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Proceedings of the

Workshop on Environmental Assessment

Held at
National Bureau of Standards
Gaithersburg, MD
December 15-18, 1981

Compiled by: E. C. Watson

Sponsored by
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TABLE OF CONTENTS

I. INTRODUCTION 1

A. Objectives 1
B. Discussion 2
C. Workshop Organizational Staff 4
D. Participants 4
E. Workshop Agenda 6
F. Summary 9

II. WORKSHOP ORIENTATION 11

Welcome - F. J. Arsenault, NRC 11
Expectations of Workshop - E. F. Conti, NRC 12

III. ENVIRONMENTAL ASSESSMENT PERSPECTIVES 14

D. R. Muller, NRC 14
N. F. Barr, NRC 19
M. A. Reilly, State of Pennsylvania 31
J. S. Mattice, EPRI 35

IV. ENVIRONMENTAL SURVEILLANCE 60

How Did We Get Here? - J. P. Corley 60
Environmental Pathways NCRP-SC64 - W. L. Templeton 77

V. SMALL GROUP SESSIONS 81

A. Organization 81
Appendix V-A 85

B. Aquatic Pathways 88

1. Issues 88
2. Radiological Discussion 90
3. Aquatic Pathways - Radiological Subgroup 93
4. Aquatic Ecosystem Effects 100
   References 114
   Appendix V-B1 117
   Appendix V-B2 118
5. Transport and Fate of Contaminants 120
   Reference 130

C. Atmospheric Pathways 131

1. Issues 131
2. Discussion 132
   References 138

D. Terrestrial Pathways 140

1. Issues 140
2. Discussion 141

FIGURES

1 EPRI Program Guidance 36

2 EAED Organization 38

3 Environmental Assessment Department 39

4 Perception of Interrelationships 40

5 Ecological Studies Program Logic 42

6 Ecological Studies Program 43

7 Atmospheric Deposition Subprogram 44

8 Current EPRI Acid Precipitation Research 45

9 Ecological Effects of Acidic Deposition Technical Approaches 47

10 Ecological Studies 48

11 Toxic Substances Subprogram - $1.2M 49

12 Tactics 51

13 Toxic Substances Subprogram - 1982 52

14 Aquatic and Terrestrial Resources Subprogram - 1982 (~$1M) . 53

15 Resource Utilization, Management, and Mitigation 55

16 Ecosystem Analysis and Assessment 55

17 Perspectives 61

18 Stages of Development - Environmental Radiological Assessments 62

19 Dose Response Relationship 65

20 Dose Criteria Relationships for a Maximum Exposed Individual 66

21 Environmental Radiological Dose Assessment 68

22 Dose or Concentration Increasing 70

23 Comparison Chart - Environmental Radiation Standards 71

24 A Routine Environmental Surveillance Program 73

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PROCEEDINGS OF A WORKSHOP ON ENVIRONMENTAL ASSESSMENT

Sponsored by the U. S. Nuclear Regulatory Commission

December 15-18, 1981

National Bureau of Standards
Gaithersburg, Maryland

I. INTRODUCTION

Licensees of nuclear facilities (including, but not limited to, light-water-cooled nuclear power producing reactors, LWR) are required to carry out environmental monitoring programs whose overall purpose is to monitor levels of radiation and radioactivity in the plant environs resulting from the plant operations. Sufficient guidance for conducting environmental radiation monitoring programs is provided for operating LWRs, and this same guidance has been adapted more or less successfully for use at other than LWR installations. There is relatively little regulatory guidance, however, on assessing the impact of facility operations; i.e., how such measurements are to be interpreted in terms of dose to individuals or populations, although Regulatory Guides 1.109, 1.110 and 1.111 provide guidance for interpreting reactor effluent measurements.

A. Objectives

To assist NRC staff in identifying and evaluating research necessary to carry out their regulatory mandate, Battelle staff at PNL were asked to organize an environmental assessment workshop consisting of participants from the scientific and regulatory (at both State and Federal levels) communities. The objectives of this workshop are:

- To review and evaluate the state-of-the-art of environmental impact assessments as applied to the regulation of applications of nuclear energy and related ancillary systems.

- To identify areas where existing technology allows establishing "acceptable methods" or "standard practices" which will meet the requirements of the NRC regulations, standards and guides for both normal operations and off-standard conditions including accident considerations.

- To illuminate topics where existing models or analytical methods are deficient because of unverified assumptions, a paucity of empirical data, conflicting results reported in the literature or a need for observation of operating systems.

- To compile, analyze and synthesize a prioritized set of research needs to advance the state-of-the-art to the level which will meet all of the requirements of the Commission's regulations, standards and guides.

- To develop bases for maintaining the core of regulatory guidance at the optimum level balancing technical capabilities with practical considerations of cost and value to the regulatory process.

B. Discussion

Regulatory Guide 4.1 (issued by NRC in 1975) describes an acceptable basis for monitoring radioactivity and radiation in the environs of LWRs. In addition, Regulatory Guide 4.8 (1979) offers acceptable formats for sampling frequency and guidance concerning evaluation of samples (i.e., gross beta, gamma, ^{131}I, etc.). The objective of both guides is to protect the environment and human health by keeping releases as low as reasonably achievable. The current dilemma is that information is not generally available in an organized and usable form that permits evaluation of the adequacy of the resulting monitoring programs. There is no readily apparent method (in either guide) whereby any of the required monitoring data can be used to quantitatively ascertain how well the objectives are being met (only qualitative statements that indicate monitored values appear to be low, or below technical specifications).

Many monitoring objectives can only be met by designing monitoring programs to answer specific questions and those questions (hypotheses) must be formulated in a fashion that relates directly to objectives. For example, monitoring plans can be devised to quantitatively:

- assure compliance with standards
- define change as a function of time
- detect unique events - i.e., releases, spills
- estimate inventories - where and how much.

For each of the preceding examples the field monitoring design, including sampling frequencies and radionuclides to be measured, could be different. Clearly, the four examples above (easily rephrased as testable hypotheses) do, in fact, aid in meeting the objective of Regulatory Guides 4.1 and 4.8, and they are far more specific.

There are many factors that will greatly affect the reliability and significance of the results generated in terms of either the potential dose to people or the potential impacts on ecosystems. One factor not often considered is the differences between the environmental assessment for normal operation and the corresponding assessment for an accident situation. Each must be addressed uniquely. Another important consideration is the nature of the released radioactive materials and the physical form (i.e., gases, solids, or liquids) both for normal and offstandard conditions. The chemical species must also be taken into account since these influence selection of the appropriate sampling system and will also affect the fate of the effluents in the environment. Other considerations often overlooked are the relationship between the effluent source term and concentration at various points in the environment and application of this relationship in designing environmental monitoring programs. Statistical considerations that involve sampling locations, sample size, frequency, analytical sensitivity, costs and the sampling protocol itself need to be taken into account, but frequently are not. Particular attention needs to be given to ecosystems affected, concentration factors for certain radionuclides and the food web relationships that might well determine the viability of a sampling system design.

As important as the preceding technical and statistical considerations are in developing an adequate environmental assessment program, regulatory aspects must also be taken into account since regulations are generally the driving force in determining the acceptability to the public of a program. At times, however, either the regulatory requirements are insufficiently taken into account or programs are far more elaborate than necessary just to assure that requirements are met. It is conceivable that some environmental monitoring programs may have been designed primarily to conform to emotionally generated perceptions of need. Guidelines are needed to help nuclear facility licensees distinguish between necessary monitoring programs and objectives and those that are considered desirable, but perhaps unimportant. NRC-sponsored studies and staff position statements, including a 1978 Task Group Report (NUREG-0475), have addressed these problems with only limited success. Additional regulatory and licensee operational experience is available to draw upon. A fresh attempt is now in order to determine if present objectives are still appropriate and to determine if additional environmental surveillance program guidance for licensees of nuclear facilities is needed.

C. Workshop Organizational Staff

The following NRC and Battelle staff members were instrumental in organizing the present workshop:

E. F. Conti	U. S. Nuclear Regulatory Commission
F. Swanberg	U. S. Nuclear Regulatory Commission
J. P. Corley	Battelle-Northwest
R. E. Jaquish	Battelle-Northwest
R. R. Kinnison	Battelle-Northwest
D. H. McKenzie	Battelle-Northwest
Y. Onishi	Battelle-Northwest
J. V. Ramsdell	Battelle-Northwest
D. A. Shields	Battelle-Northwest
J. K. Soldat	Battelle-Northwest
J. M. Thomas	Battelle-Northwest
E. C. Watson	Battelle-Northwest
N. A. Wogman	Battelle-Northwest

D. Participants

Aquatic Working Group

Mr. W. L. Templeton, Chairman	Battelle-Northwest
Mr. Marshall Adams	Oak Ridge National Laboratory
Mr. Charles Billups	U. S. Nuclear Regulatory Commission
Dr. B. G. Blaylock	Oak Ridge National Laboratory
Mr. R. B. Codell	U. S. Nuclear Regulatory Commission
Dr. J. W. Falco	U. S. Environmental Protection Agency
Dr. C. R. Faust	Geotrans, Inc.
Mr. Paul Hayes	U. S. Nuclear Regulatory Commission

Mr. J. S. Mattice	Electric Power Research Institute
Dr. D. H. McKenzie	Battelle-Northwest
Mr. I. P. Murarka	Electric Power Research Institute
Dr. Y. C. Ng	Lawrence Livermore National Laboratory
Dr. Yasuo Onishi	Battelle-Northwest
Dr. C. C. Osterberg	Department of Energy
Dr. P. R. Reed	U. S. Nuclear Regulatory Commission
Mr. R. B. Samworth	U. S. Nuclear Regulatory Commission
Mr. J. M. Thomas	Battelle-Northwest

Atmospheric Working Group

Dr. J. P. Bradley, Chairman	Murray and Trettel, Inc.
Dr. Sarbes Acharya	U. S. Nuclear Regulatory Commission
Dr. Clifford Carlson	E. I. DuPont de Nemours & Company
Mr. L. K. Cohen	U. S. Nuclear Regulatory Commission
Dr. Frank Congel	U. S. Nuclear Regulatory Commission
Mr. L. Joe Deal	Department of Energy
Dr. T. C. Kerrigan	Drexel Institute of Technology
Dr. W. S. Lewellen	Aeronautical Research Associates of Princeton, Inc.
Mr. J. V. Ramsdell	Battelle-Northwest
Ms. M. A. Reilly	Bureau of Radiation Protection
Dr. Ronald Ruff	SRI International
Dr. I. A. Van der Hoven	NOAA
Dr. N. A. Wogman	Battelle-Northwest

Terrestrial Working Group

Dr. G. B. Wiersma, Chairman	EG&G
Dr. E. F. Branagan, Jr.	U. S. Nuclear Regulatory Commission
Dr. J. C. Corey	Savannah River Laboratory
Mr. T. W. Dziuk	Bureau of Radiation Control
Dr. F. O. Hoffman	Oak Ridge National Laboratory
Mr. R. E. Jaquish	Battelle-Northwest
Dr. R. R. Kinnison	Battelle-Northwest
Mr. G. E. Laroche	U. S. Nuclear Regulatory Commission
Mr. H. T. Peterson, Jr.	U. S. Nuclear Regulatory Commission
Mr. J. K. Soldat	Battelle-Northwest
Dr. R. G. Schreckhise	Battelle-Northwest
Dr. R. L. Watters	Department of Energy
Mr. C. G. Welty	Department of Energy

The NRC/BNW team posed a number of basic issues and established topics for the purpose of initiating discussions in the workshop.

Several speakers, representing different viewpoints, were invited to present their views to the participants on the first day. The heart of the workshop, however, was designed to be the discussions in the small group sessions on the second and third days. These sessions were organized according to environmental media; i.e., aquatic atmospheric and terrestrial. Basic issues were developed for each group (see pages 88-90; 131-132; and 140-141).

E. Workshop Agenda

The agenda for the workshop is presented on the next two pages.

NRC ENVIRONMENTAL ASSESSMENT WORKSHOP

Conducted by Battelle Memorial Institute,
Pacific Northwest Laboratories for the
Nuclear Regulatory Commission

NBS Conference Center, Gaithersburg, MD
December 15 - 17, 1981

December 14 - Monday

1:00 - 5:00 p.m.	Arrival, registration, Sheraton Potomac Inn, Rockville, MD	
6:00 - 8:00 p.m.	Reception (no-host), Sheraton Potomac Inn, Rockville	

December 15 - Tuesday

8:00 - 9:00 a.m.	Registration, NBS Conference Center, Gaithersburg, MD	
9:00 a.m.	Announcements	E. C. Watson, BNW
	Welcome	F. J. Arsenault, NRC
	Workshop Objectives	E. F. Conti, NRC
	NRC's role in Environmental Assessment	D. R. Muller, NRC/NRR
	DOE's role in Environmental Assessment	Nathaniel F. Barr DOE/OHER
10:30 a.m.	Coffee break	
	States' role in Environmental Assessment	M. A. Reilly, Pennsylvania
	Utilities' role in Environmental Assessment	J. S. Mattice, EPRI
1:00 p.m.	Lunch	
2:00 - 3:00 p.m.	Environmental Surveillance: How did we get here?	J. P. Corley, BNW
	NCRP-SC64 Environmental Pathways A Status Report	W. L. Templeton, BNW

3:00 p. m.	Objectives and Issues for Small Group Discussions:[a]	E. C. Watson, BNW
3:30 - 4:45 p.m.	Initial Meeting - Small Group Introductions	

December 16 - Wednesday

8:30 a.m. — Small Group Discussions

AQUATIC PATHWAYS: W. L. Templeton, Chairman
ATMOSPHERIC PATHWAYS: J. P. Bradley, Chairman
TERRESTRIAL PATHWAYS: W. B. Wiersma, Chairman

Topics:
- Dose pathway models
- Dispersion models
- Field instrumentation
- Laboratory capabilities
- Sampling and sample preservation
- Statistical applications
- Ecological impact methodology
- Accident considerations
- De minimis considerations
- Data management
- Quality Assurance

10:30 a.m.	Coffee break
1:00 p.m.	Lunch
2:00 - 4:45 p.m.	Continue small group discussions and draft recommendations
5:45 p.m.	Social Hour (no-host), Sheraton Potomac Inn, Rockville

December 17 - Thursday

8:30 a.m.	Presentation of small group recommendations and discussion
10:30 a.m.	Coffee break
1:00 p.m.	Lunch
2:30 - 4:45 p.m.	Panel Discussion - Workshop Wrap-up

(a) Small groups determined by environmental pathway of interest; i.e., Aquatic, Atmospheric and Terrestrial.

Each Small Group Chairman was given instructions designed to assure that the discussion of all three groups remained focused on the workshop objectives. See Appendix V-A. These instructions were also intended to serve as a guide to the topics to be considered.

F. Summary

Conclusions reached by participants of the workshop are discussed in detail by small group beginning on page 90. Although stated in different words, several research needs were identified as common to all three groups:

- Validation of models
- Characterization of source terms
- Development of screening techniques
- Basis for de minimis levels of contamination
- Updating of objectives for environmental monitoring programs

Model validation was a high priority item for each of the three groups. The view often expressed was that there simply is no basis in fact for having a high degree of confidence in estimates derived from existing models.

Source term characterization was mentioned to some extent by all three groups, but it is a particular need for modeling of atmospheric dispersion, especially for accident situations. The physical and chemical characteristics of the source term determine not only the atmospheric transport of the released material, but also its effective release height. Knowledge of the initial division between gases and particles and an initial size distribution of particulates are needed to estimate transformations that occur within the plume and depletion of the plume due to dry deposition and washout by precipitation. Some information exists on the size distribution of particles released during normal operation of nuclear facilities, but little or no information exists for releases during accidents.

Development of formal screening methods were mentioned specifically by both the Aquatic and Terrestrial Groups. These groups felt that screening methods would more efficiently identify and separate trivial problems from important problem areas requiring further research. This could be done by:

- developing a sequence of screening techniques (or models) starting with the use of simple, reasonably conservative models to identify impacts, pathways, nuclides, and other pollutants which warrant a high priority for further research. Such screening levels are most effective when de minimis levels of impacts have been established.

- defining and establishing de minimis levels of radiological and ecological impact. To this end, research is needed to quantify risks and impacts associated with alternative energy systems and to estimate levels of risks and environmental degradation considered by various groups to be de minimis; i.e., levels below which there is no concern.

There is a need to update the objectives for Environmental Monitoring Programs. The participants felt that the quality of data now being collected is insufficient to be used for model validation. Some expressed concern that existing programs may not even produce data of sufficient quality to verify compliance with existing regulations.

Many other areas of research have been identified by this workshop; the reader is encouraged to study the individual group reports documented here.

It is the pleasure of team members to express their gratitude for the very able assistance provided by Mrs. Dee Shields, Mrs. Carolyn Schauls, and Mrs. Pattie Freed. The successful conduct and documentation of this workshop could not have been completed without their help.

II. WORKSHOP ORIENTATION

ED WATSON:

Good morning, ladies and gentlemen. I'm Ed Watson of Battelle-Northwest. I want to thank each of you on behalf of my NRC counterpart, Frank Swanberg, for agreeing to participate in this workshop. Some of you have already devoted time and effort in its planning, and I want especially to thank you. The efforts of this workshop could not have reached this stage without your contributions. I refer specifically to Rico Conti, Frank Swanberg, the Battelle team members and particularly the session chairmen, John Bradley, Bill Templeton and Bruce Wiersma. We are particularly indebted to our speakers for today--Dan Muller, NRC/NRR; Nat Barr, DOE/OHER; Margaret Reilly, Pennsylvania Bureau of Radiation Protection; Jack Mattice, EPRI; Jack Corley, BNW; and Bill Templeton, BNW.

To welcome you, I would like at this time to call on Frank Arsenault, Director of the Division of Health, Siting and Waste Management within the NRC's Office of Nuclear Regulatory Research. Frank.

FRANK ARSENAULT:

Welcome to the NRC Environmental Assessment Workshop. Although that welcome concludes my official function, I trust you won't object if I take a few minutes to add some observations. During the past decade we have gone through a period of adjustment in the way social, political and technical decisions are made in the Federal government, in particular, but also in state and local level governments and in industry. A major element in this evolution, although it has some aspects of a revolutionary change, in decision making, a major aspect of this has been environmental assessments--looking ahead. Terms like intergenerational equity are arising in this aspect of our decision making. We are looking a lot further ahead and in far greater detail at the impacts of some of the major decisions made by our society. After ten years of this, we have gone up a number of blind alleys; we have discovered a number of notable and important facts. After ten years of this activity, the question of have we gone far enough is being raised. How much more do we need to know? How much more money do we need to spend?

It's time for a stocktaking and this workshop is a part of that effort. What areas of impact need to be looked at in the immediate future? How much more data do we need to collect relative to some of the important questions that we are facing. These are the questions that are being laid in front of the workshop over the next few days.

We would like your advice and council on what you see as the important questions to be asked and how far we need to go in gathering information and answers. With that weighty burden laid upon your shoulders, I will conclude my welcoming remarks. Thank you for coming. We do appreciate it and I wish you well in your endeavors.

ED WATSON:

The next speaker to talk about the objectives of our workshop is Rico Conti, who is Branch Chief, Siting and Environment Branch with the NRC Health, Siting and Waste Management Division. Rico wanted me to be certain to advise you that he, along with several others in this room, prepared the Regulatory Guide 1.109. Rico's been with the AEC and NRC for a number of years--about 20 in all, I guess--was formerly with the Office of Standards Development and is now with the NRC Office of Research.

ENRICO CONTI:

Both Frank Swanberg and Ed Watson gave me very strict instructions to make my remarks short. I suspect the reason for that has something to do with the fact that, with our reorganization, I'm getting involved in the research program in this area just at a time when we were doing some sole searching ourselves in a number of our major laboratories. We are talking about new programs and instilling all sorts of enthusiasm, while at the same time our budget moved from 5 million dollars to 2 million dollars. I know that this is nothing unusual in the United States these days, though it's probably more common in the environmental area than it is in other areas.

