mills. An analysis of the tailings piles associated with mills was also included. This review was prepared in support of EPA's proposed standards for the nuclear fuel cycle, 40 CFR Part 190 (4).

Since publication in 1973, considerable new information on the uranium milling industry has become available (5,6,7,8); in particular, the engineering survey report (6), "Correlation of Radioactive Waste Treatment Costs and the Environmental Impact of Waste Effluents in the Nuclear Fuel Cycle for Use in Establishing 'as Low as Practicable' Guides - Milling of Uranium Ores," has been prepared by Oak Ridge National Laboratory for the Nuclear Regulatory Commission (NRC). This report contains an extensive review of the costs and the effectiveness of various control technology systems for uranium mills and mill tailings piles.

The EPA believes it to be worthwhile to revise its previous technical review of the milling industry, taking into account these new sources of information. Because radon-222 releases from fuel cycle facilities have been specifically excluded from EPA's proposed standard, analysis of radon-222 releases from uranium mills and uranium mill tailings piles has been omitted from this document. Radon-222 will be the subject of separate regulatory actions at a later date.

2.0 General Description of the Milling Process

A uranium mill extracts uranium from ore. The product is a semi-refined uranium compound (U_3O_8) called "yellowcake" which is the feed material for the production of uranium hexafluoride (UF_6). As of March 1975, seventeen mills (7) were operating in the United States (table 2.0-1) with nominal capacities ranging from 250 to 7,000 tons of ore per day. These mills are characteristically located in arid, isolated regions of the west. Areas with significant high grade ore reserves are (6): Wyoming, 55 million tons; New Mexico, 50 million tons; Texas, 11 million tons; Colorado - Utah, 6 million tons; all other areas combined, 7 million tons.

Eighty percent of yellowcake is currently produced by a process that uses sulfuric acid to leach the uranium out of the ore; the remainder is produced by a sodium carbonate, alkali leach process. Exact details vary from mill to mill, but, as an example, the principal steps in an acid leach process mill are as follows:

a. Ore is blended and crushed to pass through a 2.5 cm (1 inch) screen. The crushed ore is then wet ground in a rod or ball mill and is transferred as a slurry to leaching tanks.

b. The ore is contacted with sulfuric acid solution and an oxidizing reagent to leach uranium from the ore. The product liquor is pumped to the solvent-extraction circuit while the washed residues (tailings) are sent to the tailings pond or pile.

c. Solvent extraction or ion exchange is used to purify and concentrate the uranium.

Table 2.0-1 (7)

URANIUM MILLS IN OPERATION AS OF MARCH 1975

COMPANY	LOCATION	YEAR OPERATIONS INITIATED	NOMINAL CAPACITY (Tons of Ore/Day)
Anaconda Company	Grants, New Mexico	1953	3000
Atlas Corporation	Moab, Utah	1956	800-1500
Conoco & Pioneer Nuclear, Inc.	Falls City, Texas	1961	220-1750
Cotter Corporation	Canon City, Colorado	1958	150-450
Dawn Mining Company	Ford, Washington	1957	0-400
Exxon, U.S.A.	Powder River Basin, Wyoming	1971	2000
Federal-American Partners	Gas Hills, Wyoming	1959	500-950
Kerr-McGee Nuclear	Grants, New Mexico	1958	3600-7000
Petrotomics Company	Shirley Basin, Wyoming	1962	525-1500
Rio Algom Corp.	La Sal, Utah	1972	500
Union Carbide Corp.	Uravan, Colorado	1950	0-1300
Union Carbide Corp.	Natrona County, Wyoming	1960	1000

Table 2.0-1 (Continued)

COMPANY	LOCATION	YEAR OPERATIONS INITIATED	NOMINAL CAPACITY (Tons of Ore/Day)
United Nuclear-Homestake Partners	Grants, New Mexico	1958	1650-3500
Utah International, Inc.	Gas Hills, Wyoming	1958	750-1200
Utah International, Inc.	Shirley Basin, Wyoming	1971	1200
Western Nuclear, Inc.	Jeffrey City, Wyoming	1957	400-1200
TVA (Mines Development, Inc.)	Edgemont, South Dakota	1956	250-500

d. The uranium is precipitated with ammonia and transferred as a slurry.

e. Thickening and centifuging are used to separate the uranium concentrate from residual liquids.

f. The concentrate is dried at 400°F and is sometimes calcinated at 750 to 950°F.

g. The concentrate or yellowcake is packaged in 208 liter (55 gallon) drums for shipment.

Large amounts of solid waste tailings remain following the removal of the uranium from the ore. A typical mill may generate 1,800 metric tons per day of tailings solids slurried in 2,500 metric tons of waste milling solutions. Over the lifetime of the mill, 100 to 200 acres may permanently be committed to store this material. These "tailings piles" will have a radiological impact on the environment through the air pathway by continuous discharge of radon-222 gas (a daughter of radium-226), through gamma rays given off by radium-226, radon-222 and daughters as they undergo radioactive decay, and finally through air and water pathways if radium-226 and thorium-230 are blown off the pile by wind or are leached from the pile into surface waters.

3.0 Releases of Radioactive Effluent from Uranium Mills

The radioactivity associated with uranium mill effluents comes from the natural uranium and its daughter products present in the ore. During the milling process, the bulk of the natural uranium is separated and concentrated, while most of the radioactive daughter products of uranium remain in the uranium-depleted solid residues that are pumped to the tailings retention system. Liquid and solid wastes from the milling operation will contain low level concentrations of these radioactive materials, and airborne radioactive releases include radon gas and particles of the ore and the product uranium oxide. External gamma radiation levels associated with uranium milling processes are low, rarely exceeding a few mrem/hr even at surfaces of process vessels.

3.1 Airborne Releases

Airborne releases from uranium milling operations include both particulate matter and gases. Dusts containing uranium and uranium daughter products (thorium-230 and radium-226) are released from ore piled outside the mill. Dusts containing uranium and uranium daughter products are released from the ore crushing and grinding ventilation system, while a dust containing mostly uranium without daughters is released from the yellowcake drying and packaging operations. These dusts are discharged to the atmosphere by means of low stacks.

Because uranium is discharged to the air pathway as ore dust and as calcinated yellowcake, it will be considered as an insoluble aerosol. Radium-226 and thorium-230 discharged as ore dust will also

be considered insoluble aerosols.

The air flow through a typical crushing and grinding ventilation system is about 27,000 cfm, that through the yellowcake drying and packaging ventilation system is about 6,000 cfm. Because of the different air flows, dust characteristics, and locations within the plant, separate air cleaning equipment systems are usually required; a mill is therefore usually considered to have two separate airborne effluent release streams, each with its own control systems, costs, and source terms.

Radon gas is released from the leach tank vents, ore piles, tailings retention system, and the ore crushing and grinding ventilation system. There is no practical method presently identifiable that will prevent the release of radon gas from uranium mills.

As an example, table 3.1-1 gives the estimated maximum release rates and conservative estimates of site boundary concentrations considering all potential sources of airborne dust fumes and mists as predicted for the Highland Uranium Mill in Wyoming (9,10). The capacity of the Highland Mill is about 1,200 MT/yr of yellowcake.

Toward the end of the operating lifetime of a tailings retention system, some of the tailings will no longer be under water and will dry out to form a beach (6). Wind erosion can then carry off tailings material as airborne particulate matter unless control measures are taken to prevent such erosion.

Table 3.1-1 (9,10)

Predicted airborne releases of radioactive materials from the Highland Uranium Mill

Radionuclide	Release rate (Ci/yr)	Site boundary A [a] Air concentration (pCi/m^3)	Site boundary B [b] Air concentration (pCi/m^3)
Uranium-natural	0.1	0.003	0.0004
Thorium-230 (insoluble)	.06	.001	.0001
Radium-226 (insoluble)	.06	.001	.0001

[a] Distance to site boundary A assumed to be 800 m (2,600 ft) west of mill.

[b] Distance to site boundary B assumed to be 5,200 m (12,700 ft) east of mill.

3.2 Waterborne Releases

The following discussion refers to the best of current procedures of handling mill liquid wastes, in which these wastes plus tailings are stored in a tailings retention pond system which uses an impervious clay-cored earth dam combined with local topographic features of the area to form an impoundment.

The liquid effluent from an acid-leach process mill consists of waste solutions from the leaching, grinding, extraction and washing circuits of the mill. These solutions, which have an initial pH of 1.5 to 2, contain the unreacted portion of the sulfuric acid used as the leaching agent in the mill process, sulfates, and some silica as the primary dissolved solids, along with trace quantities of soluble metals and organic solvents. This liquid is discharged with the solids into the tailings pond.

Concentrations of radioactive materials predicted in the 2,500 MT/day of waste liquor from the Highland milling plant are shown in table 3.2-1 (9,10). Radioactive products of radon decay may also be present in small concentrations. Since the concentrations of radium-226 and thorium-230 are about an order of magnitude above the specified limits to 10 CFR 20, considerable effort must be exerted to prevent any release of this material from the site. The waste liquor is, therefore, stored in the tailings retention pond which is constructed to prevent discharge into the surface water system and to minimize percolation into the ground. This is a continuing potential problem requiring monitoring programs to insure that there is no significant movement of contaminated liquids into the environment.

Table 3.2-1

Concentrations of radioactive effluents in waste liquor from the Highland uranium mill (9,10)

Radionuclide	Concentration (pCi/l)
Uranium-natural	800[a]
Radium-226	350
Thorium-230	22,000

[a]About 0.001 g/ml.

If an earth-fill, clay-cored dam retention system serves as a collection and storage system for the liquid and solid process wastes generated in the mill, it will permit the evaporation of most of the contained waste liquids and serve as a permanent receptacle for the residual solid tailings. However, after the initial construction of the retention system, it is to be expected that there will be some seepage of radionuclides through and around the dam (9,10) and downward into the soil beneath the impoundment area. It has been estimated that this seepage will diminish over a period of about 2 years because of the sealing effect from accumulation of finer particles between the sandstone grains. On the other hand, sealing may not occur. Examples of the total quantities of radionuclides that are estimated to be released through and around the dam are shown in table 3.2-2. Radium-226 is a radionuclide of concern in this case. Radium-226 levels as high as 32 pCi/l (11) have been found in seepage from current operating mills. Assuming a seepage rate of 300 liters per minute, the concentration of radium-226 seeping into a stream of 140 liters per second (5 cubic feet per second) is approximately 1 pCi/l which is 1/5 of EPA's proposed interim Primary Drinking Water Regulation for radium-226 (12). In the applicant's environmental report for the Highland Uranium Mill (9,10), a seepage concentration of 350 pCi/l radium-226 was assumed, bringing the concentration of radium in such an offsite stream up to 12 pCi/l. The Highland Uranium Mill is also estimated to release to the tailings pond 22,000 pCi/l thorium-230 and trace quantities of short-lived radon daughter products.

Table 3.2-2

Estimates of quantities of radionuclides seeping through the impoundment dam of a uranium mill initially and at 2-1/4 years (9,10)

Radionuclide	Initial seepage per day	Seepage per day[a] after 2-1/4 years
Uranium	350 μCi	35 μCi to 3.5 μCi
Thorium-230	9,600 μCi	960 μCi to 96 μCi
Radium-226	150 μCi	15 μCi to 1.5 μCi

[a]Seepage assumed to be inhibited due to sealings effect from accumulation of fines between sandstone grains.

As an additional example, the analysis of plant tailings effluents for the Humeca Uranium Mill, which uses an alkaline lead process, is given in table 3.2-3 (13).

The radiological significance of seepage from tailings ponds will depend on the location of the pond. In arid regions, the seepage may evaporate before leaving the site, leaving the radioactivity entrained and absorbed on soil. Should the tailings pond be located near a river, minor leakage might be diluted sufficiently by the additional river water to meet relevant drinking water standards. Discharge of pond seepage into streams providing insufficient dilution and not under the control of the licensee would not be acceptable. In such cases, a secondary dam may be built below the primary dam to catch the seepage which may then be pumped back into the tailings ponds.

Table 3.2-3 (13)

Analysis of plant tailings effluents from the Humeca Uranium Mill (alkaline leach process)

Radionuclide	pCi/l
Radium-226	10 to 2,000
Thorium-230	0.1
Uranium-238	4,000

4.0 The Model Uranium Mill

A model plant has been assumed in order to achieve a common base for the comparison of radiation doses, committed health effects, and radioactive effluent control technology.

The model mill is defined in terms of contribution to the nuclear fuel cycle that is consistent with current designing and projected commercial industry practice (6). However, it is not necessarily representative of presently operating facilities. Characteristics of the model mill are assumed to be:

a. 600,000 MT ore milled per year,

b. 1,140 MT U_3O_8 as yellowcake produced per year,

c. use of the acid leach process,

d. a tailings retention pond system which uses a clay-core earth dam and local topographic features of the area to form the impoundment,

e. collection and return of any seepage through the dam to the tailings pond, and

f. location in a western State in an arid, low-populated density region.

While Reference 1 considered the radiological impact of seepage through a model clay core impoundment dam, it is now believed to be standard practice (6) to collect and return any such seepage to the tailings pond so that there are no routine liquid discharges of radionuclides to water pathways from mills. The cost of a seepage control

system is nominal compared to the cost of the tailings impoundment system itself.

Radiation dose rates and health effects that might result from the discharges of airborne radioactive effluents from the model mill were calculated using standard χ/Q values, dose conversion factors, model pathways, and health effect conversion factors that are similar to those for other facilities in the previous discussion of the fuel supply cycle. These factors and assumptions are discussed in Appendix A of Reference 1.

The operating lifetime of a uranium mill is commonly from 12 to 15 years, depending upon the local ore supply and the demand for uranium. In a few instances, the operating lifetime may be longer, and allowances are sometimes made for that possibility if it appears feasible. For the model mill, an operating lifetime of 20 years has been selected.

5.0 Radioactive Effluents from a Model Uranium Mill

Because regulations have not required uranium mills to report the total amounts of each radionuclide discharged per year, the source terms chosen for model mills are based on somewhat limited operational information (6). Source terms listed in table 5.0-1 for model mills are believed, however, to be reasonably accurate estimates of the quantities of radioactive materials discharged to air pathways with base case controls. The controls assumed as the base case consist of an orifice scrubber on the crusher and fine ore bins, and a wet impingement scrubber in the yellowcake drying and packaging areas. The milling procedures are so similar for acid and alkaline leach processes that source terms for the two types of mills are considered identical, except that the alkaline leach process does not remove thorium from the ore so that, in this case, there is very little thorium-230 as an impurity in the yellowcake dust.

The model mill is also assumed to use clay-core dam impoundment technology for tailings with a catch basin if required to contain seepage through the dam. Unless the impoundment area is lined with an impervious material, considerable quantities (as much as 10 percent) of the liquid effluent from the mill will leak out through the bottom of the pond. However, because of the ion-exchange properties of most soils, radionuclides dissolved in this effluent will attach to soil particles and will not reach offsite locations or ground water. The model mill is considered, therefore, to deliver no radiation exposure to members of the general population through liquid pathways.

Table 5.0-1

Discharge of Radionuclides to the Air from Model Uranium Mills[a] and Tailings Piles (6)

With Base Case Controls

Radionuclide	Chemical or Physical State	Acid Leach Mill Source Term (mCi/yr)	Alkaline Leach Mill Source Term (mCi/yr)
Uranium-238 and 234	ore dust (oxides)	9.0	9.0
Radium-226	ore dust	4.5	4.5
Thorium-230	ore dust	4.5	4.5
Uranium-238 and 234	yellow cake (oxides)	170.	170.
Radium-226	yellow cake	0.2	1.7
Thorium-230	yellow cake	4.7	---
Uranium-238 and 234	tailings sand (0-10 μ)	0.2 - 0.8	0.3 - 2.2
Radium-226	tailings sand (0-10 μ)	1.3 - 4.2	2.3 - 1.5
Thorium-230	tailings sand (0-10 μ)	1.4 - 4.5	2.4 - 1.5

[a] 6% moisture ore, radon-222 releases excluded

Each site must be evaluated individually. If the ground water table is high and the soil is low in ion exchange capacity so that it becomes likely that radium-226 and thorium-230 will escape from the tailings impoundment into underground waters, then the pond area could be lined with an impervious membrane of asphalt to minimize seepage. Acid wastes would have to be neutralized beforehand to prevent damage to this type of liner.

The amount of radioactive particulate material removed from the tailings beach by wind erosion is believed to depend on the area of the beach, the wind velocity, and particle size distribution of the tailings (6). Estimates of this source term are included in table 5.0-1. Particles greater than 10μ in diameter are not considered to be respirable particles and are not included in the inhalation source term pathway. Historically, windblown tailings have caused elevated gamma exposure levels around piles, however, the inhalation pathway has been determined to be the critical pathway. Levels of control sufficient to limit radiation exposure through the inhalation pathway will also prevent, to a significantly greater degree, exposures through the ground deposition, whole body exposure pathway.

6.0 Radiological Impact of a Model Mill

Estimates of the radiation doses to individuals through the air pathway in the vicinity of an acid leach model mill using base case controls from routine emissions are shown in table 6.0-1. The estimated collective lung doses to the population in the vicinity of an acid leach mill are given in table 6.0-2. The collective lung dose is determined by summing the average individual radiation dose equivalent to individuals living within 80 kilometers of the mill over the total population within 80 kilometers of the mill. The models for the dispersion and dose calculations are discussed in detail in Appendix A of Reference (1). Based on the information available at the time that analysis was performed, an effective half-life of 1,000 days was used for insoluble class Y compounds in the pulmonary region of the lung in calculating the lung doses from mill emissions. In accordance with what is now becoming accepted practice, in this report all dose conversion factors are calculated using a 500-day effective half-life (18), and are, therefore, reduced by a factor of two from the previously used values.

The dose conversion factor used to calculate the lung dose is believed to be an order of magnitude more conservative than the dose conversion factor used in Reference (6). Reasons for this difference which relate to assumptions regarding lung model parameters, are discussed elsewhere. It is also assumed that food consumed by individuals living near the mill is not produced locally so that exposure through

Table 6.0-1

Radiation Doses to Individuals due to Inhalation
in the Vicinity of a Model Mill with Base Case Controls

Radionuclide	Source Term (mCi/yr)	Critical Organ	Dose Equivalent to Critical Organ	
			Individual at Plant Boundary (mrem/yr)	Average Individual Within 80 kms (mrem/yr)
Uranium-234 and 238	180	Lung	170	3.9×10^{-2}
Thorium-230	15	Lung	15	3.4×10^{-3}
Radium-226	10	Lung	15	2.2×10^{-3}
Total	205		200	4.5×10^{-2}

Table 6.0-2

Collective Dose to the General Population in the Vicinity of a Model Mill with Base Case Controls

Radionuclide	Source Term[a] (mCi/yr)	Pathway	Critical Organ	Collective Critical Organ Dose (person rem/yr)
Uranium-234 and 238	180	Air	Lung	2.2
Thorium-230	15	Air	Lung	0.2
Radium-226	10	Air	Lung	0.1
			Total	2.5

[a]Releases to water pathways assumed equal to zero, and doses from radon-222 are not included.

food chains is not significant compared to lung exposures resulting from the direct inhallation of radioactive particulate matter. The radon exposure pathway was excluded from this report.

Because there are no liquid releases from the model mill, there is no projected radiological impact through water pathways.

7.0 Health Effects Impact of a Model Mill

Potential health effects to members of the general population in the vicinity of a model mill using base case controls are estimated to be 0.0002 lung cancers per year of operation, or 0.005 such effects for 30 years of operation. The models used for the calculation of health effects are given in Appendix A of reference (1).

8.0 Control Technology for Uranium Milling

8.1 Airborne Effluent Control Technology

Hazardous airborne gaseous and particulate wastes are generated in the milling operation from a number of different sources. The major areas of the milling operations in which gaseous and particulate matter effluents must be controlled are the ore crushing area, the fine ore bins, and the yellowcake drying and packaging areas. Mills often prefer to use multiple dust collection systems rather than design a single, more elaborate system. There will usually be two or more ore dust collectors and separate systems for the yellowcake dryer and for the yellowcake packaging rooms.

Dust collector systems that are currently used or that can be adapted for use by uranium mills are discussed in reference (6). They are for the most part control technologies that have been proven and are standard industrial equipment.

Briefly, these treatment methods are:

a. Orifice Scrubbers - The dusty air flows through a stationary baffle system coated with a sheet of water. The dust particles penetrate the water film and are captured.

b. Wet Impingement Scrubber - The dusty air carrying water droplets added by preconditioning sprays passes through perforated plates to atomize the water and to wet the dust. Particles are then collected by impingement on baffle plates and a vaned demister.

c. Venturi Scrubber - The dusty air is passed through a venturi, increasing its velocity. Water is added which atomizes in the gas stream and collects the dust by impingement. The wetted dust is

removed by demisters. Raising the pressure drop across the venturi increases the collection efficiency, but this requires higher energy levels and raises the costs.

d. Bag Filters - These filters are made of woven or felted fabric and have high collection efficiencies provided the air being filtered is cool and dry.

e. HEPA Filters - These filters are made of fiber glass. They have very high efficiencies but have a number of limitations; in particular, they can only be used in conjunction with a prefilter and on dry air streams.

Current practice involves the use of wet dust control systems, although several mills use bag filters for air flows from ore handling and from the yellowcake packaging area. The costs and percent effluent reduction for the various control systems suitable for effluent streams of the model mill are given in table 8.1-1.

Particulate material can be prevented from being windblown off the tailings pile beach by back filling with overburden and, as an interim measure, by chemical stabilization by spraying with petroleum derivatives. Chemical stabilization lasts about a year and must be repeated on a regular schedule.

