UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

November 10, 1988

The Honorable Lee M. Thomas
Administrator
U.S. Environmental Protection Agency
401 M Street S.W.
Washington, D.C. 20460

EPA-SAB-RAC-89-003

OFFICE OF
THE ADMINISTRATOR

Dear Mr. Thomas:

The Radiation Advisory Committee of the Science Advisory Board has reviewed the Office of Radiation Program's plans for revising the technical basis for the Radionuclides NESHAP. The Science Advisory Board's Dose and Risk Subcommittee sent you separate reports on Low-LET radiation risks and on risks associated with radon. This letter transmits the report of the Sources and Transport Subcommittee.

The Director of the Office of Radiation Programs presented its approach to the revisions in the May 23, 1988 memorandum, "Radiation Risk Assessment Methodology" and in the June 21, 1988 memorandum, "Review of Clean Air Act Risk Assessments by Radiation Advisory Committee." Staff from the Office of Radiation Programs supplemented these memoranda with presentations at the open meeting of July 13-15, 1988 . Members of the public provided extensive written and oral public comment on technical issues.

In considering whether the Office of Radiation Programs approach was state-of-the-art and scientifically defensible, the Subcommittee addressed many issues including: the accuracy and completeness of the technical data, the validity of the modeling approach, the relevance of the data and modeling to the objectives, the presentation of results, and uncertainty.

Of the numerous findings by the Subcommittee, we wish to highlight three which we believe to warrant the most serious attention by the Agency:

1. Portions of the AIRDOS-EPA methodology are no longer state-of-the-art, and must be updated to incorporate important recent advances in modeling radionuclide transport through environmental pathways.

2. To date, EPA's treatment of modeling uncertainties has been qualitative rather than quantitative although state-of-the-art methods for estimating uncertainty are available.

3. Best estimates (defined on page 9 of the report) with appropriate uncertainty statements should be used in all risk assessments. The "best" estimate should be statistically defined, according to the target population or individual and the shape of the uncertainty distribution.

To correct these deficiencies, the Subcommittee urges the Agency to make use of qualified groups and individuals to help implement immediate and long-term improvements in model structures, uncertainty and sensitivity analyses, and model validation. Results from evaluations of similar radiological assessments are available which the Agency could use now to guide its immediate activities. Longer-term efforts should involve a substantive upgrading of radionuclide transport codes and ensure that the methodology gains and maintains a state-of-the-art status.

Detailed recommendations which deal with these and other topics are found in the report.

These concerns aside, the Subcommittee commends the Agency for its intentions to present radiation consequences as a function of risk level, as in the benzene example cited in the presentation; for the initial steps taken to validate the atmospheric dispersion code within AIRDOS-EPA; and for the use of simplified models for initial screening in the case of compliance procedures.

The Subcommittee hopes the Office of Radiation Programs will incorporate this advice into the Background Information Document and reminds the Agency that the Radiation Advisory Committee has asked to review Volumes I and II of the new Background Information Document when they are available.

In considering the results of this review it is important to recall that very similiar findings and recommendations were offered to the Agency by the Science Advisory Board in January 1984. The apparent lack of responsiveness on this matter by the Office of Radiation Programs during this four year period is of grave concern to the Science Advisory Board. It is the opinion of the Board that action is required now to assure that future reviews will yield evidence of a more defensible scientific basis for regulatory decisions on radionuclide emissions.

The Subcommittee appreciates the opportunity to conduct this scientific review. We request that the Agency formally respond to the scientific advice transmitted in the attached report.

Sincerely,

Norton Nelson, Chairman
Executive Committee
Science Advisory Board

William J. Schull, Chairman
Radiation Advisory Committee
Science Advisory Board

John Till, Chairman
Sources and Transport Subcommittee
Radiation Advisory Committee

Enclosure

cc: J. Moore
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R. Guimond

"NATIONAL EMISSION STANDARDS FOR HAZARDOUS AIR POLLUTANTS (NESHAP): STANDARDS FOR RADIONUCLIDES"

REVIEW OF ASSESSMENT METHODOLOGIES

Sources and Transport Subcommittee

of the

Radiation Advisory Committee

U.S. Environmental Protection Agency

Science Advisory Board

November 1988

U. S. ENVIRONMENTAL PROTECTION AGENCY

NOTICE

This report has been written as a part of the activities of the Science Advisory Board, a public advisory group providing extramural scientific information and advice to the Administrator and other officials of the Environmental Protection Agency. The Board is structured to provide a balanced expert assessment of scientific matters related to problems facing the Agency. This report has not been reviewed for approval by the Agency and, hence, the contents of this report do not necessarily represent the views and policies of the Environmental Protection Agency, nor of other agencies in the Executive Branch of the Federal government, nor does mention of trade names or commercial products constitute a recommendation for use.

ABSTRACT

The Environmental Protection Agency's Office of Radiation Programs described its plans to update the technical basis supporting the National Emission Standard for Hazardous Air Pollutants (NESHAP) for radionuclides. Plans relating to sources of radionuclides in the environment, transport modeling, exposure, sensitivity analysis, and uncertainty analysis were described in a series of briefings at public meetings and documents including Radionuclides, Background Information Document for Final Rules (1984) and two memoranda from the Director of the Office of Radiation programs "Radiation Risk Assessment Methodology" May 23, 1988 and "Review of Clean Air Act Risk Assessments by Radiation Advisory Committee," June 21, 1988.

The Sources and Transport Subcommittee of the Science Advisory Board's Radiation Advisory Committee reviewed these plans. Major findings and recommendations were made regarding the state-of-the-art of the transport model (AIRDOS-EPA), uncertainty and sensitivity analysis, model validation, and the use of best estimates in risk assessment. The Subcommittee found that portions of the AIRDOS-EPA methodology are no longer state-of-the-art, nor are they completely defensible from a scientific viewpoint because important advances in modeling radionuclide transport have not been incorporated. Because treatment of modeling uncertainties in radiation risk assessment by the Office of Radiation Programs has not been quantitative or rigorous, the assessments cannot be scientifically evaluated. The Subcommittee recommended that best estimates with appropriate uncertainty statements should be used in all risk assessments. The "best" estimate should be statistically defined, according to the target population or individual and the shape of the uncertainty distribution.

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1.0 INTRODUCTION

The Science Advisory Board's Radiation Advisory Committee initiated this review because revision of the "National Emission Standard for Hazardous Air Pollutants; Standards for Radionuclides" (NESHAP) is an important activity which could benefit from the use of new data and improved scientific techniques developed in the last five to ten years. This report will generally refer to that standard as the "Radionuclides NESHAP".

The Radiation Advisory Committee formed the Sources and Transport Subcommittee to conduct the review. The roster for this Subcommittee appears at the front of this report. The Subcommittee based its review on two memoranda (see appendices) from the Director of the Office of Radiation Programs (ORP) with their attachments (1,2), oral presentations by ORP staff at the July 13-15, 1988 meeting, and public comments.

The objective of this review was to examine the scientific basis for the evaluation of source terms and radiological assessment models that will be used in the revisions to the Radionuclides NESHAP Background Information Documents scheduled for completion late this winter. The Subcommittee review of the risk assessment methods was scheduled at this time to assist the Agency in meeting its court-mandated deadlines for issuing a proposed rulemaking of February 28, 1989.

The following members of the public provided comments on July 13, 1988:

Dr. Donald Scroggin of Beveridge and Diamond PC
on behalf of the Idaho Mining Association

Dr. Leonard Hamilton of Brookhaven National Laboratory

Mr. Joe Baretincic of IMC Corporation
on behalf of The Fertilizer Institute

Dr. Edwin Still of Kerr-McGee
on behalf of the American Mining Congress

Mr. Louis Cook of Chevron Resources Corporation
on behalf of the American Mining Congress

Mr. Tony Thompson of Perkins Coie
on behalf of the American Mining Congress

Dr. Douglas Chambers of SENES Consultants
on behalf of the Americang Mining Congress
and The Fertilizer Institute

The Subcommittee appreciates these public comments, which were well prepared and technically enlightening, and believes the information provided should be considered by the Agency in its ongoing revision to the NESHAP Background Information Documents.

Staff from the Office of Radiation Programs briefed the Subcommittee on planned changes to the methodology and data bases that will ultimately be incorporated into the Background Information Document for the radionuclide NESHAP. However, since the Office of Radiation Programs is under severe time constraints, the Subcommittee was not able to review the results of calculations or revisions to methodologies that will be used. Such results may not become available until late winter. Therefore, key issues and recommendations of the Subcommittee are based on its review of previously documented methods, the appended memoranda and oral presentations by the Office of Radiation Programs staff.

Since no formal issues were raised by the Agency in preparation for this review, the Subcommittee, after studying the supporting documents and listening to briefings, identified five major topics for discussion. These topics along with specific recommendations follow.

2.0 OVERALL APPROACH TO THE USE OF DATA AND MODELS IN THE RISK ASSESSMENT

2.1 Use Dose/Risk Assessment Models for Deriving the Radionuclide NESHAP

The Subcommittee focused on the extent to which models should be used in lieu of efforts to obtain measured data; whether the model should be usable for both deriving a standard and determining compliance; and the manner in which input/output data are presented, especially the output data regarding risk distribution and uncertainty.