The job that I have today is sort of like the preacher whose job it is to not only remind you of what you have already been told, but to try to remind you in such a way that you will remember it during your endeavors over the next two days. So I have an abbreviated version of the workshop objectives that you all received in the package.

- Review state-of-the-art of environmental impact assessments
- Identify areas where knowledge allows establishing "acceptable methods" or "standard practices"
- Identify areas where existing models or analytical methods are deficient
- Compile a prioritized set of research needs to advance state-of-the-art of environmental impact assessments

- Develop bases for maintaining an optimum level of regulatory guidance

I have a couple of remarks to make about those objectives. One, from our perspective of looking at what support information we need, we keep attempting to look at the regulatory requirements that we have in this area in the NRC and to identify a number of information needs. How much information do we actually need? What form should it be in? And that inevitable problem that we have of timeliness--we keep getting criticized for having the information come along just a few days after we needed it to make a regulatory decision. Why didn't we have it last week when we really needed it?

I would suggest that some of you should challenge the NRC staff and other people that are representative of other agencies to help you work on, if possible, the answer to the question of what is an acceptable amount of information. We have identified a number of these objectives in a way that leave some open questions. On the second objective we identify establishing acceptable methods. For the third objective we imply that there will be areas where we can identify deficiencies; coupled with the assumption that there would be something significant about our identifying where existing models or analytical methods are acceptable, but acceptable for what? You may want to ask us what it is that we have in mind when we are saying that you don't need to go any further in that line of work.

In the last objective we indicate a need for an optimum level of regulatory guidance. I would only say that, to a certain extent at least, it gets difficult to plan a meaningful program over a period of time to come up with the information that we need. The problem that we have in the NRC is that some of the decisions that have to be made, as I said earlier, need to be made on a pre-established time-line and cannot wait for getting improved technical information.

Again, both the objectives for the workshop and the information you will develop will allow us to do a better job to identify how we should shape our program of research. As Frank Arsenault said earlier and I point out to you, in regard to our budget level--and this is certainly true in other agencies--it is time to make the dollars that we spend be as effective as they can be.

III. ENVIRONMENTAL ASSESSMENT PERSPECTIVES

ED WATSON:

Our plan of attack here to get us all in the same framework. We will attempt to do this by hearing statements from various agencies that have to do with the regulatory aspects of nuclear industry. Our next speaker is going to talk to us from NRC's point of view. Dan Muller has a Master's degree in nuclear engineering from North Carolina State. He is presently the Assistant Director for Environmental Technology in NRC and he has considerable experience in environmental assessment work at NRC--roughly ten years from 1970 to the present.

DAN MULLER:

I look around and see a number of familiar faces here. I can't say hello personally to each of you but I will say hello from up here anyway. Nice to see you all.

It's been a long time. As I look back over ten years, a lot has happened and what I'm going to try to do as I speak here is to talk about those ten years and put into some perspective what we have done in the past, how the NRC used the environmental research work that was done in the past, and then project toward the future and again give you some perspective as to what we see as research needs at least from the NRC management point of view.

Going back, first in the '60's and up until 1971, which was obviously about the time, or shortly after, NEPA (National Environmental Policy Act) was passed, the Commission was reluctant to do environmental things Until '71 the safety of the nuclear plants was the paramount consideration of the Atomic Energy Commission--or the Commission. I guess you all know that we have changed from AEC to NRC recently. During that period, up until '71, the various safety decisions that were made on the plants were done with absolutely no consideration of cost. At that time the entire overriding consideration, was public health and safety. The concept that we have now of cost benefit or the balance in cost vs. safety or value impact, or whatever you want to call it, did not exist. Obviously, environmental impacts were not a part of the regulatory scene.

Well, then roughly from '71 until '76 the environmental window opened up. This was a time of opportunity of environmental research. In late '69, December 31, 1969, NEPA was passed, and the environmental movement achieved great importance. There were many decisions at that point made within the Commission from the point of view--interesting--both of safety and environment that were made under the umbrella of NEPA. The spinoff that we have from the safety point of view is that, up until then, when a utility proposed something, and I think back of situations like Ravenswood where Ravenswood was a nuclear plant that Consolidated Edison of New York proposed to put on the East River just opposite Manhattan--in fact very close to where the UN Building is now, we went through a great deal of effort to find a way to say "no" to the utility. The utility at that time was saying, "Well, look, we'll include multiple containment and all sorts of engineering safety features--everything that will assure that there will be no release--no harm to the public. If you guys can figure out a release path, we'll fix it." So there was not a good way to say "no." Somehow I think we outwaited them and eventually the application was withdrawn.

Under NEPA though, there is a way of saying "No." What we do is look at alternatives and say to the utility there's a better alternative. Looking in balance at the pros and cons of various siting considerations, there is a better alternative and we have used that NEPA process to make some safety decisions on plants.

During the period from '70 to '76 there is also a large amount of impact-related research that was initiated and financed by the Commission. I think that the primary emphasis of this research was to analyze and quantify the impact of nuclear plant effluents, of radioactivity, of heat and of chemicals on the aquatic and terrestrial organisms. Research was directed toward understanding movement of radioactive material in the soil and the water as well as a considerable amount of work on thermal plume dispersion. This was a period were the Commission spent a considerable amount of money and there was a lot of study on a variety and diversity of subject matters. The outcome of most of this research, from the Commission management point of view, was to verify that the environmental impacts of nuclear plants on aquatic and terrestrial organisms is really not that serious. I don't want to say that this work was not important. I don't want that implication at all. It was very important because at the time, if you will think back to 1970 or so, no one really knew what the impacts would be and a considerable amount of research was necessary to verify what the impacts are and place them into some perspective. I might add that a considerable amount of notable research was conducted: the work on the thermal tolerance of organisms, thermal plume modeling, the significance of entrainment and impingement, the work on chlorine toxicity, and finally, the work that was done on shipworms at Oyster Creek and on the blue-gill loss at H. B. Robinson due to excessive copper.

Then in about 1974 or 1975, the Congress passed the Federal Water Pollution Control Act and this placed the requirement on all new sources of release that closed-cycle cooling be used. This, in effect, removed one of the great concerns we had about thermal impacts of the plant, and it certainly served to make plants that were proposed at that time even more benign. It also, at that time, removed the regulatory responsibility for water quality from the Commission. We no longer are required to place water quality matters in our technical specifications for plants. On the other hand, still as a part of the environmental impact reviews that we perform, we have to consider the overall impacts of the plants, including water quality.

Finally, still looking back now to about 1976 or 1977, a number of events occurred that began to move safety again into a paramount position in the Commission. As I said, there was a consensus that was largely verified by the results of your research that the operation of plants, particularly those with cooling towers, did not really result in a great deal of impact.

Then in March 1979, the accident occurred at Three Mile Island. This accident sent waves of concern through the Commission as well as through the nation. The end result of this was to place a great deal more emphasis on the safety of nuclear plants and a lot less on environmental considerations, and as I look at this, I'm not really sorry. I think probably the pendulum is swinging back to perhaps about the right spot. It may have swung a little too far toward safety at the present time, but I think certainly in retrospect as I look at the past, there was a period where we were concerned too much about environmental impacts so probably we are approaching a somewhat better perspective. We've reached a good perspective on the significance of environmental impacts of the plants and found them to be relatively mild from environmental impact point of view. In the future, the Commission is going to continue to prepare impact statements or appraisals on the various licensing actions that we conduct. We will continue to look for important impacts but all of this will be done in the perspective of the relative importance between environment and safety. I think, based on what I've said so far, you can see that the easy days of environmental research are over, and obviously, as Rico just said, the budget is decreasing. Any research that is conducted is going to have to be very carefully justified.

One point that I would like to make before I outline some possibilities for future research is that I don't endorse research that has the objective of just better understanding something that has already proven to be minimal. You have to remember that when I say things like this, I wear a regulatory hat, and most of the regulatory type decisions we make are based on a broad understanding of impacts rather than details. We base decisions on this broad understanding of impacts and comparison of alternatives.

Here are some of ideas and thoughts for future research needs, some of which Rico already noted. It would be helpful to have some guidelines as to what level of environmental information is needed to make a responsible regulatory decision. I'm thinking of the spectrum somewhere between reconnaissance level information and information that results from the detailed surveillance of the environment. One of the activities that is going on at the present time within the Commission is the development of a statement of acceptable level of risk in nuclear plants. This is the issue of how safe is safe enough, which any number of people have talked about. Work needs to be done on the manner in which these nuclear plant risks can be placed into perspective relative to risks from either other power sources or other risks that everyone is exposed to.

Another area that is getting a lot of activity in the Commission is placing safety in a probabilistic framework. And I would suggest that you look toward expressing environmental impacts also in some sort of a probabilistic framework.

One of the ongoing concerns is our ability to quantify cost benefit. I think there is room for work in quantifying the benefits of nuclear plants, electricity. The costs are somewhat more difficult because of environmental impacts on a variety of things. If there would be some way of quantifying this in some areas it would be helpful.

Certainly there is a considerable need for continued research in fuel cycle, particularly the back end of the fuel cycle and waste disposal. That needs hardly to be said.

Then, finally, there will always be a variety of hot items that come up, like recently in the last few years it was concern about pathogens in cooling tower effluents. If I could think of what the hot items would be for the next year, I'd probably have a better job, but certainly there will be issues that will come up and we will need answers overnight. We'll be asking you if you can come up with a decision tomorrow, and obviously you won't be able to.

We have a fair understanding of the effects of radiation on people. We also have had considerable ongoing research directed toward the course of severe accidents within the nuclear plants, and there is considerable work on the transport of radioactive materials once they might be released from the plant. Right now there is a great deal of interest in given an accident, exactly how much material will be released if there is a failure of the containment vessel.

On the other hand, what we don't have at the present time is a good handle on human behavior after an accident. What would be the cost of an accident on the social fabric of the community--and by community I mean people that live within 10 miles of the plant. Just think this way--given an accident in which radioactivity would be deposited over some square miles of land in the vicinity of the plant, and given that this would render the area unsuitable for human occupancy for some time, the question that we will be looking at is what is the societal cost of this type of an event. Focus on what would be the impact of maybe 10,000 or 20,000 people being told to evacuate but they can't return to their homes or jobs. How do you quantify this in terms of dollars? What type of social upheaval would there be? Finally, if many people were allowed to return at some point, the background level of radiation would be higher than normal. What would be the impacts of this on the society? This is something that we are working on, we are beginning to focus on this type of an issue, and we'll be focusing on it in the future in our environmental impact statements.

I guess you have heard for the third time--from Frank and Rico--that we are in a time of transition and the research that you people focus on and propose in the next day or so should have a direct application to the type of regulatory decisions that we are making today.

In closing, I can only wish you good luck and good thinking as you talk in the next couple of days. In each of the sessions there is an NRC staff person to help direct some of your thoughts. Thank you very much.

ED WATSON:

Thanks very much, Dan. I was pleased to hear your remarks near the end of your presentation. They served to remind all of us here that we are talking about the whole fuel cycle and not just nuclear power reactors, so please, all of you, keep that in mind.

Our next speaker from DOE is Nat Barr who is the Manager of Health and Environmental Risk Analysis Program for the Office of Energy Research. Nat has a Ph.D. in chemistry from Columbus and has a considerable number of years of experience with the Atomic Energy Commission and DOE. Nat is going to give us the perspective from the DOE point of view.

NAT BARR:

Frank Arsenault suggested that perhaps there had been some sort of transition in the last ten years in how we frame technological knowledge for the purpose of social decision. I certainly believe that there should be a change in how we do that, but I've been in business since 1961 concerned with the problems of putting technical information in the hands of the public so that people can reach proper public decisions in very complicated social questions. And I have to say, I am really discouraged; I don't see any sign of progress in this direction. I don't know if this is what you want me to talk about. It is really discouraging. The Department of Energy is about to release, within a couple of weeks, a revised environmental impact statement on the fast breeder reactor. It seems to me that the Department of Energy is going to release this after a couple of man-months of review updating a document that six or seven years ago caused all sorts of furor because it was criticized at almost every level the point of view for not incorporating and not analyzing data that was currently in hand. And now the Department of Energy is just going ahead with this as a public document--as a decision document supporting their more rapid movement in breeder development. I just wish I were a member of the National Resources Defense Council sitting out there waiting to receive this document because I could really take it to pieces. I sat for six months about six months ago on a review panel looking at loan guarantees for gasification and oil shale plants that cost four billion dollars a copy. And companies come in and say, "Here's why we think we should go ahead with this plant. This is a venture analysis and here's how we look at our uncertainties of the market; here's how we look at our uncertainties regarding the technology; here's how we see the regulatory picture." And all of this goes on for about 15 feet of good material: gathered; condensed; understandable at a corporate level. We have a little requirement in there--"describe the health and environmental consequences of this operation." Three pages in that 15 feet of books that describe what the health consequences of this operation will be. Plenty of talk about zero release; plenty of talk about being well within existing regulations. No description of; is arsenic toxic? Does pyrolyzed kerogen behave any different than burned gasoline? None of this stuff. So here we are 10 years--20 years since I've been in the business, and in major documents we don't have descriptions of health consequences of major emerging technologies. And I think it is really distressing.

I am supposed to talk about environmental assessment from DOE's point of view. I'll just say a few words about that. We are attempting to look at each emerging energy option from the point of view of what its potential health and environmental impact might be, if it was installed. So we're looking at maybe 10 or 12 emerging energy technologies like oil shale, coal liquefaction, gasification, diesel cars, electric batteries, fluidized bed combustion--things like that. We're saying, "Hey, if we should be successful and if we were to put in an industry to produce about a quad per year in this area, what can we identify as the principal health consequences of developing, installing, operating, decommissioning an industry like that? And what can we now say about the range of uncertainty regarding potential health consequences? And we have had about a year's good work on this and we have such descriptions--the way we do it is we assign 3 to 5 man-years/year to take the technology and look at it in the future as a quad/year industry and then ask; what kind of health consequences did you get in installing it, operating it and decommissioning it? Then write down these health consequences and tell us what the range of uncertainties are. It's looked upon as a continuing analytical procedure, but every year they give us a document that says at this point in time this is how we see the uncertainties.

Now we do it because we are largely a research program. We have somewhere around $150 million a year that we spend on environmental research, so we tell ourselves when we do an analysis like this, it will display to us where the critical uncertainties are in our description of these types of environmental consequences and then we can go back and sift through our research program and see if it is possible to identify and conduct in an orderly fashion research that will reduce those uncertainties.

We haven't been very successful. Our first ten documents show very little analytical association of research needs and the uncertainties that the industries face. It's a discouraging observation for the first round. I hope it will get better.

We're up to our eyeballs with people who list research needs for us. We have to know, they tell us, everything from a better understanding of the hydrogen bomb to genetics. We have research lists that are just volumes and volumes and volumes. What we don't have is good analytical associations between current information, bounds of uncertainty that they set on our ability to describe health impacts, and descriptions of how additional information will reduce that uncertainty. That is really our target--to come forward with some description such as this. I can say that after a year, we are hopeful that it will improve in the future.

I would like to make another comment about environmental assessment. I think that it has a happy prospect for guiding research needs, but in the process of societal decision, what with the President's executive order-12291 I think it is, which requires the use of risk assessment plus benefit analysis and unification of congressional regulations, is this heavy emphasis on the use of the environmental assessment as a tool to implement current regulations. I think that that is an important use, but I think it is far less important than the matter of using environmental assessments for guiding the Congress in writing regulations that make sense. I think that there is no possibility at all, to give you an example, to use quantitative risk assessment to implement Section 110 of the current Clean Air Act as written. You can gather technical information until you're blue in the face on criteria pollutants, and gather them into criteria documents and you will never have a mechanism for using that technical information to permit the Administrator of the EPA to set a level below which there is no health consequence for a sensitive portion of the population. It's a morass and a mire and there is no way that technical people can ever get into that again. So the most important aspect it seems to me of environmental assessment is preregulatory--before judgments are made regarding: how safe is safe enough; what is an acceptable level; is this an environmentally acceptable technology? All of these decisions should be made after the environmental assessment is done. The environmental assessment makes none of these judgments. It simply lays out what it is we know and, embarrassingly enough, what it is we don't know about the environmental impacts. Then it can go to policy decision and public decision for these important judgments as to what is acceptable.

I have to beg off, Ed, with respect to research areas. I don't know that I can make any sensible comment to the group on areas for research. I find that in the area of environmental assessment, the principal need is for courage and reasonably clear analytical thought. Courage because people beat on you all the time that it can't be done because there isn't enough information to make useful assessments. And you need the courage to recognize that there really is quite a bit of information to permit some sort of a statement of knowledge of uncertainty.

And then one needs a balanced analytical approach in the sense that "By God, we've got dispersion models that spin me around five or six times just at the first level of sophistication, and if I'm doing an analysis of the health consequences of an industry, I don't want to get more and more and more and more sophisticated in meteorology if I'm not understanding how this meteorology is associated with a health consequence." So one of the things that one needs in an environmental assessment is analytical judgment that says how much meteorology is enough, how much genetics is enough and how does the whole thing look once we have the entire picture.

ED WATSON:

Thanks very much, Nat. You struck a harmonic cord in that last statement. I haven't checked this out with either Dan or Nat yet but I would like to open the floor here, and get discussion going. If any of you have any questions, I'm sure Nat and Dan would be happy to respond at this time.

QUESTION: The term, safety, has been used very frequently here, and we still have the question, "How safe is safe?" An individual here said that NRC is going to make that determination. I would like to propose that there is a definition. I think that it ought to be in terms of something the public understands. We mentioned probabilistic. That doesn't mean a whole lot, I don't believe, to me or to the public. It is my contention that the nuclear industry has been made the scapegoat of the whole environmental movement and I think it ought to be reversed. I would like to propose that the nuclear industry allow 10,000 deaths a year. And everybody laughs. But you see that's what the automotive industry does--they contribute five times that. And nobody seems concerned about it. So I think we ought to use 10,000 deaths per year as a definition of how safe do we want to be safe?

ED WATSON: Anyone want to respond to that?

NAT BARR: Well I don't think that technology should tell the public what is acceptably safe or not. I think the best that technology can do is to demonstrate that they understand what the consequences of the operation are; what the sources of uncertainties are to the public health; come forward with that as a description; and then let the public through the political process make its crazy decisions about if they want to have 55,000 automobile deaths and still restrict krypton releases from the nuclear industry, that's fine. That's a matter of public policy decision that I feel technical people have very little to contribute to. The nuclear industry has really fouled itself up in this matter of describing health consequences.

AUDIENCE RESPONSE: To the public but not themselves.

NAT BARR: You know, I've talked to nuclear people for 15 years. I've talked to the head of Military Applications, the head of Reactor Development, and these people say we're going to run the damn nuclear industry without producing any health consequences. This is as recently as three or four years ago. O.K.? And they believed it. We're going to run within the existing standard, and hence we're not going to produce any health consequences. And members of the industry go along with this. John Gofman made a specialty of going around talking to nuclear plant managers and asking them what health consequence was going to arise from their release of krypton and tritium. You know what they said? None. And that's a lie. You can't do it. All I'm saying is that you have to lay it up front, describe what you know and your uncertainty, and then maybe get the public to buy into it.

QUESTION: Well, then what are the health consequences? How many people have been lost in the nuclear industry? How many people did we lose at TMI?

NAT BARR: What were the potential health consequences from the releases at TMI? That's the best you can do as a technical person. Can you calculate the population dose? Can you calculate an upper limit on the potential health consequences of that dose? Though it's small, go ahead and do it and say it's small and then you're through.

AUDIENCE RESPONSE: Well, that's been done and here we are. We can't even make nuclear reactors in this country.