Other sources of gas and dust which can be controlled are the open pit mine haul roads and the ore storage and blending piles. In some instances, the liquid content of the ore as mined may be sufficiently high to eliminate most dust formation in the ore storage and blending area; due to insufficient information, this case

Table 8.1-1

Cost and Efficiencies of Control Technology for Mills[a]

Control Method	Capital Cost (dollars)	Annual Operating Costs (dollars)	Present Worth[b] (dollars)	Percent Effluent Reduction (%)
A. Gaseous (Crusher and Fine Ore Bins)				
1. Orifice Scrubber	101,000	7,200	172,000	93.6
2. Wet Impingement Scrubber	116,000	8,600	200,000	97.9
3. Low Energy Venturi Scrubber	173,000	17,000	340,000	99.5
4. Bag Filters	300,000	21,000	506,000	99.9
B. Gaseous (Yellowcake Drying and Packaging)				
1. Wet Impingement Scrubber[c]	(35,000)	(3,500)	(69,000)	97.9
2. Low Energy Venturi Scrubber[c]	(35,000)	(6,900)	(103,000)	99.5
3. High Energy Venturi Scrubber	46,000	15,000	193,000	99.9
4. High Energy Venturi Scrubber + HEPA Filters	106,000	22,000	322,000	>99.99
C. Liquids, Solids, and Windblown Particulate Matter				
1. Clay Core Dam Retention System with Seepage Return and 0.6 Meters (2 feet) of Earth Cover Plus Rock Stabilization[e]	2,250,000	50,000[d]	2,750,000	
2. Chemical Control of Windblown Dust from Tailings Pond Beach	63,000	8,000	142,000	100.00
3. Asphalt Liner for Tailings Pond[e]	800,000	0	800,000	100.00

(a) 1974 dollars, radon-222 emissions not included.
(b) Present Worth = Capital Cost + (Annual Cost x 9.818); 8% Discount Rate, 20 yr. Plant Lifetime.
(c) Costs for all yellowcake effluent control are shown for completeness. In actual practice, the value of recovered product more than compensates the cost of control options B1 and B2.
(d) Includes investment to provide for perpetual care.
(e) [illegible]

will not be considered at present beyond stating that the problem appears potentially significant and, that it can be controlled in principle through sprinkling and by use of wind breaks. Dust generation on ore haul roads can also be controlled by sprinkling.

8.2 Waterborne Effluent Control Technology and Solid Waste Control Technology

New mills in the Rocky Mountains area are using impoundment technology in order to approach zero liquid discharge levels. Recent practice for treatment of solid and liquid wastes is to select a natural ravine which has three basic qualifications for waste storage: (a) limited runoff, (b) dammable downstream openings, and (c) an underlying impermeable geologic formation. Diversion systems (dams and canals) are used to limit the runoff area emptying into the storage basin to prevent flooding of the ravine during a postulated 50-100 year maximum rainfall occurrence. The tailings dam, which should be clay-cored, is keyed into the underlying impermeable formation, which, in one example, is a low porosity shale. Tailings solids slurried in waste process liquids are pumped to the impoundment reservoir for storage and liquid reduction. Liquid reduction is accomplished primarily by evaporation, but also by seepage through the dam, the reservoir walls and floor. By filling a dammed natural depression with tailings, a relatively flat, stable contour is achieved.

Two methods for seepage collection and return are being considered for new mills. Seepage has been estimated to occur from a clay-core retention dam at a rate of 300 liters per minute. In that situation when an impermeable geological formation underlies the retention system, seepage can be collected in a catch basin located at the foot of the dam. The collected seepage can be pumped

The total dose from effluents is almost equal to the EPA whole-body dose and could exceed the organ dose limits. The total dose could be higher than that which could occur from exposure to effluents if consideration is given to radiation from N-16 in the turbine of a BWR station, from storage of radioactive materials onsite, from transportation of radioactive material, from nuclear facilities other than LWR, or from other nuclear sites in the near vicinity of the station site.

3. Conceptual Differences Between Appendix I and the EPA Proposed Standards

There are substantial conceptual differences between the "design objective" and "limiting conditions for operations" features of the NRC 10 CFR Part 50 Appendix I and the standards presented in the EPA proposed 40 CFR Part 190. The design objectives of Appendix I are values which NRC has selected with due consideration of technical feasibility and cost effectiveness. Design objectives are values which the designers and the operators of the facility are to use in selecting station features and operating procedures. A substantial technical effort was undertaken by NRC in order to provide a data base for defining design objective values. Representative values were selected for each of the numerous parameters which are required to be considered in order to estimate the quantities of each radionuclide which might be released and the exposures and doses which might occur as a result of the release.

NRC recognized that each parameter could have a range of values and the selected value was believed to be "realistically" conservative but any particular facility, depending on actual experience, might have greater or lesser releases or impacts than predicted by analytical models used by the NRC staff. NRC also recognized that any particular facility could experience operating difficulties more severe than those assumed in developing the staff analytical models. In recognition of these difficulties in predicting impact, the NRC Appendix I of 10 CFR Part 50 provides for operating flexibility between the "design objectives" and the "limiting conditions" which are reflected in the "technical specifications which define plant operating limits. If the limting conditions are exceeded, the station personnel must report the matter to the NRC, determine the reasons for the higher releases, and determine a course of action which will reduce the releases to the design objective levels. This may be viewed as a graded scale of action rather than a limit.

In contrast, the values proposed by the EPA in 40 CFR Part 190 are limits rather than design objectives, and if they are exceeded the facility presumably would have to cease operations unless the NRC made a "variance" finding that the release was unusual, of a temporary nature, and the societal interests would be served best by continued operation.

4. Direct Radiation Exposure from Onsite Sources

The proposed EPA dose limits include dose contributions from direct and scattered radiation arising from radioactive materials which are confined within onsite structures. Appendix I defines as low as reasonably achievable design objectives for radioactive materials in effluents and

does not address direct radiation. Dose contributions from this source would be additive to the doses arising from effluents. Neither the Draft Environmental Statement nor the referenced technical documents provide adequate bases for limiting the combined dose due to direct radiation and radionuclide discharges to the proposed limits.

Studies of the direct dose due to N-16 in BWR turbines [1-5] show that the dose rate falls off rapidly with distance from the turbine building and, therefore, does not represent major source of population exposure. Individuals residing near the site boundary could receive whole-body dose contributions from this source. The magnitude of this exposure is very dependent upon plant design conditions (power level, turbine design and shielding, equipment orientation, etc.), upon the geometric relationship of the receptor to the source (distance, direction, and orientation to the turbine axis), and upon the habits of the exposed individual such as the type of residence (which determines shielding) and the amount of time spent at that location (occupancy). Because of the multitude of factors which can affect the exposure, it is difficult to specify the magnitude of the individual dose contributed from this exposure pathway except for specific sites and plants. Appendix A provides calculations which indicate the potential magnitude of these doses. Although parametric studies of turbine shielding have been performed [6,7], the costs of backfitting shielding installations would be highly dependent upon individual plant design characteristics. Because of the difficulty in formulating a general model for estimating turbine shine, this source of exposure is addressed by NRC on a case-by-case basis in its licensing actions.

5. Fuel Reprocessing Plants - Thyroid Dose Rates

In 1973 the AEC (now the NRC) staff initiated comprehensive engineering, environmental, and cost studies to provide part of the data base for establishing "as low as reasonably achievable" levels of radioactiv material in effluents from fuel reprocessing plants.[8]

The initial step in the studies, which were performed at the Holifie d National Laboratory (formerly the ORNL), was to develop a model fuel reprocessing plant typical of current design and operation using presen licensing limitations on the release of radioactive materials. The cos benefit of decreasing the release of radioactive wastes through the use of ~~the reasonably~~ effective radwaste systems was analyzed. Decontamination factors and source terms were evaluated for each radwaste system. The radwaste systems ranged from present practice to the foreseeable limits of available technology and were analyzed with respect to normal operation. The technology of several of the radwaste systems considered has not bee demonstrated on a production basis, and those systems, therefore, are not available for immediate application. Thus, some of the radwaste systems that were considered for purposes of a cost-benefit assessment might not achieve projected removal efficiencies with demonstrated practicability.

Radiological impact on the environment depends upon effluent and site characteristics, population distribution, and land and water uses. Two site regimes, similar to sites previously approved by the AEC, were selected for the study in order to assess the range of impacts from site-related characteristics: a site on a plain in a rural southeastern coastal area

adjacent to a continuously flowing stream which empties into an estuary; and a site located on a plain in a rural midwestern environment adjacent to a continuously flowing stream which empties into a large river. Human activities and land and water uses for each site regime were hypothesized and analyzed to determine potential radiation exposure pathways. Doses from identified exposure pathways were calculated for individuals in the vicinity of the plants and for the population within 55 miles of the plants. Hypothetical doses to individuals, to the population, and to organisms near fuel reprocessing plants were evaluated for interaction of radioactive material in effluents from the plants with food and water and irradiation of persons in the environs. Dose models and pathways used in the study to assess exposures are consistent with those used in the licensing of facilities to evaluate the environmental impact from proposed activities. Average meteorologic data from representative midwestern and southeastern coastal regions were used to calculate average atmospheric dispersion factors for use in calculating doses to individuals and to the population. The dose commitments calculated for these sites might be significantly higher than those that are actually experienced owing to the conservatism introduced in the calculation in lieu of definitive data from operating experience.

The results of these studies indicate that the maximum annual dose commitment via the milk pathway to the thyroid of a child located at a distance of 0.5 mile from the plant could approach 500 mrems per year during equilibrium operations of a plant that reprocessed fuel cooled for 160 days

A significant fraction of this estimated dose commitment is due to the release of I-129. Therefore, variation in cooling time beyond 160 days would have very little effect on estimated dose rates. The ALAP studies indicate that the dose could be reduced to about 190 mrem per year at a total annual operating cost of approximately $35,000 [8] (about $3.80 per person-thyroid-rem on a population basis) using macroreticular resin rad-waste treatment equipment. It should be noted that only preliminary laboratory studies have been made of the performance of these macroreticular resins. Development work would be needed to confirm the practicability of the process, which is similar otherwise to conventional ion exchange processes, and to establish suitable methods for resin regeneration and handling of the resins and the spent regenerant. The elapsed time to demonstrate the practicability of this process has been estimated to be three years from project initiation. [8]

The staff believes that this dose rate could be reduced to less than 1 mrem per year by modifying the processing to evolve iodine during dissolut and providing additional treatment equipment. This process is not complex and conventional equipment would be used in a commercial reprocessing plant. The process has been successfully demonstrated on a laboratory scale. However, engineering development and a demonstration of the proc with irradiated LWR fuel and dissolver solution are required. It is estimated that the development and design engineering, equipment procure and installation, start up and testing, and integration into the overall plant circuit could reasonably be accomplished in about 5 years from pro

initiation in view of the simplicity of the process and the use of conventional equipment. Operation of this equipment could require an annual operating cost of approximately $275,000[8] ($130 per person-thyroid-rem on a population basis).

Recent public hearings have been conducted on the environmental impact of the Barnwell Nuclear Fuel Plant pursuant to the National Environmental Protection Act of 1969 (NEPA). The staff has estimated that normal operations of the Barnwell Nuclear Fuel Plant could yield maximum iodine thyroid dose rates to the thyroid of an infant via the milk and inhalation pathways of 88 mrems per year.[9] This dose rate has been estimated for a location at a distance of 1.5 miles from the facility (i.e., the closest uncontrolled distance from the plant).

On the basis of the above studies, and depending on the location of the nearest "real" cow, it appears that compliance with the proposed EPA standard of 75 millirems per year to an individual's thyroid may not be achievable with practicability a consideration, within the next 2 years as required by the EPA standard. We note that the EPA report, which is stated to provide the technical backup for the proposed standard, acknowledges that the technology required to control iodine and krypton releases from spent fuel reprocessing plants is "unproven." (EPA-520/9-73-003-D, Table B2, page B15 However, it is likely that plants designed and approved after 1980 could comply with the level of exposure proposed for 1980 in the standard, but the plants then operating might require additional time to modify (backfit) equipment.

6. Fuel Reprocessing Plants - Quantities of I-129 Released

EPA proposes a standard of 5 mCi per gigawatt-year electrical for the release of I-129, with an effective implementation date of January 1, 1983. Studies carried out at the Holifield National Laboratory include consideration of the control of the long-lived radioiodine, I-129 (half life = 1.6×10^{7} years). The studies indicate that the use of treatment systems incorporating macroreticular resins, could contain I-129 releases to 10^{8} 62 mCi per gigawatt-year electrical at an annual operating cost of about $35,000 for a model plant. Further NRC staff analysis indicates that this improvement can be reduced to practice in about 3 years from project initiation. The addition of iodine evolution equipment to the reprocessing system is believed to be capable of reducing I-129 releases to about 1.6 mCi per gigawatt-year electrical for a model plant and is estimated to require approximately $275,000 in annual operating costs. Reduction of this advanced equipment to practice is expected to require about 5 years from project initiation. Therefore implementation of the proposed 5 mCi per GWe-year effluent limit for iodine-129 appears to be achievable by 1983.

The improvements listed above have been discussed in relation to thyroid doses of individuals from radioiodine. The EPA proposed standards also address I-129 releases per gigawatt-year electrical. We expect that the installation of radwaste treatment systems to satisfy the proposed individual thyroid dose rate standards also would satisfy the proposed standards related to I-129 release quantity.

7. Uranium Mills - Organ Dose Rates

The function of uranium mills is to extract uranium in concentrated form from naturally occurring ore deposits which generally contain three to six lbs. of U_3O_8 per ton of ore (0.15 to 0.30% U_3O_8). In addition to uranium, the ores contain other radioactive constituents, such as thorium-230, radium-226, radon-222, lead-210, etc., which are radioactive decay products of uranium.

At the beginning of 1974, there were 15 operating mills in the United States, plus one mill on a standby basis. Information regarding these mills is provided in Table II. The nominal capacities of the mills range from 400 to 7000 tons of ore per day.[10]

TABLE II. URANIUM MILLS IN THE UNITED STATES IN 1974

State	Status of Mill	No. of Mills	"Nominal" Capacity Short Tons of Ore Per Day
New Mexico*	Active	3	13,500
Wyoming	Active	7	9,050
Colorado*	Active	2	1,750
Washington*	Active	1	400
Texas*	Active	1	1,750
Utah	Active	1	500
TOTAL		15	26,950
Utah	Inactive	1	1,500

*Agreement states

After ore is received at a mill, it is first crushed and then finely ground into a wet slurry. After the ore has reached a fine sand-like consistency, it is contacted with chemicals which selectively dissolve or leach the uranium from the finely ground solids. The barren solids (tailings) are then separated from the pregnant solution and pumped to waste storage areas (tailings ponds). The pregnant solution is then chemically treated to extract and purify the uranium. The stripp solution is then used as the pumping fluid to convey the solid waste tailings to the tailings pon .

It is important to characterize the locale of uranium mills and the type of radioactive materials that are released. Two primary sources contribute radioactive materials to the atmospheric environment. These are: (1) the release of effluents containing radon and particulates carrying radioactive material from the discharge stacks following in-pla dust collection and effluent treatment; and (2) the escape of radon gas and the wind transport of particulates carrying radioactive materia fro the tailings area.

Doses from radon are specifically excluded from the standards proposed by EPA. Practicable means are not presently available to cont releases of radon from either mill discharge stacks or tailing areas.

The application of existing dust collection techniques will control doses from the releases of airborne particulates from mill discharge stacks to within the standards proposed by EPA.

The major dose contribution from uranium milling is from wind transported particulates from tailings retention systems. The tailings retention systems at uranium mills are constructed similarly to those of other ore dressing and hydrometallurgical plants.[11] In the usual case an initial earth dam is constructed using native soils or mine wastes. Tailings slurries are then discharged along the inner edges of the embankments.

Tailings retention systems range in size from a few acres to hundreds of acres containing millions of tons of tailings. During the construction and operation of tailings retention systems, substantial areas of tailings will form beaches due to evaporation, seepage, and drainage of the liquid fraction of the waste slurry by gravity to lower elevations within the overall waste retention system. Thus, as tailings become exposed by beach formation within these waste retention systems, the finely ground solid tailings, containing the radioactive descendants of uranium, become subject to wind erosion. This erosion, along with the diffusion of radon from tailings systems, results in the dispersal of radioactive materials into the surroundings of uranium mills.

Environmental surveys in the environs of uranium mills have been based on the collection and analyses of airborne samples collected by mill licensees, an AEC program to determine airborne concentrations of radioactive materials around tailings piles at closed mills,[12] an AEC-PHS sponsored program[13] to determine radon concentrations around such systems, and an HEW evaluation of the potential effects of unstabilized inactive

piles on the Colorado River Basin.[14] In addition, limited calculations have been made pursuant to the National Environmental Policy Act to estimate potential exposures to individuals by inhalation only from milling activities at three new mills commencing operations since 1970.[15] Engineering, cost, and environmental studies have also been initiated at the Hollifield National Laboratory[16] under the direction of the NRC for the purpose of providing information on "as low as reasonably achievable" effluent releases from uranium mills.

The AEC measurements[12] of airborne concentrations of radioactive materials around tailings piles at inactive mills indicate that airborne concentrations of thorium-230 at 1500 feet from a tailings pile, which had only been inactive a few months and which contained significant moisture, averaged 55% of applicable 10 CFR Part 20 limits. This corresponds to a lung dose rate of about 825 mrem per year from inhalation of thorium-230 alone to an individual continuously present in such an environment. It is recognized that tailings at inactive mills are more prone to wind erosion than those at active mills. The question of ALARA releases from uranium mills is under active study by the NRC staff.

The "as low as reasonably achievable" studies performed by HNL estimate the total maximum annual bone dose rate to a hypothetical individual at 0.5 miles from a theoretical model operating uranium mill and tailings area in Wyoming to be 1060 mrem per year, assuming total occupancy at that location and that 100% of the food consumed is produced locally. It is recognized that this dose rate overestimates reality because of the sparse

population in the vicinity of most mills and the unlikely assumption that an individual obtains all his food locally. However, the subject of real doses to real people will require further study before firm conclusions can be reached with regard to establishing the conformance to generally applicable limits as they affect uranium mills.

Recent evaluations[15] of environmental impacts from uranium mills pursuant to NEPA resulted in the calculated dose rate equivalents presented in Table III.

TABLE III. ESTIMATED OFFSITE DOSES FROM URANIUM MILL AIRBORNE EFFLUENTS[15]

Mill	Location	Dose (mrem/year) Bone	Lung
Petrotomics	Outside Fence	38.6	38
Humeca	Ranch	42	23
Highland	Ranch	3.4-12	1
Shirley Basin	Ranch	0.4	1.0

These calculated dose rates result from inhalation only. These are a small fraction of the 3 rem bone and 1.5 rem lung limits of Part 20. The boundary dose rates are hypothetical, since no individual resides at the site boundaries. The dose rates include radionuclides from the mill and mine ventilation systems, but do not include radionuclides that have become airborne owing to wind erosion of tailings. Again, additional studies would be required to identify the dose to a real individual.

8. Removal of Noble Gases from Fuel Reprocessing Plant Effluents

The principal concern arising from the release of noble gases from reprocessing plants (particularly Kr-85) is the dose commitment (man-rem) delivered to populations. Over the period 1980-2000, the United States would contribute approximately 25% of the Kr-85 dose commitment to the world population. Thus, if the United States were the sole nation to require noble gas removal from reprocessing plant effluents, the desired consequences of control would be largely negated. Similarly, the costs associated with reductions in dose commitments may be related to both the United States population and that of the world. Estimates of these costs are provided in Table IV.

TABLE IV. COST ESTIMATES PER MAN-REM REDUCTION OF KR-85 DOSE COMMITMENT FROM U.S. LWR REPROCESSING PLANTS

Year	No. of Plants[1]	Cost in Dollars Per Man-Rem Reduction[2]			
		U.S. Population		World Population	
		Holdup	Holdup and BF[3]	Holdup	Holdup and BF[3]
1975	0				
1980	0				
1985	2	29,800	36,500	352	393
1990	4	19,900	26,500	228	277
1995	8	20,400	25,000	224	249
2000	11	19,700	23,500	204	222

1. In addition to NFS, AGNS, and MFRD plants.
2. In dollars of 1973.
3. Plants built prior to 1983 backfitted (BF) to recover 99% of the krypton in the fuel received.

As may be seen in Table IW, the costs per man-rem reduction in dose to the population of the United States is about a factor of 90 greater than that to the worldwide population. An interim value of $1,000 per man-rem and $1,000 per man-thyroid-rem are specified in Appendix I for judging the cost effectiveness of efforts to reduce population doses. Kr-85 removal equipment installation and operation would not be cost-effective when considering the U.S. population dose from Kr-85. Only in terms of world population can the installation of Kr-85 removal systems be argued as justifiable in terms of cost effectiveness. Unilateral action on the part of the United States to remove Kr-85 would have little effect on the dose delivered to the entire world population. Foreign fuel processing will contribute about 3 times the Kr-85 dose contributed by processing in the United States if Kr-85 is not collected by any country. Given these considerations, it is the view of the staff that the self-imposition by 1983 of Kr-85 removal systems upon United States fuel reprocessing plants should be deferred pending resolution of developing standards now in progress under auspices of the International Atomic Energy Agency.

A delay in imposing standards for Kr-85 release for the purpose of establishing policy will impose virtually no added risk to any individual. Estimated dose rates as a result of assumed releases from all worldwide facilities of Kr-85 through the year 2000 are about 0.03 mrem whole body per year or about 1/2500 that of natural background radiation.[17] Skin dose rates for such conditions are calculated to be about 3 mrem per year.

Prior to the imposition of release standards for Kr-85 with the consequent investments in equipment and operations, the staff believes that these costs should be examined in terms of societal risks and alternative beneficial investments of the nation's resources. This view is in consonance with a conclusion given in the BEIR report[18] that states "... it is becoming increasingly important that society not expend enormously large resources to reduce very small risks still further, at the expense of greater risks that go unattended; such unbalances may pass unnoticed unless a cost-benefit analysis is attempted. If these matters are not explored, the decisions will still be made and the complex issues resolved either arbitrarily or by default since the setting and implementation of standards represent such a resolution."

While the above considerations appear to be overriding, the development of krypton removal equipment to practice in fuel reprocessing plants should be fostered and continued, particularly in view of the possibility of international agreements to limit releases of Kr-85. The staff also notes that the unilateral requirement of restricted Kr-85 release by the U.S. could also adversely affect the competitive position of the U.S. in processing fuel compared to that of foreign countries which do not have such a requirement.