The Subcommittee concurs with statements of the the Environmental Engineering Committee in its June 1, 1988 draft resolution on modeling (3),

> The use of mathematical models for environmental decision-making has increased significantly in recent years. The reasons for this are many, including scientific advances in the understanding of certain environmental processes, the wide availability of computational resources, the increased number of scientists and engineers trained in mathematical formulation and solution techniques, and a general recognition of the power and potential benefits of quantitative assessment methods. The increased reliance on mathematical models is evident within the U.S. Environmental Protection Agency (EPA), where integrated environmental release, transport, exposure, and effects models are being developed and used for rulemaking decisions and regulatory impact assessments.

Despite its appreciation of modeling, the Subcommittee believes that measured data best represent source strengths and environmental concentrations and also near-source atmospheric and environmental concentrations from sources subject to complex diffusion (such as near a building complex or large gypsum or uranium tailings pile). The use of measured source data for elemental phosphorous plants is a good example of a case in which EPA has successfully benefited from this approach. Where such data are not available or cannot be obtained on the schedule required, it is appropriate to use assessment models.

2.2 Objectives of Assessment Calculations

Although the 1984 Background Information Document (4) describes in Volume 1 Chapter 6 methods to model the movement of radionuclides through environmental pathways, it fails to identify clearly the specific objectives of the calculations. Examples of assessment objectives are: the calculation of the maximum effective committed dose equivalent to the average individual in an exposed population, the effective dose equivalent per individual in the most exposed population group and the probability that the average dose in a critical group does not exceed a predetermined value. Although the methodology for various objectives may be similar, input data will differ substantially depending on whether average or highly conservative estimates are desired.

The Subcommittee believes that ultimately it is necessary to estimate the expected number of health effects in the population as a consequence of routine emissions (including predictable seasonal and episodic releases) and to be able to relate this to an expected exposure level. The uncertainty of the estimated health risks inherently incorporates the uncertainty in the exposure level. Therefore, full disclosure of the source and transport uncertainty may help quantify the total risk uncertainty and provide additional input that can be used in setting emission standards.

2.3 Input/Output Parameters

The Subcommittee is concerned about both how input/output parameters for dose/risk models are chosen and about the actual parameters selected. This concern stems from the knowledge that data and it's interpretations which are clearly and thoroughly presented are more easily understood, more accurately interpreted, and more readily related to other common data or studies.

2.4 Perspective on and Understanding of Calculated Health Risks

It is essential to provide scientific data and analyses to the scientific community, to the risk management decision-maker, and to the public in ways which show that often the calculated health effects may be derived for a population at very low individual risk. One effective tool for this purpose is presenting the population distribution of the calculated risk by individual risk level as is being considered in the draft revised benzene standard documents (5). A decision to ignore very low individual risk levels is clearly risk management rather than risk assessment; however, the data should be available to decision makers in a way that provides the perspective necessary for informed judgments. Similarly, comparisons of these estimated risk levels with other commonly encountered and accepted risks is necessary for perspective.

2.5 Limitations of Dose Assessment Codes on Mainframe Computers

The Subcommittee understands that the Agency is proceeding to develop a replacement code for AIRDOS-EPA. These new models will be embodied in a Computerized Radiological Risk Investigation System (CRRIS) on mainframe machines. Models implemented on mainframe computers are generally inaccessible to all but a few specialists, are difficult to modify, and are expensive. The restriction on accessibility limits interaction with peer and interested user groups with the result that state-of-the-art methodologies rarely get widely implemented in a timely manner. Current generation microcomputers are approximately equivalent in power to late 1970's mainframe machines on which current EPA dose assessment codes were written. It has been demonstrated that many transport and dose models can now be implemented on current generation personal computers.

The advantage of dose assessment models implemented on microcomputer systems is that they can routinely be made available for peer-review. Such interactions would likely result in significant state-of-the-art improvements being made to the Agency's methodology at no cost to the Agency.

2.6 Recommendations on the Use of Models for Radionuclides NESHAP

Clearly the use of measured data as the basis for the Radionuclides NESHAP is preferable to calculational models whenever it can be reasonably obtained because there is no need to estimate exposures if real and representative data are used. For example, measured ambient air concentration are more defensible than an estimate of air concentration based on an approximate source term and an atmospheric dispersion model. When used with care, models can be and are a necessary tool for deriving and complying with the Radionuclides NESHAP; however, attention should be given to uncertainties and the presentation of model inputs and outputs in understandable and useful formats. The Subcommittee makes the following recommendations concerning the use of models for the radionuclides NESHAP:

1. The EPA should use site-specific measured data on source terms and environmental concentrations especially for sources that represent complex assessment situations where current models fail. EPA should also use site-specific measured data, or at least generic study results, where available, for other input parameters to the models.

2. Where sufficient data are not available, the EPA must apply updated state-of-the-art calculational models in its derivation of the radionuclides NESHAP. To do so, EPA must intensify its efforts to employ current and state-of-the-art models for each major model component used to determine the risk to public health from various radionuclide emissions sources. EPA must also incorporate both recent advances in modeling methods and the results of validation studies in environmental transport and plume dispersion models.

3. The EPA must clearly state the objectives of the risk assessment calculations. The Subcommittee recommends clarifying both the objectives of the assessments and the steps necessary in the ecological and dosimetric modeling to meet those objectives. Statements of objectives are necessary to provide information regarding the intended conservatism or realism of the assessment calculations. The clarification of objectives will also serve as a guide in making decisions to use conservative or realistic model assumptions and in the choice parameter values. Specifying the objectives will be invaluable in justifying the choice of parameter values, thus making the results more defensible.

4. The Subcommittee strongly suggests that dose estimates be realistic, relevant to defined populations, and accompanied by a quantitative statement of uncertainty which can be propagated into the dose-risk framework. Scenarios can be used as part of this approach. For example, if continuous exposure at a certain location is part of the scenario, the occupancy factor is fixed (at 100%) and only the variations in the other parameters contribute to the uncertainty estimate.

5. The EPA must clearly display input/output parameters used in the calculational models for the Radionuclides NESHAP risk assessment. Particular attention should be given to the population distribution of calculated health effect estimates among the population at risk. These estimates must be displayed as a table showing the distribution of risks over the population, broken down by such categories as:

a. the individual risk level,

b. the size of the population subgroup at that risk level, and

c. the estimated incidence of particular effects that occur at the given individual risk level in the particular population subgroup.

The Subcommittee strongly supports the presentation of calculated risk data for the Radionuclides NESHAP standards in a format similar to that in the memorandum on benzene (5).

When preparing supporting documents for the Radionuclides NESHAP, EPA should display all assumptions, input parameters and research and studies upon which they were based. The presentation of uncertainties (See Section 5.0) will also contribute to greater credibility and understanding of the risk assessment process.

6. All dose assessment computer codes for radionuclides should be developed for use on microcomputers unless code size and complexity requirements justifies the use of mainframe machines. Such codes must be made readily available for review by outside peer, expert, and user groups.

3.0 SCIENTIFIC BASIS OF RISK ASSESSMENT METHODOLOGY

Portions of the AIRDOS-EPA methodology are no longer state-of-the-art, and must be updated to incorporate important recent advances in modeling radionuclide transport through environmental pathways. The current transport methodology was state-of-the-art and scientifically defensible some 5-10 years ago. However, EPA's general methodology, and the radionuclide transport sections of AIRDOS-EPA in particular, have not changed substantively since that time. Many advances have been made in the field of modeling radionuclide transport within the last five years but EPA has not incorporated such advances into its own methodology. Examples of such advances that are not currently reflected in AIRDOS-EPA are discussed below under the categories of model structure, model validation, model uncertainty, parameter sensitivity, and model documentation and accessability.

3.1 Model Structure

The foodchain portion of AIRDOS-EPA is a steady-state model adapted from earlier codes such as HERMES(6)and formulations in the U.S. Nuclear Regulatory Commission Guide 1.109(7). The main differences between AIRDOS-EPA and these earlier methodologies involve the choice of certain parameter values. The deposition-ingestion sections of AIRDOS-EPA are based on straightforward formulae that are well-documented and generally accepted. The choices of parameter values are generally based on relevant scientific literature.

The Subcommittee favors the use of dynamic models because there are distinct disadvantages of steady-state models such as AIRDOS-EPA. For example, predictions of steady-state models only apply accurately to chronic, constant release scenarios. In practice, emissions from many types of facilities are not constant, but rather episodic or seasonal. Furthermore, steady-state models are not well-suited to handle the very marked seasonal changes in climatological conditions, agricultural practices, and food distribution patterns. Finally, steady-state models are not fully testable because many data sets are in the form of time-series measurements, which cannot be directly compared to steady-state model predictions. In short, steady-state foodchain models are limited in application, not realistic, and not readily subject to direct validation. Several dynamic foodchain models have been developed outside EPA, including RAGTIME (8), ECOSYS (9) RADFOOD(10)and PATHWAY(11). These codes incorporate the dynamic processes necessary for more realistic simulation of radionuclide transport through the environment. Dynamic models of course, do handle chronic, steady-state release easily, and they are not difficult to structure or program.

Numerous parameters which are known to vary considerably in time and space are treated as constants in AIRDOS-EPA. These include, for example, the pasture intake of dairy cows, the foliar interception fraction, and the source fraction of various foods to people in a particular locale. Recent, more updated models, have successfully dealt with these variations to produce more realistic estimates (11).