NAT BARR: Well, I think we can try to do that job better with future technologies. I hope that when we go forward with an oil shale industry, we are not going to say we are going to have zero release and we're not going to hurt anybody; or when we have a fusion industry, we are going be within 1% of existing standards. I hope we can lay out what we see as health consequences of running one will be. I don't think we did this in the early days of the nuclear industry. We talked about ICRP, NCRP, and other international bodies, and predictions that the nuclear industry would operate within the standards.

AUDIENCE RESPONSE: I think only really within the last year or two is the NRC willing to face severe accidents. You know, up until then, they sort of acknowledged that there could be a worse accident than a loss of coolant accident, but never really did anything about it. Just hid behind the guise that the probability of this accident is so low that we are not going to consider it. Then people had reason to begin to focus on what is the real risk and it turns out that the severe accident is a dominant risk and we're beginning to spend some time on that type of event. I think we are hopefully moving toward telling the public in a better way what the real risks are of nuclear plants. I don't think we're there yet; we've got a long way to go, but I think we're being a little more honest anyway at the present time.

NAT BARR: And I'm really glad to see it, because I think with two billion dollars worth of environmental information and 20 years of experience, we should really be able to lay it out for the light-water reactor and LMFBR in a very clear technical way. And when we've got an uncertainty like we have in the probability of a major accident, we should say so. It doesn't hurt us except when the critics indicate that we haven't been forthcoming.

QUESTION: There was a lot written about thousands and thousands of curies at TMI, but very little was written about zero deaths.

AUDIENCE RESPONSE: Well, you see the problem is that it is very difficult to express to the public, it wasn't zero deaths; it was statistically .3 or 1., I don't remember what the number was, but it was some low number, you know. And, then you sort of put that into perspective and say, well, anyway these deaths statistically would occur years in the future and aside from that there are so many thousands of cancer deaths anyway and so we can't see it. You know that sounds for all the world like a coverup.

AUDIENCE RESPONSE: And I think the technical people understand that. I don't think the public does.

ED WATSON: One of the difficulties in comparing deaths from an industrial operation with the deaths from operating automobiles, is that the public sees the immediate benefits and are willing to accept the associated risk. If they would make a risk benefit judgment on the their own, intuitively, I believe, their feelings would dominate; i.e., I need my car.

NAT BARR: Could I give a brief, different interpretation of that. I think that the public--and I am a member of the public--is more afraid of the unknown than the known. You walk up to an automobile accident and you see people maimed and killed, and still you climb into your automobile and you work in that framework. But if somebody tells you that if a nuclear reactor blows up, it's going to wipe out 14 states and do untold genetic damage to all future generations, you're scared. All right, you go to the Atomic Energy Commission and you get, until the Brookhaven Reactor Study, "Don't worry about it." "Chances are small and we are going to put another layer of containment around it and that makes it even less." So the public comes up and says, "Look, we trust your engineering; we think the probability is small, but what would happen if it did." Three layers of containment and still no description of what would happen. Even Rasmussen didn't do it right at first. I mean he only calculated the number of people that would fall down and die if they got 500 rads. He didn't calculate anything associated with fission products at large distances. It took the API to multiply him by ten so he looked like he was dissembling. I'd like to see it done better in the future.

AUDIENCE RESPONSE: One of the problems I think is with perception of what is safe. You know, if you define safe as being equal to zero risk (which is what I think the public perception is except as how they apply it in everyday life) when in fact you should say, yes, the automobile is safe--but we should point out that automobiles kill tens of thousands of people each year. I think that's the problem, but you also have the problem I think with the way the industry says it, because they'll have spokesman who'll say this is absolutely safe. There is no absolute safe in anything. I think you have this problem between a zero risk and then some finite but small risk. That's the perception that you have to get across regarding what is safe; it is--yes, there is some risk but it's small compared to the alternatives. In fact, you can't have an absolute in safety (zero risk). I've never seen in my lifetime an absolute cost benefit. They're all relative.

AUDIENCE RESPONSE: Certainly, one of the ways of looking at the safety or risk of nuclear plants is to put them in perspective with other alternative generating sources. That problem tends a little bit self-serving, because it turns out that indeed nuclear, even considering accidents in a probabilistic way, is considerably safer than the alternatives of coal and even oil and I guess about the same as gas. The unique problem of nuclear though is the conventional ways of generating electricity, oil, coal, gas, hydro, etc. people are only at risk when the thing is operating appropriately, because that is when they have effluents etc. As soon as they stop operating, they have no problem at all. Nuclear is almost the opposite. When they are operating well, there is really no particular problem because the effluents are small, but when they have an accident they have that unique situation where potentially, at least theoretically, calculation-wise you can get into the situations where you can calculate tens of thousands of prompt fatalities and untold hundreds of thousands of latent problems. The problem is how do you express this in some rational way that people can understand. It can only be done with a great deal of difficulty.

AUDIENCE RESPONSE: To a certain extent we have been beating our breast and saying that there is a possibility of killing tens of thousands, yet we don't look at the rest of society. Would you allow aircraft tankers to fly and football games to be held since there is a probability of an aircraft tanker crashing into a football stadium and killing tens of thousands of people? And I'll bet you it's higher than most people think since football stadiums tend to be built in metropolitan areas near airports like Shea Stadium in New York. The probability of a large aircraft hitting a football stadium is probably higher than a Class 10 accident.

AUDIENCE RESPONSE: I hear a lot of people saying things which I don't really believe and which I haven't heard except from environmentalists and the media. I've been working in the nuclear industry since 1948, and I don't ever recall the auto industry saying they have absolute zero risk. That's my first point. Second is, I do believe that there are zero health effects for tritium and krypton release from operating nuclear power plants if they stay within the limits. Because I don't necessarily believe in the linear non-threshold theory. Another thing is how can you say that there is no long-term environmental detriment from hydrocarbons released from fossil fuel plants; we don't know--we haven't studied it. They may be just as bad as the long-term effects of radiation.

NAT BARR: That's exactly the point. You don't know that there are any health consequences at the limit, but neither do you know that there are none. And that's what I call an uncertainty. So somebody says that there might be zero effects from all tritium releases and I don't argue with that. But somebody will stand up and say as far as we know it's an environmental problem and, on the basis of direct observation, the effects might be as high as so and so. And there are enough people who would stand up and say that was wrong. So that's an uncertainty. When you run a nuclear industry and you release 10,000 curies per gigawatt year, you say at the most this could produce so many deaths due to cancer and at the most so many congenital abnormalities. Now if you have never heard anybody in the nuclear industry say that it will not do this, I don't know where you have been for 20 years.

AUDIENCE RESPONSE: What I said was that I have not heard anyone say it was absolutely zero.

AUDIENCE RESPONSE: I find this discussion very interesting. I don't think we're going to get anywhere from being here this week if we pursue it, because we have been trying to pursue this question now for 20 years and we still haven't gotten anywhere with it. Ultimately this is a question that is going to be solved only through the political arena. And some people here have more to do with that and more influence in solving it than others. I think the question that was proposed by Nat that we can address is the influence the environmental assessments have in guiding the necessary research. The question is; why hasn't it already been done in the past?--because it seems like such a logical step to go right from the questions that have been asked in the assessments to prioritization of research. But we don't really see that.

NAT BARR: I think the reason it hasn't been done is that the Atomic Energy Commission grew up with a staff and with associated laboratories that grew by experience and understood many of the research questions almost by intuition, so that well into the '60's there was a Washington research organization that had a feel for research related to radiation and to ecological research, and there wasn't really a necessity to have it sharpened up like this. But when AEC turned into ERDA, the staff got itself confronted with oil shale, coal conversion and satellite power systems; then it really had no intuition as to priorities, and such a process was clearly necessary not only to headquarter's staff but to researchers as well. And it hasn't been going along fast because it is a damn difficult thing to do and very few people are willing to do it.

AUDIENCE RESPONSE: I'm switching gears a little bit. I have a question for Dan Muller. See if I interpreted one of your statements right. You seem to indicate that the NRC maybe has laid to bed some of the environmental concerns. But you seem to indicate that all environmental concerns have sort of been laid to rest and you'll continue to monitor anyway. Is that the kind of thing you were getting at?

DAN MULLER: I guess I'm not exactly sure of the context of what I said, but I don't want to imply that 100% of the environmental concerns have been laid to rest. I think probably that there are some areas that still need to be looked at, but I think that what I want to be sure that you people understand is, I don't want to go into second order understanding of impacts. As I said before, we are not interested in understanding more and more detail about meteorological dispersion. I think we have enough information in a lot of areas. So, the type of research where you say you want to go into a lot more detail when we already know that there's no impact, is really of no interest to us.

AUDIENCE RESPONSE: How do you know there is no impact?

DAN MULLER: Well, something where you have already established that there is no particular impact of interest to us. The thing you want to go into deeper and understand it even more.

AUDIENCE RESPONSE: The question is whether an impact is only interest to you where it might actually be occurring--the impact may in fact be occurring but it might not be of interest to you because it has not been observed yet. Because a lot of impact assessments are made on semi-quantitative or subjective judgments without the data base or validation to back them up. I'm just saying that some of these things that might have been laid to rest by a regulatory agency are based on semi-quantitative or subjective judgments where, in fact, impacts may be occurring.

AUDIENCE RESPONSE: The question I guess you have to ask yourself is what is the significance of this impact; is this worth spending the money for? Of course there are other things. We're ending up prioritizing, and, as Rico said, we (the NRC) have something like 2 million bucks to spend which isn't very much really, and we really have to put the effort where we have the biggest payoff.

AUDIENCE RESPONSE: So you have to make an a priori judgment on the significance of the impact before you put your money into the research.

ED WATSON: I hope that this is something that each of the small groups gets into tomorrow and Thursday. I think that is an important aspect to this whole thing is determining what is significant or what's a de minimis level if I can use that term, a determination of the level below which you should not be concerned about.

AUDIENCE RESPONSE: You end up making a decision when you don't know enough really very often to make a decision, so you have to exercise your judgment.

ED WATSON: I'm sure it's a reiterative process.

AUDIENCE RESPONSE: We could separate out a few examples, I think, to answer what you're getting at. There are some circumstances where you can give a maximum, approximate effect. If that maximum, approximate effect is such that it still yields an acceptable impact, you won't have to follow up on it. But if some of the semi-quantitative judgments are made where you have enough uncertainty so that you may not be getting a maximum effect, then you would want to pursue it further. Under no circumstances can we make judgments with not all the data at hand and say it can't be greater than "this" and "this" is acceptable, then, as an administrator, "I'm not going to furnish any more additional funds to pursue it."

AUDIENCE RESPONSE: This is a worst-case approach.

AUDIENCE RESPONSE: If it lends itself to it, but not all do.

ED WATSON: Any other comments?

AUDIENCE RESPONSE: I'd just like to make an observation here on the thermal aspect. I wasn't sure that you were able to say thermal was no longer a problem, because the Clean Water Act resolved that by essentially forcing everybody to treat their effluents, or if you concluded that there wouldn't be a problem either way. It seems to me, we have a cost-benefit situation here; maybe we should do less treating for thermal and we need to look at that further.

AUDIENCE RESPONSE: I guess the unfortunate thing is, we have the Federal Water Pollution Control Act which in effect says install closed cycle cooling on all plants. I agree with you completely. Probably thermal, as I look back over the last ten years, thermal really was the bad person--the bad guy on the block. We were all concerned about thermal, and likely as you begin to focus on it, it probably wasn't so bad after all. I suspect a lot of the plants that have cooling towers at the present time really shouldn't have cooling towers from an impact point of view but, on the other hand, we've got the law on the books. The question is, should we end up using our resources today maybe to demonstrate to Congress that they made a mistake? I'm not sure I'm willing to do that.

AUDIENCE RESPONSE: Just to clarify one thing. I think most of you who are active in this area are aware of it, but there is a provision whereby a utility can deal with once-through cooling. I think a couple of things happened simultaneously and by the time the Clean Water Act had resulted in guidelines which seemed to dictate closed-cycle cooling, the utilities had probably learned where and how to site plants where once-through cooling would be acceptable and probably we're coming to the same conclusions as to where closed-cycle cooling would be necessary. All of this was going on as the size of the units were getting bigger, the size of the stations were getting bigger, and I have a feeling that the utilities would have gone to closed-cycle cooling at most of the stations where they've adopted it, even without the Clean Water Act.

AUDIENCE RESPONSE: A lot of things were going on simultaneously in the early '70's. I personally think that those who were doing the research in the thermal areas deserve a good bit of credit for helping the utilities do a better job of siting and designing.

AUDIENCE RESPONSE: I guess I am concerned about a couple of things that have been said here. Finally, however, we're going to come to grips with them in a technical sense. This gentleman said that we would have to try to cover the maximum approximate effect. And I see a number of different groups going at this ball game, each of which has their own range of uncertainties. I'll be in the atmospheric group and we know the uncertainties, maybe, for one type of scenario pretty well and another type of scenario not well at all; maybe we can predict within a factor of 10. If we couple that with uncertainties in the health consequences which may be also factors of 10, then assume the pathway doesn't come directly from the atmosphere to the receptor--but comes through the ground--you would have another factor of 10. Are we talking about uncertainties of factors of 1000. How do we couple all these things?

ED WATSON: I think those of us who have been in the business for awhile recognize that that may well be more than just a possibility, and that we are talking about ranges of a factor of 1000. It brings to mind something that I want to caution all of you about, as I will again later this afternoon. That is; the purpose of this workshop is not to solve any of these problems, but merely to identify and try to prioritize them.

AUDIENCE RESPONSE: I think though to do that we need to know something about the other groups. I know you do have plenary sessions.

ED WATSON: We do plan to get together again on Thursday and discuss the various groups' findings. And some of us will be floating around between groups and, hopefully, we can assist cross-communication in the workshop.

AUDIENCE RESPONSE: While the title of this workshop is Environmental Assessment - 1981, which is sufficiently broad and obscure so that it will allow a great deal of interpretation, I've been sitting here, thinking to myself that the questions that I'd like to hear asked by the group still are only suggested and not really voiced. The kind of things I'd like to hear come out in the smaller sessions are:

- What is a valid assessment?
- What is a subjective judgment?
- What is an acceptable upper level of risk?
- When does an uncertainty become an unacceptable unknown?

ED WATSON: Good questions! We should have those duplicated and distributed.

Our next speaker has made a heroic effort to be here this morning. She travelled through ice, sleet and snow. Margaret Reilly is Chief of the Division of Environmental Radiation for the Pennsylvania Department of Environmental Resources. Margaret has an M.S. in radiation sciences and a number of years of experience in routine environmental surveillance and emergency planning. I'm sure that those of you who know Margaret know that she has some very strong, opinionated views on this subject. Margaret, you're on.

MARGARET REILLY:

I notice there is a meteorologist in the audience here. I just wish they would do something about their modeling of winter storms. As usual, they predicted 1 to 3 and we got 5-1/2. Anyway, there are enough familiar faces in here for me to say, once again here we are talking to ourselves. I couldn't believe, as it were, the discussion going on before in the group, because I've heard that so many times in the last few years--if I had a nickel for every time, I'd have the house paid off. I'm not sure that there are answers to it; it's much along the line of how many angels are dancing on the head of a pin today. But be that as it were, I guess we'll get time to batter that around some more during the sessions here.

First, I'm going to tell you something about what state rad health programs do in general, especially ours. If you want wealth of experience in radiation protection, work for a state, because we see everything. We regulate medical and industrial radiation-producing machines. This goes from your friendly local dentist up through accelerators which, on one occasion in Pennsylvania, caused a guy to lose his hands and feet. So we start out big. Anything that happens in radiation protection in the country happens to us first. We regulate radium and accelerated produced isotopes, we conduct routine environmental surveillance around 4 nuclear power stations, we maintain and keep working on plans to outwit the next reactor accident in Pennsylvania. We respond to everybody's radioactive materials transportation accidents--even Mother Nature's. Recently, we had someone choked up about a jar of KCl which broke. You can see a jar of KCl through a plastic bag with a Geiger counter. So we even get involved with accidents involving Ma Nature's material. We try to keep up to speed with what's going on at TMI and that's sort of a continuing saga that would make excellent material for a soap opera or other sort of expression. We're trying to keep up to speed on the low-level waste disposal issue, as most of you know all of states have to get in some kind of compact by January 1 of with '85 or '86, and have some place to squirrel the stuff away. And that's another saga there.

We also have a little anomaly called Cannonsburg which might ring a bell for the DOE people. It's a facility in western PA where first they stripped radium from pitch blend and threw the residues in the ground. Then the Manhattan project came along, and they cranked the uranium out of it and threw those residues in the ground. So we have a lovely mixed bag of stuff in the ground in Cannonsburg. There were assessments which have been conducted as a result of that.

We're trying also to keep up to speed with natural radioactivity problems that do not involve industry, but which involve things like what are peoples' houses made of and what is in their private wells. I'm beginning to think radon measurements is the growth industry of the '80's. Nuclear power can go down the tubes and we can still keep ourselves quite busy on radon problems and other non-industrial type of radioactivity problems.

Our particular state engages in zero research because we have other good stuff to do. The other state representative, Tim Dziuk, is in the back row there; he's from the state of Texas. They have done some modeling regarding uranium mining and other operations. In Pennsylvania we haven't gotten into that yet, but you never know. I know there are people who are prospecting in the state today.

We don't, in Pennsylvania anyway, we don't model reactor sites. Although much modeling has been done by one entity or the other, we ourselves don't do it. Our basic problem with modeling with facilities that don't put much of anything out anyway, you have no way of ever verifying your model. It would seem to me that one of first tenets of a regulation should be -- Don't promulgate a regulation unless you think you can verify compliance. And I don't think you can do it with models for nuclear power stations. As a result of The Accident (notice I didn't use the initials) The Accident, we had several useful outcomes, one of which was money which everybody likes. The accident itself influenced our thinking about how to do routine surveillance; namely, you have to know and love TLD's, and that we think there is a lovely bank of them up there particularly for future accidents. One thing I think a lot of people missed before the accident was one of the motives of routine surveillance; namely, that of having stuff out there so that when the crap hits the fan, you have some data to go hang your hat on. Again, as a result of the accident, not only ourselves but the utilities and NRC itself have gotten into much more extensive use of TLD's. There are so many TLD's around Three Mile right now that a photon can't get out of there uncollided.

Another thing as a result of the accident, sort of, it's probably more due to the money influences that we've gotten into compositing more samples than previously. In the old days you would go down to the bridge, throw a bucket with a brick over the edge--you've got to have a brick in there or it's never going to get down in a 20-mile-an-hour wind--and you slurp up a sample, take it back to the laboratory, and do 16 parameters on it; which I never thought was too terrifically brilliant. You know, if you have a shlucky sample, you don't run 16 parameters on it. So now we've gotten more into getting domestic water supply companies to collect larger composites and we will use a piece of this. I feel a little more confident when we do a fancy analysis on it; that we have at least a fancy enough sample to make it worthwhile.

Also, as a result of the accident money, we're beginning to corner the liquid nitrogen market greater Harrisburg. We're GeLi-ing a lot more samples. We have the luxury now of running a milk sample for a thousand minutes overnight on an expensive machine to get one picocurie sensitivity. I keep wondering how badly do you want to find one picocurie.

Also, with the modeling business, we found early--and especially in the light of the current regulatory climate--that routine surveillance really can't verify long-term models, especially in the case of nuclear power plants anyway. This is routine operations. It is very difficult to do unless you have the detector in the discharge pipe of the reactor. Long-term models also don't buy you anything during an accident, because the accidents never follow the normal course of events. The long-term models don't help you much for that. We've never been nuts about models; we play with what we have.