It is expected that noble gas removal systems appropriate to the fuel reprocessing industry could be operational in 1983 if appropriate research and development efforts were to be initiated now.[8] This date, when compliance with the EPA Kr-85 release standards is proposed, may be optimistic

However, the EPA proposes that the development program on noble gas removal be reviewed in the future to establish the practicability of removal systems prior to 1983. At present, two noble gas removal systems appear to have the greatest promise. These systems may be described as the selective absorption and the cryogenic distillation systems. Description of these systems and estimated schedules for their proof of practice certifications are provided in References 17 through 26.

9. Utility of the EPA Proposed Standard

In 1971, the AEC amended 10 CFR Parts 20 and 50 to include the following criteria:

10 CFR Part 20.1(c)

"... persons engaged in activities under licenses ... should, in addition to complying with the requirements set forth in /10 CFR Part 207 ... make every reasonable effort to maintain radiation exposures and releases of radioactive material in effluents to unrestricted areas as far below the limits specified in /10 CFR Part 207 as practicable."

10 CFR Part 50.34a(a)

"... The applicant /for a permit to construct a nuclear power reactor/ shall ... 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."

The terminology "as low as practicable" is defined in 10 CFR Parts 20 and 50 to be:

"... 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 health and safety and in relation to the utilization of atomic energy in the public interest."

In 1971 the AEC proposed numerical guidelines for radioactive material in LWR effluents to meet the criterion "as low as practicable." An evidentiary public hearing was held on the rulemaking action. About 4,200 pages of testimony, a three-volume environmental impact statement, and thousands of pages of written testimony and exhibits were produced in this rulemaking action. The public hearing was completed on December 6, 1973, and the NRC published Appendix I as an amendment to 10 CFR Part 50 on May 5, 1975. While the rulemaking action was time consuming and extensive, it permitted participation by all interested parties and was responsible for the development of a substantial data base upon which a sound rule could be drawn. Further, the criterion "as low as practicable" which exists in 10 CFR Parts 20 and 50 was applied in the licensing of reactors in an effective manner during the four-year period that was required to complete the rulemaking process.

Upon completion of the public hearing on Appendix I, an effort was initiated to develop the generic technical and economic data base for selection of numerical guides to meet the "as low as practicable" criterion for uranium fuel cycle facilities other than LWR power stations. While a substantial amount of data has been produced from this effort, the generic effort has not been completed and the numerical guidelines for all uranium fuel cycle facilities are specified on a case-by-case basis in the licensing review.

In view of the effective effort demonstrated by the NRC to restrict exposures and releases of radioactive material from licensed nuclear facilities to as low as reasonably achievable levels, it appears that the proposed EPA 40 CFR Part 190 would not significantly reduce the population exposure from reactor and fuel cycle effluents, but it does have significant administrative impacts in other areas as described below.

0. Implementation of the EPA Proposed Standard

Among the alternatives to 40 CFR Part 190 considered by EPA was one which would set lower values for the standard. This alternative was rejected by EPA because, as stated in the EPA DES, "... it would impose a large administrative burden on NRC in order to insure compliance." Should the proposed 40 CFR Part 190 become an effective rule, implementation of that rule would impose a substantial administrative burden. The following technically substantive administrative problems are representative of those which would be presented to NRC if 40 CFR Part 190 were to become a rule.

a. Revise 10 CFR Part 20 and the recently amended Part 50 (Appendix I) to implement 40 CFR Part 190.

b. Revise Technical Specifications for all licensed LWR power stations to reflect the requirements of 40 CFR Part 190.

c. Review all licensing actions to identify facilities which will require additional radwaste treatment or other features which will permit compliance with 40 CFR Part 190 and identify methods by which compliance could be accomplished and demonstrated.

d. Decide, as a matter of policy, whether the facilities should be designed for current land and water usage by persons in the near vicinity of the station and require backfit or restrictions should usage change, or design for potential land and water usage to avoid the more costly backfitting, operating restrictions, and extensive surveillance requirements.

e. Determine whether the quantities of Kr-85 and I-129 which would be permitted by 40 CFR Part 190 after January 1, 1983, refer to all uranium fuel processed after that date or only to that fuel which was used to generate electrical power after that date. A finding on this issue could influence decisions on matters such as the schedule for processing spent fuel and similar issues dealing with fuel and waste management

f. Provide guidelines on what constitutes "a temporary and unusual operating condition" for a nuclear facility for which the NRC may grant a "variance". Guidelines also would have to be provided for judging the "necessity to protect the overall societal interest with respect to the orderly delivery of electrical power" should the need for a variance by NRC be required for a uranium fuel cycle facility.

g. Review the analytical models currently used by NRC staff to estimate potential doses and consider possible modifications or adjustments for doses to "real people" as stated by the EPA in the DES. It is actually impossible to determine accurately the actual doses to specific individuals owing to the mulviple exposure modes, the levels which are too low to measure, the mobility of individuals, unique characteristics of individuals, and other factors.

h. Perform studies to determine the relationships between releases of radioactive material and the doses which might be received by individuals in a region where interactions of dispersion patterns from multiple nuclear facilities overlap.

i. Determine what modifications on siting criteria for uranium fuel cycle facilities might be required to comply with 40 CFR Part 190. In view of the low dose limits specified in the EPA proposed standard, distance requirements required to assure compliance for normal operations of the facilities might be more restrictive than those required in consideration of serious accident situations.

j. Devise a system for relating release quantities of Kr-85, I-129, and long-lived transuranic elements to the power generated by LWR power stations and allocating permissible release quantities among uranium fuel cycle facilities. Allocation of release quantities among newer and older facilities would be complicated by factors such as possible competitive advantages which might be realized by older stations, which might not have features which will be included in new facilities, should they be granted release allotments based on considerations other than fuel burnup quantities. On the other hand, backfitting of older facilities can be extremely expensive and place these facilities at a competitive disadvantage if the backfitting is required.

If the contributions of the iodine-129 and alpha-emitting transuranics from light-water-cooled nuclear reactors would have to be assessed in order to comply with the proposed standards, then a considerable expenditure of effort

and money would be required to measure radionuclides which, in themselves, contribute insignificantly to the radiation dose from nuclear power reactors. If the reactor contribution could be omitted, then the standards would represent effluent limitations solely for spent fuel reprocessing plants.

Even if the contributions from the reactor facilities were omitted, determination of a priori effluent limitations (such as the technical specifications in NRC licensing conditions) would prove almost impossible. Because these proposed limits are tied to energy production, knowledge of the fuel burnup and the thermal efficiency of the reactor (to convert thermal energy to electrical energy) would be required for each batch of fuel reprocessed. Because of the variation in individual reactor design, power level, and fuel management practices, it would be nearly impossible to specify, beforehand, the total equivalent energy generated by the annual reprocessing plant throughput of spent fuel. The reprocessing facility would have to keep a running account of the total activity released to the environment and the total energy which had been generated by the fuel. The ratio of these quantities would have to be computed prior to initiation of processing for each batch of fuel in order to determine whether that batch could be processed without exceeding the EPA standard. Even if a given reprocessing plant were to remain in compliance, the ratio of the total activity discharged and the total equivalent energy production for all reprocessing facilities would have to be calculated by NRC for every batch of fuel reprocessed to insure that the overall totals were in compliance.

11. Perspective of the Impact of the EPA Proposed Standard

The EPA Draft Environmental Impact Statement (DES)* states that implementation of the proposed 40 CFR Part 190 would avert an estimated 1030 "potential health effects" which would occur if current NRC regulatory practices were to continue. The DES presents values for the potential health effects attributable to operation of the nuclear fuel cycle through the year 2000 at various environmental radiation protection levels. Table 10 on page 82 of the DES contains columns which contain estimated values based on existing "Federal Radiation Guides," "Current AEC Practice," and "EPA Generally Applicable Standards." According to this table, there would be a substantial difference between the values projected under FRC guidance and AEC practice only for short-lived materials where Appendix I has been recognized to restrict releases in effluents to levels below the FRC guides. The values projected under FRC guidance and AEC practice are identical for all other sources. The DES does not present sufficient details to determine the bases for the estimates presented, but apparently the estimates do not recognize that the nuclear facilities have not been operated in a manner which would result in doses to individuals at levels as high as those permitted by the FRC standards nor does it recognize the existence of the "as low as reasonably achievable" criterion which the NRC applies to all uranium fuel cycle facilities and which assures that the dose levels are well below the FRC guides.

---

*Table 10, page 82, DES

In addition, the potential health effects are estimated assuming a linear nonthreshold relationship of somatic and genetic effects to radiatic dose at levels which approach zero and which are delivered at a very low dose rate. The bulk of the health effects are postulated to occur as a result of integrating the extremely low doses from long-lived materials to the world's population over several decades.**

Without a perspective, the estimated 1030 health effects postulated to occur over about 150 years might appear to be substantive. Placed in perspective, the estimated 1030 health effects are small, a small number in a statistical sense when compared to the billions of such health effects which can be estimated to occur from other causes during the same time period. Table V presents an estimate of the normal incidence of cancer and serious genetic diseases of the types referred to as "health effects."

Numerical estimates of "health effects" presented in the Draft Environmental Impact Statement for the Uranium Fuel Cycle standard are based upon the hypothesis of a linear, non-threshold, dose rate independent relationship between biological effects and doses applied at levels which approach natural backgsound. This is consistent with the recommendations of scientific authorities in matters of radiation protection. However, experimental data are inadequate to verify or to

---

**Table 3, page 12, Environmental Analysis of the Uranium Fuel Cycle, Part III, Nuclear Fuel Reprocessing, EPA-520/9-73-003D, Oct. 1973

deny this hypothesis. An alternate hypothesis is that the probability of biological effects are reduced when the doses are delivered at low dose rates and that an effective threshold exists. If this alternate hypothesis is correct, the probability of biological effects at very low dose levels could be zero. More than 93% of the total-body dose commitment, which represent essentially all of the calculated health effects, are the result of summing doses far less than one mrem per year to the entire population of the world over several decades. Thus, a fair statement would be that the expected impact is likely to be within the range from zero to 1030 health effects.

TABLE V. ESTIMATED NORMAL INCIDENCE OF "HEALTH EFFECTS" IN THE U.S. AND IN THE WORLD

Period	Population	Cancer	Genetic
1970-2020 [1]	U.S. [2]	1.8×10^7 deaths [3]	--
		3.7×10^7 cases [4]	--
1970-2120 [5]	U.S.	--	5.0×10^7 cases [6]
1970-2020	World [7]	5.9×10^8 deaths [8]	--
		1.2×10^9 cases	--
1970-2120	World	--	3.0×10^9 cases [9]

Total health effects (cancer + genetic) cases

U.S.	8.6×10^7 cases
World	4.2×10^9 cases

1/ A 50-year period was selected for evaluating cancer incidence to compare with the EPA postulated number of somatic effects resulting from doses from exposures to radiation originating in U-fuel cycle facilities during the several decades.

2/ The population of the U.S. was based on Fig. D.1, p. D-9 of EPA-520/9-73-003D

3/ A cancer death rate of 1.29×10^{-3} per person year from the U.S. was selected from World Health Statistics Annual 1966-67.

4/ The number of new cancer cases was assumed to be twice the number of cancer deaths per the NAS/NRC BEIR Report.

5/ A 150-year period was selected for evaluating genetic disease incidence to correspond to the time period for the EPA genetic estimates.

6/ A value of 6% was selected for genetic disease incidence based on estimates in the BEIR Report.

7/ The world population was assumed to be 3.5×10^9 in 1970 and to increase by 1.9% per year to be consistent with p D-15 of EPA-520/9-73-003D.

8/ A cancer death rate of 1.22×10^{-3} per person year for the world was estimated from data in the World Health Statistics Annual 1966-67.

9/ The U.S. genetic disease incidence (6%) was assumed to apply the world population.

Further, the United States will contribute only about one-quarter of the Kr-85 worldwide inventory from uranium fuel cycle operations which will be the source of these worldwide low-level doses. Neither national nor international authorities in radiation protection have specifically addressed the significance of worldwide low-level doses and the need for international control of Kr-85 and similar radioactive sources.

While the values for normal incidence presented in Table VII are gross estimates, it is clear that the estimated 1030 health effects which EPA postulates to be averted by implementing the proposed 40 CFR Part 190, even if correct, would cost about $100,000,000 to the United States and would represent an increase of less than 0.0003% in the normal incidence of these health effects.

1. Lowder, W. M. and Raft, P. D., "Environmental Gamma Radiation Exposure Rates from Nitrogen-16 in the Turbines of a Large BWR Power Plant, Health and Safety Laboratory, USAEC, New York, October 1971.

2. Lowder, W. M., Raft, P. D. and Gogolak, C. V., "Environmental Gamma Radiation from Nitrogen-16 Decay in the Turbines of a Large Boiling Water Reactor," Health and Safety Laboratory, HASL TM 72-1, USAEC, New York, February 1972.

3. Lowder, W. M., Raft, P. D. and Gogolak, C. V., "Environmental Gamma Radiation from Nitrogen-16 Decay in the Turbines of a Large Boiling Water Reactor," Health and Safety Laboratory, HASL-271, USAEC, New York, January 1973.

4. Blair, L. M., LeClare, P.C., Philbin, T.W., and Tuday, J.R., "The Evaluation of Direct Radiation in the Vicinity of Nuclear Power Stations," Environmental Analysts, Inc., Garden City, N.Y., Publication No. 303, June 1973.

5. Memorandum to Participants in the April N-16 Radiation Surveys at the Arnold and Cooper Nuclear Power Stations, W. M. Lowder, ERDA/HASL, June 11, 1975 (and attachments).

6. Private Communication, James M. Smith, Jr., Nuclear Energy Division, General Electric Company, San Jose, California, to William [illegible], USAEC, January 17, 1975.

7. Private Communication, E. A. Warman, Stone and Webster Engineering Corporation, to J. Kastner, USAEC.

8. Blanco, R. E., et al, Correlation of Radioactive Waste Treatment Costs and Environmental Impact of Waste Effluents in the Nuclear Fuel Cycle for Use in Establishing "As Low As Practicable" Guides - Nuclear Fuel Reprocessing, ORNL-TM-4901, in press.

9. "Supplemental Testimony Regarding the Health Effect to the Local Population from Normal Operations of the Barnwell Nuclear Fuel Plan (The Reprocessing Facility)," F. J. Congel and K. F. Eckerman, Docket No. 50-332, undated.

10. Statistical Data of the Uranium Industry, U.S. Atomic Energy Commission, p 62, 1974.

11. Merritt, Robert C., The Extractive Metallurgy of Uranium, Colorado School of Mines Research Institute, 1971.

12. HASL Technical Memorandum, 64-14, July 31, 1964.

13. Evaluation of Radon-222 Near Uranium Tailing Piles, U.S. Public Health Service, DER by-1, March 1969.

14. "Disposition and Control of Uranium Mill Tailings Piles in the Colorado River Basin," Federal Water Pollution Control Administration, Region VIII, U. S. Department of Health, Education and Welfare, Denver, March 1966.

15. Environmental Statements for Highland Uranium Mill (Docket No. 40-8102), the Shirley Basin Uranium Mill (Docket No. 40-6622), and the Humeca Mill (Docket No. 40-8084) and the Environmental Impact Appraisal for the Petrotomics Co. Uranium Mill (Docket No. 40-6659).

16. Blanco, R. E., et al, Correlation of Radioactive Waste Treatment Costs and Environmental Impact of Waste Effluents in the Nuclear Fuel Cycle for Use in Establishing "As Low As Practicable" Guides - Uranium Milling, ORNL-TM-4903, in press.

17. "The Potential Radiological Implications of Nuclear Facilities in the Upper Mississippi River Basin in the Year 2000," USAEC, WASH-1209, January 1973.

18. "The Effects on Population of Exposure to Low Levels of Ionizing Radiation," Report of the Advisory Committee on the Biological Effects of Ionizing Radiations, Division of Medical Sciences, National Academy of Sciences National Research Council, Washington, D.C., November 1972.

19. Stephenson, M. J., et al, "Experimental Demonstration of the Selective Absorption Process for Krypton-Xenon Removal," Proceedings of the 12th Air Cleaning Conference Held in Oak Ridge, Tennessee, August 28-31, 1972, CONF-720823, Vol. 1, January 1973.

20. Hogg, R. M., "New Radwaste Retention System," Nuclear Engineering International 17, 98-99, 1972.

21. Nichols, J. P. and Binford, F. T., "Status of Noble Gas Removal and Disposal," ORNL-TM-3515, August 1971

22. Bendixsen, C. L. and Offutt, G. F., "Rare Gas Recovery Facility at the Idaho Chemical Processing Plant," IN 1221, April 1969.

23. Bendixsen, C. L. and Rohde, K. L., "Operational Performance and Safety of a Cryogenic System for Krypton Recovery," Trans. Am. Nucl. Soc., 15(1), 96, 1972.

24. Davis, J. S. and Martin, J. R., "A Cryogenic Approach to Fuel Reprocessing Gaseous Radwaste Treatment," Trans. Am. Nucl. Soc., 16, 176-77, 1973.

25. Draft Environmental Statement, Limerick Generating Station, Dockets 50-352 and 50-353.

26. Draft Environmental Statement, Susquehanna Steam Electric Station, Dockets 50-387 and 50-388.

APPENDIX A

CALCULATED ^{16}N TURBINE DOSES

Measurements at several boiling water reactors [1-5] have shown that the dose rate from direct radiation falls off exponentially with distance according to the formula:

$$D(r) = Ae^{-br}$$

where D(r) is the dose rate at distance r in mrem/year, r is the distance from the turbine in meters, and A and b are parameters which are determined by fitting the model to experimental data. These constants are highly dependent upon the turbine building design and the reactor power level as shown in Table A-1. At present, these variations are not well understood. The parameters generally represent the dependence of the dose rate upon distance in the direction of the highest measured dose. The dose rate is also related to the direction with respect to the turbine axis so that the doses calculated using those parameters represent upper bound estimates. The exponential nature of the model indicates that the dose rates fall off rapidly with distance.

TABLE A-1

EXTERNAL DOSE PARAMETERS DETERMINED FROM EXPERIMENTAL MEASUREMENTS [1-5]

Code	Reactor Power Level MWe	A	b
1	600	1250	0.0132
2	1840	716	0.0088
3	1555	543	0.0091
4	1000 (normalized)	108	0.011
5	1000 (normalized)	125	0.0066
6	1000 (normalized)	858	0.0099
7	1000 (normalized)	2470	0.0161

In order to estimate the doses which may exist at typical reactor sites, the site boundary (exclusion radius) distance and the distance to the nearest residence were examined for 13 BWR reactors selected at random. These distances were measured from the reactor building and not the turbine axis, but they give approximate estimates of the distances which could represent actual site conditions for real reactor installations. The range of values is represented in Table A-2.

TABLE A-2

REPRESENTATIVE BWR SITE PARAMETERS

	Minimum	Maximum	Average I S. E.
Site Boundary (meters)	21	1340	650 ± 110
Nearest Residence (meters)	43	1560	925 ± 115

These distances were used with the models in Table A-1 to determine the range of doses which might be expected to occur at real sites and distances. The results of these calculations are shown in Table A-3. As can be seen, the majority of the calculations yield doses which are considerably below 1 mrem/year. However, for smaller sites the contributions to the external dose rate could be appreciable fractions of the proposed EPA standard. The site boundary doses assume continuous occupancy which would not actually occur, but even with a 10% occupancy (880 hours per year)

the site boundary doses at the smallest site might be 7 - 10 mrem/year. These doses could be additive to the dose contribution from radioactive materials in the facility effluents and could, thereby, result in total doses in excess of the proposed standard of 25 mrem/year. Because the turbine doses are highly dependent upon individual site and reactor design parameters, the NRC staff believes that they can be more properly addressed in individual licensing actions on a case-by-case basis, rather than by a general standard.

TABLE A-3

CALCULATED DIRECT RADIATION DOSES FROM BWR TURBINES

Location	Distance (m)	Model	Calculated Dose Rate (mrem/year) 1	2	3	4	5	6	7	Average
Site Boundary	215	minimum	73*	108*	76*	10*	30*	102*	78*	68*
	1340	maximum	<0.0001	0.0056	0.0026	<0.0001	0.018	0.0015	<0.0001	0.003
	650	average	0.23	2.4	1.4	0.085	1.7	1.4	0.07	1.(
Nearest Resi[illegible]	433	minimum	4.0	16	10	0.92	7.2	12	2.3	7.
	1560	maximum	<0.0001	0.0008	0.0003	<0.0001	0.004	0.0002	<0.0001	0.00
	925	average	0.006	0.21	0.12	0.0041	0.28	0.090	0.0008	0.1

*hypothetical doses based upon continuous occupancy

ATTACHMENT A

NRC SUPPLEMENTARY ANALYSIS OF THE PROPOSED 40 CFR PART 190

MARCH 8, 1976

TABLE OF CONTENTS

INTRODUCTION

The Nuclear Regulatory Commission (NRC) staff submitted written comments on the proposed EPA regulation 40 CFR Part 190 on September 15, 1975. A copy of these previous comments is attached. In our comments we identified several technical and administrative issues which should be resolved. We have reviewed the Supplementary Information dated January 5, 1976 in which EPA addressed some of the same issues raised in our previous written comments. This supplemental information has not altered our view that the proposed EPA standard (1) would provide little, if any, additional benefit beyond that provided by current regulatory practices, (2) would impose substantial additional regulatory burden, and (3) could prove to be impracticable in compliance by major components of the uranium fuel cycle.

We note in the Supplementary Information it is concluded that Appendix I to 10 CFR Part 50 provides "adequate assurance," prior to operation, that a light water cooled nuclear power reactor (LWR) facility is capable of compliance with the proposed standards for sites containing as many as five reactors but a substantial number of rules, guides, and other licensing procedures would have to be altered to be consistent with the proposed standard. We will address these and other aspects of the practicability and feasibility of implementing and demonstrating compliance with the proposed standard.