Several basic pathways which are frequently important in the natural environment are not included in AIRDOS-EPA. For example, resuspension of

recent deposits on the soil by wind or other disturbance is a very important process for arid and semi-arid environments, especially when longer-lived radionuclides are involved (11). Sensitivity analyses for many simultaneously varying parameters reveal that resuspension can be, in some cases, a dominant process affecting dose to man (12). Another example of omitted pathways in AIRDOS-EPA is soil ingestion, both by cattle and people, especially children. These phenomena, and numerical estimates, are well-documented in the literature (11,13). The relative importance of soil ingestion is usually small, but under some circumstances, this pathway can be considerably more important than others. These pathways, by their omission, may in some cases offset the generally conservative choices of parameter values in AIRDOS-EPA.

As another example of shortcomings in model structure, in the atmospheric diffusion portion of AIRDOS-EPA, the code does not deal adequately with complex terrain and building wake effects. Furthermore, the use of the harmonic mean of morning and afternoon lid heights throughout the day was questioned by the Subcommittee.

3.2 Model Validation

Efforts by EPA to validate or test the accuracy of AIRDOS-EPA appear to have been minimal, especially for that portion of the model subequent to dispersion which treats deposition, environmental transport and ingestion. The Gaussian plume model portion, however, has been compared to real data sets with encouraging results, for which EPA should be commended. Without a good deal of effort to validate as many steps in the risk assessment calculations as is possible, the results will always be subject to criticism by the public, as well as the scientific community. For example, there has already been considerable criticism by representatives of industry who claim that due to over-conservatism in the assessment models, the regulatory standards are unreasonably restrictive. Others are likely to look for the other extreme, arguing that standards are too permissive. Without convincing model validation data, EPA will be unsure of their degree of conservatism or accuracy and therefore have continual difficulty in defending some of its regulatory positions.

The field of radionuclide transport model validation is relatively new, but rapid advances are currently being made in the U.S. and in numerous other countries. We are rapidly progressing from peer-review and model comparison exercises to real-world comparsions between model predictions and independent field data sets. Because of its scrutiny by peers and the courts, the PATHWAY model received fairly exhaustive validation testing some five years ago with data sets made possible by extensive foodchain sampling programs in the western U.S. during the latter part of the weapons fallout era (14). More recently, the BIOMOVS (Biospheric Model Validation Study) effort was initiated by the Swedish Government and has matured into a truly international effort, involving some 15-20 nations. The BIOMOVS program gained exceptional momentum from the Chernobyl accident, which resulted in the accumulation of extensive data sets from at least a dozen sites world-wide. Active U.S. participants have not included people from EPA. A similar model validation effort has been initiated as a Coordinated Research Program by the International Atomic Energy Agency, but again, without EPA participation.

Clearly, model validation is crucial to the achievement of public and scientific credibility of risk assessments. A reasonable, workable methodology exists, as do numerous data sets. There is ample opportunity for EPA to bolster its effort in the area of model validation.

3.3 Model Uncertainty

The general field of risk assessment is rapidly moving away from the practice of giving single, perhaps worst-case estimates, to that of providing best estimates along with a statement of the uncertainty of that best* estimate. This new, evolving practice reflects the attempt by scientific modelers to exercise complete honesty and full disclosure in arriving at dose or risk estimates. All model structures and parameter values have inherent and unavoidable uncertainties which owe to real-world complexity and variability, as well as to a lack of knowledge, data, or both. Therefore all model predictions contain corresponding uncertainties. Without rigorously derived uncertainty estimates, the credibility of dose or risk values cannot be judged. Any enlightened reviewer will likely assign a very low credibility to an estimate not accompanied by a statement of uncertainty.

In the case of AIRDOS-EPA, it is clear that little or no formal propagation of uncertainties through the methodology has been carried out. While data with which to construct uncertainty distributions on many parameters is lacking, it is still reasonable to construct such distributions, reflecting the actual degree of ignorance on the part of the modeler. Methods for propagating uncertainties through radionuclide transport models are available (15,16), as are published estimates of uncertainty for many critical transport parameters (12,17,18,19).

3.4 Parameter Sensitivity

An important aspect of model evaluation is that of understanding the relative degree to which individual processes or parameters affect the model prediction, and the degree to which uncertainty in a parameter affects model output uncertainty. A sensitivity analysis can be carried out simultaneously with an uncertainty analysis (12), or it may be done independently. Modeling is seldom perfect, so as long as needs justify and resources permit, modelers should strive to continually evaluate and improve their models. Conducting a series of sensitivity analyses is the most efficient way to reveal the most influential pathways and parameters, and thus to guide the expenditure of resources and effort for the sake of model improvement. Sensitivity analysis techniques are readily available and have been successfully applied to dose assessment models (11,12,20). It is not evident to the Subcommittee that EPA has made any substantive effort in the area of sensitivity analysis related to the Radionuclides NESHAP or, in particular, AIRDOS-EPA.

* The Subcommittee defines "best estimate" as the arithmetic mean in the case of normal distributions and the geometric mean (median) in the case of log-normal distributions. The best estimate for other distribution shapes requres specific statistical definition to avoid confusion.

3.5 Model Documentation and Accessability

The current EPA codes for radiation dose assessment are not clearly and concisely documented, nor are they readily available for outside use or peer review. This hinders progressive evolution of the codes because independent critique and input is made difficult. It is useful to concisely document models in the open literature so that they can be openly examined. Such documentation should include a clear statement of the objectives of the models, including a definition of the target individuals or population groups to which the output applies as well as a careful exposition of and justification for the model structure and parameter values. The advances in the power and speed of personal computers have been shown to make possible their use for many complex models. The ability to distribute models enhances the process of positive model evolution.

3.6 Recommendations on Models Used in EPA's Radionuclide Risk Assessment

1. The Office of Radiation Programs must become state-of-the-art in its risk assessment methodologies. The transport portions of AIRDOS-EPA need extensive revisions. Methods already developed by other groups for model validation, uncertainty and sensitivity analysis need to be incorporated. This task may be accomplished most efficiently by establishing a close, continuing working relationship with a group or individuals acknowledged to be current in these fields. Immediate use of uncertainty estimates and validation exercises from other transport models is essential if EPAs short-term goals for NESHAP development are to be achieved. For the longer-term, EPA should develop its own capabilities with the help of others and participate more actively in national and international meetings devoted to these topics.

2. The Office of Radiation Programs should carefully define the generic individuals and/or populations to which its risk assessments are targeted and carefully articulate these definitions in the Background Information Document and other relevant documents.

3. The dose/risk assessments conducted by EPA must provide best estimates (as defined on page 9) along with statistically appropriate measures of uncertainty. The probabilitites of individuals receiving doses or risks at various fractions or multiples of the best estimates should be clearly revealed in all numerical presentations.

4. As the Office of Radiation Programs develops new software to accomplish dose/risk assessments, codes compatible with personal computers should be encouraged. This strategy is not only cost-effective, but it facilitiates future improvements, communication capabilities, and credibility within the public and scientific community.

These recommendations are consistent with, and in some cases almost identical to, those developed during the Science Advisory Board's 1984 review (21).

4.0 THE USE OF SITE-SPECIFIC DATA

4.1 Data from Other Federal Programs Should be Incorporated in the BID

The EPA is not always using the most appropriate data available in the performance of radionuclide NESHAP development. Since preparation of the Background Information Document in 1984, a great deal of new data, of significant potential value to this work, has been produced. While much of this information is not yet published, it must be accessed and used by EPA in preparing the Radionuclides NESHAP

Review of available documentation (provided by the EPA for the SAB Subcommittee review, and presented during the July 13-15, 1988 Subcommittee open meeting in Washington, D.C.) demonstrates that data available from current non-EPA programs directly related to EPA guidelines development work are not being used. For example, the Uranium Mill Tailings Remedial Action Project (UMTRAP) has produced significant quantities of data (22,23) that should be used to support the derived source term for mill tailings sites. These data include monitoring results for radon and radioactive particulates in air, mill tailings pile radionuclide inventories, etc. Uranium mill tailings pile airborne particulate emissions are monitored constantly at all UMTRAP mill tailings sites undergoing remedial action. Monitoring is performed at background (remote) locations, upwind and downwind of the site, and at several other locations including the closest resident's home. Particle filters are regularly analyzed for gross alpha contamination, and analyzed quarterly for Ra-226 and Th-230, the two principal radionuclides of concern in suspended dust from tailings piles. These data are regularly reviewed by the U.S. Department of Energy (DOE), and are quality assured using National Bureau of Standards standarization of all measurements. Other recent projects, including DOE's Formerly Utilized Sites Remedial Action Program (FUSRAP) and Surplus Facilities projects should prove to be good sources of new air concentration data for additional radionuclides. During current development of the Radionuclides NESHAP, access to such recent data is essential.

4.2 Site-Specific Parameters and Measurements Should be Used Whenever Possible

Site-specific parameters and measurements should be used whenever possible, in place of default or generic parameters, when modeling the potential impact of facilities. While the Agency has employed site-specific parameters in some of the Radionuclides NESHAP work reviewed, additional effort is needed in this area to be more certain that exposure, dose and risk estimates accurately reflect existing conditions.

Uranium mine and mill exposure estimates within the exisiting BID are based on model facilities, when data concerning release rates, transport, and exposure could be employed to make a more accurate estimate of facility impact. In certain cases, (for example, the Mount Taylor uranium mine in New Mexico), site-specific modeling could lead to significantly more realistic exposure estimates for the nearby population.