Our emergency planning activities are influenced somewhat by everybody's favorite models in WASH-1400. We're rather interested in the fault-tree analysis modeling (I don't know whether you could call it modeling), but the technique used in WASH-1400. We use it as one part of our accident assessment technique for whatever accidents lie in the future. It's used basically to find out in a circuitous way whether you think you're going to lose the reactor or containment. It seems to us that with most of the reactor accidents that you could postulate, they either fall into the league of consequences being so small you don't have to do anything; or those accidents where you might get PAG type doses and dose commitments, but the thing is going to happen so fast you can't move the people around anyway. Then we get into those where you're going to lose the reactor and containment. In that circumstance you had better move people out whether it goes through the roof or through the floor, because in both instances you're going to be bowled over with public health effects.

We aren't particularly interested in accident frequency and emergency planning type, it's purely consequence problems. We're intensely interested these days in some of the speculation going on about cesium iodide formation and some of the other things that would tend to reduce the size of the sphere of influence of even a nasty reactor accident. When I read excerpts of WASH-1400 and some of the other documents that have spun off it, I wonder how you're going to make any aerosol remain an aerosol in sufficient quantity to give people 200 rad at 10 miles. If you have the technology that you think has a reasonable probability of doing that and you have to write emergency plans for it, then I wonder if you need the technology.

Another item that is of interest to us especially in emergency planning is the matter of reconciling everybody's favorite plume projection models. There is a different model for anyone who is marketing them or using them. Everybody, it seems, has a different way of reconciling what the iodine mix is; they have different ways of going from field readings back to source terms. There are some that don't correct for going to the middle of the plume; they just go for any reading back to source term which is kind of strange. We're still considering acquiring a plume forecasting model ourselves and at times I kind of wonder whether it is the wise way to go with the funds that are going to be required both to purchase it and to keep it going. Especially from the standpoint that we don't use--Pennsylvania is weird since the accident--we've gotten to be very simplistic--we don't do plume forecasting any more from the standpoint that if things are going to be bad enough to move people, you don't really need to know what's going on in the plume. Our other simplistic notion is that if have to move anybody, you move everybody, so that since everybody is going, you don't really need to know where the plume is to make your protective-action decision. Plume forecasting or plume modeling to us would be useful after-the-fact when you're trying to establish what the population exposures were and what the exposure distribution was and also to identify those areas where if you have to embargo agricultural products or something else, you know where to go first, but in both instances even though you have a computer model, in the case of embargoing, one could verify that by field measurements either on the ground or from aircraft anyway, because after all, that's where the stuff is. With the matter of population dose assessment we have the TLD's out there to begin with.

Be that as it may, I'm rather interested in seeing what goes on here in the next few days and hope both Tim and I can be of some help. Thank you.

ED WATSON: Thank you, Maggie. I'm sure you bring up a subject that's dear to some of us, and that is the question of whether to evacuate people on the basis of a calculated dose. I hope we get into some discussions on this.

Our next speaker is Jack Mattice from EPRI who is going to give us a little bit of perspective from the utility point of view. Jack is a project manager at EPRI, has a Ph.D. from Syracuse University. Interestingly, he spent a year at the Polish Academy of Science--doing post doctorate work there--rather interesting some of the observations he has of that country that is so much in the headlines these days. He's a former research staff member of Argonne National Laboratory and has long studied the effects of power plant effluents on aquatic environments. Jack.

JACK MATTICE:

The title suggested for my talk was "Utilities' Role in Environmental Assessment." I'm not exactly going to follow this title and I'll get into why not a little later. What I would like to do is review ecological assessment research sponsored by the Electric Power Research Institute and emphasize three things: First, I want to present the internal reasons for the directions that you'll see in the research; second, I'd like to outline the organization of the Environmental Assessment Department and talk a little bit about the interactions between programs in this department; and finally, I'd like to talk about the rationale or the strategy for some of the projects that we are sponsoring at present, and indicate some of the areas we expect to expand in the next couple of years. I think from that you'll get an idea of what we think are priority areas for research sponsorship.

Figure 1 provides a brief description of guidance that comes down from upper management to the program managers at EPRI on which to base their research programs, and I'd like to emphasize particularly the three underlined areas. First, the research that I'll describe will emphasize <u>coal combustion</u> because of the need to decrease the use of foreign resources such as oil and gas. Secondly, in the last 10 or 12 years the industry has spent a lot of money meeting environmental regulations. Some of these I believe personally are good, some I don't. Anyway, the emphasis is on developing <u>reasonable</u> regulations to minimize the cost of energy generation as well as to keep the

EMPHASIZE SUPPLY AND CONSERVATION

REDUCE USE OF FOREIGN RESOURCES -- OIL, GAS

Coal Combustion Emphasized

MINIMIZE FINANCIAL AND REVENUE REQUIREMENTS

Reasonable Environmental Regulations

MINIMIZE ENVIRONMENTAL EFFECTS

Improve Understanding of Effects of Air and Water Effluents, Electric Fields, and Solid Wastes

Control Technology

MIX OF SHORT ($\leq$ 10 YR) AND LONG-TERM (25 YR)

69% 31%

FIGURE 1. EPRI Program Guidance

environmental effects to a minimum. And we need to understand the interface of power plants and other generating facilities with the

environment and what the effects are so that we can then minimize these and apply the proper control technologies if they are required.

EPRI sponsors a mix of short- and long-term research. In the next five years this mix will be about 2 to 1 for the short-term, meaning equal to or less than about 10-year projects. This is probably a little unrealistic as it's applied to ecological studies. I think we emphasize a little more the short-term projects.

I'll be emphasizing the Ecological Studies Program here because that's where I work. This is part of the Energy Analysis and Environment Division (Figure 2). You can see that there are four programs within the Environmental Assessment Department--Environmental Physics and Chemistry, Ecological Studies, Environmental and Occupational Health, and Environmental Risk and Issues Analysis. You can easily imagine that there is a substantial amount of interaction between these four programs. I will be pointing out these interactions as I go along.

The objective of the Environmental Assessment Department (Figure 3) is to assess the health and environmental effects of energy production and transmission. I want to emphasize in these next two statements the first two words--provide information and provide data, EPRI is a research-sponsoring organization and the Environmental Assessment Department sponsors research in the areas indicated in Figure 3. We do not sponsor research in the area indicated in Figure 3. We do not sponsor environmental impact statements or conduct routine monitoring programs. We do not support research in control technology, although we do provide environmental information to evaluate the control technologies. Finally, and most importantly, the reason that I can't follow the suggested title is that we don't promote industry decisions. We are not an advocacy organization. We do not make industry policy, and therefore I can't speak for the industry. I can only speak about EPRI's conception of what the industry needs or wants and that's as far as I can go. We do have industry advisory panels, so we think we do know what they need and want, but this is coming to you second hand.

Part of the importance of the ecological assessment area is based on the perception of the interrelationships shown in Figure 4. The whole system is driven by the need for power, by regulations, and by responsibility of all of us to be good citizens. I'm sure some of you think that utilities haven't been good enough citizens, but sponsorship of research through EPRI is an indication of their good intentions.

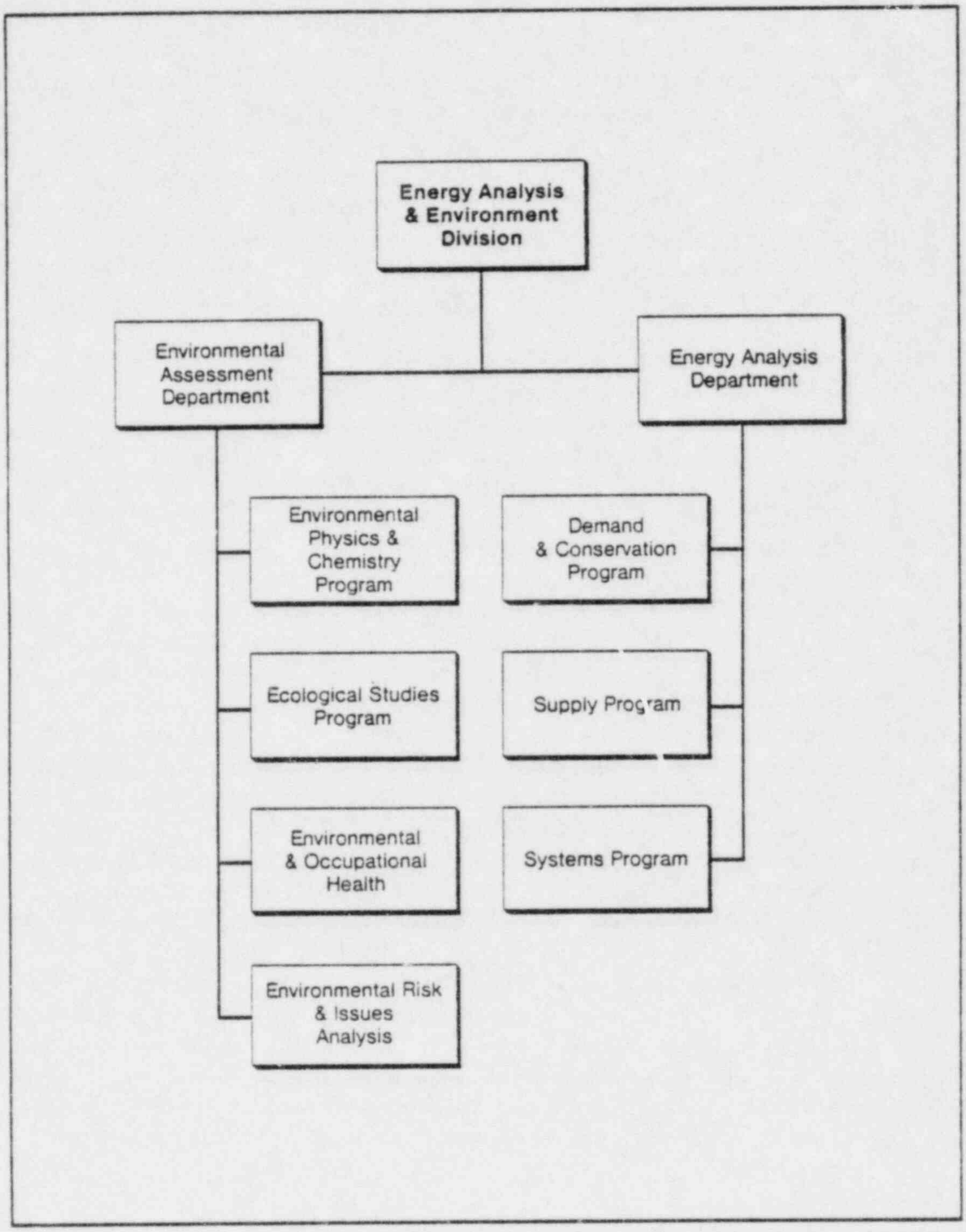

FIGURE 2. EAED Organization

OBJECTIVE: To assess the health and environmental effects of electricity production and transmission

IN ORDER TO

1. PROVIDE INFORMATION FOR CONTROL TECHNOLOGY
2. PROVIDE DATA FOR THE DESIGN OF MEANINGFUL REGULATIONS

WE DO	WE DO NOT
Evaluate health effects	Write environmental impact statements
Study pollutant distributions	Conduct routine monitoring
Design predictive models	Support research on control technology
Measure effects on ecosystems	maintain routine data files
Make risk assessments	Promote industry positions
Conduct socio-economic studies	

FIGURE 3. Environmental Assessment Department

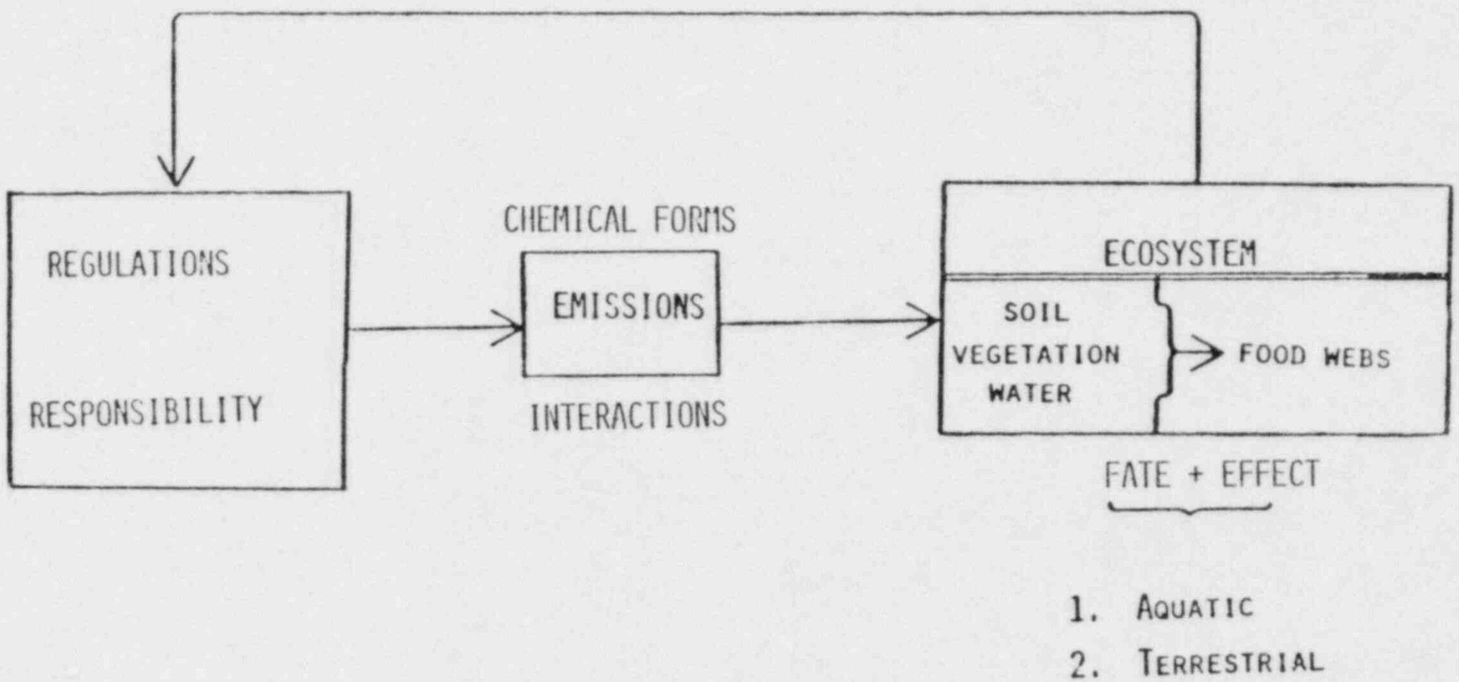

FIGURE 4. Perception of Interrelationships

I've emphasized here (Figure 4) emissions; however, we could just as easily insert entrainment or impingement. In terms of emissions, we're interested in the chemical forms released and their interactions with ecosystems--both aquatic and terrestrial. What are the effects of these emissions on the ecosystem? Using that information we can then either support or change existing regulations so that we can minimize these environmental effects. This same schematic would apply to proposed technologies or development and implementation of control technologies.

Let's get a little closer to what I really want to talk about. Figure 5 illustrates the organization of the Ecological Studies Program. The budget for CY 1982 is between 5 and 6 million dollars. EPRI works on one-year and five-year planning cycles. And the emphasis in this five-year planning cycle is toward larger, more intensive, more cohesive, more integrated projects rather than a whole series of small projects to cover every problem that we visualize for the industry. So what we have done is to determine the issues, concentrate on a few of them that we think are most important, and put more money into those projects. This way we feel we can cover less but do a better job. An example of this larger amount of money input is in the Atmospheric Deposition Subprogram. This developed out of the recent concerns for acid precipitation and its effects on aquatic environments. In the next five years we expect to sponsor about $20 million worth of research in this area alone.

For those of you who don't know the cast of characters, Figure 6 shows the structure of the Ecological Studies Program. Bob Brocksen is the program manager and there are four others of us who direct the projects that we fund. You can see that each of us interacts with more than one of the subprograms. Most of this interaction across the subprogram outlines is because of expertise that each of us has developed in our earlier professional careers.

I would like to use the Atmospheric Deposition Subprogram to indicate the strategy that we use in sponsoring research (Figure 7). I'll use this one because it is much further along in integration. First of all, we identify the environmental issues. The environmental issues for atmospheric deposition are lake acidification, crop, forest, and grassland production and effects on aquatic biota including those resulting from mobilization of different metals. Once we've identified these issues, we try to direct our moneys toward answering the important questions with respect to the environmental issues. Here (Figure 8) you can see some of the interaction. These include in-cloud processes and transport which are handled by the Environmental Physics and Chemistry Program. Deposition of these materials on land

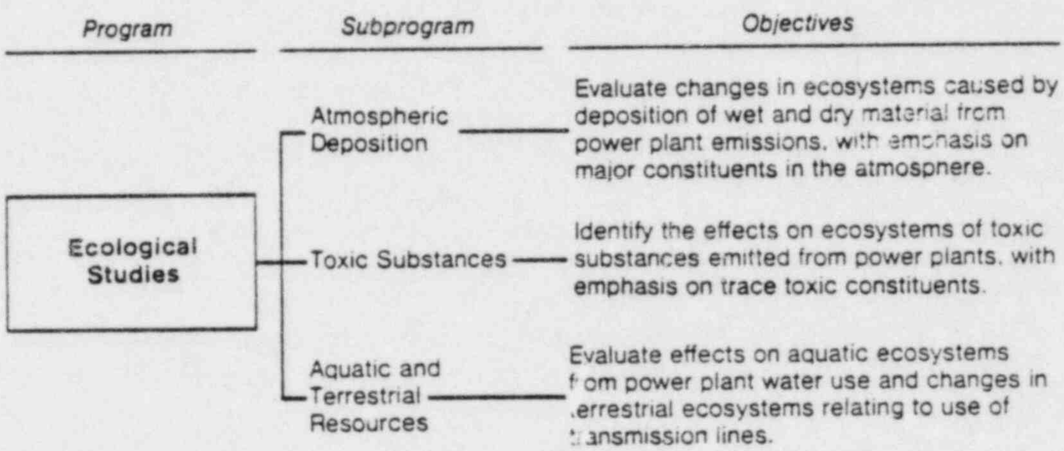

FIGURE 5. Ecological Studies Program Logic

PROGRAM MANAGER

Robert Brocksen

SECRETARY

Barbara Cox

PROJECT MANAGERS	AREAS OF RESPONSIBILITY	
Robert Goldstein	Atmospheric Deposition	- Lake Acidification Gaseous Pollutant Effects
John Huckabee	Toxic Substances	- Trace Element Cycling and Effects
	Atmospheric Deposition	- Terrestrial Ecosystem Effects
	Aquatic/Terrestrial Resources	- ROW Effects
Robert Kawaratani	Toxic Substances	- Microcosm Studies - Aquatic Biocide Effects
	Aquatic/Terrestrial Resources	- Cooling Lake Studies
Jack Mattice	Aquatic/Terrestrial Resources	- Cooling System Effects
	Toxic Substances	- Microcosm Studies

FIGURE 6. Ecological Studies Program

ENVIRONMENTAL ISSUES

- Lake Acidification
- Crop Production
- Forest Production
- Grassland Production
- Aquatic Biota Effects