I. LIGHT WATER COOLED NUCLEAR POWER REACTORS

A. Experience Gained from 10 CFR Part 50, Appendix I Rulemaking.

In the Appendix I rulemaking proceeding, some important regulatory experience was gained which we believe can be helpful in the present standard setting effort.

Appendix I of 10 CFR Part 50 establishes numerical guidelines for meeting the "as low as reasonably achievable" (ALARA) criterion for levels of radioactive material in effluents of light water cooled nuclear power reactors. Appendix I was promulgated after an extensive rulemaking proceeding extending over a period of about four years, including an evidentiary public hearing.

The AEC, in initiating the rulemaking effort to specify numerical guidelines which would satisfy the "as low as reasonably achievable" (ALARA) criteria in 10 CFR Parts 20 and 50, faced a situation similar to the one EPA now faces. Light water cooled nuclear power reactors were selected for the initial effort at quantifying the ALARA criteria, not because the reactors were identified as a dominant source of exposures, but rather because commercial-scale power reactors had been operating for more than a decade and a substantial amount of experience and data were available. These data were thought to be adequate to provide a sound technical base for selecting practicable numerical guidelines which would be generally applicable to commercial-scale power reactors.

The data from effluent measurements by licensees prior to 1971 and other sources were reviewed to select representative values for the "source terms" (quantity and identity of radionuclides in effluents). The source terms were used in analytical models to estimate potential doses to individuals and to populations in the vicinity of nuclear power reactor sites. The numerical guidelines which were derived in this manner in 1971 were thought to represent "good demonstrated engineering practice." Subsequently, in 1973, in developing information for the Environmental Impact Statement for the Appendix I rulemaking proceedings (particularly for the cost-benefit analysis), it was necessary to relate source terms to specific station design features and operating modes. In doing this, it was realized that the existing data on source terms were adequate to demonstrate compliance with the Federal Radiation Councils' radiation protection guides (RPGs)* embodied in 10 CFR Part 20, but inadequate to provide a basis for selecting numerical guidelines substantially below the radiation protection guides. Indeed, minor pathways for release of radioactive material from the LWR stations were identified which previously had not been monitored at all.

---

*Radiation Protection Guides for individuals and for suitable samples of exposed groups in the general population were presented by the Federal Radiation Council in Report No. 1 (May 1960) and Report No. 2 (September 1961). The RPG values are:

Population:

Individuals	0.5 rem/yr to whole body 1.5 rem/yr to thyroid gland 0.003 microgram Ra-226 in skelton
Average for population	5 rem/30 years to gonads
Average for suitable sample of exposed group in general population	0.5 rem/yr to thyroid gland 0.001 micrograms Ra-226 in skelton

While these pathways yielded small fractions of dose relative to the higher levels of radiation protection guides, they were substantial contributors relative to the lower ALARA levels.

In summary, as we gained experience in our study of LWR source terms and equipment capability in operation, we concluded that some features of the numerical guidelines proposed in 1971 could not practicably be achieved.

In recognition of this finding, the proposed guidelines were revised to higher values. More importantly, we then first recognized that rather than simply reflecting contemporary "good engineering practices," the values were in part, based on the use of extensive and untested station design features. That is, these unproven features would have to perform as designed in order for LWR stations to achieve compliance with the higher numerical guideline values proposed in 1974. The regulation (Appendix I of 10 CFR Part 50), which became effective on June 4, 1975, is an even further relaxation of the numerical guidelines that were proposed in 1974, partially because it reflects the recognized uncertainties in source terms owing to the lack of data from operating commercial power stations with advanced design features.

We believe it is important that recognition be given to the fact that an adequate technical data base is required for selecting the limit values in 40 CFR Part 190, if the limits practicably are to be achievable. The lessons learned in developing Appendix I concerning the practicability and feasibility of effluent controls imply that the proposed 40 CFR Part 190 is impracticable for those portions of the uranium fuel cycle in which undemonstrated effluent controls must be used to meet the proposed standard.

B. Graded Scale of Action (design objective values) vs. Limits.

"Design objective quantities" and "limiting conditions of operation," which are specified in Appendix I, represent a graded scale of action rather than a limit. The design objective quantities may be thought of as goals which NRC believes can and should be attained in the design and operation of LWR stations. This regulatory concept recognizes that there are many variable factors which affect the ability of a licensee to meet the goals and that there will be occasions when the design objective quantities may be exceeded even though every reasonable measure is being taken to keep effluent levels as low as reasonably achievable.

In contrast, the values presented in the EPA proposed standard are limits.* The proposed standard, in EPA's view, if promulgated, would supersede for uranium fuel cycle facilities the current Standards for Protection Against Radiation, 10 CFR Part 20, which derive from RPGs promulgated by the Federal Radiation Council under Presidential authority [Supplementary Information, Part A, p. 3]. Historically, compliance with RPGs has been demonstrated by restricting potential exposures to levels well below the limiting values and by requiring only sufficient monitoring to verify that potential exposures were well below the limits. This has been done as a practical matter because if the operation of a nuclear facility were such that potential doses could be very near the limits, additional and costly monitoring and surveillance programs would be required to assure that the limits are not exceeded. If the limit is lowered to about 1/20 of the current RPGs, as proposed by EPA, it be impractical to

*The standard does provide that a "variance" can be granted by NRC for unusual and temporary conditions if it is the public interest to do so. We will discuss this feature of the proposed standard in several sections below.

demonstrate compliance by restricting releases to a small fraction of the lowered limits and it will be necessary to require substantially expanded monitoring and surveillance programs. We further discuss the demonstration of compliance with the proposed standard in Section V.

C. Reactor vs. Site Limits.

In the Supplementary Information dated January 5, 1976, it is stated that the NRC has issued guidance for single LWRs [Supplementary Information, Part A, p. 2] and concludes that it is unlikely that doses from each of several reactors sharing a common site would be additive. [Supplementary Information, Part C, p. 15] This conclusion is wrong.

Appendix I of 10 CFR Part 50 presents numerical guidelines for each light water cooled nuclear reactor. When multiple reactors are placed on one site, the calculated potential doses at a location beyond the site boundary could be only slightly greater than the calculated dose for a single reactor on the site, but there is no such regulatory requirement. Rather, for substantial periods of time the potential doses at that location is expected to be several times greater than the potential dose value for a single reactor on the site. The practicability conclusions of Appendix I are very specific in permitting this. It is important to recognize that if several reactors are located on a site, the individual reactors can (and probably will) have specific design features which differ from the others sharing the site. They may have been designed and built at different times, or reactors which are located more distant than others from a limiting dose receptor offsite may need less radwaste

processing equipment in order to meet the criteria of Appendix I. Further, it is common practice for two reactors to share common radwaste systems and effluent release locations. Thus, isodose lines for each of the reactors on the site could intersect or overlap and the potential doses can and probably will be additive. If each of the several reactors sharing a single site had identical design features, it would be less likely that the potential doses from the several reactors would add in a manner to be substantially greater than the potential dose from a single reactor, but even then it could occur, and it is not prohibited by Appendix I.

We stated in our previous written comments that three reactors operating within the design objective values of Appendix I on a single site could exceed the limits of the proposed standard. That is, they would be designed to meet Appendix I which is equivalent to design criteria which would permit violation of 40 CFR Part 190 as proposed. Since limiting conditions of operations are twice the design objective values, two reactors on a single site also could exceed the proposed standard. Thus, we cannot agree with the conclusion that Appendix I would provide de facto assurance that as many as five reactors on a single site would comply with the proposed standard. [Supplementary Information, Part A, p. 4] While we agree philosophically that it would require combinations of liquid and air pathways of exposure which could be simultaneously intercepted by real individuals for the proposed standards to be exceeded at a site containing several reactors, we believe that the potential for this combination could arise whenever two or more reactors are evaluated

for a single site and NRC would be required to demonstrate that the combination will not occur. It is reasonable to expect that new procedures would be required for LWRs to demonstrate, at the licensing review stage, reasonable assurance of compliance in operation with 40 CFR Part 190.

Appendix I numerical guidelines are applied by calculating the potential doses which might be received by individuals at various locations. They also are applied to potential land and water usage and food pathways which could exist near the site. EPA has stressed that the dose limits in its proposed standard are actual doses to real people. While we believe that it is proper for the standard to be so qualified, it also must be recognized that it is not practical to accurately determine actual doses to real people when there are many variable factors which can affect the doses actually received. Many of these variables cannot be controlled or determined, and there is no practical way to directly measure the doses to an individual from all pathways of exposure.

Thus, dose estimate must be based on analytical models and a considerable range of uncertainty always will be inherent in establishing a relationship between the estimated potential doses to individuals and "actual" doses they receive. As we develop more "realistic" models, the calculated doses will sometimes underestimate the actual doses owing to the variable nature of the parametric values.

Generally, anticipated potential land and water uses are taken into consideration in selecting station design features. While the consideration of potential land and water use in licensing procedures tends to introduce an element of conservatism, this is not necessarily the case over the lifetime of the station.

EPA places considerable reliance on the Commission's statement in its Statement of Considerations for Appendix I that several LWRs on a single site can operate with doses to individuals less than 5% of the present 10 CFR Part 20 limit; i.e., presumably 25 mrem/yr to the whole body as 5% of the 500 mrem/yr limit [Supplementary Information, Part C, p. 3]. It should be noted that the quoted statement of the NRC is not part of the regulation, Appendix I to 10 CFR Part 50. While the values so quoted may be appropriate for multi-LWR sites on the average, the limiting conditions for operation in the regulation permit operation at twice the design objective values and radiation sources other than effluents are not included in Appendix I (e.g., N-16, storage sources, etc.). The sum of all dose contributions at a multiple reactor site can, and probably will, exceed 5% of the current RPGs.

This misunderstanding of the way Appendix I works in practice is amplified when one realizes the added difference between yearly average performance and short term field measurements required by EPA to demonstrate noncompliance with the proposed 40 CFR Part 190 (see Section V, below.)

D. Prospective vs. Retrospective Dose Estimates.

EPA suggests that NRC licensing actions for LWR stations "...should be limited to a finding, either for specific sites or on a generic basis, as appropriate, that the facility has been provided or has available to it adequate means to provide reasonable assurance that these standards can be satisfied during actual operations" [Supplementary Information, Part A, p.4]. EPA suggests that compliance with Appendix I should provide the reasonable assurance of compliance. But nowhere on the record of this proceeding has that conclusion been supported. It is arbitrary. We find substantial

differences between Appendix I and the proposed standard and we cannot agree that there now exists a technical basis for concluding that meeting the criteria of Appendix I would necessarily provide reasonable assurance of compliance with the proposed standard.

NRC licensing of nuclear facilities requires a finding that the facility can be operated in a manner such that it can comply with all applicable laws and regulations. As the licensing process procedes from early stages of site selection through construction permit, and to full operating license, the station design develops from general concepts, to general design features, to specific design features, to actual equipment and layout. At each licensing stage, evaluations by NRC are required before proceeding to the next stage. The bases for these evaluations must be made known, and the decisions defended. If the proposed standard is promulgated, NRC also will be required to make findings concerning the capability of the facility to comply with 40 CFR Part 190, before any operating data are available, and to defend these findings. In lieu of specific operating data, it is difficult to defend other than conservative extrapolations of the available data. Faced with uncertainty in projected station operating characteristics, it is likely that the licensee would be faced with either including additional design features (e.g., augmented radwaste systems) in the original station design or to add these features subsequent to startup (at substantial cost penalties) if necessary to comply with 40 CFR Part 190.

Should NRC adopt the EPA suggestion that compliance with Appendix I is reasonable assurance that the facility can comply with 40 CFR Part 190 (given some as yet undeveloped basis for such assurance), the licensee still would be required to either gamble that augmented systems will not

have to be added at a later date (backfit) or add these features as part of the original station construction simply because the EPA standard provided limits for operation and not a graded scale of action as provided in Appendix I. Experience has shown that "backfitting" costs frequently range up to several times the cost of original installation. Further, costly "down time" could be required for backfitting. Given replacement power costs for fossil fired plants which range from $250,000 to $2,000,000 per day (depending on local air quality standards and availability of fuels), there are substantial financial uncertainties for the consumers associated with this aspect of the proposed standard.

E. Practicability of Compliance.

Compliance with the proposed standard is impracticable. We have identified several technical deficiencies in the development of information on the practicability of the proposed standard which partially account for this. With respect to LWR stations, EPA cites (1) the report EPA 52019-73-003C, Environmental Analysis of the Uranium Fuel Cycle, Part II-Nuclear Power Reactors, (2) AEC and NRC Environmental Impact Statements for various LWR stations, (3) the Concluding Statement of Position of the AEC staff on Appendix I, and (4) "Conservative" evaluations by NRC staff in licensing proceedings as demonstrating the practicability of compliance. These are insufficient bases for a finding of practicability for compliance with the proposed standard for the following reasons.

1. EPA Report on Reactors

The EPA report 52019-73-003C (Reactors) contains calculated potential dose values based on source terms similar to those used by AEC in 1972

but different from those experienced by licensees in practice and used by NRC in licensing today. Using our current source term estimates, the potential doses calculated by EPA generally would be higher.

It is instructive to review some of the principal changes which NRC has made in the analytical procedures for estimating source terms and doses since February 1974. These principal changes are:

(a) Added procedures for calculating releases of particulates, carbon-14, argon-41, and gaseous tritium releases;

(b) Revised procedures for calculating the liquid effluent releases due to anticipated operational occurrences;

(c) Revised calculational models for containment purge to account for plant operating experience;

(d) Revised calculation of the I-131 releases from BWR ventilation system exhausts as shown below; and

Source of I-131	Old Rate (Ci/yr)	New Rate (Ci/yr)
Turbine Bldg.	0.34	0.19
Reactor Bldg.	0.01	0.17
Auxiliary Bldg.	none	0.17
Radwaste Bldg.	negligible	0.046
Mechanical Vacuum Pumps	negligible	0.03
Total	0.35	0.61

(e) In addition to the source term changes, dose calculations for intermittent releases are based on short term meteorologic dispersion rather than annual average dispersion factors.

Further, organ doses from radioactive material in gaseous effluents are now summed for all pathways of exposure.

Generally, the revisions have resulted in increased calculated releases and, in some cases, in increased calculated dose values. Item (d) is of special interest in that the total release has been increased and the source is from several buildings rather than essentially from one building. This requires more radwaste equipment for the several buildings to reach the same level of control of releases and potentially reduces the overall cost-effectiveness of the augmented treatment systems. This affect is not accounted for in the cost-effectiveness analysis for the proposed 40 CFR Part 190.

2. NRC Environmental Impact Statements

NRC Environmental Impact Statements (EIS) are intended to realistically portray the anticipated effects of nuclear facility operations. The EIS projections are based on the best design information available at the time they are written, which is in advance of plant operation. Therefore, the calculated dose information is not the definitive operating data necessary to judge compliance with a standard set at levels very near the anticipated operating levels. Some of the EIS written a year or more ago contain information which differs from the information which would be contained in an EIS written today. And on the basis of this obsolete information, EPA finds evidence that it will be feasible and practicable to implement limits at or below the level of practicability. The EPA, in fact, does not rely on EIS data for determining compliance. Rather, it is required that actual environmental measurements be used for verification of noncompliance.

Table 1, Part C, p. 5 of the Supplementary Information, is cited as evidence supporting the conclusion that "as many as five LWRs would result in individual exposures that are appreciably less than 25 mrem/yr to the whole body and 75 mrem/yr to the thyroid." Table 1 contains selected information from EIS for three and four unit LWR stations for which EIS were written between 1972 and 1975. (The table should be corrected to indicate that WPPS is not a four unit site, but two units each on two different sites.) The table is an incorrect basis for this conclusion because:

a. When these EIS were written, it generally was assumed that the station design features would be those required to satisfy the AEC staff's proposed numerical guidelines for effluents, i.e., 15 mrem annual thyroid dose at the site boundary for the combined operations on the site. (Recall that AEC staff had proposed numerical guidelines in 1971 and 1974). The NRC promulgated Appendix I on May 5, 1975, and it contains numerical guidelines which differ from the previously proposed guidelines in the magnitude of the values selected and in the sense that they apply to each reactor on the site rather than all reactors on the site. Consequently, licenses for multi-unit LWR stations which had committed to provide augmented radwaste features have the option of reconsidering those commitments in view of the present

numerical guidelines which generally require less radwaste features than previously proposed guidelines; i.e., utilities may omit those features not required to satisfy Appendix I. Thus the dose values presented in EPA's Table 1 likely would be higher if evaluated today owing to differences between the proposed Appendix I numerical guidelines and the final Appendix I guidelines which were higher for practicability reasons.

b. The doses shown in EPA's Table 1 are based on calculational models that will not be capable of verification for several years when reactors of this size with these design features are operating. For PWRs, in particular, there is little operating data to support the realism of the source term calculational models. Further, the provisions of Appendix I require the use of analytical models which will not substantially underestimate exposure of an individual. In the future, as uncertainties in operating performance decrease, data will feedback on calculational models and the calculated and actual doses to individuals are expected to become equal. Said another way, NRC fully expects future stations to operate very near the design objective release rates specified in Appendix I. EPA's Supplementary Information shows convincingly that EPA has misunderstood this aspect of the practicability of the proposed 40 CFR Part 190.

In actuality, the analytical models and the selected parametric values which are used to estimate source terms and to calculate

doses have been undergoing frequent review and modification since they were presented in the Appendix I Environmental Impact Statement (1973). The net effect of these changes in some cases has been to increase the calculated dose values for individuals near the site boundary. The dose values have not been recalculated for those stations listed in EPA's Table 1 because generally these stations are between the construction permit and operating license stages. However, the calculated dose values for other stations, for which EISs were issued a year ago, have now been recalculated. Some of the dose values increase, others decrease. For the cases where doses have been recalculated, thyroid dose values have increased over a range of 2 to 20. Thus, the dose values presented in EPA's Table 1 likely would be higher if evaluated today owing to differences in analytical models used to quantify dose calculations based on new reactor operating data.

c. Reactor operations are not controlled by the estimated dose values presented in the EIS. Rather, reactors are operated in accordance with the technical specifications which are a condition of, and contained in, the station operating license. The limiting conditions of operations are expressed in terms of two release rates: (1) the instantaneous release which, if continued for a year, would result in 10 CFR Part 20 Appendix B limiting concentration values or limiting annual doses offsite and (2) the release which averaged over one calendar quarter would result in calculated doses equal to

half the (annual) design objective dose values of Appendix I to 10 CFR Part 50. The dose values presented in the EIS for the station are calculated based on the assumed full time operation of radwaste equipment. Redundancy generally is not required and, if the equipment is not operable for any reason, higher dose values than those presented in the EIS can be anticipated. Again, because of these factors doses higher than those presented in EPA's Table 1 can be anticipated but the magnitude of the doses from operating stations is now known only from calculations; only a few of these calculations have been completed subsequent to the promulgation of Appendix I; and all such calculations have yet to be verified by operational effluent monitoring.

3. Appendix I Concluding Statement

The AEC Staff Concluding Statement* in the Appendix I rulemaking contained a table which indicated that most of the reactors licensed at that time either could comply with the proposed (1974) numerical guidelines or had commited to augment existing systems to comply. However, recent revisions of analytical models used to estimate source terms have invalidated those conclusions. Further, the difference between the

*Concluding Statement of Position of the Regulatory staff. Public Rulemaking Hearing on: Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion "As Low As Practicable" for Radioactive Material in Effluents of Light Water Cooled Nuclear Power Reactors. February 20, 1974, Docket No. RM-50-2.

proposed (1974) numerical guidelines and the final version of Appendix I is another complicating factor. It is now required to reach a determination of cost-effectiveness and to establish design objective values for each reactor. Further, as stated in Section E.2.a. above, licensees may omit those radwaste features not required to satisfy Appendix I. Consequently, the 1974 AEC Staff's Concluding Statement is not now a valid basis for conclusions concerning capabilities of stations to meet the proposed 40 CFR 190.

4. Conservatism

"Conservatism" in NRC licensing analyses have been cited by EPA in several references. EPA uses its conclusions in this regard to substantiate the claim that real doses to real people will likely be less than 40 CFR Part 190 limits for stations licensed under current NRC practice. This conclusion is in error. Our comments on the specific factors identified as contributors to the conservatism are given below.

a. Predicted Dispersion and Deposition vs Measured Values.

Several NRC/EPA cooperative efforts have been made to characterize the dispersion and deposition of radioactive material in the environs around nuclear facilities. While these studies have been instructive, and have provided the most comprehensive data available today, they have been limited in scope and duration and the analyses have not provided definitive information which would permit substantial modifications of current analytical models. EPA cites these measurements as showing conservatism in current models but the results are variable - sometimes indicating values higher or

lower than the predicted values. These results are not suprising, given the uncertainties inherent in the selection of parametric values, in-put data, sampling and analytical procedures, limitations of analytical models, and our attempts to provide realistic estimates. Consider the information presented in the table on page 7 in Section C of the Supplementary Information. The stations at which the measurements were made are not representative of new stations, and the data are not representative and would not be generally applicable because:

(1) Dresden 1 is a unique reactor featuring an indirect cycle BWR and a tall stack for diluting and dispersing effluents;

(2) Yankee Rowe and Haddam Neck reactors employ stainless steel fuel rods which, experience has shown, have lower fuel defect levels than Zircaloy clad fuel. Zircaloy is used in all large LWR stations in the U.S.; and

(3) all three of the nuclear power reactors cited by EPA are small units (ranging from 600 to 1825 MWt) relative to contemporary 3800 MWt reactors.

Further, NRC reviews of EPA reports on the field studies have identified specific technical problems which characterize our concern that the results of specific measurements have been incorrectly generalized from atypical facilities. For example, we sent the following letter to one of the authors of the EPA report on the Haddam Neck field measurements. (The letter is retyped here for convenience of presentation.)