4.3 Recommendations for the Aquisition and Use of Additional Data

1. The EPA should initiate a thorough survey of all current remedial action programs sponsored by the government. The survey should identify key personnel within each project capable of quickly providing the relevant data. The Oak Ridge National Laboratory's report, Remedial Action Contacts Directory, would be a good starting point. (24)

2. The EPA should request immediate access to other federal data relevent to the Radionuclides NESHAP work. These data include the following.

a. Radioactive particulate concentrations.

b. Nonradioactive dust concentrations. (Supplementary, for comparison purposes).

c. Radon and other radioactive gas concentrations.

d. Meterological data.

e. Radionuclide concentrations in the specific source material (e.g., tailings or gypsum stacks).

f. Particle size information (pile and airborne).

g. Solubility information (standardized lung fluid tests).

h. Quality control information defining conditions under which the data were collected and analyzed.

3. The EPA should use existing data sets to correct the results of AIRDOS-EPA for specific sites. For example, environmental monitoring data provided by the Mount Taylor representatives and the New Mexico Environmental Improvement Division study of radon concentrations in the Grants New Mexico area, would provide a basis for evaluating the results of AIRDOS-EPA predictions for that specific mine's emissions. EPA should perform similar corrections for all other facilities for which measured concentration data are available.

4. Data sets acquired from outside sources must be inspected carefully for systematic quality control errors, to allow evaluation of the accuracy of results employing that information.

5.0 UNCERTAINTY

5.1 The Role of Uncertainty in Risk Analysis

Because quantitative estimates of the uncertainty provide very important information to the decision maker and others concerned with the risk decision, the Subcommittee recommends in strongest terms that EPA make quantitative estimates of the uncertainty associated with the Agency's dose and risk estimates. Calculations of uncertainty clarify the reliability of the central estimate and provide information essential to understanding the reliability of the estimate.

In 1984, the Science Advisory Board recommended (21) that the Office of Radiation Programs explicitly present uncertainties as part of the radionuclides risk assessment. The Office of Management and Budget (25), the Office of Science and Technology Policy (26), the National Science Foundation (27), and the EPA Administrator (5), have further emphasized the need for defining uncertainties in risk assessments.

The October 1984 Background Information Document (4) summarizes (Vol. I,p. 7-29) some sources of uncertainty and the "reasonable" accuracy which was stated to be a factor of three to four. The problem with this qualitative approach is that there is no way to substantiate the stated range even though a "factor of three to four" may correctly describe the accuracy of dose calculations to represent typical members of the population. This assumed range of error in the source term and environmental transport is close to that estimated for the dose response models (e.g., ORP's risk estimate of 120-750 lung cancers per million person WLM, with a central estimate of 300, implies an uncertainty factor of 2.5). (28) Because the uncertainty in the source term and environmental transport models is believed to be of the same order of magnitude as that for dose-response models, uncertainty estimates for source terms and transport play an important role in establishing the total uncertainty of the calculations of health effects.

The uncertainty statement, however, must have an interpretation that is understood and preferably is of use in decision making. The uncertainty estimate is more than simply a statement about lack of knowledge. Given the proper conceptual framework, e.g. establishing probability distributions of parameters based upon expert judgement or data, the uncertainty estimate can be used to express the probability that the true dose does not exceed a specific value. This framework enables the uncertainty estimate to be used in a meaningful way for decision making.

To avoid misleading the decision-maker, uncertainty statements should also be accompanied by a discussion of what the model does and does not include. To the extent that a model omits certain pathway or processes, it is incomplete, however, uncertainty analysis cannot assess the completeness of a model. Because uncertainty analysis, can only reflect the pathways and/or processess accounted for in the model, it cannot

defensibly compensate for the omissions of pathways and/or processes. For example, in AIRDOS-EPA the absence of relevant pathways (as identified in Section 3.0, page 7) cannot be adequately accounted for by uncertainty analysis without arbitrarily inflating the total uncertainty in an indefensible manner.

5.2 Improvements in the Estimates of Uncertainty

It is essential that the EPA progress from qualitative, estimates of uncertainty to soundly based numerical estimates that cover all portions of the calculations. The need for estimates of the uncertainty in the risk assessment results was identified in the initial review of the SAB in 1984 (21). Although some qualitative and numerical estimates were given for portions of the source, transport, and dose calculations in the 1984 BID, the overall uncertainty in the estimates of dose was not evaluated in an integrated and focused manner (4).

The ORP has stated its intention to again provide qualitative estimates of uncertainty and believes them to be adequate (2). The Subcommittee strongly disagrees because the proposed ORP approach is not state-of-the-art and the argument that it is too difficult to perform a quantitative evaluation is not valid. Currently the capabiliity to perform Monte Carlo calculations yielding probability distributions for the dose estimates is widely available on personal computers. Techniques for these stochastic calculations have been described and used by several other groups in similar evaluations of dose from particular sources of radionuclides released to the environment. (References 12,15,16,17,20, and 29, for example). The available techniques and desktop calculational capabilities permit the improvements recommended below to be accomplished in a timely manner.

5.2.1 Sensitivity Analysis: The Agency must perform sensitivity analyses to identify the most critical parameters for the important exposure pathways for the various source categories. The EPA has already identified some critical exposure pathways as the result of dose calculations presented in the 1984 Background Information Document. (See Table 7.6-1, Volume 1 page 7-28 and the assessments for specific source categories in Volume 2.) For most of the categories, inhalation is the critical pathway. Food chain transport was found to be important for the "DOE facility" category and may also be important for the "NRC licensee and other federal facility" and the "uranium fuel cycle" facility categories.

5.2.2 Parameter Variability: The EPA must define the distributions of the most important parameters identified in the sensitivity analyses. The problems in establishing reasonable probability distributions are often less difficult than expected for several reasons. This procedure can be facilitated by establishing the maximum conceivable range of values and the estimate of central tendency. Multiplicative models have been shown not to be extremely sensitive to distribution shape, a finding that can be confirmed by modifying distribution types and comparing results produced by the various assumed distributions. The EPA must

also define the distributions of the measurements or estimates of the source terms for the various categories.

5.2.3 Propagation of Uncertainty: For each source category, the EPA should perform Monte Carlo calculations to determine the dose distribution that results from variations of the critical parameters. Note that these calculations can often be performed separately on a personal computer without running AIRDOS-EPA repetitively. This is accomplished using a reduced model which explicitly considers only the critical variables.

The reduced model should yield nearly the same final result as the complex model. Monte Carlo calculations are then performed for those variables to generate frequency distributions for the estimated dose. Calculations such as those performed by Dr. Chambers and submitted as part of his testimony on July 13, 1988 exemplify what can be done (30).

It is also possible that analytical error propogation methods may work sufficiently well for simple exposure pathways. Those pathways, e.g. inhalation, that are not modeled by a large number of parameters or processes may be especially amenable to this treatment. It appears that for 8 of the 11 source categories in ORP's June 21 memorandum (2), inhalation may be the main exposure pathway. The principal differences between the pathways would be the variability of the source term and local meteorology.

When assumptions must be made regarding the shape of input parameter distributions, the uncertainties of parameters will also reflect the lack of knowledge of environmental processes. Uncertainty statements should also be made for systematic errors which result in model bias. Model bias was seen for individual sites in the comparison of AIRDOS-EPA with measured values (31). For any one site, the predictions were consistently above or below the measured values. Such comprehensive evaluations significantly contribute to the ability to make quantitative uncertainty statements. For example, the spread of predictions after adjustment for the observed bias can be used as an estimate of the uncertainty in downwind air concentrations, at least for the sites considered in the comparison.

5.3 Recommendation Regarding the Estimation of Uncertainty

The Subcommittee strongly recommends that the EPA make quantitative estimates of uncertainty for the risk assessment for each source category. These uncertainty estimates and their bases need to be presented as part of the Radionuclides NESHAP.

The EPA does not have time to conduct a comprehensive quantitative uncertainty analysis of AIRDOS before publication of the revised proposal in February 1989. It is, however, both possible and desireable for the Agency to make some interim quantitative estimate of uncertainty based on studies of similar models. Therefore, the EPA should acquaint itself with ongoing and completed studies of uncertainty in environmental transport models, report the nature of the uncertainties studied and their magnitudes, and discuss those findings and models in relation to AIRDOS. The sensitivity analysis, studies of parameter variability, and propagation of uncertainty identified above will take longer to complete and should therefore be started promptly so that they may be used in the final regulations. Experienced people could be realistically expected to complete such work within two years.

6.0 MODELS FOR COMPLIANCE APPLICATIONS

6.1 Application of Simple Models

The commercial and non-commercial use of radionuclides is licensed by U.S. Nuclear Regulatory Commission (NRC). A large proportion of these licensees involve the use of small quantities of radionuclides which likely represent a very small risk to the public. The Subcommittee believes that the series of computer codes presently employed by the Agency for the Radionuclides NESHAP are complex and virtually unavailable to most scientists and other users because they are on main frame computers. These limitations for demonstrating compliance must be recognized. The Subcommittee believes that an approach originally recommended by the National Council on Radiation Protection and Measurements (NCRP), of applying the most simple models first, followed by a more complex model, if necessary, is appropriate (32). It is, therefore encouraging to note that the Agency recognizes that other simple, user-friendly and less costly model programs are available, can meet the same objectives, and would be more appropriate to demonstrate compliance. However, a formal process must be established for comparing the results of any alternative methodologies with that of the EPA's to facilitate their approval and use.

A tiered approach which meets this criteria is being proposed for determining compliance using Annual Possession and Air Concentration Tables, application of Level II and III of the NCRP Screening Model (33) and/or EPA's microcomputer Code (COMPLY). This methodology appears to be based on sound environmental transport and radiation protection principles. However, the Subcommittee has not specifically reviewed these methods in any detail for such compliance applications.