FIGURE 7. Atmospheric Deposition Subprogram

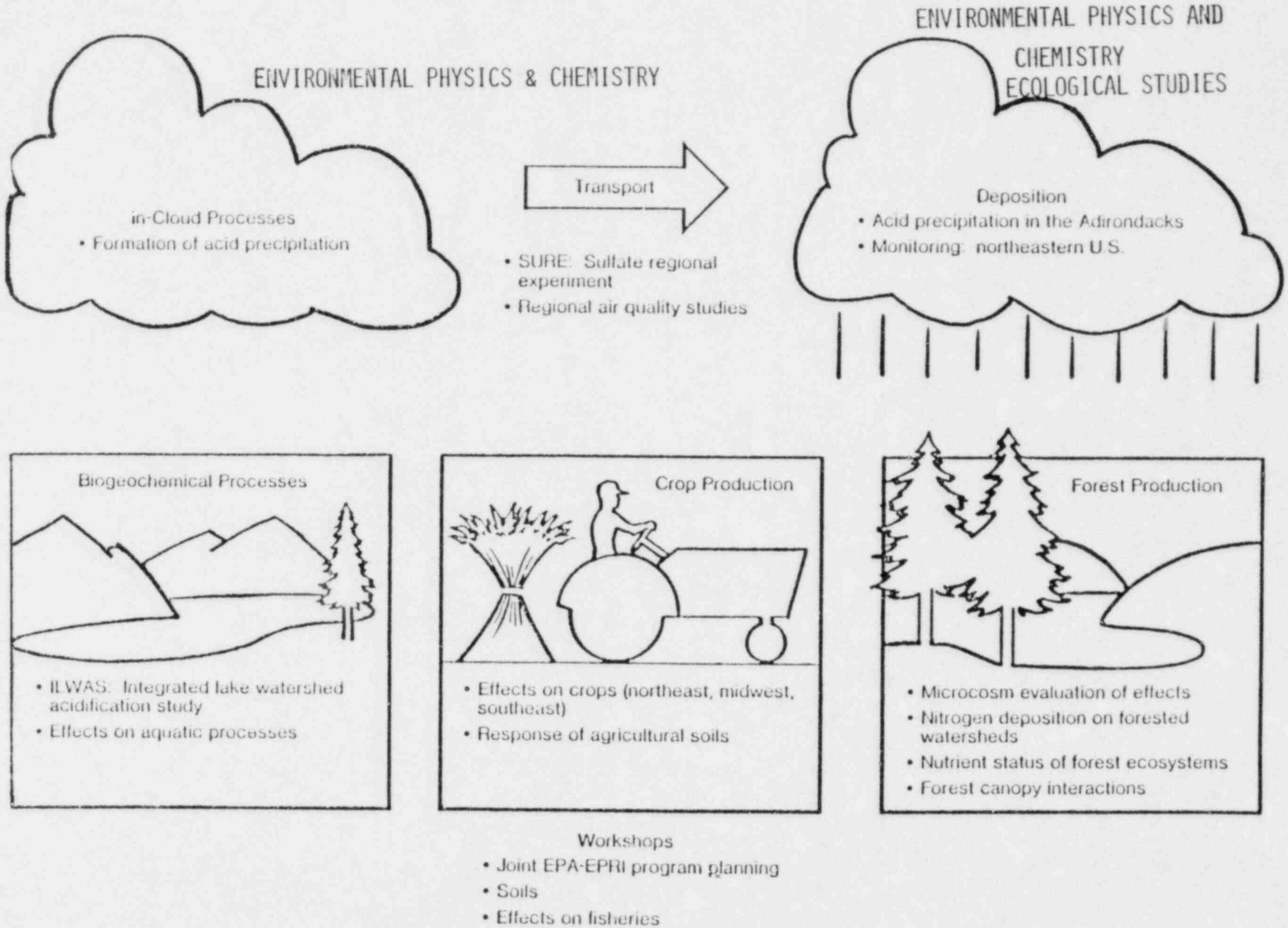

FIGURE 8. Current EPRI Acid Precipitation Research

and water is handled by both the Environmental Physics and Chemistry Program and the Ecological Studies Program. And then, as shown in the lower part of this figure, we focus on each of the environmental issues that I showed you on the last figure (Figure 7): the lake watershed study, water processes, crop production, and forest production. Each of these issues is covered by one or more projects sponsored by the Electric Power Research Institute. This is coordinated with other research funding organizations that are studying atmospheric deposition around the country, including both federal and state programs. Sometimes this involves joint funding. More often it involves coordination of research planning. Most often there is a rapid information transfer that the individual agencies can use in their own planning.

This research subprogram includes a fair number of different technical approaches (Figure 9)--field studies of different levels of complexity, controlled environmental studies using laboratory microcosms, environmental chambers, greenhouses--again at different levels of complexity--and development of mathematical models. The whole purpose is to develop good, validated, predictive models so that we can look at the relationship between acid deposition and ecosystem response, the contribution of power plants to acid deposition, and, then, the questions: do we need mitigation, what are the best strategies for mitigation, and how do we evaluate alternatives of proposed control technologies with respect to acidic deposition?

Figure 10 lists the projects which we expect to fund in CY 1982. I'm not going to talk about each one of these. I just want to make a couple of points. One is that the projects range from relatively small ones with limited scopes to considerably larger projects with broader scopes. We are talking about a significant amount of money in 1982--about $3 million. The last point is that we expect that this subprogram will increase in funding in the next couple of years to a level of about $4.5 million a year. We expect projects to continue until we've got the answers that we need.

The second subprogram that I want to talk about, second of the three, is the Toxic Substances Subprogram. This is funded in CY 1982 at about $1.2 million (Figure 11). There are two emphases--trace substances and biocides. The focus on trace substances comes from the emphasis on coal as an alternative to oil and gas. This subprogram we expect to increase through the whole five-year period to about $3 million/yr. After that we'll have to wait until next year to see where it goes.

- Field Studies
  - WATERSHEDS
  - FIELD PLOTS
- Controlled Environment Studies
  - LABORATORY MICROCOSMS
  - ENVIRONMENTAL CHAMBERS
  - GREENHOUSES
- Integrated Mathematical Models

FIGURE 9. Ecological Effects of Acidic Deposition Technical Approaches

1982 Projects Selected Next Priority Projects		Planned for 1982 Expenditures $1000
Atmospheric Deposition - 1982 ~ $3million		
RP 1109	Integrated Lake Watershed Acidification Study (ILWAS)	714
RP 1313	Photosynthetic Response to Gaseous pollutants: A Predictive approach	77
RP 1632	Microcosm Evaluation of Acidic Deposition on Forest Ecosystems	55
RP 1727	Evaluation of Nitrogen Deposition on Forested Watersheds	173
RP 1812	Effects of Acid Precipitation on Agricultural Crops (Northeast/west)	120
RP 1813	Acid Rain Effects on Forest Ecosystem Nutrients	345
RP 1907	Acid Rain/Forest Canopy Interactions	200
RP 1908	Effects of Acid Precipitation on Agricultural Crops (Midwest/Southeast)	495
E00 3	Aquatic Biota Effects	100
E00 5	Lake Vulnerability to Acidification by Atmospheric Deposition	550
E00 6	Mitigation Studies	50
E00 7	Integrated Field Studies	200
	E00 4 International Data Synthesis and Analysis	---
	E00 8 Pollutant Interactions	---
	Subtotal	3079

FIGURE 10. Ecological Studies

EMPHASIS ON

TRACE SUBSTANCES DESIGNATED AS PRIORITY POLLUTANTS

BIOCIDES USED IN BIOFOULING CONTROL

FIGURE 11. Toxic Substances Subprogram
$1.2 M

Again, there are several levels of experimental study (Figure 12). Here I've emphasized the ecological or biological studies. Certainly, as I pointed out earlier, we have to know the answers to questions that will be studied by the Environmental Physics and Chemistry Program: what chemicals are released, where do they go, and what is their form, and how do they interact?

Once we have reached that point, we use bioassays, microcosms and field work, and integrate all this information with models to predict the effect of these effluents on the environment. Specific subprojects are shown in Figure 13. The numbers out on the right-hand side indicate the project numbers--they're just to help my memory. RFP means that a request for proposal is out; RPA means the project is in internal review. At present we expect to get the projects approved, the RFP's out and, perhaps, funded during the next CY. There are two major focuses here: Methodology Development, and Distribution and Effects. There has been increased interest in moving closer to an ecosystem assessment by developing standard techniques for assessing impacts using microcosms. We expect to have the proposals in response to that RFP by the first of the year and have it funded some time in 1982.

In Distribution and Effects (Figure 13 again), the first two projects listed are fairly standard studies, although the second involves both field and laboratory work. These are essentially completed and we expect the final reports out in the next year. You can see that there is some interaction here between the Atmospheric Deposition and Toxic Substances Subprograms. For example, here (Figure 13) is a distributional study--mercury, selenium, arsenic in natural waters and sediments--which examines where these chemicals go, at what rate, and in what form. This normally would be funded by the Environmental Physics and Chemistry Program; however, they couldn't handle it with their present budget, and we thought it was important enough that we decided to fund it ourselves. This will essentially use mercury, selenium and arsenic as models for study of other metals and metaloids in the environment. And finally, the project on dechlorination was partially spawned by questions regarding effects of chlorine on the environment and the move toward dechlorination. In the State of Washington, for example, all new plants are required to dechlorinate. We thought it was important to determine whether dechlorination is a reasonable control technology for the standpoint of environmental effects.

In the last subprogram--Aquatic and Terrestrial Resources (Figure 14) --there is a bit of a mixed bag of projects because the aquatic and terrestrial groups have combined fairly recently. Two major thrusts

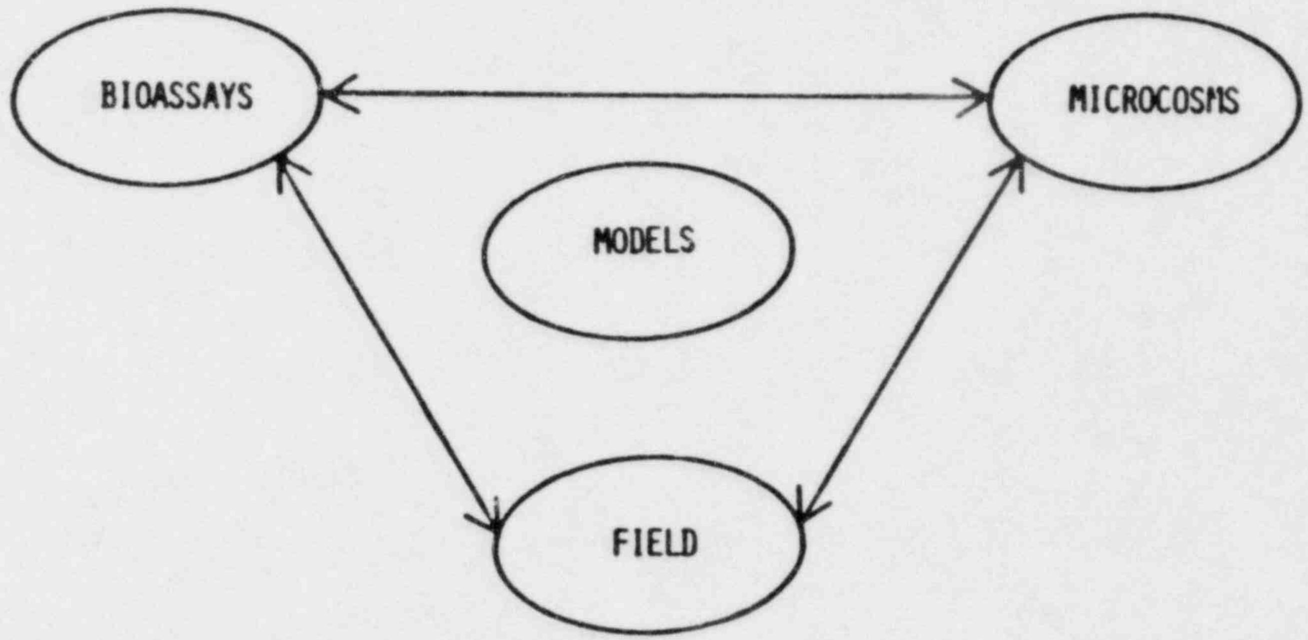

FIGURE 12. Tactics

- Methodology Development
  - Microcosms for Pollutant Studies -- 1224
  - Artificial Streams for Ecosystem Toxicity Studies -- RFP
- Distribution and Effects
  - Effects of Chlorine on Fish Mortality -- 1435
  - Selenium and Fish Reproduction -- 1631
  - Acid Rain and Aquatic Processes -- 1910
  - Hg, Se, and As in Natural Waters and Sediments -- RFP
  - Dechlorination -- RPA

FIGURE 13. Toxic Substances Subprogram - 1982

-- Ecosystem Analysis and Assessment

-- Resource Utilization, Management, and Mitigation

FIGURE 14. Aquatic and Terrestrial Resources Subprogram - 1982 ($\sim$ \$1M)

here are ecosystem analysis and assessment, and resource utilization, management and mitigation. I'd like to consider these groups of projects in reverse order. Incidentally, the Aquatic and Terrestrial Resources Subprogram is funded at about $1 million/yr right now. Our plans have been for it to drop in the next couple of years and level off at somewhat below this level for 1982. I don't think this is going to be true, which is why I've reversed the order here. Under resource utilization, management, and mitigation (Figure 15), the first two projects examined the potential use of cooling ponds: what fish should you stock into the cooling ponds, and what effect is that going to have on coincident water bodies? The third project which is in internal review is designed to look at alternatives to biocides in controlling vegetation in transmission rights-of-way. In Figure 16, ecosystem analysis and assessment, the first three projects are completed and the reports should be out sometime in the next year. The study on Legionnaire's Disease Bacteria is an ecological scoping study. It's an attempt to examine the operation of power plants with respect to distribution and virulence of Legionnaire's Disease Bacteria. If we find that human health effects seem likely, this research topic will probably be followed up under the Occupational and Public Health Program. Here is another place where we're interacting across programs in the Environmental Assessment Department.

The last two items in Figure 16 are the most interesting to me. The utility industry has spent millions of dollars in the last 10 or 12 years on monitoring programs. As at least some people in the room know, most of them are essentially worthless as far as telling us anything. So, the goal of this project, which has really just started, is to try and develop cost-effective designs for sampling programs. This isn't aimed at answering how do you sample, or what do you use; but when do you sample, how often, and how do you analyze the data. And looking at the other end of the question in terms of risk/benefit, can we predict with a certain level of assurance how much risk is involved in saying there probably won't be any effects? How much do we have to increase the sampling program to decrease risk level? And again, how much is that going to tell us as far as when to apply control technologies?

And, finally, (I wanted to treat this last because this is an area where I expect that the level of funding for this subprogram will increase) we have a project designed to examine compensatory mechanisms in fish populations. This is probably one of the most critical questions involved with impact assessment and one which has broad implications for decisions on siting and operation of power plants. This project will end with a workshop in February, and the real goal is to design the broad outlines of a research program on compensation.

Biochemical Genetics and Thermal Tolerances of LM Bass -- 1063

Sport Fishery Potential of Power Plant Cooling Reservoirs -- 1743

Terrestrial Biocide Alternatives -- RPA

FIGURE 15. Resource Utilization, Management, and Mitigation

Secondary Succession Associated with ROW -- 756

Assessment Methodology for New Cooling Lakes -- 1488

Bird Interaction with Transmission Lines -- 1636

Legionnaire's Disease Bacterium in Power Plant Cooling Systems -- 1909

Sampling Design for Aquatic Ecological Monitoring -- 1729

Compensation Mechanisms in Fish Populations -- 1633

FIGURE 16. Ecosystem Analysis and Assessment

I expect that, as a result of this preliminary study, we will design a whole series of integrated studies attacking different aspects of compensation.

That completes the overview of the research projects funded in the Ecological Studies Program. I hope that you have a better understanding of why we're doing what we're doing and where we expect to expand in the future. I went over it pretty fast so I'd be glad to answer any questions.

AUDIENCE RESPONSE: Jack, you mentioned I think a point that many of us would be interested in and that is the subject of model validation. Among all these projects that end up coming to a cumulative, say $5 million, how many of them are directly related to the objective of validating models? If they are not, how much do you think it would cost developing the kinds of models being proposed to assess the effects of acid deposition?

JACK MATTICE: I can't answer your first question at all, unfortunately. I will claim recent arrival at EPRI. This subprogram is primarily run by Bob Goldstein and I think he would be the person to contact to get that answer, and I'll be glad to give you his phone number.

AUDIENCE RESPONSE: I think the hidden reason behind my question was that I personally feel that a substantial fraction of the overall budget would have to be dedicated towards validation, if indeed you were serious about obtaining the objective of validating predictive model work.

JACK MATTICE: I don't doubt that. Cost/benefit plays a role in decisions regarding allocation of research moneys that are not unlimited. But within that framework, validation studies that are needed will be funded.

ED WATSON: I've got a question for you, Jack. You mentioned earlier an objective to assess the health and environmental effects of energy production and transmission. Does that include the fuel cycle, specifically in the case of fossil fired power plants--the coal mines?

JACK MATTICE: I think so, but frankly at this point I really don't know what's being done. That's handled by other divisions. What usually happens is that they set the framework for environmental studies' needs and we work that into our program if we've got enough lead time. But we don't have, at the present time, any projects in nuclear radiation in our department. I think, in part, that's an EPRI management decision that the topic was more in someone else's bailiwick than ours.

AUDIENCE RESPONSE: Just looking at the titles of some of the projects that EPRI funds, it seems to me that some of this work has already been done. Of course, I realize that these titles are general; for example, lake vulnerability to acidification for atmospheric deposition. Schindler and his colleagues in Canada have been studying whole lakes of fish since 1971 at a cost of millions and millions of dollars. What can EPRI hope to find out for $550K that for millions of dollars Schindler did not?

JACK MATTICE: I can't answer that question because I don't know any more about the project than the title. I have not had time to get into what each project involves as far as goals, methods, and so on.

AUDIENCE RESPONSE: I guess my question really is: what will happen with other studies? I mean, do you have a separate evaluation panel that evaluates proposals in terms of other studies?.

JACK MATTICE: When we get a response to an RFP, we have no one group of people review it. However, the research proposals are critically reviewed by a panel which includes utilities representatives as well as well-known scientists who are experts in the area of science applicable to the RFP. Included in this review are questions concerning overlap with or duplicaion of other studies. Furthermore, we project managers maintain contact with researchers conducting studies in the scientific areas of projects we are funding. Let me draw examples with respect the Acidic Deposition Subprogram. EPRI project managers are in almost constant contact with other agencies funding research in this area, both nationally and internationally. These agencies include DOE, EPA, USGS, and their counterparts in Sweden, Norway, and Canada, as well as state agencies and other utility groups. In some cases, EPRI co-funds projects with these agencies. In other cases, different aspects of a research project are cooperatively funded. Cooperation is also fostered by attendance at national and international meetings and program reviews and by exchange of research plans and publications. Because of all this interchange, I feel confident in saying that the work that EPRI supports does not duplicate the work of Schindler that you mentioned. We're all interested in getting the most we can out of a finite budget--not in reinventing the wheel.

ED WATSON: Anyone else have any questions or comments for any of our speakers?

AUDIENCE RESPONSE: I've got one that at the risk of sounding stupid, I'll ask it anyway. What is the current status of, say, dose effect relationships both from the health standpoint and biological standpoint? Can anyone here address that question?

AUDIENCE RESPONSE: It's up in the air.

AUDIENCE RESPONSE: I'll try to tell you what we're doing in NRC as far as that is concerned. We're only taking the linear portion of the dose effect relationship from BEIR I and really reserving any judgment on the linear quadratic information from BEIR III until some of the issues surrounding the new data analysis is complete.

AUDIENCE RESPONSE: How long will that be?

AUDIENCE RESPONSE: I've heard all sorts of estimates. I would say at least a year before we come up with data that at least we would be able to use in the legal process for providing the basis for some of our judgments.

AUDIENCE RESPONSE: I think that the important thing with regard to the health effects of low-level radiation is that it's really a question that Maggie brought up. "It's how many angels can dance on the head of a pin?" You're talking at most a factor of 2 or 3 difference between the two models--the linear-quadratic and the linear. It's only if you assume a pure quadratic that you get a drastic reduction in the risk of low doses and the evidence doesn't support a pure quadratic model. So if you're talking linear-quadratic, or you're talking quadratic, you're talking a factor of 2 or 3 and then, for regulatory decision-making, that is not going to be a very big, overriding factor.

AUDIENCE RESPONSE: The only concern in the regulatory processes is that we don't have something that could be undermined in the hearing process which could affect the ultimate decision. That's the only thing. It's not technically, as Hal pointed out, in terms of handling a drastic impact on conclusions.