Mr. Bernd Kahn, Director
Environmental Resources Center
Georgia Institute of Technology
205 Old Civil Engineering Building
Atlanta, Georgia 30332

December 17, 1975

Dear Bernd:

Thank you for the opportunity to comment on the report of the EPA radiological surveillance study at Haddam Neck. The report contains much useful information that we will consider in future revisions to our source term calculational models. We believe that measurements of the type you have made, when performed at a number of plants under a variety of operating conditions, provide the most valuable type of data for improving our models. Care must be taken, however, in comparing measurements made at a single plant over a period of a few months, with a calculational model that represents the 30-year operating life of the plant. Also, the measurements need to be related to the plant operating conditions and to plant activities, such as maintenance and operation of certain pieces of equipment, during, and for the period prior to, each set of measurements. In view of the many variables involved, we consider that the measured releases, which in many instances are within a factor of two of the calculated source terms in the staff's Environmental Statement, show excellent agreement with our calculational models.

In regard to your specific question about the apparent inconsistency in the applicant's reported primary to secondary leak rate and the measured releases from the main condenser air ejector, we note that your measured release rate (Table 3.5) is approximately a factor of 2.5 times higher than that reported by the licensee during the same period. The applicant's reported releases imply a primary to secondary leakage rate of approximately 300 kg/hr, which is consistent with the value you report in Appendix C.3 for measurements made on March 16, 1971. We also note that, although both the primary coolant concentration and the primary to secondary leakage rate were steadily increasing during the sampling period, your measured release rates at the air ejector were constant to within $\pm$25%. These facts lead us to conclude that the gas samples taken from the main condenser air ejector exhaust by the EPA may not be representative of true system steady state operation. Such a situation might occur due to the relatively small volume of the samples (1.8 liters) and due to the fact that samples were taken during or shortly following changes in power level, e.g., the July 24, 1970 sample was taken shortly after refueling, the September 16, 1970 sample was taken just after a startup, and the four samples in March and April 1971 were taken while the plant power level was decreasing just

prior to refueling. It also appears that the applicant's estimate of the primary to secondary leakage rate of 75 to 150 kg/day is low by a factor of two to four.

We have reviewed only the portions of the report having to do with source terms. If you desire comments on the measurements in the environment, you should contact Enrico Conti of the Radiological Assessment Branch, whose Section is responsible for environmental radiological surveillance. We have received the draft of the report on the surveillance studies at Oyster Creek from Dr. Blanchard and will attempt to provide comments on the measurements as they relate to our source term calculations.

Sincerely,

John T. Collins, Chief
Effluent Treatment Systems Branch
Division of Technical Review
Office of Nuclear Reactor Regulation

EPA has cited data from field studies as revealing "significantly lower iodine concentrations in milk than projected by models for the pathway currently used for environmental analysis" [Supplementary Information, Part C, p. 6]. This conclusion is premature. The data from the Quad Cities station have not been fully evaluated. However, there are extended periods during which the iodine concentrations were considerably higher than would have been predicted using current analytical models. The reasons for this are not fully understood at this time. We do not believe that the data from field studies fully demonstrate the conservatism of NRC analytical models. Rather, the data demonstrate that much more information is needed to obtain a full understanding of the complex relationships between the release of radioiodine in various forms and the low level radiation doses that may be received in the environment.

To demonstrate the extent to which the results of the field measurements have been misapplied to rationalize that the NRC models are conservative and that compliance is practicable, consider the "Maximum Individual Dose" table in the Supplementary Information, Part C, p. 7. The values are presented as annual doses, yet examination of the EPA reports on these studies, e.g., Radiological Surveillance Study at the Haddom Neck PWR Nuclear Power Station [EPA-520/3-74-007], shows that the data were inadequate to determine potential annual doses. The annual dose values presented for the thyroid, bone, and GI (LLI) were not based on measurements in the environment, but were based on calculations using detailed effluent data. Further, the reported annual whole-body dose values were based on measurements of external dose rates (in terms of μR/hr on discrete days which were used to determine the annual dose rates) made inside the site boundary and extrapolated by calculation beyond the boundary. To this was added the calculated whole body dose contributions from effluent data [See p. 117, EPA-520/3-74-C]. Thus, it is inaccurate to characterize these dose rate values as originating from "field studies." Further, EPA conclusions from these studies, such as the paragraph quoted on p. 7, Part C of the Supplementary Information, are not warranted or justified.

b. LWR Source Terms.

The EPA "Supplementary Information" contains, among other things, a discussion of LWR source terms which concludes that the NRC source term characterization for PWR stations are unduly conservative (hi).

We believe that this issue is exemplary of the failure to correctly interpret the practicability aspects of the proposed 40 CFR Part 190. That is, the proposed standard is based on an incorrect assessment of effluent control technology. We will further discuss source terms for that reason.

EPA makes the following statements concerning source terms.

(1) "In addition to conservative environmental dose pathway models, radionuclide source term models have generally been conservative. For example, fuel experience for PWRs has been much better than the 0.25% fuel leakage rate now used as a design basis for calculating environmental releases." [Supplementary Information, Part C, p. 10]

Comment The NRC source term models were developed to provide a realistic assessment of releases of radioactive materials contained in liquid and gaseous effluents from nuclear power reactors, averaged over the life of the station. The parameters used in the staff's models are based on data obtained from operating reactors to the greatest extent possible. Where operating data were unavailable or inconclusive, we relied on laboratory data, test data, and judgement. The "fuel leakage" value of 0.25% referenced above has not been used in our model since the spring of 1975. We presently use a value of 0.12% which is based on data provided by Westinghouse. We consider the value presently in use (0.12%) to be representative of zircaloy clad fuel experience to date for PWRs. This change is important. Future PWR radwaste equipment will be selected by using this realistic source term. Thus, "realism" as

mandated by Appendix I will make it more likely that multi-reactor stations designed and operated within the requirements of Appendix I will exceed the limits of the proposed 40 CFR Part 190.

(2) "A second important consideration with respect to conservatism in source term-models is the fact that, especially for PWRs, effluents are postulated for inplant pathways which require simultaneous levels of degradation of several parameters in order to lead to a postulated release to the environment. For example, effluents from the PWR secondary system (e.g., steam generator blowdown vent or condenser air-ejector exhaust) require the simultaneous existence of a "design basis" fuel leakage and a "design basis" assumed steam generator leakage rate of primary coolant into the secondary coolant. Since the probability of each "standard" assumption is generally significantly less than one, the probability of both occurring at the same time must be smaller than either of the individual probabilities. Thus, if the annual probability of having the "design basis" number of fuel failures is five percent and the probability of having a "design basis" primary to secondary leak is twenty percent, the probability of operating a PWR with "design basis" fuel leakage and primary to secondary leakage is of the order of one percent. In spite of this, light-water-cooled reactors have been evaluated as if these "design basis" conditions occur simultaneously, for periods of time comparable to a year (17)." [Supplementary Information, Part C, p. 11]

Comment As with our parameter for fission product leakage from the fuel, our parameter for primary system to secondary system leakage within the steam generator is based on leakage rates measured at operating reactors. Our current parameter is based on 15 reactor-years of experience and includes periods of essentially "zero" leakage as well as periods of significant leakage. In both cases, fuel leakage and steam generator leakage, the arithmetic average of the available data was used, not "design basis" upper limits as implied by EPA. Again, EPA has not accounted for the practicability and realism considerations mandated by Appendix I.

(3) "Even though the most recent environmental statements employ models specified by regulatory guides which are more realistic than those used in the past, these models are still conservative. Again, in the opinion of the Nuclear Regulatory Commission on Appendix I on 10 CFR 50 (4):

"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... The numerical guidelines are, in this sense, a conservative set of requirements and are indeed based upon conservative evaluations." [Supplementary Information, Part C, pp. 5, 6]

Comment This conclusion is in error, possibly because of a misreading of the Appendix I Statement of Considerations. The Commission's opinion referenced above does not say that the models are conservative, as suggested by the EPA interpretation. Rather, the Commission has stated that Appendix I sets forth conservative design objectives which were arrived at by conservative techniques (e.g., linear extrapolation of radiation effects to low levels) and that the degree of conservatism inherent in the selection of Appendix I design objectives negates the need for further conservatism in the form of licensing evaluations or more restrictive dose limits. This quoted paragraph is in direct contradiction to the proposed 40 CFR Part 190 since the paragraph states a formal conclusion by NRC, based on practicability considerations, that limits more restrictive than those imposed by Appendix I are not warranted for nuclear power reactors (e.g., site limits in addition to reactor limits).

As a general comment, the NRC and reactor licensees have instituted measurement programs to determine the sources, magnitudes, and species of radionuclides released in power plant effluents. On the basis of information received to date from these programs, we have made substantial revisions to our source term model for BWRs. The data obtained from recently initiated PWR measurement programs will be used to update the PWR model in coming months, in keeping with the NRC's commitment to keep the source term models consistent with operating data. It should be noted that data obtained to date have not shown the source term models to be "generally conservative," as indicated by the EPA [Supplementary Information, Part C, p. 10], but have shown in several cases that model revisions were needed to keep from underestimating radioactive releases. It should be remembered that the NRC's models are designed to predict radiological effects over the projected 30-year operating life of the plant, and that disparity between predicted average releases and short-term measurements may be indicative only of having chosen a sampling time or location that was not representative of "30 year average" conditions.

II. OTHER FACILITIES IN THE URANIUM FUEL CYCLE

A. Technical Data Base

The numerical dose and release quantity limits specified in the proposed regulation reportedly are based upon the information contained in the EPA Draft Environmental Impact Statement (DES) and the three volume report Environmental Analysis of the Uranium Fuel Cycle. Additional information

was presented in the report "Supplementary Information" but this report was issued well after the limiting values were selected.

We have related some of the difficulties which AEC encountered in the Appendix I rulemaking due to an inadequate data base for LWR reactors, several of which had been in operation for more than a decade. Even less applicable data are available for most other facilities in the uranium fuel cycle.

The AEC had planned that similar guidance for other fuel cycle facilities would be developed after completion of the rulemaking action to provide numerical guidance for LWR effluents. A Federal Register notice of intent for rulemaking to this effect was published by AEC in 1974. Recognizing that a sound technical data base is required for selecting such values, the AEC contracted ORNL in 1973 to initiate a comprehensive technical study of fuel cycle facilities, including uranium mills, UF_6 refineries, mixed oxide fuel fabrication facilities, and fuel reprocessing plants. In reports of these studies, ORNL provided evaluations of radiation source terms, evaluation of process equipment capabilities, estimated process equipment costs, and calculated potential doses to individuals and to populations in the region of a site. Basically, this is the type of information we found to be absolutely necessary in our Appendix I rulemaking. The ORNL studies were performed under the direction of AEC and continued under NRC. Four reports on these studies were issued by ORNL* in May 1975.

---

* ORNL-TM-4901 Nuclear Fuel Reprocessing
ORNL-TM-4902 Fabrication of LWR Fuel from Enriched UO_2
ORNL-TM-4903 Vol. 1 - Milling of Uranium Ores
Vol. 2 Preparation of Cost Estimates for Vol. 1
ORNL-TM-4904 Fabrication of LWR Fuels Containing Pu.

After reviewing the information in these reports and evaluating the nature of the data and other information the NRC staff has concluded that the technical data and information for all types of uranium fuel cycle facilities, except reactors, are inadequate to provide technical bases for selecting generic ALARA numerical guidelines at this time. We arrived at this conclusion for three principal reasons.

(1) Effluent data now available are adequate to provide reasonable assurance of compliance with RPGs but inadequate to demonstrate the feasibility of complying with generic ALARA numerical guideline values which are a small fraction of the RPGs, particularly for facilities with design features which have not been operated in commercial-scale plants of the design type being considered.

(2) An interim value for the monetary worth of incremental reductions in population doses ($1,000/person-rem) was selected for Appendix I cost-benefit evaluations but rulemaking proceedings on this issue may result in a change in this value; consequently, it would be untimely to apply the interim value to other than reactor facilities at this time.

(3) The NRC is considering a staff recommendation to issue its own technical status reports utilizing the ORNL effort, inter alia, rather than using the information for NRC ALARA rulemaking actions, as originally intended.

We caution that these ORNL reports provide theoretical, not empirical, analyses relative to the conclusion that implementation of the proposed standard is practicable and feasible. We do not agree the conclusion that these reports support a finding of practicability or feasibility of compliance with the proposed 40 CFR Part 190.

We also caution that ORNL-TM-4901 (Reprocessing) is currently being revised to reflect current licensing practices and evaluations. The revisions could be substantial, particularly with respect to equipment effectiveness for control of iodine releases and the associated cost-benefit analyses. Furthermore, the current baseline analyses for fuel reprocessing plants in the NRC Generic Environmental Statement for Mixed Oxide fuels show potential maximum annual thyroid doses of a few hundred mrem for typical FRP sites. These are far in excess of the 75 mrem annual limit in the proposed standard.

B. Fuel Reprocessing Plants

One commercial fuel reprocessing plant (FRP) has been operated in the United States. This FRP had a small capacity and most of the fuel processed had relatively low burnup. This plant is currently shutdown for extensive modification to increase processing capacity, to incorporate a new process (not yet selected) to solidify liquid wastes, to add equipment (not yet selected) to convert plutonium compounds to oxide forms and to modify other station features. Another FRP (Barnwell) is in the licensing process and construction is nearly completed. Design features of this new FRP differ substantially from those of the first FRP; consequently, data obtained from previous operation of the first FRP will not necessarily be applicable to the second. The Barnwell FRP will include advanced design features for which no commercial operating data are available. However, testimony presented during the licensing process for the second FRP indicates that potential release quantities of long lived material from this FRP and potential thyroid doses could exceed the proposed standard.

The practicability of installing krypton recovery equipment in the Barnwell FRP was evaluated by NRC staff in the course of licensing action for that facility. We estimated that the Kr-85 could cause an annual dose of 17 man-rem among the 657,000 persons living within 50 miles of the plant. We also estimated that C-14 could cause an annual dose of 59 man-rem to the same population. The cost of krypton recovery equipment estimated by ORNL, by Allied General Nuclear Services, and by Allied Chemical Corporation ranged from at least $5 million to about $40 million. An annual cost of $2.0 million was estimated for a $5.6 million capital cost system, which includes minor additions to be capable of recovering C-14. If the system with the lowest estimated cost were to capture 100% of the Kr-85 and C-14, the calculated annual dose to the population within 50 miles might be reduced by 76 man-rem at an annual cost of $2.0 million, or about $27,000 per man-rem reduction. We do not now consider this practicable from a cost-benefit consideration.

Practically, it is not possible to recover or to retain 100% of either the Kr-85 or the C-14 and it is conceivable that the $40 million capital cost estimate is more accurate than the $5.6 million cost estimate; thus the cost-benefit value could be even less acceptable. A larger value for the reduction of the population annual dose (commitment) can be calculated by summing the infinitesimal annual doses to the entire population of the Earth over several decades, as advocated by EPA. We do not believe that such a value is significant at this time, considering the number of FRPs. if viewed with <u>any</u> perspective such as comparisons to variations in natural background radiation with location, or other similar source comparisons.

We recognize that the cumulative inventory of Kr-85 (and other long-lived radionuclides) in the atmosphere could attain undesirably high levels by the year 2000 or later owing to the contributions from all FRPs on Earth if Kr-85 releases are not restricted by that time. We are confident that such restrictions will be provided by FRPs in the U.S. long before this potential problem becomes a real problem. Our principal differences with EPA on this issue are (1) the specific time at which it is proposed to require the restictions on releases, (2) the unilateral nature of the action, (3) the administrative problems created by stating the limits in terms of electrical energy produced, and (4) the specific nature of the proposed standard (e.g., facility specific rather than a generally applicable environmental standard).

Aside from the "practicability" issue, the proposed 40 CFR Part 190 would require application of krypton recovery equiptment in all commercial FRPs by 1983 and no effective variance provision is provided for FRPs which exceed the standard [Supplementary Information, Part A, p. ..]. A substantial research and development effort is required before krypton recovery equipment is available for commercial FRPs. If 10 years are required for the R&D effort, as estimated by ORNL and others, compliance in 1983 would not be possible. Presumably, the date for compliance could be changed if this is the case. The lack of an effective variance provision for FRPs is a more difficult matter. Without a variance, exceeding the Kr-85 limits presumably would be cause for shutdown. In order to avoid costly shutdown in the event the Kr recovery equipment is inoperative, it is likely that redundant equipment would need to be provided. This redundant equipment

would further increase the cost of equipment (recall that one cost estimate for a system which included redundant equipment was $40 million) and would decrease the cost-effectiveness of krypton removal.

In addition to these processing problems, additional problems must be identified and resolved, including safety issues concerning the operation of the equipment, and the handling, transportation, and long term storage or ultimate disposal of the collected Kr and other long-lived material. The costs or impact of these items also must be included in a realistic cost-benefit analysis.

In this regard, the National Council on Radiation Protection and Measurements, on July 1, 1975, issued NCRP Report No. 44 "KRYPTON-85 IN THE ATMOSPHERE - Accumulation, Biological Significance, and Control Technology". In the Summary, NCRP makes the following observation.

> "The dose from 85-Kr for the next several years will be of such a low order as to preclude the need for installation of recovery systems. However, as such systems become available for full-scale application, their installation in fuel reprocessing plants should be considered in relation to the costs of such installations and the benefits, if any, that would result."

In the Discussion, NCRP recommends international collaboration on this issue rather than the unilateral action required by the proposed standard.

> "In this report the subject has been addressed from the point of view of the United States atomic energy program. It is estimated that by the year 2000, the United States installed nuclear electric power capacity will be about 1000 GW compared to nearly 5000 GW for the world. Any policy adopted by the United Sates would thus deal with about 20 percent of the 85-Kr generated in the year 2000. This is clearly a general

question that requires careful international collaboration and the NCRP urges that the International Atomic Energy Agency and the International Commission on Radiological Protection give prompt attention to the need for developing policies that will be acceptable on an international scale."

This NCRP recommendation is in complete accord with our previous recommendations to EPA [see attached comments dated September 15, 1975].

C. Uranium Mills

Uranium mills in the United States generally are located in arid regions and relatively sparse populations. Tailings piles (i.e., solid waste from the milling process released as a slurry and generally retained by earthen dam systems) are recognized as an important source of airborne radioactive material offsite. In most instances, the nearest inhabitated area is well beyond the perimeter of the tailings and, owing to the arid nature of the region, locally produced vegetables are not commonly found. Tailings piles are subject to erosion by wind as the solid material dries. Airborne radioactive material from these tailings is extremely variable and representative samples obtained from monitoring programs are difficult to evaluate with respect to estimating potential dose equivalents on a yearly average basis for the lifetime of the facility. Furthermore, sufficient data on airborne radioactive material from tailings to estimate potential doses from all exposure pathways do not exist. The source term characterization presented in the ORNL studies* and cited by EPA [Supplementary Information, Part H, p. 1] are based primarily, on calculations which require the selection of parametric values, for which data are not available, and represent judgement which has not been verified by measurements. The estimated source terms and

*ORNL-TM-4903, Volumes 1 and 2.

calculated potential doses do not contribute the needed data base required to select the values in the proposed standard or to judge the feasibility of complying with the proposed standard.

EPA suggests that readily available techniques such as stabilizing the tailings with "chemical binders" or covering the tailings with soil would eliminate completely the erosion by wind and assure compliance with the proposed standard. [Supplementary Information, Part A, p. 8]. NRC staff is not aware of any method which has been demonstrated to provide stabilization of active tailings piles sufficient to assure compliance with the proposed standard. Further, we are not aware of any cost effectiveness evaluation provided by EPA for stabilization of mill tailings.

We are aware of an ongoing research project being jointly sponsored by ERDA and EPA to study mill tailings. This project, which is projected to be completed in 1977 will have cost about $2.5 million and will provide a substantial amount of information concerning:

1) Gamma dose rates from windblown tailings;
2) Soil sample analysis to determine content of Ra-226 and other radionuclides;
3) Background concentrations of Ra-226;
4) Erosion of tailings by rainfall and streams;
5) Leaching of activity from tailings to aquifers;
6) Migration of activity from tailings into subsurface soils;
7) Air concentrations of radon and daughters
   - long term and short term

- correlation with meteorologic conditions
- "exhalation" rates for radon from tailings piles;

8) Population exposure estimates;

9) Analyses of tailings components;

10) Contamination levels of land and buildings near site;

11) Alternative milling processes to remove more radioactive material from tailings before discharge;

12) Determine factors which affect "exhalation" rate from tailings, e.g., temperature, barometric pressure, moisture, compaction, thickness and characteristics of cover materials, etc.;

13) Effectiveness of controls of sealants above and/or below the tailings; and

14) Effectiveness of vegetation covering over the tailings piles.

It is precisely this kind of information which is now lacking and which we believe is necessary to provide the basis for rulemaking or other generic regulatory actions on mills. For reasons such as those described above, the NRC is currently considering a staff recommendation to initiate a generic Environmental Impact Statement and associated studies for uranium mills.

D. Uranium Enrichment Facilities

NRC has never received an application for a commercial enrichment plant license so our licensing experience in this area is nil. We note that EPA has not provided a cost-benefit study for enrichment plant effluent

controls. Consequently, we do not understand why these facilities have been included in the proposed 40 CFR Part 190. Since NRC has not licensed uranium enrichment facilities, we recommend that ERDA speak to the feasibility and cost-effectiveness of these facilities complying with the proposed standard.

E. UF_6 Conversion Facilities and Enriched Uranium Fuel Fabrication Plants

From our studies to date, we believe that it is likely that conversion facilities and enriched uranium fuel fabrication plants practicably can comply with the proposed standard.

F. Transportation of Radioactive Material

For sites which require substantial numbers of shipments of radioactive material, the proposed standard would require the apportionment of dose limits, not only among the facilities on the site and nearby facilities, but also adjusted to accommodate the contribution from transportation. Additional radwaste equipment could be required to provide the additional dose reduction from the facilities to accommodate the dose contribution from transportation. This could require radwaste equipment for control of radioactive material in effluents beyond that considered to be "justifiable" by EPA when considering potential doses from effluents alone.

We defer to the Department of Transportation, which is responsible for regulation of the transportation of radioactive material by trucks, to speak to the feasibility of compliance with the proposed standard and the

practicability of compliance in terms of cost-effectiveness beyond the site boundary. We note that EPA has not provided a cost-benefit justification for inclusion of the transportation source term in the proposed standard.