6.2 Recommendations on Alternative Compliance Screening Model Development

The Subcommittee recommends that EPA develop criteria for the evaluation of alternative compliance models and publish a process for gaining their approval. The Subcommittee strongly supports the EPA's proposed tiered approach for NRC License compliance and recommends its application for the Radionuclides NESHAP. The Subcommittee also strongly encourages EPA to subject these compliance procedures to peer-review. High priority must be given to making the proposed methodologies available to users in a timely manner.

The Subcommittee also encourages EPA to apply the same philosophy and approach, i.e. simple models first, followed by more complex methods, where appropriate to assess compliance for categories of sources other than radionuclides.

7.0 REFERENCES

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APPENDIX A

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

MAY 23 1988

OFFICE OF
AIR AND RADIATION

MEMORANDUM

SUBJECT: Radiation Risk Assessment Methodology

FROM: Richard J. Guimond, Director
Office of Radiation Programs (ANR-458)

TO: Donald Barnes, Director
Science Advisory Board (A-101)

At our April 12, 1988, meeting on radionuclide NESHAPS, we agreed to supply past background documents used to support NESHAPS rulemaking. Attached for transmission to the Radiation Advisory Committee of the Science Advisory Board (SAB) are copies of the background information documents produced in support of the various Clean Air Act radionuclide rulemakings. A copy of the latest document describing our risk assessment methodology, to be used in support of a low-level radioactive waste management standard, is also attached.

The risk assessment methodology that will be used to develop new background information documents will be virtually identical to that used in the past with respect to source, dispersion, and pathway modeling. However, we propose to incorporate a dose-risk factor range of 120 to 1200 fatal cancers per million person-rem to account for the uncertainty in that factor. The central estimate of risk for whole-body, low-let radiation to the general public will be determined by using a risk factor of 400 fatal cancers per million person-rem, corresponding to the linear, relative-risk model in BEIR III. The whole-body risk will be allocated among the various target organs, consistent with an organ specific relative risk model for all cancers other than leukemia and bone cancer.

Also, we propose to base the radon risk estimates on the preferred model contained in BEIR IV. We will send you another memorandum which expands on our proposed treatment of radon and requests your comments.

Other modifications to the methodology will compute the effective dose equivalent, as defined by ICRP, and the radon equilibrium ratio as a function of distance from a radon source.

Of lesser importance, we propose to make adjustments in our thyroid risk estimates in light of current information as summarized in NCRP Report No. 80. First, the estimate of 20% mortality for radiation-induced thyroid cancer would be changed to 10%. The 20% figure relates to mortality from all thyroid cancers; however, there is ample evidence that the types of thyroid cancer induced by ionizing radiation have a mortality of only about 10%. Second, I-131 would be considered to be one-third as effective as x-rays for induction of thyroid cancer, rather than one-tenth, as assumed previously. The data regarding this question are incomplete and somewhat conflicting--one animal study has shown I-131 to be considerably more effective than previously thought.

It is extremely important that we obtain your review of our current risk assessment methods and our proposed changes to these methods by August 1, 1988. This date is made necessary by our plans to finish the recalculation of risk assessments by early September in order to have decision documents ready for Agency and Administrator reviews this fall. We will make every attempt to incorporate your comments as we proceed. However, our schedule is inflexible due to a court-mandated proposal date of February 28, 1989. If we receive your comments after August 1, 1988, we may not be able to utilize them in performing the risk assessment which will support the development of the proposed rule although it may be possible to take note of your comments in the preamble to the proposed rule and consider them for the final rule, which has a court-mandated promulgation date of August 31, 1989.

If the Radiation Advisory Committee has any questions about the attached material or our approach to risk assessment, please let me know.

5 Attachments

cc: Gordon Burley (ANR-458)
J. William Gunter (ANR-460)
Terrence A. McLaughlin (ANR-460)

United States
Environmental Protection
Agency

Office of
Radiation Programs
Washington, D.C. 20460

EPA 520/1-84-022-1
October 1984

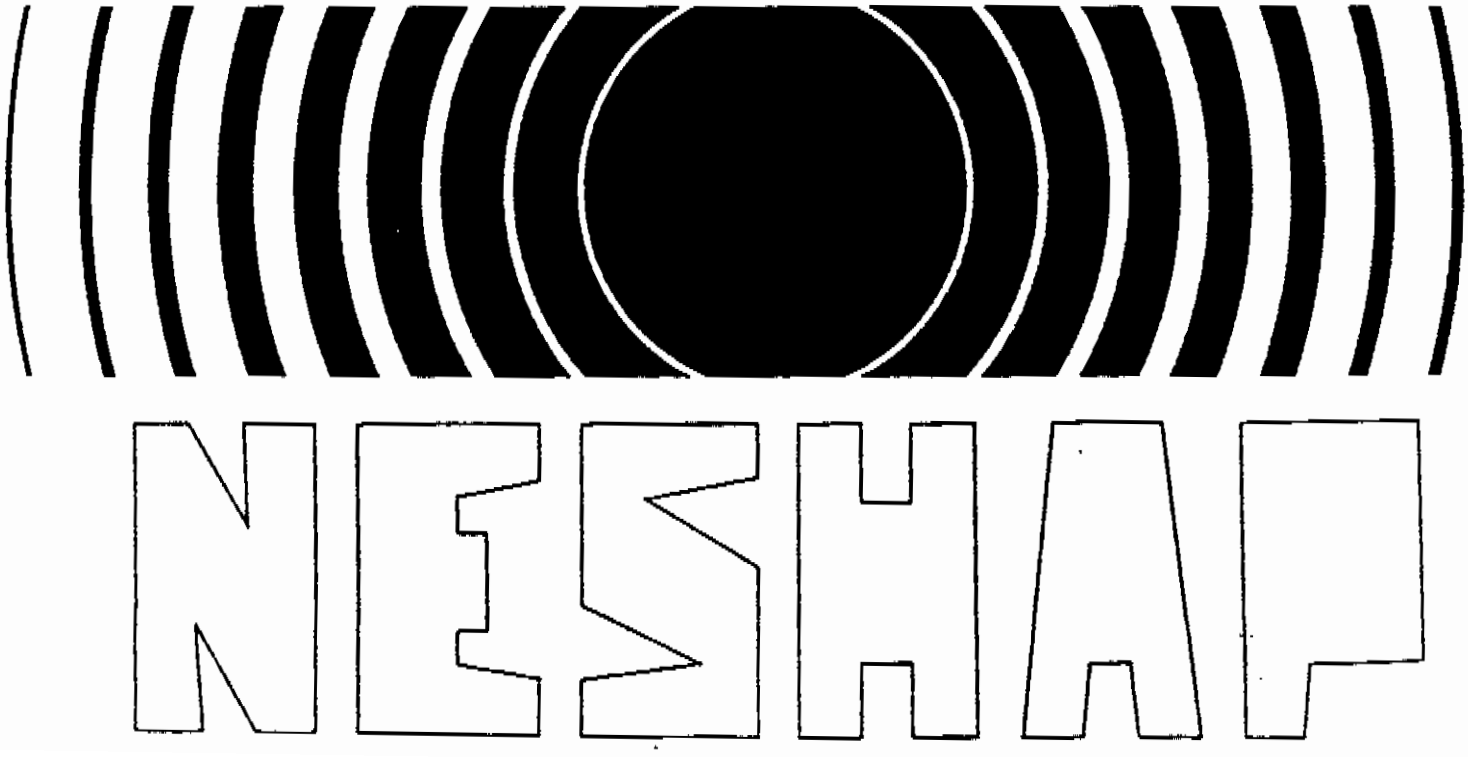
Radiation

EPA

Radionuclides

Background Information Document For Final Rules

Volume I



CONTENTS

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Radon-222 from DOE Facilities

- There are about 5 facilities with radon-222 emissions due to uranium ore residues remaining from the former Manhattan Engineering District Sites.
- Major sites are the Fernald site and the Monticello tailings pile.
- All sites will be assessed using site specific data.
- Source term data will be somewhat uncertain due to fugitive emissions; control technology and cost data good.
- This is new work.

Coal-fired Boilers

- There are about 1200 utility boilers, and tens of thousands industrial boilers.
- Boilers will be characterized and grouped and model boilers developed.
- Number of people at risk will be uncertain; considerable exposure overlap is expected due to the large number of boilers.
- Latest OAQPS data on risk and emissions to be used.

Uranium Fuel Cycle Facilities

- There are approximalty 100 major nuclear power stations that require approximately 30 to 40 support facilities of various kinds.
- Previous analysis in 1975 is obsolete.
- Sites will be assessed based on models.
- Uncertainty is moderate due to model approach.
- This is new work.

High-level Radioactive Waste

- No facilities are in existence.
- Previous EPA work under Atomic Energy Act authority judged sufficient.
- This category is given low level of effort.

Phosphogypsum Piles

- All sites (80) will be assessed using site specific data.
- Data will be good; uncertainty moderate largely due to uncertainty in emissions data.
- This is all new work.

For Each Source Category

T the extent possible, we will provide for each category the following information:

- Individual fatal cancer risks based on site specific meteorology, demographics, and emissions.
- The number of people at risk of fatal cancer by range of risk and incidence.
- Feasibility and cost of controls and resulting risk reduction.
- Health effects in addition to fatal cancer, to the extent known.
- Uncertainties.