ED WATSON: I don't know if I agree with what you say that a factor of 2 or 3 would make no difference in the regulatory process because I've seen a lot of money spent on the basis of just 10%.

AUDIENCE RESPONSE: O.K., a factor of 2 or 3 in the risk estimates because the risk estimates we don't actually use in the regulations per se--those design objectives aren't risk design objectives.

AUDIENCE RESPONSE: I have a question just for clarification. If I remember right, looking at the table in BEIR III, the differences between the linear-quadratic equation stem from about 100 rad down to about 10 millirad. However, the major differences I believe in terms of looking at the linear hypothesis vs. any other hypothesis is when we get into collective dose assessments whereby each individual is receiving doses in the femto rad or even lower values in which case we're assuming a linear hypothesis, it's sometimes questionable as to what meaning very low risk to a single individual have, even though we multiply that risk times 4 billion people.

AUDIENCE RESPONSE: There is an influence of a dose effect model on a regulatory strategy in terms, for example, if you have a pure quadratic dose-effect relationship, then the worst thing you can do--the thing you want to do is actually lower the standards and force the industry to use more people and distribute the dose more uniformly. If you have, in fact, a fractional power, as some of the critics have said; i.e., less than a linear model, d to the 1/2 power, so that the dropoff at low doses isn't as great as we think, then the worst thing you can do is lower the standards because you don't get a corresponding decrease in the risk. So, in lowering the standards, you may in fact require more people to be exposed, assuming that you can't hopefully remove all sources of radiation or reduce the risk by physical means, but you have to use more people then. You get an entirely different aspect if you look at collective dose than you would assume just looking at an individual. Fortunately, with regard to the linear quadratic it looks like a factor of 2 or 3 and that does not have an impact on which strategy we use, whether we want to use a few number of people highly exposed or a lot of people exposed to lower doses.

AUDIENCE RESPONSE: I'd just like to add that a factor of 2 or 3 in the dose response model isn't really much more than what you had versus the health effects model, absolute versus relative risk in the BEIR I report, 1972. So there's not a great deal more uncertainty.

AUDIENCE RESPONSE: In fact if you use the BEIR III linear modeling, it is very much equal to the BEIR I linear model. The situation with regard to risk is not going to change the way things are regulated in this country.

AUDIENCE RESPONSE: The only difference is the arena that we deal in very frequently; that is why I mentioned right off that primarily the regulatory legal problem the best attack is to stay away from it until there is some consensus.

IV. ENVIRONMENTAL SURVEILLANCE

ED WATSON: We're going to get to the crux of the matter now. Jack Corley is an old hand at Hanford. He's been involved with the environmental surveillance program for many, many years. He did quite a bit of work on dispersion and water quality in the Columbia River in the early days. In 1965 he became Manager of the Hanford Environmental Surveillance Program and, subsequently, assumed the responsibility for a number of supporting studies for the Atomic Energy's Environmental Protection Branch including preparation of the Environmental Radiological Surveillance Guide. He's been very active in preparing numerous environmental assessments and several major environmental impact statements. At present, he's a technical leader in Battelle's Radiological Sciences Department and manager of a technical assistance project for the Environmental Protection group in the Department of Energy's Office of Operational Safety. I've known Jack for many years and he is highly qualified to talk about our present environmental surveillance program, particularly at Hanford, and how we got to where we are today. I believe its development closely parallels most of the environmental surveillance programs at the major DOE facilities.

JACK CORLEY:

Thanks Ed. Since it's after lunch, I'll have to speak loudly. I hope I don't blast your eardrums, but I want to be sure that everybody hears me, even though I may not have as much significant to say as some of the earlier speakers. As a matter of fact, they have stolen most of my message. However, I do have a personal perspective on this business of environmental assessment to provide, primarily because I have been for a number of years in the status of a user of your research results, attempting to apply in a practical manner to the formulation of management of environmental surveillance programs, primarily radiological surveillance programs. I did say, I think, perspective; some of you may be acquainted with a columnist named Sidney Harris who does the "I, you and he" bit (Figure 17) on a number of things and this is, with apologies, my definition of perspective. So on these matters I'm going to exercise my professional judgment, and if you disagree, you may be expressing a particular point of view, and those kooks down the street are obviously displaying their personal prejudices. One of our grand old men at Hanford, Herb Parker, whom most of you know, once said, "One man's perspective is another man's prejudice," and that's a similar idea.

In any case, what I'd like to do is give you a very personal appreciation of what I consider to be something of a time line (Figure 18)

(With apologies to columnist Sydney Harris)

I exercise my professional judgment-

You express a particular point of view-

He displays his personal prejudices

FIGURE 17. Perspectives

		TECHNOLOGY DEVELOPMENT:	APPLICATION:
O	1940	• RADIATION PHYSICS • PORTABLE INSTRUMENTATION	• NONE
I	1950	• RADIOECOLOGY • RADIOCHEMISTRY • CONCEPTS FOR PROTECTION OF ENVIRONMENTAL POPULATIONS • EFFLUENT INSTRUMENTATION	• "UNIVERSE" SAMPLING • EFFLUENT CONTROLS
II	1960	• EXPOSURE PATHWAYS, MODELS • LABORATORY INSTRUMENTATION	• ENVIRONMENTAL DOSE STANDARDS
III	1970	• STATISTICAL APPLICATIONS • EPIDEMIOLOGY, ASSESSMENT OF "HEALTH EFFECTS" • *IN SITU* INSTRUMENTATION	• CRITICAL PATHWAY CONCEPT, COMPOSITE DOSE ESTIMATES • ENVIRONMENTAL IMPACT STATEMENTS
IV	1980	• "TOTAL RISK" CONCEPT (ICRP)	• "ALARA" • STATISTICAL APPLICATIONS • *IN SITU* MEASUREMENTS
		?	*DE MINIMIS* LEVELS? HEALTH EFFECTS STANDARDS?

FIGURE 18. Stages of Development - Environmental Radiological Assessments

for environmental assessments. Here again I will be talking primarily of radiological assessment because that's my background. I certainly don't mean to ignore the equal importance of nonradiological assessment, which is perhaps in many cases today of even greater importance. It happens, as I look back and from what I remember about what happened, that it seems to me that we can break down what has happened to a number of stages, and roughly in decades--don't hold me to those exact years because obviously many of these things happened, many advances were made and were put into practice in different years. Nor did the bulleted items happen to occur in exactly that particular order, nor were they confined to those decades. What I'm attempting to present here is at least in terms of the development of the technology, the real advancements in the applied science. We had a general sequential order like this. If you'll note in the second column, where I'm talking about applying some of the things that we knew, or wanted to know or were learning, that eventually the technology was to be translated into practice but not concurrently. It took, and still takes, some period of time, some years before what your advancements in science are telling us we can do until they're actually applied, particularly until the time they are put into some kind of regulatory requirement.

Then at the very end down here (Figure 18 again), which is approximately where we are right now, I've indicated what I think would perhaps come recently into practice into our field and perhaps a couple of suggestions--these may not occur. Some of the things that are perhaps going to come out of this workshop are what is going to happen in terms of technology advancement in the next 5 to 10 years, plus what is already available and ready to be applied on a regulatory basis that is not now being done. Now, in radiological assessments, of course, we have the one major advantage over nonradiological pollutant assessment of having a common basis for evaluation. Obviously, part of our current problem in nonradiological impact assessment is the fact that we do not have such a common basis. As a matter of fact, we have a mixture of regulatory concepts, if you will, in the difference between such things as category groups and non-category hazardous groups, or between carcinogens and non-carcinogens. We have a real mishmash in this area, and as somebody who would like to be able to advise people on what they need to measure and how to measure, frankly, I don't know what to do at this point in time from the nonradiological standpoint. Maybe here again this workshop could help to point some appropriate directions.

In any case, to get back to the radiological basis for assessment and control, at the very beginning of the Manhattan Engineering District, in World War II and well into the atomic era, we really were operating and controlling exposure on the basis or on the concept of some kind of a threshold event. (Figure 19) Our regulatory concept was based as it had been, and still is for some toxicity tests, on an attempt to define a dose-response curve with the assumption that somewhere there is indeed a zero response--a threshold--and by applying some kind of appropriate safety factor, or factor of uncertainty if you will, that we could set some kind of a working level with which we would feel comfortable. And of course in the environmental area, when environmental limits were first proposed, really all that was done was to apply another factor, another margin of error, from an occupational or operational working level to some environmental exposure level. And as long as the dose-response curve is truly as indicated by Curve A, with no detectable effect below some level D_0, an increase in response up to 100% response (D_{100}); this is a very acceptable approach. We may argue about the appropriate factor of safety to be applied to D_0 to provide a safe working level, D_w, and the desirability of applying an additional factor to permissible exposures to the population, D_p.

For radiation protection, we no longer make that assumption. We say now we're dealing with something like Curve B which is a linear extrapolation from some known effects with no threshold at all. And so if we're working on a log scale in terms of dose, trying to find some kind of zero response, how far do we have to go? That, as has been stated, is a real problem for all of us and I'm sure you're going to be getting into that discussion.

What has happened is something like this. (Figure 20) This particular chart happens to be a simple scale of some applied dose criteria for an exposed individual, where this is an annual whole-body dose in mrem. 10 CFR 20 still says our limit for any individual in an uncontrolled area is 500 mrem/yr. That's a limit; that is not what the regulations say we have to live with. The regulations say, particularly for a nuclear reactor, anywhere from 5 to 20 depending on the nuclide and pathway of exposure. EPA's limits for the light-water reactor fuel cycle indicate a total of 25 from all sources, and so on. Somewhere in this whole range then, really we're talking about "as low as reasonably achievable" or if you are on an *a priori* basis, some kind of a design objective. This, a de minimis value, at present has been suggested but is not written into the regulations. We sure do need some number, and I don't care and I don't think most people care whether that's 1 or 0.1, but somewhere we need a number. You might also note that for some of our nonradiological pollutants, we are also faced again with this zero threshold of application; we may also really be faced with need to

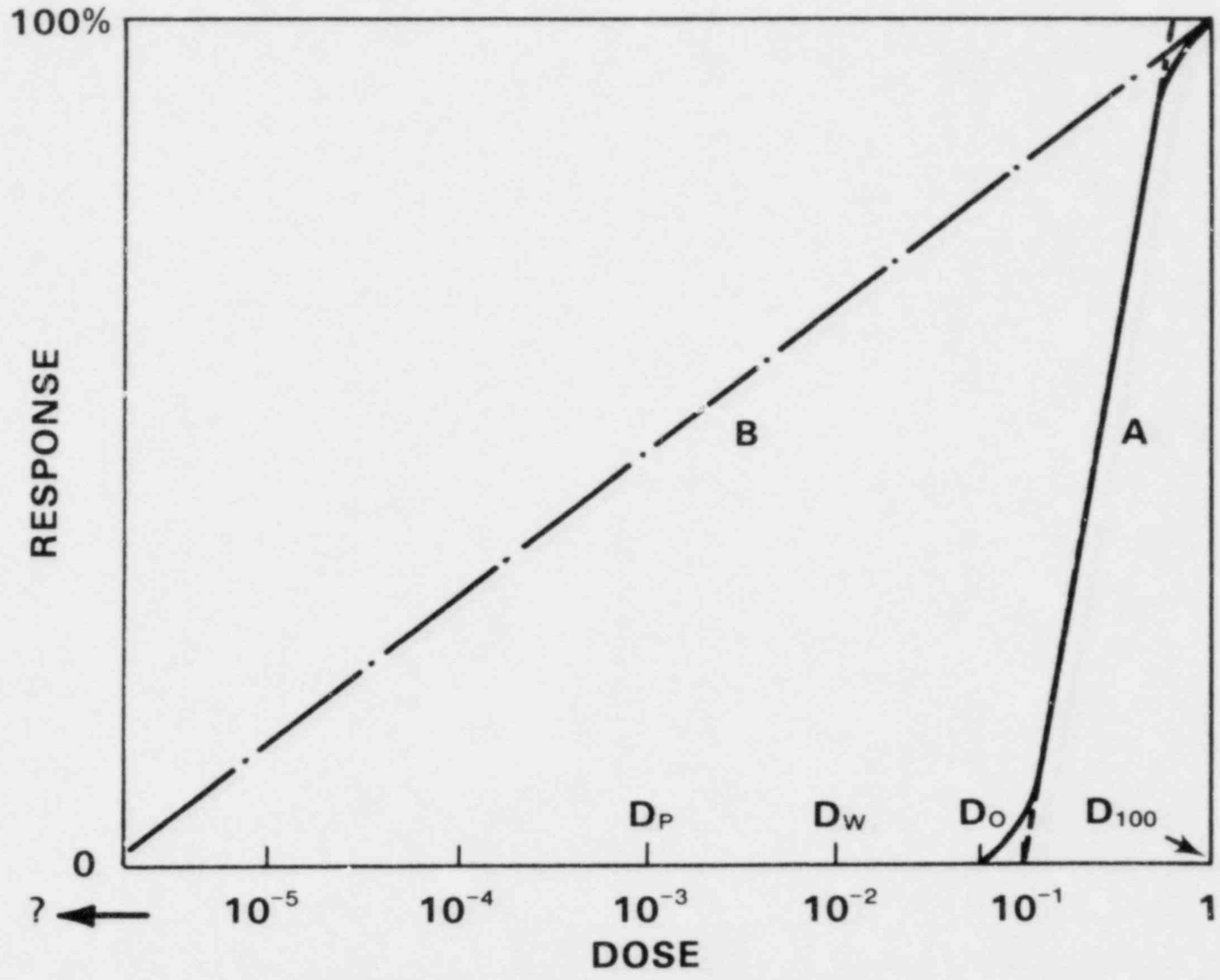

FIGURE 19. Dose Response Relationship

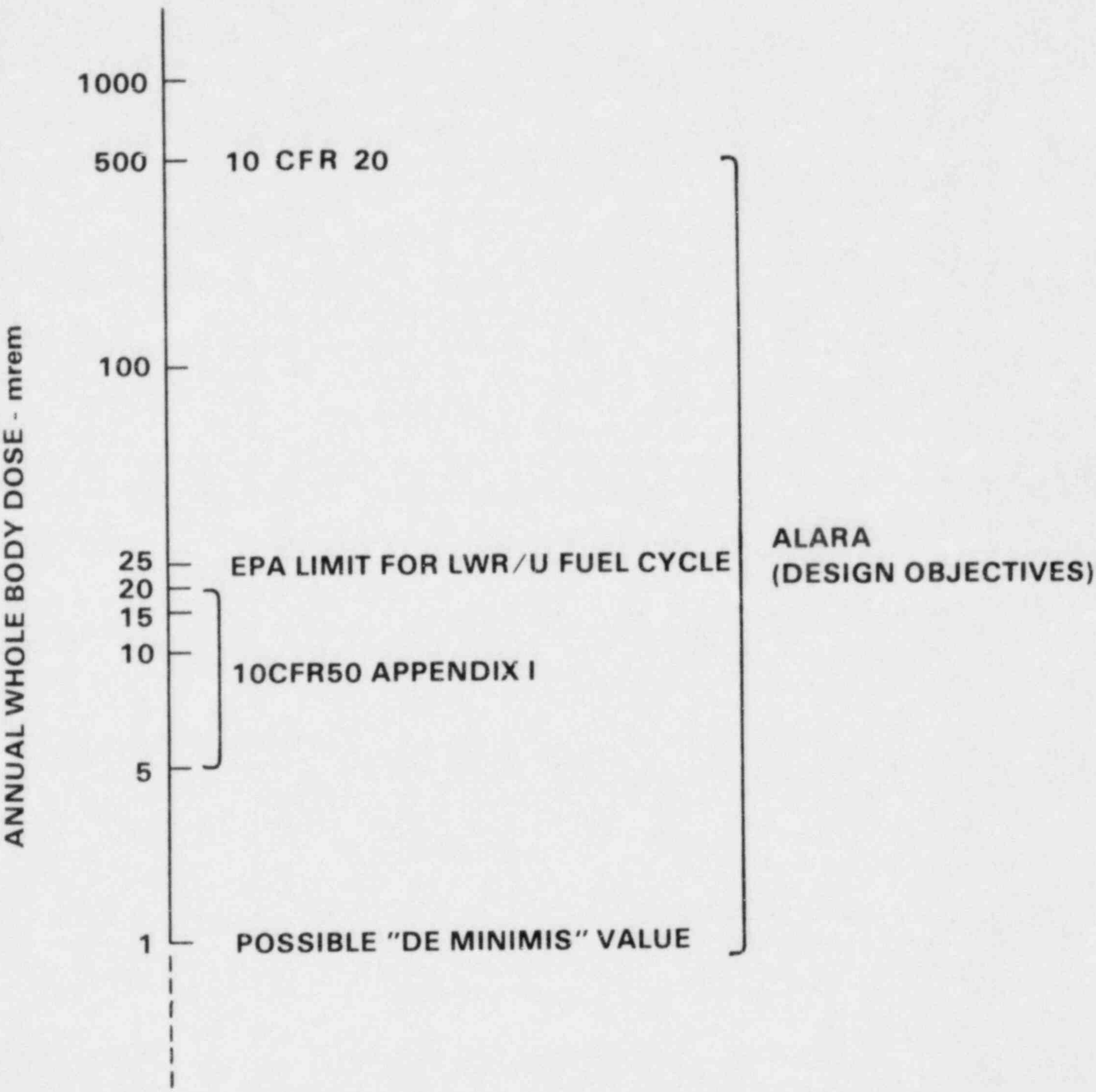

FIGURE 20. Dose Criteria Relationships for a Maximum Exposed Individual

define somewhere, some kind of a de minimis or, if you will an ignor able concentration or ignorable exposure level, if we are to be sensible about providing monitoring activity (not assessment).

Now you can take two basic approaches to determining or estimating environmental doses. (Figure 21) When I took my first environmental control sample, it consisted of taking a sample of reactor effluent. We put it in a little beaker, and looked at it with an electroscope and measured the time of drift of the quartz fiber across the scale. Of course, there were no offsite personnel exposures for that kind of level when our limits were in terms of hundreds of mrem/yr to an offsite population, even though this was crude instrumentation with a very rough approximation of pathways, our dispersion models were satisfactory. As our need and our interest for lower and lower levels became apparent, it was not enough to take our effluent data and go through a set of calculations, however crude, and end up with population doses. It may have been enough but we could do better because at that time, at many of the old AEC sites at least, we could actually make some environmental measurements in situ and the laboratory instrumentation improved, we were able to get better and better and much more inexpensive concentration measurements in the laboratory. As a result we were able to bypass this dispersion calculation part of the scheme and go directly to environment data collection, and from the environmental data itself as close as possible to the points of exposure, through exposure calculations and using pathway models under development at the time, perform dose calculations for comparison to standards. What has happened as once again our exposure levels or dose levels of interest have gotten lower and lower, we are reaching the point where we can no longer do that. What's especially true, and perhaps it's always been true, when we're talking predictive doses for environmental impact statements, for assessing the impact of changes in process or facility, for environmental program designs, and if we can't reasonably measure environmental levels at the dose levels of interest, then we're back here performing our dose estimates, comparing them against these much lower standards on the basis of effluent measurements and this whole series of models.