III. EPA TECHNICAL REPORTS

We have reviewed the Draft Environmental Statement; the Environmental Analysis of the Uranium Fuel Cycle, Part I - Fuel Supply, Part II - Nuclear Power Reactors, and Part III - Fuel Reprocessing, EPA - 520/9-73-003; the report Environmental Dose Commitment: An Application to the Nuclear Power Industry, EPA - 520/4-73-002; and the Policy Statement: Relationship Between Dose and Effect, ORP. In order to make a complete evaluation of these reports, it would be necessary to essentially duplicate the studies independently and then to compare differences; we have not done this. However, our review disclosed a substantial number of items where we and EPA differ in technical evaluations, economic considerations, judgments, and conclusions. It is not worthwhile discussing the details of the numerous technical differences which we have with these reports at this time, but there are some important issues which we will identify.

A. Source Terms

Essentially all of the postulated health effects (1020 of 1030) which EPA believes will be averted by promulgation of the proposed 40 CFR Part 190 would be due to retention of long-lived material [DES, p. 82, Table 10]. Fuel reprocessing plants are the dominant consideration in this regard. Among the assumptions used in estimating the number of averted health

effects is the assumption that the postulated effluent characteristics of the typical FRP analysed by EPA will be representative of the 50 FRPs to be operated over the next 50 years [Supplementary Information, Part F, pp. 24].

While it is recognized that NRC has an effective ongoing generic effort to assure that releases of radioactive material in effluents of LWR stations are "as low as reasonably achievable" as part of the licensing process, the EPA analysis does not recognize that the same licensing finding is required for FRPs on a case-by-case basis. With respect to krypton recovery, NRC staff has taken the position that FRP licensees should provide adequate space to permit installation of krypton removal equipment when it becomes available and the FRP scheduled for operation in 1985 will include krypton recovery equipment (the EXXON facility). Thus, even without the proposed standard, of the three commercial FRPs which will operate in the U.S. by 1985, one will control krypton release and the other two will be able to accommodate the processing equipment when it becomes available. Assuming that development of technology for krypton recovery equipment continues to advance favorably, it is reasonable to assume that effective krypton control will be provided by FRPs in the U.S. within a decade. Similar changes in the design features of the FRPs to provide further control of the release of other long lived material also can be anticipated. This means that 1020 of the 1030 averted health effects associated with the proposed 40 CFR Part 190 will in fact be averted even if 40 CFR Part 190 is withdrawn today. Thus, the principal benefit claimed for the proposed standard is not real.

B. Health Effects

We have reviewed the EPA Policy Statement, dated March 3, 1975, concerning the adoption of the theoretical linear, nonthreshold, dose rate independent relationship of dose and biological effects extrapolated to zero dose. We do not agree with the adoption of this theory (and we emphasize that it is a theory rather than an established fact) without reservation and proceeding to treat the resulting calculated risk values as though they were actual risks. The data available today do not rule out a zero risk from low doses delivered at low dose rates. Thus we believe that when integral population doses are calculated from low doses at very low dose rates and related to calculated health effects, a factually correct statement would be that the number of health effects is likely to be within the range from zero to N, where N is the value calculated using the linear theory. Since cost-effectiveness is judged by EPA in considering the cost of averting potential health effects, it is important to realize that if the health effects are indeed zero, any cost realized to reduce the value is not justified from a health viewpoint.

The importance of the issue is apparent when considering the cost-effectiveness of Kr-85 capture. The numerical integration of the very low level doses delivered at very low dose rates for several decades to the entire population of the Earth is necessary to justify Kr-85 capture on a cost-effective basis. This rationale completely ignores that (1) the number of health effects might be zero; (2) if not zero, the number is statistically insignificant when any perspective is provided; and (3) the

contribution to the world-wide Kr-85 inventory from sources outside the U.S. will exceed substantially those originating within the U.S. The National Academy of Science, on p. 17 of the 1972 BEIR Report, states "Tritium and krypton-85 should be assessed on a basis of world-wide production because of their distribution patterns" (Emphasis added). In our previous written comments to EPA, we pointed out that the control of long lived radioactive material which could be dispersed world-wide is an international problem and unilateral actions on the part of the United States would have only a modest effect on reducing the world-wide dose commitments. We continue to believe that international discussions on this matter would be more appropriate than promulgation of a National standard at this time.

Recognizing that EPA has applied the linear theory to all non-zero doses, we do not understand why the 100-year time interval was arbitrarily selected for integrating doses used to calculate health effects. A time interval of thousands or millions of years would be equally rational and equally arbitrary.

An additional area of concern is that the selection of thyroid dose limits based on the "biological equivalent" of whole-body dose has not been demonstrated [DES-pp. 65-66]. Using the risk values selected by EPA, it can be shown that the thyroid dose would have to be several times higher than the factor of three times the whole body dose to be "biologically equivalent."

C. Economic Considerations

The EPA reports do not present the detailed cost values needed to

independently verify important elements of the costs. Further, solid waste handling systems were not included in EPA radwaste costs.

EPA utilizes a discount rate procedure for radwaste system costs but does not employ a similar procedure to discount potential health effects in the future. This costing procedure improves the apparent cost-effectiveness. Perhaps a discounting procedure is applicable to both costs and postulated health effects. It is clearly incorrect to discount one side of the cost-benefit equation and not the other. In the absence of a method for translating health effects into economic benefits, comparisons should be made on an undiscounted basis. Certainly, it is a subject worthy of discussion among economists and radiation protection experts.

EPA does not explain how the dose limits for individuals were justified by "...weighing cost-effectiveness and cost of control relative to the total capital cost..." [DES, p. 24]. If the values selected for the annual dose limits for individuals are justified only on the basis of the cost of controls relative to the capital cost of the facility, the procedure would not preclude arbitrary decisions to require controls which are not cost-effective.

The DES for the proposed EPA standard does not provide a detailed description of the radwaste systems which would be required to meet the proposed standard or provide the reasoning process by which the values in the proposed standard were selected. However, the systems required can be identified from the data included in Figure 12 of the DES. When this information is used in conjunction with the cost-effectiveness data of Figure 4 of the DES it can be seen that use of some of these "required" systems would result in spending substantially more than the $500,000 per potential health effect averted, which the DES indicates is the least cost-effective of the systems which should be required.

The radwaste systems identified by this analysis are described in the three volume set on the Environmental Analysis of the Uranium Fuel Cycle issued by EPA in 1973. The costs per averted potential health effect can be derived from these data and are shown in Table A, below. The values range from a low of $0.79 million to a high of $29 million per averted potential health effect. It may be that EPA did not mean for all of these systems to be required, the presence or absence of a given system in Table A being determined by the absence or presence of the letter "P" following the radwaste system description in Figure 12 of the DES. But it does indicate the need for a far more detailed examination and description of the reasoning process by which the values in the proposed standard were derived. There are indications that at least some of the dose models used in the analysis may overestimate the doses and some of the costs may be underestimated. If alternative values were used the costs per averted potential health effect could be substantially higher.

Table A

Required Radwaste Systems for Which the
Costs per Averted Potential Health Effect Exceed $500,000

Radwaste System	$ Millions Health Effect	Reference Vol.	Table #	Page
HEPR drying system (Mill)	1.4	I	2-11	52
Bag (crushing) filter (Mill)	29[a]	I	2-11	52
Seepage return (Mill)	6.7	I	2-12	53
2nd bag filter (Conv. WS)	0.79	I	3-10	93
2nd bag filter (Conv. HF)	5.3	I	3-10	93
Settling tanks (Fuel Fab)	1.2	I	5-12	135
Iodine Case (BGIE-2-BWR)	19.	II	57	153
Liquid Case BWR-3	7.8	II	61	157
Iodine Case PGIE-3-PWR	3.8[b]	II	59	155

[a] Value from Figure 4 is about 3.

[b] Value from Figure 4 is about 10.

IV. CURRENT NRC EFFORTS

Current NRC regulations require that exposures of persons to radiation be maintained at as low as reasonably achievable levels below existing Federal Radiation Council guidance. In this regard, Appendix I of 10 CFR Part 50 provides numerical guidelines for light water reactor effluents. For other facilities, for which no generic numerical guidelines are currently available, ALARA levels are determined on a case-by-case

licensing basis. When an adequate technical data base exists for these other facilities, generic numerical guidelines likely will be proposed by NRC. Having recognized the inadequacy of the current data base, technical programs have been initiated to obtain the required additional data. We are optimistic that this information will be available within the next several years.

NRC and EPA staffs have been cooperating in programs to obtain data which will permit better predictions of dispersion and deposition of radioactive material in the environs of nuclear facilities. Data collected by this program to date are the best available, but much more extensive data and analyses still are needed if the current analytical models are to be improved. We believe that this cooperative effort not only should continue, but should be expanded to provide the sound data base which both agencies (and others) recognize as being required.

NRC has participated in joint meetings with General Electric and EPA to discuss technical issues concerning N-16 "shine" from BWR turbines. We believe that these meetings can lead to the satisfactory resolution of this problem area and this would be more desirable than the present case where N-16 shine has been included in the proposed standard without a cost-benefit determination.

V. IMPACT OF 40 CFR PART 190 ON NRC ACTIVITIES

We have previously cited several administrative and technical problems which would pose a substantial burden on the NRC if 40 CFR Part 190 is promulgated [see letter to Russell E. Train from Lee V. Gossick dated September 15, 1975 appended to this testimony]. EPA acknowledges that a

substantial number of revisions would be required in NRC regulations, regulatory guides, and technical specifications [Supplementary Information, Part A, pp. 13-14], but underestimates the effort required to make these revisions. While the administrative burden would be substantial indeed, perhaps a greater burden would be the technical effort required by our Office of Inspection and Enforcement which would be responsible for verifying compliance by licensees of all uranium fuel cycle facilities.

A. Environmental Measurements

EPA has indicated that environmental measurements should be made to confirm noncompliance with its standard when calculational values indicate that such confirmation is necessary [Supplementary Information, Part A, p. 5]. However, EPA has not addressed any of the difficulties or uncertainties that can be encountered in applying this approach or made any estimate of the effort and cost that such a program would involve. Neither has any data been presented to support the conclusion that such an approach can, in fact, be applied successfully in actual practice.

Environmental monitoring as a means of measuring dose and demonstrating compliance with an exposure limit (RPG) has some of the same limitations and uncertainties as do calculational models based on effluent data. Therefore, simply making an environmental measurement does not mean that we have accurately determined dose and demonstrated compliance. Estimations of radiation exposures based on environmental data are subject to substantial error. One of the greatest uncertainties is how closely the measured environmental level or concentration represents the actual exposure.

These uncertainties in dose estimates based on environmental measurements are a result of the following considerations.

(1) Low concentrations or dose rates are very difficult to measure and even more difficult to distinguish from already existing levels or background levels. This results in a net measured value which has a large uncertainty associated with it.

(2) Sample distributions resulting from variable or intermittent releases from stationary sources are not well understood and therefore the relationship between sample measurements and the data population from which these samples have been collected is not well defined. Extrapolation of data from individual samples to the sample population can therefore potentially lead to considerable error.

(3) The habits, intakes, and ages of individuals vary considerably and are subject to constant change. The variability and changeability of these parameters can introduce considerable uncertainty into dose estimates.

Because of these large uncertainties, data from present "state-of-the-art" monitoring programs can provide only rough estimates of the potential radiation exposure to an individual. Since the range of these exposures are still well below the present RPGs, these programs have been deemed to be adequate for the purposes for which the data are used. However, if environmental monitoring programs were required to provide data to accurately determine compliance with RPGs 1/20 of the present values, then the present "state-of-the-art" monitoring programs would be totally inadequate. Extensive and costly monitoring programs would have to be implemented to assure compliance with the proposed EPA standard. An environmental

"compliance monitoring program" for demonstration of compliance with the EPA standard would have to include the following:

(1) frequent measurements taken over long periods of time would be required to assure that the data closely represents the exposure pathway measured;

(2) a large number of sampling locations would have to be utilized to assure that the variability of dose rate or concentration with location has been adequately considered;

(3) the sample distribution would have to be established in order to assure that the samples collected can be interpreted with respect to the population which they are meant to represent;

(4) extremely reproducible measurement techniques would have to be employed in order to be able to distinguish between dose-rates resulting from releases from a facility and those already existing or background levels; and

(5) to be able to distinguish this incremental dose above background it would be necessary to continually maintain an extensive program for measuring background dose-rates and concentrations so that this data base will be available should "compliance monitoring" be required.

EPA refers to a number of special field studies which it has conducted at various operational uranium fuel cycle facilities. It is informative to recognize that even these costly studies, in most instances, would not have provided an adequate data base for determining compliance with the proposed EPA standard based on environmental monitoring data. The time periods over which some of the environmental measurements were made were

relatively short and the frequency of sampling was very limited with collections in some cases being limited to a single sample.

B. FRC Guidance

Since EPA has stated that the proposed 40 CFR Part 190 as a revision of the current RPG values for the nuclear power industry [Supplementary Information, Part A, p. 3], it is instructive to consider the existing FRC guidance for implementing RPGs because it includes guidance for environmental surveillance and control. The FRC, in its Report No. 2 of September 1961 "Background Material for the Development of Radiation Protection Standards," presented guidance which included a graded scale of action to be taken to assure compliance with the current RPGs.

The following information is quoted from the FRC Report No. 2.

"Control of Environmental Radioactivity

1.16 The objective of the control of population exposure from radionuclides occurring in the environment is to assure that appropriate RPG's are not exceeded. This control is accomplished in general either by restrictions on the entry of radioactive materials into the environment or through measures designed to limit the intake of such materials by members of the population. The most direct means of evaluating the effectiveness of control measures is the determination of the amount of radioactive material in the bodies of the members of exposed population groups. Although the determination of such body burdens may at times be indicated in routine practice potential exposures will generally be assessed on the basis of either one or a combination of two general approaches: (1) calculations based upon known amounts of radioactive material released to the environment, and assumptions as to the fraction of this material reaching exposed populations groups, or (2) environmental measurements of the amount of radioactive material in various environmental media.

1.17 Both of these general approaches involve the calculation or determination of actual or potential concentrations of radioactive material in air, water, or food. As stated above, controls should be based upon an evaluation exposure with respect to the RPG. For this purpose, the average total daily intake of radioactive materials by exposed population groups, averaged over periods of the order of a year, constitutes an appropriate criterion.

1.18 There is for any radioactive material a daily intake which is calculated to result, under specified conditions, in whole body or organ doses equal to a Radiation Protection Guide. The resulting value represents either the continuous or the average daily intake of radioactive material might fluctuate very widely around the average and still result in an annual dose which would not exceed the associated RPG.

1.19 The control of the intake of radioactive materials from the environment can involve many different actions. The character and import of these actions vary widely from those which entail little interference with usual activities, such as monitoring and surveillance, to those which involve a major disruption, such as condemnation of food supplies. Some control actions would require prolonged lead times before becoming effective, e.g., major changes in water supplies. For these reasons, control programs developed by the agencies should be based upon appropriate actions taken at different levels of intake. In order to provide guidance to the agencies in developing appropriate programs, this report describes a graded approach for the radionuclides considered, involving three ranges of transient rates of daily intake applicable to different degrees or kinds of action.

1.20 The objective of the graded scale of actions is to limit intake of radioactive materials so that specified RPG's will not be exceeded. Daily intakes varying within the total extent of all three ranges of intake might result in annual doses not exceeding a single RPG. However, in instances in which the daily intake is fluctuating above the average which would meet the RPG, it may not be possible to be assured that this will be the case. The actions outlined below would be appropriate, not only when intakes are fluctuating so as not to exceed a given RPG, but also in those situations in which valid reasons exist for the responsible agency to permit the possibility of doses which would exceed the RPG.

1.21 A suggested graded system of actions is outlined below. For each of the ranges of transient rates of daily intake, specific values for which are given in the sections devoted to the specific radionuclides, the general type of action appropriate for the range is outlined.

RANGE I*

Intakes falling into this range would not under normal conditions be expected to result in any appreciable number of individuals in the population reaching a large fraction of the RPG. Therefore, if calculations based upon a knowledge of the sources of release of radioactive materials to the environment indicate that intakes of the population are in this range, the only action required is surveillance adequate to provide reasonable confirmation of calculations.

RANGE II*

Intakes falling into this range would be expected to result in average exposures to population groups not exceeding the RPG. Therefore such intakes call for active surveillance and routine control.

Surveillance

Surveillance must be adequate to provide reasonable assurance that efforts being made to limit the release of radioactive materials to the environment are effective. Surveillance must be adequate to provide estimates of the probable variation in average daily intake in time and location. Detection of sharply rising trends is very important. In some cases, because of the complexities of the environment, surveillance data may have to be sufficiently reliable to be used as a rough check on whether radioactive materials in the environment are behaving as expected. Not only the radioactive material in question, but also the environment must be studied. Appropriate efforts might be made to obtain measurements in man as well as to study physical, chemical, and metabolic factors affecting intake. Appropriate consideration should be given to other independent sources of exposure to the body (the same organs or different ones) to avoid exceeding RPG's.

*Further FRC guidance indicates that Ranges I, II, and III correspond to 0 to 10%, 10% to 100%, and >100% of the RPG values, respectively, for suitable samples of the exposed population group.

Control

Routine control of useful applications of radiation and atomic energy should be such that expected average exposures of suitable samples of an exposed population group will not exceed the upper value of Range II. The sample should be taken with due regard for the most sensitive population elements. Control actions for intakes in Range II would give primary emphasis to three things: (1) assuring by actions primarily directed at any trend sharply upward that average levels do not rise above Range II, (2) assuring by actions primarily directed either at specific causes of the environmental exposure levels encountered or at the environment that a limit is placed on any tendencies of specific population segments to rise above the RPG, and (3) reducing the levels of exposure to segments of the population furthest above the average or tending to exceed Range II.

RANGE III*

Intakes within this range would be presumed to result in exposures exceeding the RPG if continued for a sufficient period of time. However, transient rates of intake within this range could occur without the population group exceeding the RPG if the circumstances were such that the annual average intake fell within Range II or lower. Therefore, any intake within this range must be evaluated from the point of view of the RPG and if necessary, appropriate positive control measures instituted.

Surveillance

The surveillance described for intakes in Range II should be adequate to define clearly with a minimum of delay the extent of the exposure (level of intake, size of population group) within Range III. Surveillance would need to provide adequate data to give prompt and reliable information concerning the effectiveness of control actions.

Control

Control actions would be designed to reduce the levels to Range II or lower and to provide stability at lower levels. These actions can be directed toward further restriction of the entry of radioactive materials after entry into the environment in order to limit by humans. Sharply rising trend in Range III would suggest strong and prompt action." (Emphasis added)

---

*See footnote on previous page.

The FRC guidance is practicable at current RPG levels but becomes impracticable (if not impossible) at the lower levels of the proposed standard because at the lower levels the environmental monitoring and radiochemical analyses will require use of techniques and procedures that are currently associated with research or special laboratory studies. Further, since the lower RPG values proposed by EPA are very near the operational levels which we anticipate for the uranium fuel cycle facilities, a substantial number of facilities can be anticipated to be in all three of the FRC "ranges" described above and will require extensive additional surveillance and controls.

C. NRC Surveillance

In the existing NRC regulatory program for effluent controls there are two levels which are of concern to our Office of Inspection and Enforcement. The first is the 10 CFR Part 20 limit which corresponds to FRC guidance, and the second is the design objective guidance which corresponds to essentially one percent of the 10 CFR Part 20 limit for each LWR on a site. The level at which a licensee must initiate some kind of action occurs at two times the ALARA design objective guidelines. At this level, we can rely heavily on modeling, even though imprecise, because for a single LWR we are still a factor of fifty below the FRC limit. Consequently, environmental monitoring is not used as the basis for determining the potential dose to individuals--but rather as a backup to the effluent monitoring program, as a means of public assurance, and as an indicator of the general applicability of the models. Reliance on modeling using effluent release data has been

preferred for practical rather than philosophical reasons. At the present state-of-the-art it would be impossible for routine monitoring programs to determine actual doses to real individuals.

In addition, we have always believed strongly that enforcement should be immediate and not retrospective. Consequently, effluent release limits back-calculated from dose models are a more reasonable means of regulating the operation of a nuclear reactor or other facility than environmental samples--the results of which generally require laboratory analyses which involve a waiting period of several weeks. In that respect, the Commission has indicated in the Statement of Considerations for Appendix I that measurements of Appendix I levels in the environment would not be required and that compliance with Appendix I would be based on dose modeling calculations. Now, however, the proposed standard would eliminate the large gap between design objective values and the applicable radiation limit. If NRC or the licensee is required to verify compliance with the proposed standard it would be reasonable that such verification procedures would not wait until it is assumed that the standard has been exceeded but, rather, verification would begin at some level below the 40 CFR Part 190 limit. This, of course, would be contrary to the philosophy that the Commission has previously stated and would require additional monitoring effort. If we follow the FRC guidance for the ranges discussed above for the RPG values proposed by EPA, NRC or the licensee will be required to initiate verification procedures at 10% of the 40 CFR Part 190 values which would correspond to 50% of the design objective quantities of Appendix I for a single reactor on a site.

At the present time, we are not certain as to the frequency with which environmental studies would have to be implemented to determine compliance with the proposed EPA standard or if such studies could demonstrate non-compliance. With the general philosophy expressed in the Commission's opinion on Appendix I to use more realistic assumptions in determining environmental impact, it is reasonable to assume that a substantial number of LWRs, and probably most of the other facilities in fuel cycle, during their lifetime, will require additional studies of some aspect of their impact on the environment. These would be useful in better describing the uncertainties mentioned above.