/TERAGENCY AGREEMENT/AMENDMENT
Part I — GENERAL INFORMATION

3. Type of Action: New Agreement

4. Program Abbreviation: ORP/HO

5. Name and Address of EPA Organization:
Environmental Protection Agency
Office of Radiation Programs
401 M St., SW
Washington, DC 20460

6. Name and Address of Other Agency:
U.S. Department of Energy
Oak Ridge Operations Office
P.O. Box E Oak Ridge, TN 37831

7. Project Title:
Assessment of Risk to Population of the U.S.from Radon Emissions from Phosphogypsum Stacks.

8. EPA Project Officer (Name, Address, Telephone Number):
Christopher Nelson (ANR-460)
Office of Radiation Programs
Environmental ProtectionAgency
Washington, DC 20460 FTS 475-9640

9. Other Agency Project Officer (Name, Address, Telephone Number):
Frank R. O'Donnel
Oak Ridge National Laboratory, (4500S,
MS-102, P.O. Box X
Oak Ridge, TN 37831 FTS 626-2132

10. Project Period: February 1, to June 30, 1988

11. Budget Period: February 1, to June 30, 1988

12. Scope of Work (Attach additional sheets, as needed):

See Attached Scope of Work

13. Statutory Authority for both Transfer of Funds and Project Activities:
Economy Act of 1932 (U.S. C. 686) as amended, Clean Air Act 1977

14. Other Agency Type: Federal

FUNDS	PREVIOUS AMOUNT	AMOUNT THIS ACTION	AMENDED TOTAL
15 EPA Amount		$30,000	
16 EPA In-Kind Amount			
17 Other Agency Amount			
18 Other Agency In-Kind Amount			
19 Total Project Cost		$30,000	

20. Fiscal Information

Program Element	FY	Appropriation	Doc. Control No	Account Number	Object Class	Obligation/Deobligation
B99F2B	88	688/90108	XX0035	8B9935X0CN	2573	$ 30,000.00

Work Assignment 1-41, Change 1

- Scope of Work Amendment

  Section V. Scope of Work, under item 1 add the following:

  The contractor shall prepare a detailed examination of cost effectiveness for all control options for phosphogypsum stacks. This shall include cost estimates using actual data from representative stacks in the industry.

  The contractor shall also prepare a ~~Regulatory~~ Economic Impact Analysis (RIA) in support of the rulemaking activities for phosphogypsum stacks. The RIA shall include the industrial profile prepared under WA1-41. In addition, the contractor shall prepare an economic inpact analysis and a cost-benefit analysis for all control options.

  The RIA shall also include summary discussions of emission levels, risk levels, feasible control options, and an examination of the possible misuse of phosphogypsum and the benefits of preventing this misuse. The RIA shall also include a Regulatory Flexibility Analysis. The RIA shall be of adequate scope and depth of analysis to support a major rulemaking.

  Section V. Scope of Work, under item 4 add the following:

  The contractor shall prepare an evaluation of the work performed by other program offices within EPA as described in WA 1-41.

- Economic Analysis Report Change

  Section VI. Reports is changed as follows:

  Draft outline for EA chapters: 5 copies, 7 days after W.A. Assignment Change 1 is issued.

  Schedule for EA chapters: same as above.

  Draft EA: 20 copies, October 1, 1988

  Final EA: 20 copies, December 1, 1988

Chapter 8. Phosphogypsum Stacks

Scope of Work

Task 1: Risk Estimates

The Contractor shall prepare a report, for use in the BID, on the frequency distribution of risk levels from Phosphogypsum stacks in the U.S. for use in the Background Information Document (BID). The Contractor shall use EPA-approved assessment models, such as ISC/LT, in consultation with the Task Manager, to compute the frequency distribution, as well as existing risk estimates (using AIRDOS/DARTAB) which are available from EERF.

In preparing the report, the contractor shall address the following technical issues:

1.1 Make adjustments for the variation of radon decay product equilibrium fraction as a function of distance. Current estimates assume a constant 70% equilibrium fraction. This adjustment will lower the risk to populations within 20 kilometers of each stack.

1.2 Compute the correct number of people at each risk level for phosphogypsum stacks that are co-located. This will involve the resolution of two problems: 1) Summing the radon exposures to individuals from multiple piles, and 2) correctly counting the populations exposed to each pile without double-counting those populations exposed to multiple piles. The contractor shall examine the problem of considering the varying equilibrium fractions to individuals exposed to multiple sources at varying distances and determine if a practible solution exists. The contractor shall incorporate this solution in consultation with the Task Manager.

1.3 Evaluate the effect of using an elevated height for the radon release from a model phosphogypsum stack. Current AIRDOS/DARTAB estimates used a ground level release on the assumption that this would correctly account for the plume downwash caused by the wake effect.

1.4 Make recommendations regarding the calculation of the source term for phosphogypsum stacks. The current estimates are based on half the flux for the top layer of phosphogypsum, which accounts for the ponded area. However, this does not account for the reduced flux on the sides of the stack, which have crusted over and generally have a flux about 20% of the top layer. Also, the Contractor shall examine the effect of calculating the source term based on flux characteristics averaged over the lifetime of the stack.

Task 2: Evaluation of Misuse of Phosphogypsum

The Contractor shall prepare a report for use in the BID and RIA that examines the potential for misuse of material in phosphogypsum stacks. This may be a significant problem for stacks in California, which reportedly have disappeared from being used for soil conditioner. Phosphogypsum can also be misused for drywall production. This report shall be of sufficent scope and quality to support a Regulatory Impact Analysis for rulemaking activities involving an industry cost of $100 million.

Estimated Level of Effort

Task 1: 1000 labor hours
Task 2: 1000 labor hours

Schedule and Reports

Draft Report: July 1, 1988, 5 copies
Final Report: August 1, 1988, 5 copies

CAP '88

Clean Air Act Assessment Package/1988

SCOPE OF WORK
Computer Science Corporation - Las Vegas
Contract #68-01-7365-039

Title: DESIGN AND CODING OF AIRDOS-EPA, VERSION 2

Background:

The Criteria and Standards Branch, ORP, needs to establish an upgraded version of the codes used for dose and risk estimation for standard-setting activities. These upgraded code will incorporate the latest refinements in calculation methodologies, be more flexible and easy to use, and generate output more immediately useful to Agency decision makers. In order to make these modifications, the current version of mainframe codes AIRDOS and DARTAB require three general modifications: incorporation of new assessment methodologies, enhancement of input and output procedures, and generation of presentation-quality graphics.

Description of Work:

A) Incorporation of New Assessment Methodologies:

Under the direction of EPA experts, the contractor shall modify the existing mainframe AIRDOS/DARTAB codes to:

1) Vary equilibrium fraction of radon decay products as a function of distance.

2) Calculate "Effective Dose Equivalent" according to ICRP26 and 30 methodology.

3) Incorporate new dose and risk factors.

4) Recompile selected sections of code for more efficent operation.

5) (tentative*) Calculate national impacts of radon

6) (tentative*) Allow for multiple sources, not co-located.

7) (tentative*) Calculate building wake effects.

* Methodologies for items marked "tentative" are presently being developed by the Bioeffects Analysis Branch (BAB). Coding of these items will require that a satisfactory methodology be developed by BAB.

B) Enhancement of Input and Output:

1) Set up the codes to run in full screen/interactive fashion. The code should prompt the user to input data in a straight-forward and logical manner, preferably using a menu format similar to that used by the AIRDOS-PC code. The code shall be VERY user-friendly and forgiving of errors. If practicable, the code should run in real time and not batch mode. Assessments for individual facilities should be easily accessible from a menu or directory, so that a modified run can be easily made.

2) Allow the user to select meterological data from a menu. Set up a data base of data sets that can be accessed easily. Code an identification in each meterological data set that will allow the program to identify the source of the data and the proper format.

3) Allow the user to select from existing population grids or generate new ones easily.

4) Refine output for each assessment such that it succinctly summarizes input, file names and important dose and risk data. Be able to print out any and all location tables and other output from a menu.

5) Have the code make sure that distances selected match the population grid, if applicable. Set up to run population and individual assessments at the same time (the codes must now be run separately to alter imported food fractions and distances.)

6) Store the output from each run in a master data base that will allow for recalculation of doses and risks if the factors change, and to do graphical output summaries for ALL assessments on demand (described later).

7) Generate output in three ways: for each facility that is assessed, for all facilities in a source category, and across all source categories. Categories will be further broken down into Radon and Non-radon groups. There are now a total of 11 source categories:

Non-Radon:

NRC licensees, DOE facilities, High Level Waste Facilities, Uranium Fuel Cycle facilities, Elemental Phosphorous Plants, Coal Fired Boilers.

Radon:

Underground and Open-Pit Uranium Mines, Active Mill Tailings, Disposed Mill Tailings, Radon from DOE facilities, Phosphogypsum Piles.

8) Include in the output for each facility the following items:

   a) Do a synopsis on just a few pages that summarizes facility name, user input, date, run number, and file names used and selected output. The selected output should be the five highest organ doses and effective dose equivalent for individual (mrem/yr) and collective assessment (PR/YR), the maximum individuals lifetime risk, total fatal cancers/yr, and a table showing number of people at various risk levels. The table of people/risk should be modified to include total number of deaths/yr due to this risk or higher, take the risk level down to 1E-10, and print risks in X.X EXX format.

   b) Plot isopleths of individual dose on a map of the facility and surroundings (Scale to be determined). Include population grid information on this plot, so that approximate numbers of people at various doses can be easily seen. Put a legend at the bottom of the graphic showing facility name, scale, etc.