Now look what we have here. First, we may have generalized and in most cases site-specific meteorological and hydrological data which we feed into some type of dispersion models. We've had much discussion on appropriate models; every site has their own favorite set of models or at least parameter values. From those we can use the effluent data collection, determine a statistical treatment, make dispersion calculations, come up with some kind of exposure levels in terms of concentrations--air, water, perhaps direct exposure. And then again we can apply current pathway models, generalized as in 1.109, or more specific

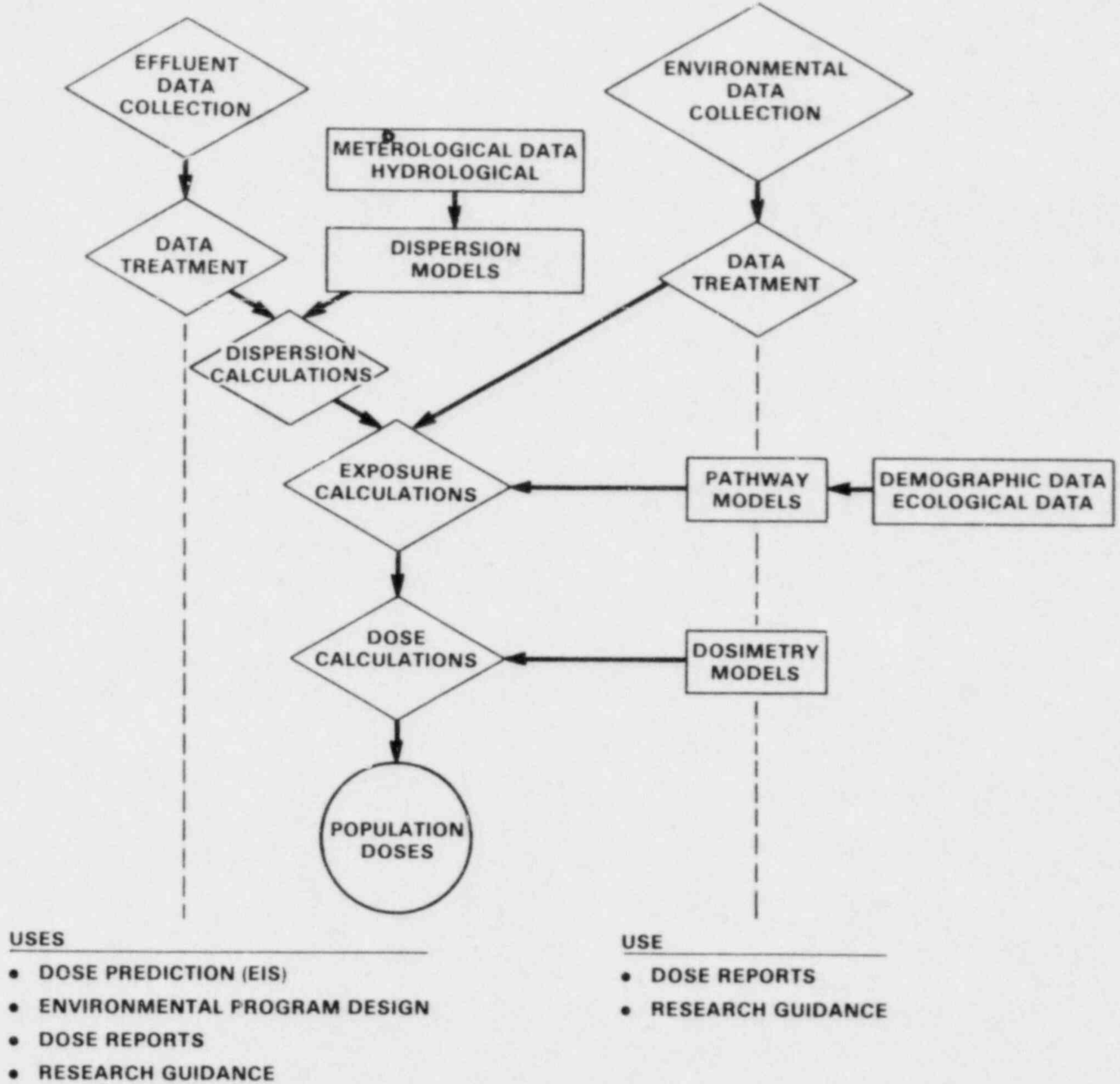

FIGURE 21. Environmental Radiological Dose Assessment

on the basis of site-specific data, local demographic and ecological data and determine dose calculations and make those dose calculations down just as low or almost as low as we want for predictive purposes. And based on effluent measurements these days, we can calculate population doses well below one mrem per year. However, we can't measure numbers that low, and certainly we can't on a routine basis without going to considerable expense in terms of multiple measurements and their careful quality control.

So, as we were in the early days we're back primarily to relying on effluent measurement these days. For nonradiological pollutants, I'm really not all that sure. We have our controls--in this case they are almost always based on effluent measurements. However, once again as with radiation, the true basis for the standards lies in environmental exposures whether its to "critters" or people. And we're still faced with this problem of having adequate models, adequate modeling, and appropriate parameters to feed into the models.

Now, Figure 22 illustrates a point you are all acquainted with, and once again if we're dealing with very readily determined impacts, we have a very different situation than we do if we have a very minor impact on top of some natural background. Now every measurement we take has a statistical distribution. As you're all aware, it is not a point. We determine an average, but there will always be some distributions around those points and even with our best instrumentation--we're talking about trying to find, in some cases, very small differences between what is truly background and what is truly background plus a potential small increment. We can apply models and we do. We can apply controls and we do. We can apply our regulations even when they're proposed in different terms.

This table (Figure 23) simply illustrates that fact for a series of stages from inventory through release, dispersion and/or reconcentration in the environment, intake and exposure modes, some actual radiation dose within the person or within the "critter," potentially some health effects. Going from one stage to another, if we can avoid having to calculate or determine this multiplicity of factors that are involved in proceeding from one stage to the other, at each stage as we proceed downward in this table we are removing a number of sources of uncertainty provided we are still at the point where we can make direct measurements. Right now at the current low dose levels of interest for radiation protection, we have real problems determining any epidemiology. What can be said to be specifically and surely health effects due to radiation. For many nonradiological effects the same problems would apply. In any case, we have no standards--we have no performance standards--in terms of heath effects. Perhaps this is one of the

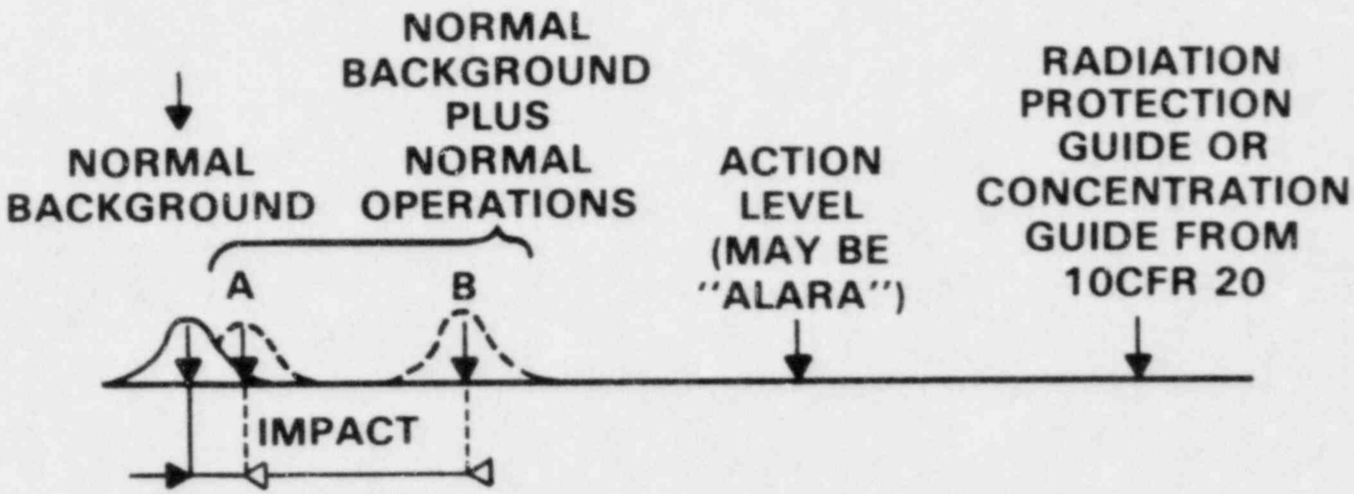

FIGURE 22. Dose or Concentration Increasing

Stage	Factors	Bases for Evaluation	Standards or Criteria
A. Inventory	Quantities, physical and chemical forms	Measurements on vessels and containers, shipping records	Inventory Limits
B. Release	Release fractions, rates of release, effluent concentrations	Measurements of effluents	Release Guides, Operating Limits
C. Dispersion and/or Reconcentration	Meteorology, biology, hydrology, physical and chemical forms, concentration factors	Measurements of environmental concentrations, physical models	Concentration Guides, Contamination Limits
D. Intake and Exposure	Exposure periods, consumption rates	Measurements of direct radiation, bioassays, *in vivo* counting, pathway models	Intake Ranges--FRC Annual Limits of Intake--ICRP
E. Dose	Uptake and absorption factors, distributions in body, biological half-lives, body dimensions, radiation types and energies	Dosimetry models for maximum individual and population average	Dose limits--DOE Orders, 10CFR20, 40CFR190-191, NCRP Reports, ICRP Reports
F. Health Effects	Dose/response relationships, demography	Calculated probabilities from laboratory studies, epidemiology	(None)

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FIGURE 23. Comparison Chart - Environmental Radiation Standards

advances that the Regulatory bodies need to reevaluate. It's certainly been proposed. There have been, once again, various numbers proposed. For example, WASH-1400, as has been mentioned, has made an *a priori* assumption that people would be willing to assume a certain level of risk which implied a certain number of health effects. For that there was little basis in fact nor is there today, for radiation. As we saw, we still have our basic standards in terms of dose by working back up the chain; yet we can derive working levels at each of these stages, including inventory.

Now I said in the beginning I was giving you a personal perspective. And certainly this chart (Figure 24) is. I have listed here what I consider today what we realistically can expect an environmental surveillance and/or a dose calculation schema to do. And you may well disagree--I would be very much surprised if you agreed with everything I have said here. But let me say that I think that an environmental surveillance program of measurement, or a schema for calculating environmental doses for predictive purposes, should demonstrate compliance of regulatory requirements. That's sort of a given. The program should be maintaining meaningful environmental data bases for comparison against any disturbances in the future. It should be able to distinguish between plant impacts from natural or other sources--for plant impacts here read if you will detectable or at least meaningful increases in concentrations and/or radiation levels from facility operations. A routine program of calculations should confirm the effectiveness of effluent controls. We hope, in other words, that the effluent controls are indeed effective and that our program will demonstrate that that is true, except when we have an unusual release, an operational upset, in which case, if our models are correct, we should be able to find some proof of such an upset at a meaningful level by one or more environmental measurements. Now, ten years ago I would have said and did say frequently I suppose, that the routine program also should provide valid estimates of population doses from the environmental program. I can no longer say that due to the greater uncertainties at the lower levels of interest. Now, if releases are large enough or if you're willing to fund enough measurements which have good enough quality control, you indeed may be fortuitous to have an environmental program that will give you a handle on population doses. But it will be not in most cases cost effective to do that; it may and it may not. Once again, a routine program may, and again this may be perhaps fortuitous, detect previously unsuspected modes of exposure or newly or previously unsuspected significant pathways. But to attempt to design and operate a program, or to attempt to provide or accumulate all the knowledge required to insure that both of these conditions will be met, will be in almost all cases beyond the financial means of the facility.

SHOULD:

- COMPLY WITH REGULATORY REQUIREMENTS
- MAINTAIN A MEANINGFUL ENVIRONMENTAL DATA BASE
- DISTINGUISH PLANT IMPACTS FROM NATURAL AND OTHER SOURCES
- CONFIRM EFFECTIVENESS OF EFFLUENT CONTROLS
- CONFIRM OCCURRENCE OF UNUSUAL RELEASES

MAY:

- DETECT UNSUSPECTED MODES OF EXPOSURE OR LONG-TERM ACCUMULATIONS OF RADIOACTIVITY
- PROVIDE VALID ESTIMATES OF POPULATION DOSES

SHOULD NOT:

- PROVIDE PRECISE ESTIMATES OF RADIOACTIVITY INVENTORIES IN THE ENVIRONMENT

FIGURE 24. A Routine Environmental Surveillance Program

Now, I would have said 10 or 15 years ago, and I can still say this without having to hedge, no routine environmental program can bear the cost of continually providing precise estimates of the inventory in or the fate of all nuclides that have been released to the environment. It does not say that nothing can be done; there will be instances when that must be done and it may well be worthwhile doing--but not on a continued basis--not with that much effort saddled on the back of the routine environmental surveillance program. You've got two different animals. You want to ride this horse or you want to ride that horse, but you don't want to ride both horses at the same time.

And that gentlemen is my message. And I'm open to questions.

AUDIENCE RESPONSE: Would you care to elaborate a little bit upon how you foresee the establishment of de minimis levels thereby alleviating much of the problem with environmental monitoring.

JACK CORLEY: Why do I think it will?

AUDIENCE RESPONSE: Yes, I could probably tell you, but I'd rather have you tell me.

JACK CORLEY: Once again, its related to some extent, as you well know, to the need to define the number of parameters--once we're dealing with extremely low releases. If we don't have to define those, if we don't have to make measurements on a continuing basis because we have effluent measurements and we're sufficiently satisfied with the accuracy of all our models, we can just wipe out full sets of environmental measurements and/or effluent measurements. What we will frequently find of course, as you well know, is that some very simple indicator measurements may be all that is required and satisfy everyone that whatever exposures are occurring are well below this level of interest. Does that answer your question? Or perhaps you would like to add to that.

AUDIENCE RESPONSE: I guess a follow-up would be what techniques must we have at our disposal to insure ourselves that in fact we are below this de minimis level? In other words, a model that just gives you a best estimate may not necessarily be adequate to give yourself reasonable assurance that you are below some level that can be ignorable.

JACK CORLEY: Yes. You are quite right. However, what we are faced with is proving that something is zero or as close to zero as can possibly be measured. As I say, at the present time, there really is no zero; we can only approach it asymptotically, and the cost of approaching that asymptote goes up exponentially, as we attempt to get to smaller and smaller levels of discrimination between the real effect and the non-real effects occurring in the real world. This is what I wanted to show in Figure 22. Now if this difference represents 10 mrem/yr, it may well be worthwhile to have taken 100 samples/yr on some particular medium at some particular location it takes to quantify that difference. But if that difference really represents one-tenth mrem/yr to the maximum individual and much less than that to most of the population, then it may no longer be worthwhile taking more than one or two measurements a year simply to verify that conditions really haven't changed. Or to extrapolate from other measurements that you may have--your effluent streams or other indicator measurements--that you still don't have to start up that kind of program.

AUDIENCE RESPONSE: That was the point I was striving for. I think that once we can establish de minimis levels, then it becomes a simple task to agree upon screening level models--models that give us reasonable assurance that the effect would not likely be higher than what the model predicts. And just use effluent monitoring to establish that we're in compliance with operational tech. specs.

ED WATSON: I think you have to start further back up the chain. I think you've got to first decide--when you start talking de minimis, you've got to start thinking in terms of what are the de minimis number of health effects that you're going to tolerate. And then you work backwards from that to see how that translates into system capability. The whole system has got to be looked at.

JACK CORLEY: I think you're right, Ed, except I don't think it's, here again I'm expressing a personal opinion, the province much less the responsibility of the person responsible for evaluating the radiological impact or the nonradiological impact of a facility, to determine what level of health effects and/or other environmental effects is acceptable. That is the province and responsibility of the regulator. Now I was much interested in hearing Nat, this morning, say he felt that that was something that the regulator was going to have to have the courage to do.

ED WATSON: I hope that in the small-group sessions that we have in the next two days we can forget our various backgrounds and our various affiliations and really freewheel on this subject.

JACK CORLEY: Certainly I think we will both agree that it is up to a scientist and technologist (calling myself that) to give the regulator --the person who is responsible for making these social legal decisions --the best possible advice we can and to tell him when we are in need of better information on which to provide the knowledge that he will need to make an appropriate decision. That is what we're concerned about here this week.

Anybody else want to throw a rock?

AUDIENCE RESPONSE: Well, I've got to make one distinction from a regulator's point of view--we don't set "acceptable limits"; we set "allowable limits" and that's more than a semantics difference.

AUDIENCE RESPONSE: That's the problem; what we say is "allowable" is not in the public's mind, today, "acceptable."

JACK CORLEY: Yes, I can understand that.

AUDIENCE RESPONSE: I think you are going to have a little bit of trouble basing regulations on health effects, because the first rule of regulation writing is you better be able to establish compliance. And as far as doing a body count, I think you're in trouble. You have to write the regulation around something which you can establish compliance.

ED WATSON: You might be able to go through that process without stating what the de minimis number of health effects is and just start with what that results in, in terms of concentrations, without really stating the basis. That's done all the time.

JACK CORLEY: Now the Legislature or the Congress may preempt you--this has been done in the case of certain nonradiological pollutants.

AUDIENCE RESPONSE: Would you indicate de minimis for individuals as well as de minimis limits and levels for other measurements?

JACK CORLEY: Yes, I think so. They wouldn't necessarily be the same number.

AUDIENCE RESPONSE: How about different organ systems?

JACK CORLEY: I'm not sure, with the concept we are dealing with here, that it's really warranted to worry about differences of 2 or 3. I would hope that we are sufficiently far below any level of concern that we can really ignore that small difference. And here again that is a personal opinion.

ED WATSON: You know, we're really going to get into trouble in trying to apply this concept to nonradiological effluents. I don't think we have an adequate guide here for health effects. Anybody disagree with that?

MAGGIE REILLY: What do you mean when you say "we?"

ED WATSON: "Us'ns." (indicating those in the room)

JACK CORLEY: Well, those of us who are responsible for attempting to work within a few bucks--Maggie, you're faced with this too--you've got so much of a budget to work with; you've got to cover a broad range of activities as you described this morning. Where do you put your money? It's not easy. You've got to make some hard choices sometimes. Don't you?

MAGGIE REILLY: Yes, some pretty dumb ones that are politically driven.

JACK CORLEY: That's right!

MAGGIE REILLY: Never have so many bucks chased so many samples to find so little.

ED WATSON: Winston Churchill just rolled over in his grave.

JACK CORLEY: Well, Ed, I took four more minutes than I was supposed to so I'll turn it back to you.

ED WATSON: Our next topic is going to be a brief update on the NCRP Scientific Committee 64 by Bill Templeton. Bill joined Battelle in 1965. He, for 15 years, was a senior biologist with the UK AEA studying bioaccumulation and the effects of radionuclides in the oceans. Since coming with Battelle, he has been interested in thermal effects, EISs for AEC, NRC; he's a consultant with the IAEA on definition and recommendations for ocean dumping and chairman of the NEA executive group on research for ocean dumping. Bill is now Associate Manager for the Ecological Sciences Department at Battelle. Bill, I'll turn it over to you.

BILL TEMPLETON

Thank you, Ed. I was given some good advice yesterday afternoon by someone who had taken a course on Persuasive Presentations. That was, "Do not talk for more than 10 minutes, otherwise you lose everybody's concentration." So I'm going to try to stick to that, partly because I'm not going to go through in detail what the NCRP task group is doing. Our recommendations are in the penultimate draft stage. It won't be too long before the NCRP publishes it--it may be out the first part of next year.

NCRP Scientific Committee No. 64 was set up about two or two and one-half years ago at the instigation of Dick Foster and Jack Healy. They thought that it was probably time that NCRP had a committee which dealt with environmental problems rather than 63 committees which have been dealing only with biomedical problems. They obviously made a good case because it was approved. Dick Foster was the initial chairman and he recently handed it over to Mel Carter.

The first project involved a review of the current status of the application of radionuclide transport models from source term to intake by man. There are two task groups--the terrestrial group, chaired by John Till, and aquatic group chaired by myself. I will warn you, we have three task group members here, so if anybody does ask any questions afterwards, if they are relevant, I'm going to throw them to both these people.

I think we started off by agreeing, and I don't think you will disagree, that the ultimate goal for radiological assessment is the determination of the relationship between the input, or release rate, and the intake and hence the dose rate. It's as simple as that. However, if it were that easy, probably half of us wouldn't be here today. I think Jack Corley pointed out earlier very clearly that one of things that has happened over the last 20 to 30 years is that the allowable limits are being reduced and reduced under ALARA and are getting closer and closer to some actual dose values. Thirty years ago we did not have to worry too much; we operated, in most cases, way below the then allowable limits but now they have been reduced.