It should also be recognized at this point that, as stated above, determining doses to individuals at these low levels is extremely difficult and is in general beyond the capabilities of the NRC licensees and beyond the scope of the "field studies" performed by EPA to date. Sampling and analytical procedures for many of the pathways must still be developed. At the levels which EPA is proposing as limits for the uranium fuel cycle facilities, monitoring becomes very difficult and expensive. For example, TLDs are currently used to measure exposure rates near the site boundaries of reactors. Relative to other instruments, such as pressurized ionization chambers, TLDs are very inexpensive. However, TLDs are not adequate to measure exposure rates at the low levels of our ALARA effluent controls or the proposed standard. If such measurements must be made, pressurized ionization chambers will be required. We estimate that such systems would cost more than $100,000 per site plus operating expenses. For this reason, and also because in many instances verification of compliance would entail

regional aspects (that is, the summation of doses from two or more facilities), the responsibility for these programs is likely to fall on the NRC rather than on our licensees. This concept of divided responsibility for environmental monitoring is distasteful since it runs counter to the practice of placing responsibility for the operation of a facility on the licensee. If NRC must conduct verification programs because of their complexity or expense, or because of a perceived need for an official verification in the granting of variances, then there is a considerable added administrative, technical, and economic burden to NRC.

At the present time, we have a limited arrangement with the Health Services Laboratory in Idaho Falls, Idaho whereby periodic intercomparisons are made with licensees to confirm specific measurements or to determine the analytical capability of a licensee. This program could form a basis for an extended program as outlined above. A more efficient approach would be to establish an NRC laboratory. It is difficult to make estimates of the man-years of effort required for individual studies. However, as a first approximation, we believe that a laboratory with the capability and size of the ERDA Health and Safety Laboratory, New York City, would be required. Because of the peculiarities of a regulatory agency in this situation we believe this laboratory (1) must have national recognition, (2) must have experience with the type of activities NRC regulates, (3) must not perform these services for the nuclear industry, (4) must have proven expertise in a wide range of technical areas and (5) must have a philosophy and mode of operation that will be responsive to the problems which will be presented.

In order to provide some perspective as to the costs of operating such a laboratory, the Health and Safety Laboratory (HASL) currently employes 106 people, (60 professionals) and has an FY 76 total budget of $4,500,000 plus $200,000 for equipment. The additional need for technical and administrative management of the laboratory and the program it would conduct would probably require about 10 more persons. Such a laboratory would be required to do instrumentation, radiochemistry and sampling procedure development plus respond as needed to perform verification analyses. We estimate that the capital cost of the equipment and auxiliary features of a laboratory like HASL to be about $2 million. A building of about 60,000 square feet also would be required.

VI. EXAMINING THE NEED FOR CHANGING RADIATION PROTECTION GUIDES

EPA on Page 13 of their DES, cites the National Academy of Sciences (BEIR Report) as presenting an admonition to lower the current radiation protection guidelines [DES, p. 13]. The full text of the paragraph, from page 2 of the BEIR Report follows.

> "There is reason to expect that over the next few decades, the dose commitments for all man-made sources of radiation except medical should not exceed more than a few millirems average annual dose to the entire U.S. population. The present guides of 170 mrem/yr grew out of an effort to balance societal needs against genetic risks. It appears that these needs can be met with far lower average exposures and lower genetic and somatic risk than permitted by the current Radiation Protection Guide. To this extent, the current guide is unnecessarily high."

We have underlined sections of the paragraph which were omitted in the EPA paraphrase of the paragraph. The omissions are important. We believe that NAS was not suggesting a need to change the RPGs

generally, as stated by EPA. We believe that NAS was identifying a need to augment the current RPGs with population exposure guidelines (not standards). What NAS finds to be unnecessarily high is the population dose that would be permitted by the current limits of 500 mrem/yr for an individual and 170 mrem/yr for critical population groups if it were to be applied to every individual in the population. We will show how our interpretation is supported by the complete text in the BEIR Report.

Preceding the paragraph quoted above, the BEIR Report states:

> "Given the estimates for genetic and somatic risk, the question arises as to how this information can be used as a basis for radiation protection guidance. Logically the guidance or standards should be related to risk. Whether we regard a risk as acceptable or not depends on how avoidable it is, and, to the extent not avoidable, how it compares with the risks of alternative options and those normally accepted by society."

We have underlined what we believe is an important observation -- that in order to judge whether a risk is acceptable or not requires consideration of those risks which are normally accepted by society. We are not aware of any consideration given to this important factor in the studies leading to the proposed standard.

In the paragraphs which follow the one cited by EPA, further guidance is provided. Those paragraphs which are applicable to nuclear facilities are presented below.

> "It is not within the scope of this Committee to propose numerical limits of radiation exposure. It is apparent that sound decisions require technical, economic and sociological considerations of a complex nature. However, we can

state some general priniciples, many of which are well-recognized and in use, and some of which may represent a departure from present practice.

a) No exposure to ionizing radiation should be permitted without the expectation of a commensurate benefit.

b) The public must be protected from radiation but not to the extent that the degree of protection provided results in the substitution of a worse hazard for the radiation avoided. Additionally there should not be attempted the reduction of small risks even further at the cost of large sums of money that spent otherwise, would clearly produce greater benefit.

c) There should be an upper limit of man-made non-medical exposure for individuals in the general population such that the risk of serious injury from somatic effects in such individuals is very small relative to risks that are normally accepted. Exceptions to this limit in specific cases should be allowable only if it can be demonstrated that meeting it would cause individuals to be exposed to other risks greater than those from the radiation avoided.

d) There should be an upper limit of man-made non-medical exposure for the general population. The average exposure permitted for the population should be considerably lower than the upper limit permitted for individuals.

f) Guidance for the nuclear power industry should be established on the basis of cost-benefit analysis, particularly taking into account the total biological and environmental risks of the various options available and the cost-effectiveness of reducing these risks. The quantifying of the "as low as practicable" concept and consideration of the net effect on the welfare of society should be encouraged."

"i) In regard to possible effects of radiation on the environment, it is felt that if the guidelines and the standards are accepted as adequate for man then it is highly unlikely that populations of other living organisms would be perceptibly harmed. Nevertheless, ecological studies should be improved and strengthened and programs put in force to answer the following questions about release of radioactivity to the environment: (1) how much, where, and what type of radioactivity is released; (2) how are thse materials moved through the environment; (3) where are they concentrated in natural

systems; (4) how long might it take for them to move through these systems to a position of contact with man; (5) what is their effect on the environment itself; (6) how can this information be used as an early warning system to prevent potential problems from developing?

j) Every effort should be made to assure accurate estimates and predictions of radiation equivalent dosages from all existing and planned sources. This requires use of present knowledge on transport in the environment, on metabolism, and on relative biological efficiencies of radiation as well as further research on many aspects."

We strongly recommend these NAS principles and suggestions to EPA for consideration in deciding if, when, and in what form to issue 40 CFR Part 190. We believe that EPA has gone beyond these suggestions with the proposed standard and, in doing so, may be in contradiction to the recommendation in item (b) by attempting to reduce small risks even further at the cost of large sums of money that spent otherwise clearly would produce greater societal benefit.

Item (c) suggests that the upper limit of exposure for individuals in the general population should be such that the risk of serious injury from somatic effects in such individuals is very small relative to risks that are normally accepted. It is our understanding that this was a principal consideration in selecting the current RPGs and similar guidelines recommended by the National Council on Radiation Protection and Measurements (NCRP) and the International Commission on Radiological Protection (ICRP). We are unable to determine how EPA selected the values for annual dose limits for individuals in the proposed standard. We do <u>not</u> find a rationale in the EPA reports which indicates that the somatic risks at current RPG values are unacceptably

high or that EPA's proposed reduction in annual dose limits for individuals is based on a finding of cost effectiveness. In fact, we cannot relate the annual dose limits for individuals proposed in the standard to any technical base developed in the EPA reports.

Item (d) speaks to the need for an exposure limit for the general population and suggests that the average exposure permitted for the population should be considerably lower than the upper limit permitted for individuals. On page 9 of the BEIR Report, the NAS expands on this issue. In discussing the current PAGs, the following paragraphs are presented.

> "A major difficulty has been the misinterpretation of these standards, particularly in the public mind. The intent as stated is that no individual in the general population should receive whole-body exposure of more than 0.5 rem/year and that the average exposure of population groups should not exceed 0.17 rem/year. What is often not realized is that one or the other limits may be governing depending on the nature of exposure. For example, if the exposure were to arise from specific locations such as nuclear power plants or reprocessing plants and it were assured that no individual at the boundaries of the installations could be exposed to more than 0.5 rem/year, it would be physically impossible for the U.S. population averages to approach anywhere near the level of 0.17 rem/year from such sources. Accordingly, we feel (disregarding numerical values) that both individual and the average population guidelines should be maintained but that clarification should be included as the integral part of the regulatory statement."

> "In addition to individual and average population guidelines, we recommend that an additional limitation be formulated (not as a basic standard but for generating guidance) that takes into account the product of the radiation exposure and the number of persons exposed: this might be expressed in terms of person-rems. This need arises from acceptance of non-threshold approach in risk estimates which implies that absolute harm in the population will be related to such a product. Operationally, for example, there would be advantage in assessment of trade-offs

in connection with the siting of nuclear installations as related to the population of areas under consideration.

"The above recommendations could be implemented with present knowledge. We now come to an important area that requires newer approaches. It is suggested that numerical radiation standards be considered for each major type of radiation exposure based upon the results of cost-benefit analysis. As a start, consideration should be given to exposure from medical practice because of present relatively high levels of exposure and from nuclear power development because of future problems of energy production and the need for public understanding.

"The difficulties in attaining a useful cost-benefit analysis for nuclear power are formidable and will require interdisciplinary approaches well beyond those that have yet been attempted. Areas that require evaluation include: (a) projection of energy demands, (b) availability of fuel resources, (c) technological developments (clean combustion techniques, coal gasification, breeder reactors, fusion processes, magnetohydrodynamics, etc.), (d) public health and envrionmental costs of electrical energy production from both nuclear and fossil fuel including aspects of fuel extraction, conversion to electrical energy, and transmission and distribution."

We have underlined statements which we believe are important in characterizing the NAS concerns and suggestions. We find the observation that if the near individual is limited to not more than 0.5 rem/year, it is physically impossible for the U.S. population averages to approach the level of 0.17 rem/year. Clearly, NAS is stating that item (d) is satisfied for exposures arising from specific locations. NAS recommends limiting the population annual exposure in terms of person-rem/year, not as a basic standard but for guidance. The only feature of the EPA proposed standard which relates to limiting the population annual exposure is the limit on the amount of long lived material released. In this case EPA has expressed the limits in terms of curies per MWe quantities, but in effect this limits the population's annual exposure

by an emission standard rather than a dose guideline -- contrary to the NAS recommendation on two counts.

NAS suggests that numerical radiation standards be considered for each major type of radiation exposure based upon the results of cost-benefit analyses. In the discussion of the difficulties in attaining a useful cost-benefit analysis, it is clear that a broader study than that provided by EPA is required to select the suggested numerical standards. For example, on page 8 of the BEIR Report, NAS cites the lack of data on fossil fuels for cost-benefit analysis.

> "Thus for example, we find relatively little data available on the health risks of effluents from the combustion of fossil fuels. Furthermore, it is becoming increasingly important that society not expend enormously large resources to reduce very small risks still further, at the expense of greater risks than go unattended; such imbalances may pass unnoticed unless a cost-benefit analysis is attempted. If these matters are not explored, the decisions will still be made and the complex issues resolved either arbitrarily or by default since the setting and implementation of standards represent such a resolution." (Emphasis added)

This paragraph also is reflected in item (f) of the NAS comments quoted above.

Items (i) and (j) suggest the need for further studies and research to permit more accurate determinations of impact of the proposed EPA standard. We believe that there is substantial progress toward satisfying this need but much more effort is needed and it is in this area that we believe coordinated efforts among the several government agencies and the nuclear industry is needed.

In summary, we see no admonition in the BEIR Report that the current RPGs should be substantially reduced as proposed by EPA. Rather, we see suggestions to more accurately characterize radiological impact so that potential problems may be identified and prevented.

The FRC, having defined the general framework for the radiation protection requirements, recognized that detailed standards could best be developed by the Federal agencies with immediate knowledge of the design and operating characteristics. This is clearly stated in the seventh recommendation of the FRC which was approved by the President [FR Doc. 60-4539, May 8, 1960, p. 4403].

> "7. The Federal agencies apply these Radiation Protection Guides with judgement and discretion, to assure that reasonable probability is achieved in the attainment of the desired goal of protecting man from the undesirable effects of radiation. The Guides may be exceeded only after the Federal agency having jurisdiction over the matter has carefully considered the reason for doing so in light of the recommendations in this paper.
>
> The Radiation Protection Guides provide a general framework for the radiation protection requirements. It is expected that each Federal agency, by virture of its immediate knowledge of its operating problems, will use these Guides as a basis upon which to develop detailed standards tailored to meet its particular requirements. The Council will follow the activities of the Federal agencies in this area and will promote the necessary coordination to achieve an effective Federal program."

It is our view that EPA is proposing to promulgate the detailed standard referenced above rather than the general framework for radiation protection. In today's terminology, we believe that the proposed standard does not meet the definition of a "generally applicable environmental standard" but more nearly represents a "detailed standard" with elements

of "emission control standard" which are better left to other agencies with a more immediate understanding of the design and operating characteristics of the facilities.

ATTACHMENT B

EFFLUENT REGULATION BY THE NUCLEAR REGULATORY COMMISSION

The commercial use of atomic energy was the first technology to be subject to comprehensive Federal regulatory control from its inception. Under the Atomic Energy Act of 1954, as amended, no person may construct or operate a nuclear facility, such as a nuclear power plant or nuclear fuel reprocessing plant, or possess or use source, byproduct, or special nuclear materials except as authorized by an NRC permit or license. In addition, the Atomic Energy Act authorizes the NRC to promulgate regulations specifying design, siting, and operating requirements for nuclear facilities to protect against possible radiation hazards arising from normal operations. The Act requires the NRC to set limits on the amounts of radioactive material that may be released during normal operations of nuclear facilities and other activities involving nuclear materials.

Under the Atomic Energy Act the NRC has a comprehensive regulatory program involving licensing, standard setting, inspections, and enforcement. Detailed regulations concerning siting, design, and other aspects of regulation of nuclear facilities and activities have been published in 10 CFR Chapter 1. In addition, we have issued more than 200 Regulatory Guides to provide guidance on methods acceptable for implementing specific parts of the Commission's regulations, to delineate techniques used in evaluating specific problem areas, and to provide other guidance to applicants and licensees.

Implementation of Radiation Protection Standards

Since its inception, the AEC, and now the NRC, has looked to the published recommendations of the International Commission on Radiological Protection (ICRP) and the National Council on Radiation Protection and Measurements (NCRP) for guidance in the formulation of rules and safety requirements in regulation of the nuclear power industry. In addition, in 1959 the Atomic Energy Act was amended to establish the Federal Radiation Council (FRC), whose function was to advise the President on radiation matters affecting health, including guidance for all Federal agencies in the formulation of radiation standards.

All functions of the Federal Radiation Council were transferred to the Administrator of the Environmental Protection Agency (EPA) by Reorganization Plan Number 3 of 1970. Also transferred to EPA by this Plan were "The functions of the Atomic Energy Commission under the Atomic Energy Act of 1954, as amended, administered through its Division of Radiation Protection Standards, to the extent that such functions of the Commission consist of establishing generally applicable environmental standards for the protection of the general environment from radioactive material. As used herein, standards mean limits on radiation exposures or levels, or concentrations or quantities of radioactive material, in the general environment outside the boundaries of locations under the control of persons possessing or using radioactive material." The NRC retained the responsibility for implementation and enforcement of EPA standards.

In its first Memorandum for the President dated May 13, 1960, the FRC recommended adoption of Radiation Protection Guides for Federal use in normal peacetime operations. Subsequently, additional radiation protection guides were recommended and adopted in Reports No. 2 and 8. Current NRC regulations conform to the FRC guidance to Federal agencies approved by the President. EPA has not altered the guidance issued by the Federal Radiation Council and the Commission's regulations remain consistent with FRC guidance to Federal agencies.

The FRC, ICRP, and NCRP guidance includes, but is not restricted to, quantitative radiation protection guides and dose limits. Since any radiation exposure may involve some degree of risk, these standards setting groups also have recommended that radiation doses be kept "as low as practicable" or, as stated by the ICRP, and now contained in NRC regulations, "as low as reasonably achievable, social and economic considerations being taken into account." Therefore, the NRC system of implementing FRC guidance is aimed at the following principal objectives:

1. To keep doses from all sources of radiation exposure, other than natural background and medical procedures, well within the FRC numerical radiation protection guides.

2. To avoid unnecessary sources of exposure and to ensure that doses received are justifiable in terms of benefits.

3. To provide for design and operational control of specific facilities and uses of materials, both individually and in combination, so that the resulting doses are sufficiently low that any further reduction in risk would not be considered to justify the effort required to accomplish it; that is, the doses are as low as reasonably achievable.

These objectives are achieved by:

1. Establishing and enforcing "regulatory upper limits" on doses and releases of radioactive material to the environment applicable to all licensed activities. These limits are not intended to be exceeded. They are set forth in the Commission's regulation, 10 CFR Part 20, "Standards for Protection Against Radiation."

2. Establishing and enforcing design objectives and limiting conditions of operation applicable to specific classes of nuclear facilities and uses of radioactive material to assure that persons engaged in activities licensed by the NRC make every reasonable effort to maintain radiation doses and releases of radioactive material in effluents to the environment as far below the regulatory upper limits as is reasonably achievable.

This approach to design objectives and limiting conditions of operation implies a cost-benefit methodology with emphasis on the differential in costs and benefits that might be involved in requiring the activity to be carried out at one level of exposure rather than another.

We believe that the application of this regulatory process, with emphasis on design criteria, operating procedures, and effluent monitoring, effectively controls releases of radioactive material and assures that the

risk from exposure to radiation resulting from normal operations of the nuclear power industry is kept at an extremely low level.

We also believe that this approach to regulation is highly responsive to the recommendations of the Advisory Committee on the Biological Effects of Ionizing Radiation, National Academy of Sciences, as reflected in their November 1972 report on "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation" (BEIR Report). Chapter II of the report, "Needs of the Times," emphasizes the need for quantifying risk and the use of cost-benefit analyses in decision-making. The report very wisely points out that this methodology brings into the decision-making process such important considerations as whether the public interests are better served by spending our limited national resources on health gains from reducing radioactive contamination or by spending for other societal needs.

NRC Experience in Implementing the "As Low As Reasonably Achievable" Concept

The effectiveness of the implementation of the "as low as reasonably achievable" concept in the regulatory process is confirmed by experience in the nuclear industry. This experience shows that licensees have generally kept releases of radioactive material in effluents at such low levels that resultant exposures to persons living in the immediate vicinity of nuclear facilities have been much less than the FRC radiation protection guides for individual members of the public. The Nuclear Regulatory Commission has published numerical guidance on design objectives and limiting conditions of operation for light-water-cooled nuclear power reactors in Appendix I to its Part 50 regulations. This regulation was the subject of extensive public rulemaking hearings, including a detailed environmental statement with

PUBLIC HEARING ON PROPOSED ENVIRONMENTAL RADIATION STANDARDS FOR NUCLEAR POWER

OPENING STATEMENT

ALLAN C. B. RICHARDSON
ASSISTANT TO THE DIRECTOR FOR STANDARDS DEVELOPMENT
CRITERIA & STANDARDS DIVISION
OFFICE OF RADIATION PROGRAMS
U.S. ENVIRONMENTAL PROTECTION AGENCY

Good morning and welcome to these public hearings. My purpose this morning is to describe the proposed standards, lay out their basis, and say a few words about our intentions concerning implementation. In the course of addressing these matters, I hope to respond to some of the more important written comments we have received. Following that, I will make myself available for your questions. I find myself in the somewhat uncomfortable position of having to summarize a large body of information that has already been carefully laid out in some detail in several places. First, in the Federal Register notice which announced these proposed standards on May 29 of last year, second, in the draft environmental statement issued at the same time, and finally, in the supplementary material issued January 5 of this year. I will do my best to summarize this material accurately. However, copies of each of these documents are available here in the hearing room and I invite any of you who are not familiar with them to consult these materials for more detail.

These standards are proposed under general authority of the Atomic Energy Act and would override the existing environmental standards contained in Title 10, Part 20, of the Code of Federal Regulations for

the nuclear power industry. In general they are lower than those existing standards by a factor of 20, and also provide additional protection against long-term exposures of human populations by long-lived materials. The proposed standards do not, however, alter existing Federal Radiation Protection Guides or Guidance--they are more properly regarded as implementing and supplementing the overall radiation protection provided for by that guidance, and I emphasize the word overall.

The proposed standards are, I believe, quite simple. They are summarized on slide one. They apply to operations defined to be part of the commercial uranium fuel cycle. This includes 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 using uranium fuel, reprocessing of spent uranium fuel, and transportation of any radioactive material in support of these operations, to the extent that these support commercial electrical power production utilizing nuclear energy, but it excludes mining operations (since these are not covered under the Atomic Energy Act). There are two types of limits. The first, which is expressed in terms of maximum dose to any real individual, is designed to provide protection of the individual and at the same time to assure that the nearby population exposure to short-lived materials will not exceed levels that can be achieved through the use of cost-effective levels of effluent control. The proposed maximum dose limits are 25 mrem/yr to the whole body or any organ except the thyroid, which

is limited to 75 mrem/yr. Incidently, the dose to any organ means the total dose delivered to that organ not just that from any single pathway or effluent. The proposed limit for the thyroid is larger than the others for two reasons: the greater difficulty (and therefore cost) of reducing iodine emissions (the principle source of thyroid exposure); and the lower level of severity of health effects due to thyroid exposure, compared to the other organs involved.