9) Include in the output for each source category the following items:

   a) show the number of facilities, total number of people at various risk levels, total population within 80 km of all facilities (assuming no overlap), total fatal cancers/yr, total effects/yr, the highest maximum individual risk (and identify the facility with the highest risk).

10) Include in the output for a summary across all categories the following items:

   a) A summary of risks, showing the categories, number of sources in each, highest individual risk, fatal cancers/yr, and total population with 80 km.

   b) The total number of people at various risk levels for each category, arranged graphically so that all categories can be easily compared in a visually appealing manner. A grouping of 3-D colored histograms may be appropriate here.

   c) A graphical ranking of highest maximum individual risk for all of the categories, with EPA-supplied uncertainty bars around the risk points. The total number of deaths/yr shall be incorporated in a notation for each category.

Item 10 (continued)

10) d) A repeat of the above with various dose standards superimposed, to show the categories that would be affected by various dose standards.

e) A repeat of the above that shows deaths/yr instead of maximum individual dose.

f) (tentative*) National impacts of radon from the assorted radon categories.

C) Graphics Package:

Add capability to produce presentation-quality graphics summarizing the dose and risk assessments for facilities, categories and across all categories to be used by Agency decision makers.

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OUTPUT FOR AIRDOS-PLUS/MAINFRAME

ID No.:_____ Date/Time:_____
Run No.:_____

Facility:_____

Address:_____

City:_____ State:_____ ZIP_____

Source Category:_____ Year:_____

COMMENTS:_____

_____

INDIVIDUAL ASSESSMENT: Location: 500 meters North

For RADON ONLY:

Exposure in WLM/Y
pCi/l at that location
Lifetime Fatal Cancer Risk

For Non-Radon:

Organ Doses in mrem/y
ICRP effective dose equivalent
Lifetime Fatal Cancer Risk

POPULATION ASSESSMENT:

For RADON ONLY:

Exposure in Person-WLM/Yr
Total Fatal Cancers/Year

For Non-Radon:

Person-Rem/Year
Total Fatal Cancers/Year

FREQUENCY DISTRIBUTION OF RISK LEVELS:

Risk Interval	Total in Interval	Total in Interval or Higher	Fatal Cancers per Year from this Interval	FC/Y from this Interval or Higher
1e-1 to 1e-2	xxx	xxxx	xxxx	xxxxx
1e-2 to 1e-3	xxx	xxxx	xxxx	xxxxx
1e-3 to 1e-4	xxx	xxxx	xxxx	xxxxx
1e-4 to 1e-5	xxx	xxxx	xxxx	xxxxx
1e-5 to 1e-6	xxx	xxxx	xxxx	xxxxx
< 1e-6 ~~to 1e-7~~	xxx	xxxx	xxxx	xxxxx
~~1e-7 to 1e-8~~	xxx	xxxx	xxxx	xxxxx
~~1e-8 to 1e-9~~	xxx	xxxx	xxxx	xxxxx
~~1e-9 to 1e-10~~	xxx	xxxx	xxxx	xxxxx

SITE INFORMATION:

MET data from: Pocatello, Idaho 1965-1969
WBAN:_____ HDR:_____ CODE:____ SET:____
Temperature: 19 'C
Rainfall: 24 cm/yr
Mixing Height: 1100 meters

SOURCE TERM

Nuclide	Class	AMAD	Stack No: 1	2	3	4	5	6
Area/Stack Height:								
Area/Stack Diameter:								
Plume Rise (units):								

POPULATION ARRAY: Latitude: ___ ___ ___ Longitude: ___ ___ ___

	500	1000	2000	3000	4000	5000	10000	20000	30000
N	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
NNW	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
NW	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
W	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
WSW	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
SW	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
SSW	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
S	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx

↓

DISTANCES USED FOR MAXIMUM INDIVIDUAL ASSESSMENT:

___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___

FOOD SUPPLY FRACTIONS:

	POPULATION ASSESSMENT:			INDIVIDUAL ASSESSMENT:		
	Local	Regional	Imported	Local	Regional	Imported
Veg.:	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Meat:	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Milk:	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx

REFERENCE FILE NAMES FOR ASSESSMENT:

Prepar File: MGUCAAR.CAA88.ELEMPHOS(FMCCONC)
STAR Array: MGUCAAR.CAA88.STARLIB(XYZ8945)
Population: MGUCAAR.CAA88.POPLIB(POCATELL)
Radrisk File: CBNRACS.CAA84.RADRISK.V8401RBD

Optional Tables (selected by user)

Environmental Transport Variables:

(do as now printed in AIRDOS)

Fraction of radioactivity retained after washing: .5
Ingestion of Produce
Ingestion of ...
....
Buildup time in soil

(consult with Barry on what variables to include; will decide case-by-case!)

Radionuclide-specific environmental transport variables:

For each NUCLIDE: ANLAM, Scavenging Coefficent, Deposition Velocity, Gravitational Settling Velocity,LAMSUR

Meterological Data:

(Using a convention of wind FROM the direction and CLOCKWISE ordering of directions): Arithmetic Average Wind Speeds, Wind Rose, Harmonic Average Wind Speeds, Stability Array, Surface Roughness length, Height of Wind Measurements (meters), Average Wind Speed

AGRICULTURAL ARRAYS:

as they currently appear in AIRDOS do NOT put in water arrays!!

CHI/Q tables:

as they appear in AIRDOS, but put direction and distances in ENGLISH, not numbers!

CONCENTRATION TABLES:

Wind Toward	Distance	Nuclide	pCi/cu.meters (not cm3!)	Dry Dep. RATE	Gnd Dep. RATE
North	5000	Po-210	2342	234	234

(deposition rates in terms of cubic meters, not centimeters)

Input values for Radionuclide-Independent Variables:

(as they now are printed in AIRDOS)

INPUT DATA FOR NUCLIDE XXXXX

as now printed in AIRDOS but DON'T print AIRDOS dose conversion factors; include Buildup Factors and parents.

Optional Tables (continued)

DOSE/RISK Conversion factors from DARTAB

(at present, units are not printed; can we put units in?)

Organ dose weighting factors used

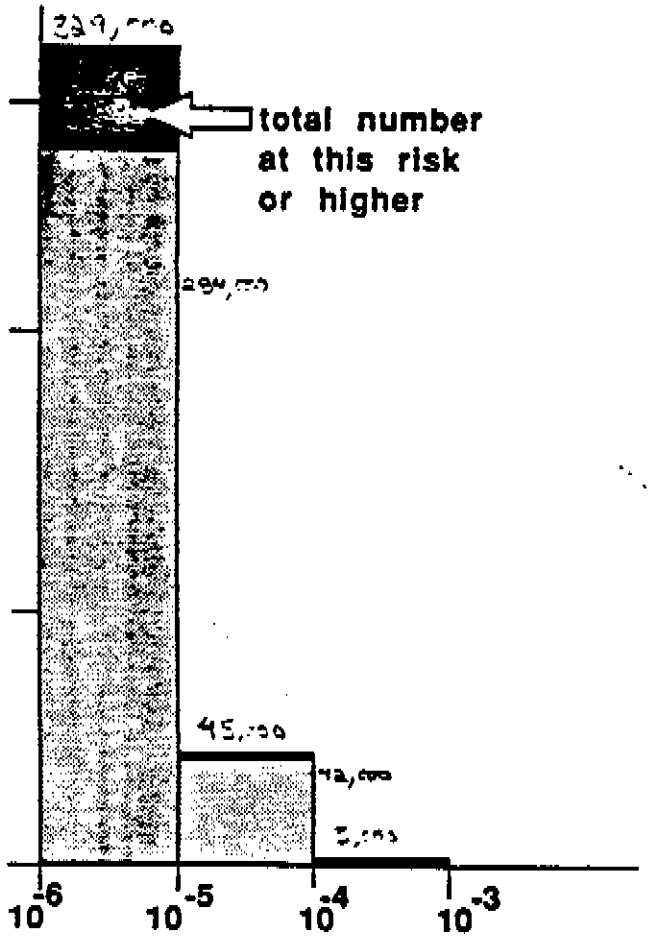
DOSE/RISK Location Tables (offer a logical menu here)

RN-222 Working Level Tables:

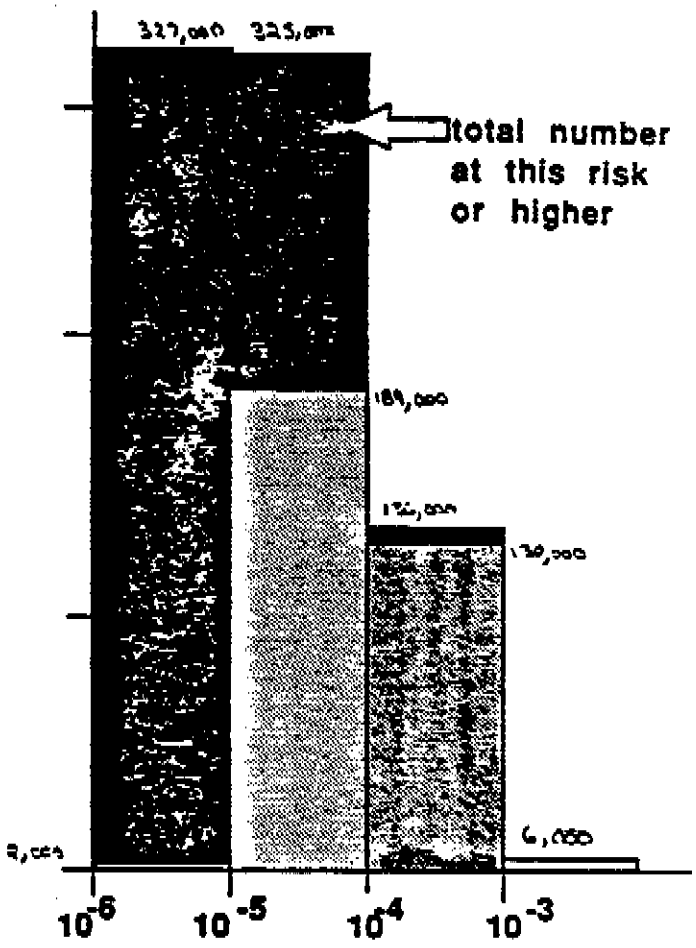
Direction	Distance	Equil. Fraction	WLM	Person-WLM
North	1000	.36	xxx	xxxxx