The second type of limit is designed to prevent the accumulation of long-lived radioactive materials in the environment. It is expressed in terms of the maximum total quantity of specific radioisotopes which may enter the general environment from the entire fuel cycle for each unit of electric power production. A number of long-lived radionuclides are currently discharged from fuel cycle operations which will result in the buildup of environmental levels and irreversible commitments for potential exposure of populations that may persist for tens, hundreds, or thousands of years. The extent of the cumulative doses to populations which may occur over the years following release of such radionuclides is related to their radioactive decay times, the details of their dispersion through environmental media, including the period over which they remain in the biosphere, and the location and size of exposed populations. The cumulative dose resulting from releases to the environment of such materials has been characterized by the Agency as an "environmental dose commitment," and quantitatively expressed in terms of the estimated number of person-rems of dose committed. The proposed standards are based, to the

extend that present knowledge permits, on such projections of the migration of radioactive effluents through the biosphere and estimates of the sum of potential doses to present and future populations during that migration. The Agency believes that it is particularly important that release of such materials be properly limited, since they represent the largest source of potential exposure of human populations from fuel cycle operations.

Since we cannot unequivocally state that potential health effects will not occur at any given level of exposure to radiation, it is not possible to specify solely on a health basis an unequivocal safe level of radiation exposure either for individuals or for populations. Because of this basic assumption concerning the health risk associated with exposure to radiation, it is necessary to balance the potential health risk associated with any particular level of exposure against the costs of achieving that level. In developing the proposed standards, EPA has carefully considered, in addition to potential health effects, the available information on the effectiveness and costs of various means of reducing radioactive effluents, and therefore potential health effects, from fuel cycle operations. This consideration has included the findings of the former Atomic Energy Commission and its successor, the Nuclear Regulatory Commission (NRC), regarding effluent controls, as well as EPA's own continuing cognizance of the development, operating experience, and costs of control technology. The standards are proposed at levels we believe to be consistent with the capabilities of control technology and at a cost

judged by the Agency to be acceptable to society, as well as reasonable for the risk reduction achieved. The Agency has selected the cost-effectiveness approach as that best designed to strike a balance between the need to minimize health risks to the general population and the need to avoid unreasonable cost penalties to the public for production of nuclear power. Such a balance is necessary in part because there is no sure way to guarantee absolute protection of public health from the effects of a non-threshold pollutant, such as radiation, other than by prohibiting outright any emissions. The Agency believes that such a course would not be in the best interests of society.

The quantity limits for long-lived materials are not specified on an annual basis, since they are normalized to total power production, which does not necessarily occur in the same year as fuel reprocessing, the operation principally affected by the quantity limits now being proposed. However, as is pointed out in the draft environmental statement accompanying these proposed standards, two important radionuclides are missing from those included under these limits that are not unique to the reprocessing operation. These are tritium and carbon-14. You will also note that of the three that are included two have effective dates eight years hence. With the exception of plutonium and other transuranics, long-lived radionuclides have not received the attention we think they should get, and consequently control methods are not yet as well-developed as they should be. It is principally for this reason that krypton-85 and iodine-129 requirements

are postponed until 1983, and carbon-14 and, possibly, tritium are not yet included. Although tritium control is under development, it is not yet at all clear whether or not it will be economic; and carbon-14 has just recently been recognized as an effluent of consequence. Although there is a paucity of data, it appears that carbon-14 effluents could contribute more population dose than all other effluents combined. Finally, the matter of radon-222 and its daughters remains unresolved by these proposed standards. As many of you are aware, an extensive evaluation of impact and costs of remedial measures at inactive tailings piles to control radon emanation is now being carried out jointly by the Energy Research and Development Administration and EPA under EPA funding.

The proposed standard contains a variance provision. This may be exercised by the NRC under conditions of "temporary and unusual" operation when continued operation is necessary to protect the overall societal interest with respect to the orderly delivery of electrical power. The correspondence of some of this language with that of Part IV of Appendix I to 10 CFR 50 is intentional, since EPA does not believe it would be appropriate to establish criteria which differ from those of NRC regarding "temporary and unusual" operating conditions. Reporting of the nature and basis of the variance is also required. This reporting would go beyond that now required by Appendix I, in that the extent of and reason for excess exposures and releases, as well as the basis and duration of the variance should be included, whereas Appendix I now requires only identification of the cause and proposed

corrective action when Technical Specifications are exceeded. It should be noted in passing that exceeding Technical Specifications by small amounts need not necessarily result in a situation requiring a variance to permit continued operation, since in many instances Appendix I design criteria will be somewhat more restrictive than these generally applicable environmental standards.

In a few instances the standards would require the use of controls that are not cost-effective, based on consideration of total population exposure alone. This is because even though adequate protection of populations considered as a whole may be assured by standards based upon the balancing of total health risk and control costs, it may not always be the case that an equitable degree of protection is assured on this basis to some individuals in these populations who reside close to the site boundaries of nuclear facilities, because of the distribution characteristics of certain effluents. Such situations are possible in the case of thyroid doses due to releases of radioiodines from reactors and lung doses due to particulates from mills. Although the absolute risk from such doses to nearby individuals is quite small, the Agency believes that it is inequitable to permit doses to a few specific individuals that may be substantially higher than those to all other members of the population from other radionuclides. Additional protection for such individuals should be provided when this can be done at a reasonable cost. The standards proposed to limit doses to individuals reflect this additional judgmental consideration where it is appropriate to do so.

It is, I believe, worth noting in passing that the proposed standards have not been based upon a cost-benefit evaluation of nuclear power relative to other technologies for the production of electricity, as has sometimes been suggested should be done. Even if such an evaluation were possible, and we do not believe that it can yet be successfully carried out, it would not provide an appropriate basis for standards-setting. The Agency believes that all sources of energy should be environmentally acceptable and minimize their impact on public health independently through imposition of cost-effective levels of control. After attaining environmental acceptability and internalizing the associated costs, the marketplace is the proper place for determination of the future use and acceptability of each of the various energy sources, rather than to use environmental costs as a means of equalizing C/B balances, or to arbitrarily equalize environmental costs. The Agency has rejected such methodologies as illogical and unsound.

I will conclude these brief comments on the basis of the proposed standards with a few words about the dose-effect relationship used and assumptions made in calculating environmental dose commitments. The Agency has adopted as policy that use of the linear dose-effect relationship is, in general, the most appropriate and prudent course for assessments which form the basis for standards-setting to protect public health. This is also the recommendation of the National Academy of Sciences. We have published an appreciation of recent views expressed by the National Council on Radiation Protection and

Measurements regarding the use and interpretation of health effects estimates in our supplementary information issued January 5, 1976. Finally, the Agency has expressed its intent to review any new information that is forthcoming in this area, and will update its policy regarding the dose-effect relationship if this appears to be warranted. Our review of information available to date, however, indicates that a change in the present policy is not justified.

The calculation of environmental dose commitments was terminated 100 years following release to the environment of each effluent considered. This was done because our knowledge of environmental pathways was not sufficient to permit credible assessments for such extended periods, and because of the difficulty in making value judgments concerning doses received at such distant times. This unsatisfactory situation is ameliorated by the observation that for the two cases where this is of possible significance, iodine-129 and the transuranics, the controls required by the standards may be characterized as "best available technology" and the level of residual annual impact is extremely low. Concern has also been expressed that the consideration of environmental dose commitments, which generally involves large populations, small doses, and long periods of time, will lead to a never-ending series of increased control requirements. Our analysis convinces us that this is not the case--the most significant radionuclides have already been identified, and the indicated levels of cost-effective control are not only bounded, but appear to be readily

achievable and reasonable in cost Increases in population sizes would not change these conclusions significantly.

I will make only a few brief comments concerning implementation, since this was the subject of an extended discussion in the supplementary information recently issued by EPA. First, it is not our intent that the regulatory implementation of these standards involve an apportionment of the dose limits among the various fuel cycle operations. Although the standards for maximum dose apply to the total contribution to any individual from the entire fuel cycle, in practice this will usually mean that each component of the fuel cycle must satisfy the same limits, since in the vast majority of situations the sum of all possible contributions from all sources other than the immediate site will be small compared to these standards, and should be ignored in assessing compliance (as it now is regarding compliance with 10 CFR 20). We believe that it would not be reasonable to attempt to incorporate into compliance assessments doses which are small fractions of the uncertainties associated with doses from the primary source of exposure.

With regard to reactor sites, the Agency has reviewed Appendix I in its final form (which applies to single reactor units), and it is our opinion that conformance to Appendix I by a planned reactor on a site containing up to five such facilities should constitute de facto demonstration to the NRC that a reasonable expectation exists that these standards can be satisfied in actual operation (unless a specific finding is made by EPA or NRC that extremely unusual combinations of

liquid and air pathways of exposure are actually present and are expected to be simultaneously intercepted by real individuals). Additional guidance may be required in the future from NRC, as noted by the Commission in its opinion filed with 10 CFR 50, Appendix I, for sites containing larger numbers of facilities. In this regard, however, we note the conclusion of the NRC's very recently completed Nuclear Energy Center Site Survey that at least 20, and probably 40 reactor units would be expected to deliver maximum doses within the limits specified by these proposed standards using types of control currently required to meet Appendix I.

It should be emphasized that these standards apply to actually operating facilities, and not to preoperational stages of the consideration of facilities, such as licensing. Consideration of the adequacy of control measures at facilities during pre-operational stages with respect to these standards should be limited to a finding, either for specific sites, or on a generic basis, as appropriate, that the facility has provided or has available to it adequate means to provide reasonable assurance that these standards can be satisfied during actual operations. Such means may include the provision of cleanup controls on discharge streams, the ability to modify, if necessary, its mode of operation to mitigate environmental discharges, or methods which interrupt exposure pathways in the environment. The important point is that the standards specify maximum doses to real individuals and maximum quantities of certain materials actually

delivered or discharged to the environment, not the specific design parameters of individual facilities.

Finally, with regard to compliance, it is not the intent of this Agency that such extreme measures as routine monitoring of individuals for compliance with maximum dose limits be instituted. In general, existing environmental and effluent monitoring programs at facilities appear quite adequate to demonstrate compliance or the possibility of non-compliance with these standards. Only in cases where normal measurements indicate the possibility of non-compliance would more detailed measurements be appropriate. In this regard, the Agency believes that existing models for calculation of exposure fields due to gaseous and liquid releases, using measured data on quantities released, local meteorology, and stream-flow characteristics, are adequately conservative to serve as the basis for verification of compliance with these standards. If reason exists to believe, based on use of such source term measurements and models, that non-compliance may exist at a particular site, then more detailed field measurements may be employed (or, of course, the facility could reduce its emissions to achieve model-based compliance).

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

(CSD)

00015

SUBJECT: Comments on "Radiation Protection for Nuclear Power Operations"

DATE: JUN 27 1975

1 Roux (...)

2 CSO

FROM: Paul C. Tompkins
Senior Science Advisor, NERC/RTP

TO: Roger Strelow
Assistant Administrator for Air & Waste Management

It has come to my attention that you cannot understand why you periodically get documents I have written objecting to something done by the Office of Radiation Programs. I believe my letter to Dr. Mills gives an adequate statement of my motive and the reasons I feel as I do. If you have any questions, I can be reached through FTS on 919-549-2611.

The enclosed memorandum to Trakowski may also help clarify the issues for you.

Sloppy thinking, sloppy writing and sloppy performance has characterized ORP operations ever since EPA was formed. How much credibility do you think EPA can have when every Health Physicist in the world except for those in EPA knows what radioactivity is?

1S3

see my comments

EPA Form 1320-6 (Rev. 6-72)

Received in Radiation Office
Environmental Protection Agency
Date 30 JUN 1975

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Research Triangle Park, North Carolina 27711

JUN 27 1975

Dear Billy:

I am writing this letter commenting on the proposed standards "Radiation Protection for Nuclear Power Operations", in Federal Register, Vol. 40, No. 104, pages 23420-23425, May 29, 1975. Since the package you sent me contained both the FR Notice and the associated environmental impact statement, my comments may apply to either or both as the case may be. Since EPA's approach and philosophy are determined higher in the EPA organization than the Criteria and Standards Division, comments 4-8 are directed primarily to Bill Rowe and Roger Strelow.

(1) Section 190.02 (f).

The definition of "Radioactive Material" is technically incorrect. I suggest language such as the following which is derived from the long established definition of radioactivity. "Radioactive material is a substance containing nuclides which undergo spontaneous disintegration with simultaneous emission of ionizing radiations."

(2) Section 190.10 (a).

The language "shall not exceed" is not appropriate since it requires a control and measurement capability no one can meet with

such absolute assurance. Appendix I language such as "is unlikely to exceed" is more in tune with reality without any implication of softening the standard.

(3) Section 190.11.

The variance approach is a good way to get around the undesirable features of a fixed and unyielding numerical limit. However, I do not forsee any condition except the operation of a power plant that would be likely to have it invoked.

The remainder of my comments bear on my observation as a professional in radiation protection that the presentation in both documents is internally inconsistent in some aspects, and contradictory in others. The overall impression, as it has been for 5 years, is that in the field of radiation protection, EPA is projecting an image to the radiation protection community, that can only be judged as demonstrating that EPA is professionally incompetent, intellectually dishonest or both. Since this may appear to be an unnecessarily harsh evaluation to some, my remaining comments bear on the reasons.

(4) Generally applicable standards

The standards proposed in the FR notice are neither environmental standards nor are they generally applicable.

The distinction was made as early as 1971 when Mr. Dominick demanded that EPA establish standards for nuclear power and Joe Lieberman opted for standards for light water cooled reactors. I pointed out then as I do now, that if the agency proposes to issue

generally applicable standards for nuclear power they would have to apply equally to light water cooled reactors, high temperature gas cooled reactors, breeder reactors and any other nuclear technology used in power generation. However, the triumvirate of Dominick, Elkins and Gregg seem to have decided that EPA would completely reject the protection philosophies developed by NCRP, ICRP and FRC and that the Agency would argue that any standard expressed in tissue dose is "generally applicable" because the radiation could originate from more than one nuclide. This was such a horrible distortion of accepted usage in radiation protection, I could not believe Lieberman was serious when he told me this, but I was wrong. The policy of deliberate misrepresentation to project a political image that is not true is still painfully evident.

It is perfectly clear from the documents that the proposed standards apply only to electricity generated by light water cooled reactors and do not apply to other technologies available to the nuclear power industry.

EPA seems to have made zero progress in the past 5 years in the direction of promulgating generally applicable standards for nuclear power. The apparent EPA argument that by making the standards cover the whole fuel cycle rather than just the power plant they meet the criterion of generally applicable standards is outright misrepresentation in that any standard which is technology specific can only be viewed as a technology specific standard - not a generally applicable one.

(5) Environmental standards

An environmental standard normally links the presence of an agent in the environment to a dose-effect function. The interpretation of whether or not an environmental standard is being met depends only on the concentration of the agent and is independent of the sources. Primary air quality standards are examples of such environmental standards.

The standards proposed in this notice are technology specific and are, therefore, analogous to the New Source Performance Standards of the Clean Air Act which are not promulgated by the Agency as environmental standards. By presenting these standards as "environmental radiation standards," EPA is presenting about the same image of professional competence and intellectual integrity as we did 5 years ago when we blandly asserted we were proposing "generally applicable environmental standards" for light water cooled reactors because the suggested standards were in the form of dose to tissue.

(6) Page 23421, last column, last full paragraph

The last two sentences read: "It should be noted that this proposed standard for maximum whole body dose which is higher than that proposed by the AEC as guidance for design objectives for light water cooled reactors, differs from those objectives in that it applies to the total dose received from the fuel cycle as a whole and from all pathways, including gamma radiation from onsite locations. It is also not a design objective, but a standard which limits doses to the public under conditions of actual normal operation." The second

sentence is a true distinction, but the first one is not. The "total dose received from the fuel cycle as a whole" is technically meaningless. There is simply no way by which a person in Georgia is going to be exposed to a measureable degree to short lived isotopes originating from a nuclear activity in California. It is possible to apply this standard separately to each area or region where nuclear activities are conducted regardless of the number or type of nuclear activities in the area but there is no way for NRC to integrate across areas on an individual exposure basis. It is also possible to apply it separately to each individual step in the fuel cycle, but this application is rejected in the documents.

The standard, as written would also include the contribution from ^{14}C and ^{3}H among the contributors to the 25mrem/yr. This poses a stickier problem since ^{3}H, for example, released in California can contribute to a 25mrem exposure in Georgia through the cycle of release, incorporation into fruits and vegetables, and shipment to Georgia for consumption by individuals in Georgia. I doubt the whole NRC budget could support the monitoring and exposure assessment program that would be needed to apply this type of requirement to all activities in the fuel cycle. The message that comes through to me is that EPA has proposed a standard it can not mean, and that the cost of compliance has not been examined correctly.

(7) Page 23422, Col. 1, first paragraph

One sentence says, "The proposed standard of 75mrem per year to the thyroid has therefore been chosen to reflect a level of biological risk comparable, to the extent that current capability for risk estimation permits, to that represented by the standard for dose to the whole body."

This argument does not wash at all. "To the extent that current capability for risk estimation permits" would justify a standard of 75mrem per year to the whole body just as readily as one of 25mrem per year since both numbers are within the error range of any estimate. In addition, the general practice in radiation protection prior to 1970 was to make the dose limit for individual organs (gonads and bone marrow excepted) three times higher than the dose limit for the whole body. The trend in the late 1960's was in the direction of considering organs equally sensitive for protection purposes, and the NCRP in Report 39, wiped out the differential in its recommended standards for exposure of the public. However, NCRP's rationale was to simplify dose calculations and made no inferences about radiation sensitivity. I think EPA will find radiobiologists do not support the contention that the radiation sensitivity of the thyroid is 1/3 that of all other organs in the body, and there is no way the radiobiologists in ORD can support that statement outside the agency.

(8) Page 23422, Col. 3

I have dissented publicly with ORP's use of the BEIR report since publication of its report on Population Dose Commitment. The basis for my dissent appears to be shared by several knowledgeable members of the Somatic Subcommittee of the BEIR Committee when one examines the list of people who participated in the preparation of NCRP Report 43. If I had to guess at the most likely level of risk at the dose levels of interest, I would pick a number about a factor of 10 to 100 below the

your (personal) value judgment versus ~~this~~. You can't support it.

estimate derived from the linear extrapolation model. This would make the probable cost fall more like 1 to 10 million dollars per hypothetical health effect averted than the $100,000 shown. I do not think the Administrator has been given a true picture of the possible social cost attached to adoption of this standard.

As a professional in radiation protection I like to take pride in the organization with which I am associated. The observation that ORP's approach to radiation protection is to continue to play a political shell game with the Administrator, other agencies and the public is repugnant to me and I remain distressed by the public image ORP has created for EPA.

Sincerely,

Paul C. Tompkins
Senior Science Advisor

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

SUBJECT: Further Thoughts on EPA Radiation Policy DATE:

FROM: Paul C. Tompkins
Senior Science Advisor, NERC-RTP

TO: A. C. Trakowski
Acting Assistant Administrator, ORD

THRU: John F. Finklea, M. D.
Director, NERC-RTP

This memorandum is to amplify and clarify my thoughts on the subject of ORD's responsibility to EPA in the radiation area. The matter surfaced when ORP issued a Technical Report "Environmental Radiation Dose Commitment: An Application to the Nuclear Power Industry." We understand the concepts in this report may soon be adopted by EPA as a policy base for the Agency's radiation program.

In my memorandum to Dr. Finklea, I pointed out three places where, in my judgement, the report could be damaging to the credibility of EPA's image for professional competence in radiation protection. In addition, I suggested a new look at the relevance of the approach to EPA's responsibility to protect both public health and the environment.

On July 24, 1974, Dr. Mills commented on my memorandum, essentially rejecting the reasons I gave for my opinion. His reply indicates three policy issues are inherent in the ORP position of which you should be aware. These are: (1) Relevance of the ORP policy proposal to the Agency Mission; (2) ORP interpretation of the BEIR Report; (3) the person rem and population dose concept. Amplifying comments on each point follow.

Relevance:

The question of relevance was raised in my memorandum to Finklea to suggest the Agency would be well advised to look at its radiation program from the standpoint of ambient environmental standards as well as from the standpoint of source by source control and technology assessment.

My understanding of the arrangements worked out under Reorganization Plan No. 3 was that EPA is responsible for the first function and AEC is responsible for the second insofar as nuclear power is concerned. The "umbrella" standard which was mentioned in the reply was at least an attempt on my part to comply with the concept of the ambient standard. The point made by Dr. Mills is quite right in that the concept was considered briefly and rejected by EPA. Instead, we took on a technology assessment approach that put us into direct competition with AEC.

My reading of the Ash memo says only that EPA should get on with the job assigned to us and cease duplicating the function assigned to AEC. My reading of the ORP position tells me that EPA has no intention of considering ambient standards but will continue competing with AEC on a broader base than separate standards tailored to the differences in individual facilities.

The question of relevance I raised is to indicate that if EPA's responsibility is to focus on technology assessment - fine, let's agree on that and get on with the job. If, however, our responsibility is ambient standards - look out - because the program is not considering anything remotely resembling the concept of ambient standards.

Delineation of EPA's primary responsibility is not the prerogative of either ORP or ORD. I am calling to your attention my judgement that a substantive issue can be involved and that EPA can be vulnerable a second time, and for essentially the same reasons that prompted the Ash memorandum.

Interpretation of the BEIR Report:

ORP's interpretation of the BEIR report as given in Dr. Mill's reply to me requires a re-interpretation of the linear extrapolation that cannot be defended on scientific grounds. The issue is whether the linear extrapolation permits an estimate of the actual number of effects to be expected at natural background levels (ORP's interpretation) or an estimate of the likely maximum number - recognizing that the true impact would fall somewhere between that value and zero (my interpretation). The linear-no threshold assumption is an established radiation protection assumption, but this does not bestow on it the property of scientific validity which the ORP interpretation requires.

The person rem concept

The concept that population risk is proportional to person rems was commented on by Drs. Black, Garner, and me. Basically it requires us to accept as true, the notion that the risk to a population is independent of and greater than the risk to the people in the population being evaluated. I think the Agency should think carefully before

adopting it as a reasonable way to describe the relationship between an environmental stress and its public health consequences.

I am preparing a paper entitled "The Use and Misuse of Population Exposures in Radiation Protection" which addresses the last two issues. It will be given at the Health Physics Society Symposium on Population Exposure on October 22, 1974. Also, I have prepared, as a Memo to File, more detailed comments on Dr. Mill's reply. These can be made available if you are interested.