(equilibrium fraction and WLM will have to be computed)

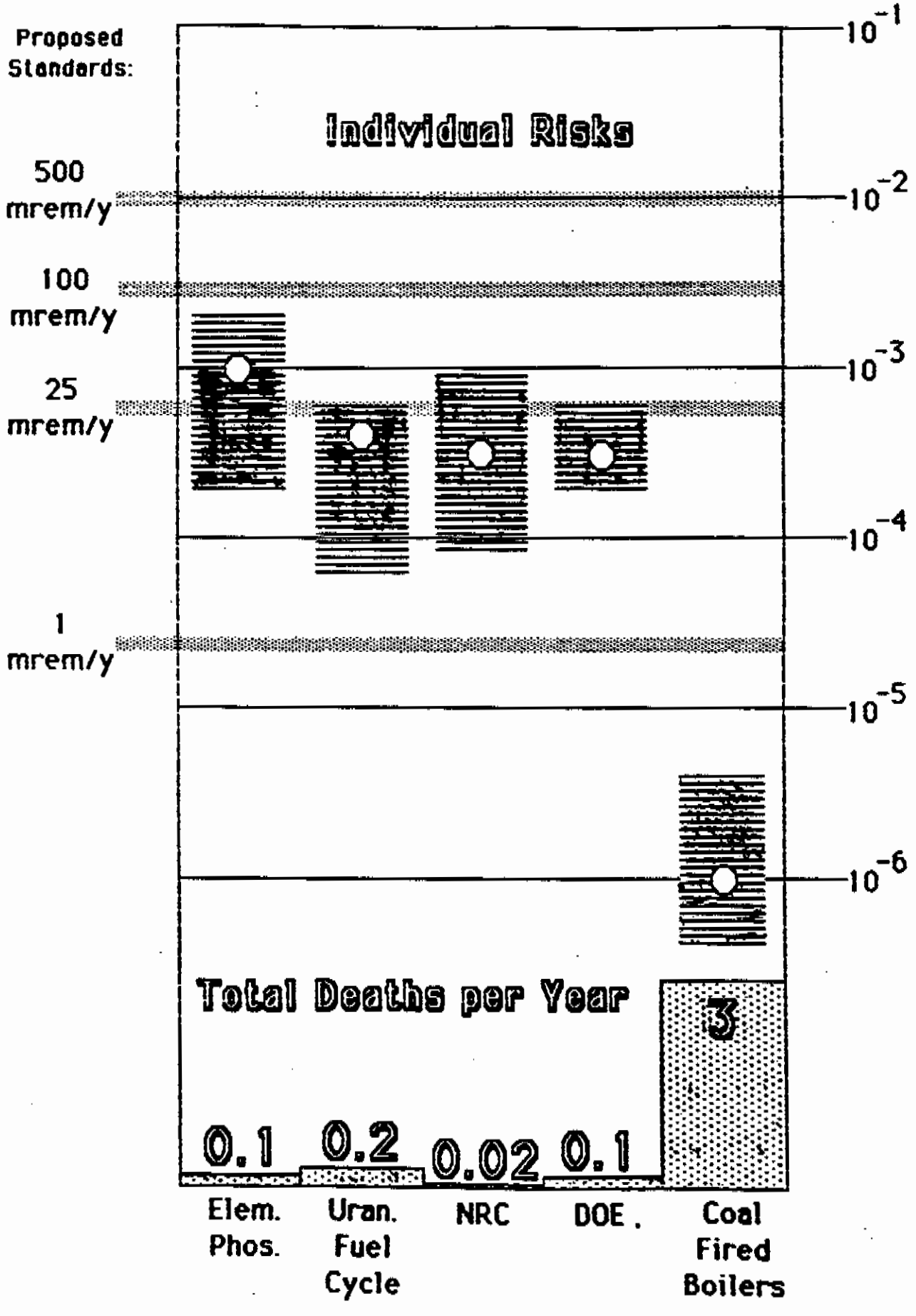
Frequency Distribution of Individual Risks

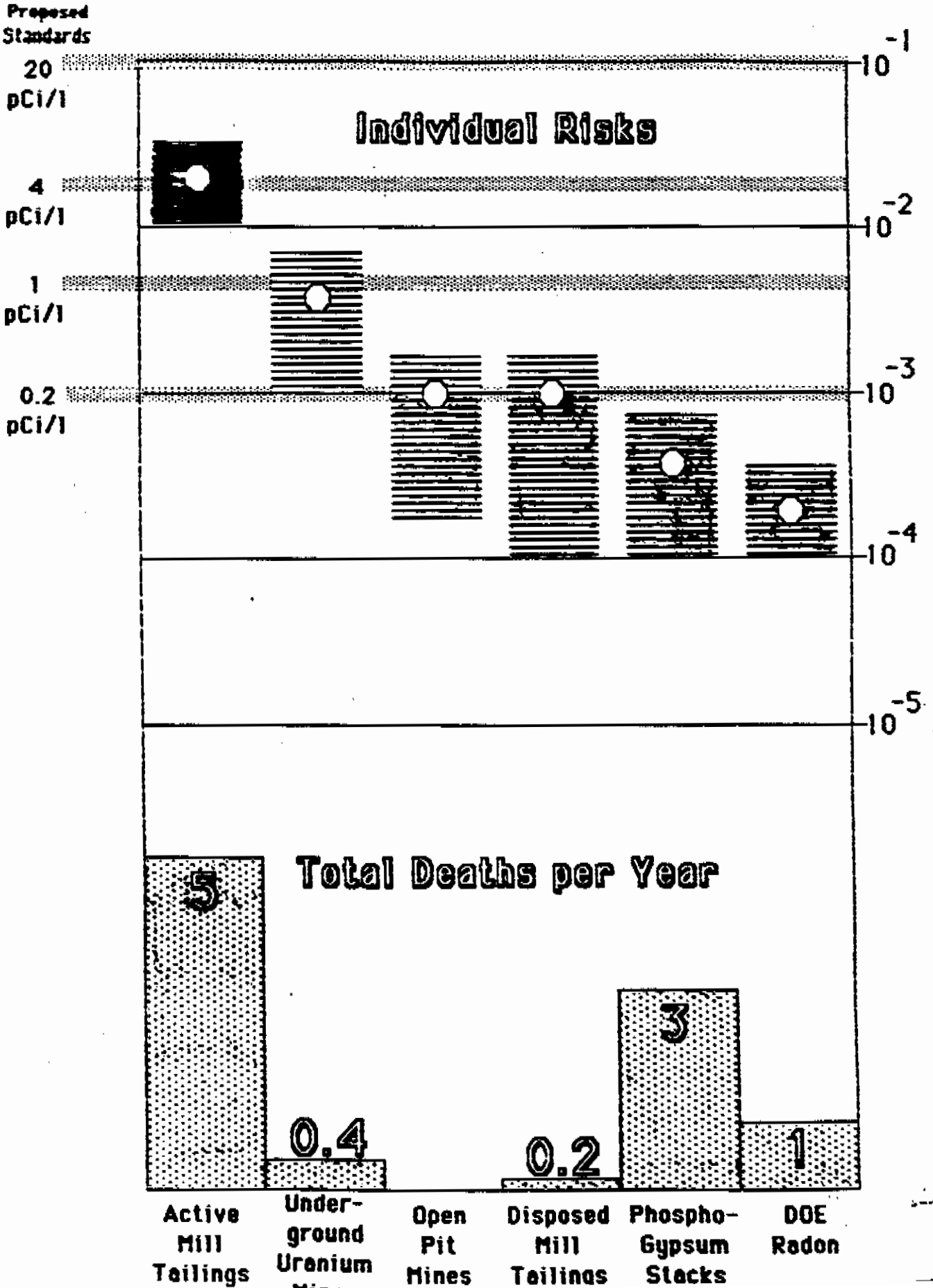


Elemental Phosphorous Plants



Active Mill Tailings


Proposed Standards:
Individual Risks
500 mrem/y
100 mrem/y
25 mrem/y
1 mrem/y
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
Total Deaths per Year
0.1
0.2
0.02
0.1
3
Elem. Phos.
Uran. Fuel Cycle
NRC
DOE
Coal Fired Boilers


Proposed Standards
20 pCi/l
4 pCi/l
1 pCi/l
0.2 pCi/l
Individual Risks
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
Total Deaths per Year
5
0.4
0.2
3
1
Active Mill Tailings
Under-ground Uranium
Open Pit Mines
Disposed Mill Tailings
Phospho-Gypsum Stacks
DOE Radon