I think the other thing that we have come to realize is that these transport models are an important tool when we get to assessing the optimum cost/benefit design for the alternatives, especially for waste treatment processes. What we attempted to do was look at the models and the data bases and review the transport, atmospheric, surface water, ground-water models, deposition, sediment uptake, bioaccumulation and food web parameters. We also reviewed the data bases for the usage factors which were ingestion, inhalation, living patterns indoors and outdoors. We only looked at chronic releases and did not consider accidental releases in any detail.

The steps we went through initially were in two groups covering terrestrial and aquatic, but it became very clear that our bottom line on this really brought us back into just one group. What we really were going through was an evaluation of predictive capabilities. These were defined as limitations of these models to meet current standards. We were particularly interested in the evaluation of all the uncertainties. What are the potential errors in the overall model prediction? We looked at data bases which are being used today and attempted to highlight the potential uncertainties in essential parameters. We also had the objective in the beginning to look at examples of model validation. However, we didn't find too many examples to assess. There were more in the atmospheri. area than any of the others.

We did not want to write a handbook. What we produced is good introduction for the neophyte and we would like to think that it would also be valuable to some of the old hands. We limited our study to the uranium fuel cycle and we selected 10 elements--cobalt, strontium, ruthenium, iodine, cesium, radium, uranium, plutonium. We also looked at tritium and carbon-14 because they're modeled in terms of specific activity approach.

I have some conclusions here but I know that they are still being rewritten so I'm just going to give you few words about some of the conclusions, even though, obviously, these are not finalized. I think one thing that has been mentioned before is that we certainly need models to estimate the radiological exposures where the actual emissions are so low that you can't go out and measure them. The accuracy required in each of these transport models is dependent, of course, upon the accuracy of these release rates and the environmental parameters. The level of accuracy that you can accept increases when in fact you are approaching the allowable limits. One has to recognize that there will always be a degree of uncertainty in model predictions, and therefore that some environmental monitoring is essential.

We felt there were two areas that we think should focus on; one is simplification of models, simple models particularly for screening purposes. There seems to be no point in using complex models initially when you have either a de minimis or a low dose rate which is insignificant. Obviously, when you have completed your screen models and come up with values that may be approaching the allowable limits, then perhaps you will need to accommodate these more complex models. But most assessment models should be simple, especially if the risks are acceptably small.

On validation, we continue to use data values in our models which at the scientific or technical level you know have an enormous amount of variability. There are some of these which could be validated in the early stages for specific sites. I think the other thing is that we have too many models; Blaylock has a list of 350 or so, and I don't think any of them have been validated. It does seem important in any event to really improve the use of these models so that they give in fact a more reliable estimate--not that one needs to do this at every site. It means that at least there should be a few carefully selected sites that are looked at in some detail. Part of the problem it seems to me is that the data required to evaluate these parameters are not being produced by present monitoring programs. Certainly they produce data but I have yet to find out who uses them. We realize also of course that detailed validation studies take a lot of time and cost a lot of money. Then one needs to go through and look at those parameters. As I said in the first place, the aim should be to develop a relationship between input and concentration in the critical materials. There is no reason why this should not be carried out fairly easily. Comparison with the model would indicate how precise the model assessment was.

In the area of field validation, the estimates of ranges of model predictions will be made using error propagation techniques. It's very clear from using this technique that you can usefully identify situations in which model simplification can be very advantageous.

Any questions? Any of the task group members want to add to what I said.

AUDIENCE RESPONSE: When did you say that was going to be published?

BILL TEMPLETON: Well, I'm not going to promise anything from NCRP. We are just hopeful that, having given them the draft within the prescribed time, they will do us a favor by getting it approved and published within a reasonable time.

AUDIENCE RESPONSE: Something that concerns me--I've heard several speakers now talk about the need for models. And I've heard people say they need models for screening purposes. I would agree with that. And I've heard people say you need models because the levels of the release are so low that you can't make reasonable environmental measurements under any conditions. Now, I might have misunderstood that, but that's what I heard. How do you deal with criticism at that point that the level is so low, why would we care about it. In a nonradiological area that gets thrown at us a lot, and if you can't measure it, why worry about contaminating the atmosphere. I find it a weak excuse for using models in an operational mode. And also I can see a third use of models that hasn't been mentioned, and that is, many of these facilities--particularly waste sites, have a future contamination from chemicals and then I can see the use of the models. Out of those three areas in my own thinking, I can see two definite needs. That one in the middle really-- intuitively, I think you're right.

BILL TEMPLETON: You're really addressing a planned facility--the question really comes down to; for the everyday de minimis we need a model which is going to demonstrate that you will, in fact, be below de minimis? Once you've shown that, you've demonstrated release compliance; you don't need to deal with other measurements.

AUDIENCE RESPONSE: Speaking from the point of view of the Department of Energy's own operating facilities, we have found it highly desirable to establish an information base from which we can develop reports that can be consumed by the public. The actual dose calculations can be presented to the public using methods by which those numbers came about. Our experience has been that these have been believable in the public domain, and it has saved us from a lot of painful problems of convincing the public otherwise that we are operating safely with exposures to the public that are at de minimis.

BILL TEMPLETON: I think that's right.

ED WATSON: Thank you, Bill

V. SMALL-GROUP SESSIONS

A. Organization

ED WATSON:

Let me tell you a little more about the plan of the workshop. We really want to make this a bonafide workshop. We feel the bulk of the good--if there is any good to come out of this workshop--will come in the next few days. We went to considerable pains to invite you all here. We could have divided the small-group sessions up any number of ways. We chose, however, to divide them up by environmental pathways--atmospheric, aquatic and terrestrial. We selected you, the invitees, on the basis of reputation--primarily experience, as we knew it. We didn't pretend to be all-knowing or think that we knew everybody that had the best experience in any given area. We did the best we could.

We attempted to load the small groups in this way; we wanted to have about six to eight people from the scientific community in each group and about four people from the "regulatory arms" of the government--both state and federal government. To do this, we visualized then that we would have one representative in each group from NRC, one from DOE, one from EPA, and one representing the states. We were only partially successful there. We were not able to get the participation from the EPA that we had hoped for and for good reason; they had an understandable conflict. We were also only able to get two representatives from the states, so one of the groups will be missing that representation.

We purposely did not want to make this a public meeting. We wanted it to be a freewheeling meeting in which people were free to express their ideas without regard to their affiliations and nobody would hold it against them. I think it is important that we get that kind of input to this workshop to make it successful. As word got around regarding our workshop, a number of people expressed interest in it, so we decided we could accommodate those people and did that by calling these people observers. It is not meant to make them second-class citizens in any way, and they are perfectly welcome to participate. We sent out a letter, not knowing how many observers we would have so we had to preclude the possibility of having far more observers in any one group than we had participants. As the number of people involved in any particular subject increases, the more difficult it is to get things down on paper.

So a number of you who are here are here as observers and I want you to feel welcome--just as welcome as the participants--I want to make one request and that is that you pick an environmental pathway group and participate in that group for the two days. We didn't pre-assign you to a group because in many cases we did not know where your particular interests lie. The aquatic group is going to be in this room. The terrestrial and atmospheric groups will meet in two rooms down the hall. There are signs indicating where these rooms are.

May I remind you again, the goal of this workshop is to identify and prioritize if it is at all possible those areas of research in the field of environmental assessment related to the regulatory process can be identified. We want to identify them--not try to solve them. I hope that in doing so you don't spend an undue amount of time on any one subject. I can visualize your getting bogged down in models and discussing their various aspects or advantages of one model or another. I hope that doesn't happen.

The objectives have been transmitted to you in writing and then were briefly itemized by Rico this morning. The chairmen of the sessions will have copies of those objectives.

We have also identified basic issues in each group. Those issues are not at all intended to be a constraint. They are merely intended to be used as a means to get the discussion going. As I said, I hope you feel free to discuss all the issues openly.

It could well be that one of your conclusions is that this isn't exactly the right kind of workshop to discuss a particular topic in. Some such topics that come to mind are; social and economic factors, or maybe criteria for evacuation in emergencies. Some of those subjects do warrant another framework. The effect of non-radioactive effluents is another that may well be the subject of another workshop. Although I think that a lot can be said about research necessary to evaluate nonradioactive impacts within the framework of this workshop. If you agree, don't hesitate to do so.

I for one certainly hope that you do give some serious consideration to certain topics (listed for small-group discussions). One of these is the de minimis concept. It seems an important concept to me. I don't care what that number is--I don't care whether it is 10^{-1} or 10^{-6}, but it seems to me we have to have a number. Zero is unrealistic and we can't live with it. We've been trying to live with it for 20 years. I think it's time to conclude that we can no longer do that--we can't afford that luxury.

Another topic that I hope to get some lively discussion going on is; "What are the objectives?" "What should be the objectives of an environmental surveillance program?" and "What role does it play in assessing the environmental impacts?" I know that the objectives of such a program today are far different from what they were 20 years ago--probably even 10 years ago.

AUDIENCE RESPONSE: Not to be facetious, but the scope of the questions we are now addressing are quite broad and quite important--what relevance do they have, given the fact that the current NRC research budget as told by Rico Conti is only $2 million? That's hardly enough to address any <u>one</u> question.

ED WATSON:

I hope that we can give him (Rico) some ammunition to ask for a return to a reasonable emphasis on environmental research. I think that's one of the objectives of this workshop. I think that is one of the reasons Rico was interested enough to sponsor this workshop. These are hard times; let's face it. So the more ammunition we can give him, the better.

To say a bit more about the composition of the small groups. We've got people in these small groups with a statistics background, with an ecology background, as well as modeling and measurements background. I don't think it's worth identifying who those people are, but at least we've got all that in there, and I'm hoping that this mix will produce the lively discussion we hope for. We have to be out of this building by 5 o'clock. What I would like to do now is take a short break, and meet back together in your small groups at 3:30. All of tomorrow will be devoted to discussion in the small groups. Thursday morning I hope that we can get back together and discuss the individual group conclusions and maybe wind up this workshop with a round-table discussion.

Finally, I want to introduce the small-group chairpersons--Bruce Wiersma and Joe Soldat back there are the Chairman and Co-chairman for Terrestrial; John Bradley and Van Ramsdell for the Atmospheric; and Bill Templeton and Yasuo Onishi for the Aquatic. The chairmen have been provided instructions for conducting their sessions (see Appendix V-A).

FRANK SWANBERG: The question was raised about why are we doing this, in view of the fact that we've only got a couple of million dollars. The proper answer to that is that we're really not too concerned about this present $2 million but what we're concerned about is what monies are to be spent after that $2 million.

APPENDIX V-A

NRC ENVIRONMENTAL ASSESSMENT WORKSHOP: INSTRUCTIONS TO SMALL GROUP SESSION CHAIRMEN

Small Group Objectives

Objectives of each small group are to answer the following equations for their respective environmental media:

- What should be done for the environmental assessment for nuclear facilities?
- Do the current regulations suffice to satisfy the need of assessment?
- Are assessments being done currently? How?
- What should be done to improve the assessment process?
- What can be done to improve the assessment process? (list items and their priorities)

Specifically, all topics covered should consider both routine and accidental releases from:

- nuclear power plants
- low-level waste facilities
- mining (e.g., uranium mill tailing problems)
- fuel fabrication plant
- fuel reprocessing plant
- other facilities.

Instructions

The media pathway starts with description of source; includes the transport, transformation, diffusion and depletion processes; and ends with the estimation of direct and indirect dose to man.

Basic issues have been identified for consideration. These issues are: a) identify and describe current environmental assessment practices as they apply to the media pathway; b) evaluate the uncertainties associated with the current practices; c) evaluate the limitations on the interpretation of model output; and d) evaluate the limitations on interpretation of a limited set of measurements. You and your committee may add to or delete from the list as appropriate. If you make any changes, please provide a discussion of the reasons for the changes.

To help meet the Workshop objectives, the following guidance is offered:

1. Your committee is to identify areas for improvement of environmental assessment technology based upon the discussion of relative uncertainties and of the available or potential alternative models or methods.

2. The potential improvements are to be ranked in order of importance.

3. The order of magnitude of the cost of realizing each improvement should be estimated.

4. The potential improvements are also to be ranked in order of estimated difficulty.

5. The variation of the responses to 1. through 4. with respect to facility operating status at the time of the assessment (i.e., preoperational or operational) and release type (i.e., routine or accidental) should be discussed.

6. Select a recording secretary as early as possible.

7. The time available for the discussion is limited, therefore the discussion should not be allowed to bog down in the details of specific models or monitoring techniques.

8. As a group, prepare a written submission at the end of the sessions:

    - listing the names, addresses and affiliations of all attendees (a form is provided for this purpose--see attachment)

- discussing the main issues addressed (and listing those not addressed);

- reporting any concensus, majority, and minority views;

- describing R&D needs;

- describing interfaces with other groups in terms of needed input to and possible output to others to aid in EM design;

- summarizing recommendations and, if possible, identifying institutions involved in carrying them out.

9. Reminders

- Remind the group of the desired goal (outcome).

- Monitor and control discussions to ensure they are aimed at the goal.

- Give all participants equal opportunity to discuss their ideas.

- Give equitable weight to all the issues (not necessarily equal time).

- Ensure viewpoints of industry, scientists, regulators, DOE, EPA, are discussed equitably.

- Identify most important issues in terms of "feelings" of the group, as well as scientific need.

- Identify interfaces with the other groups in the workshop and exchange people with them as necessary to define input needed to improve EM design.

B. Aquatic Pathways

1. Issues

Basic Issues

- What constitutes an adequate aquatic environmental assessment program?

- What are the objectives of an adequate aquatic environmental assessment program?

- Are the objectives being met with current programs?

- What research could be conducted to improve current programs (i.e., to better meet the objectives or to be more efficient by returning more effective information at a reasonable cost)? How important is it to conduct such research?

Physical/Chemical Issues

- Are present methods adequately describing the physical and chemical effects of fission-derived energy generation on water quality? (Potential insults include: Thermal discharge, biocides, blowdown, water treatment wastes, heavy metals, and radionuclides from both plant operation and fuel mining and production facilities.)

- Are sampling schemes and modeling methods designed to provide an adequate temporal and spatial description of plant effects?

- Are analytical methods adequate to describe water quality characteristics with sufficient resolution? (Consider sensitivity, accuracy, cost, reliability, and quality assurance.)

- Are data interpretation, analysis, modeling, and archiving adequate to provide ready access to reliable information? Are the data used to describe plant effects on water quality in a meaningful way?

Aquatic Ecosystem Issues

- Can important components of aquatic ecosystems be identified, considering potential for effects, importance to the ecosystem, and economic role?

- Are sampling schemes and modeling methods designed to provide a defendable description of important components of the ecosystem within the zone of influence of the plant?

- Can changes in populations be detected with sufficient resolution to describe effects of plant operation (including those resulting from water quality changes, impingement, and passage through the plant as well as those from physical structures, water circulation, and other factors)? Can such changes be related to plant operation?

- Are sampling methods, data collection, and modeling techniques adequate and quantifiable?

- Are data interpretation, analysis, archiving and modeling adequate to provide ready access to useful and reliable information? Are the data used to describe plant effects on important aquatic ecosystem components in a meaningful way?

- Has the potential for synergistic effects been considered?

Radiation Dose to Man Issues

- Assess the importance of aquatic media to the overall dose to man evaluation. What monitoring, data analysis and modeling methods should be required and how detailed must they be?

- Are data requirements adequate for dose assessment? Are data requirements reasonable? Are data available?

- Do present dispersion models adequately represent aquatic systems? Are they verified?

- Are dose pathway models adequate to represent the aquatic pathway? Are they verified?

- Do field data collection schemes provide sufficient data for adequately modeling the aquatic pathway dose to man? Do analytical methods provide sufficient resolution and accuracy?

- Are data interpretation, analysis, archiving and model descriptions adequate to provide ready access to useful and reliable information? Are the data used to evaluate the dose to man in a meaningful way?

Ancillary System Issues

- Same issues as above; i.e., ...
- Are present assessment methods adequate to describe the effects of mining and milling resulting from increases in turbidity, changes in water quality, and releases of heavy metals and radionuclides?

2. Radiological Discussion

W. L. Templeton, Chairman

The objective of the group was to evaluate the methodology used for environmental assessment of the aquatic pathways and to identify where improvements were needed. While the directions from the Workshop organizers specifically requested we consider both routine and accidental releases from the nuclear fuel cycle, other than ultimate disposal, the consensus of the group was to emphasize routine releases of nuclear and non-nuclear materials. Due to the mix of invitees and time constraints, the group agreed that it would be most productive to deal with the subject by dividing into three subgroups: Radiological, Transport and Fate, and Aquatic Ecosystem Effects. The latter two were charged with considering both nuclear and non-nuclear materials. The subgroups prioritized recommendations are shown in Table 1. Further details and justifications are presented in the individual reports.

a. The Radiological subgroup was assisted in their considerations by a draft of a NCRP Scientific Committee #64 report on "Radiological Assessment: Predicting the Transport, Bioaccumulation and Intake by Man of Radionuclides Released to the Environment."

The subgroup considered that present models are adequate for assessment; however, they made recommendations for improving the data base and reducing the uncertainties in present models. The most significant recommendation calls for the development of simple screening models and the establishment of de minimis levels of dose. These models, used in conjunction with the de minimis level, would provide NRC with a basis for deciding whether a proposed release was

Table 1

Aquatic Pathway Priorities

Radiological

Ranking	Title
1(a)	Update bio-accumulation factors
1(b)	Update usage factors
2	Uncertainty analysis
3	Screening models
4	De minimis dose limits
5	Validation of existing models
6	Evaluation of archived and current aquatic radiological data
7	Evaluation of existing pathway monitoring

Ecosystem Effects

Ranking	Title
1	Sampling designs for monitoring
1	Compensation
2	Control of Corbicula
2	Evaluation of synergism (chemicals, heat)
3	Preoperation impact predicting methodology (multiple stressors)
3	Ecosystem key components research

Transport and Fate of Contaminants

Ranking	Title
1	Model simplification and validation
2	Development of field sampling protocols
3	Estimation of uncertainty in exposure estimate
4	Completion of development and testing of transport and fate models for sorbed radioactive and non-radioactive materials and investigation of sorbed containment uptake by biota
5	Chemical mechanisms in geologia media
6	Laboratory experiments on fine sediment transport
7	Feasibility study on application of risk assessment techniques to the environment - NEPA process
8	Development of multimedia radionuclide transport and fate assessment methodologies
9	Remedial measures for mitigation of groundwater radionuclide releases to surface water due to a core meltdown
10	Assessment of chlorine releases from nuclear power plants
11	Transport and transformation of heavy metals in fresh water
12	Assessment of ^{32}P and ^{55}Fe releases from nuclear power plant
13	Portable instruments on radioactivity measurements

insignificant or not and hence requiring minimal assessment and monitoring or requiring a more stringent assessment and monitoring program. The application of these models would be very cost effective for both NRC and industry.

b. The Transport and Fate subgroup also considered that present models are adequate to describe the physical and chemical interactions of release radionuclides. However, sediment interactive models should be improved and validated. Quite independently they called for the use of simple screening models in the preliminary stages as a decision-making tool. However, the subgroup believed that insufficient attention was being given by NRC to non-nuclear toxic materials such as chlorine and copper, sediment/radionuclide and sediment/radionuclide/biota interactions. The subgroup believes that current sampling schemes are generally not adequate to provide the temporal and special descriptions at release site plants. This comment applies equally to sampling schemes for biological materials in the critical pathways. Both of these groups were concerned that very few attempts have been made by NRC to validate the models that they apply to the licensing process. While in some cases this is not possible or even necessary for whole pathway models, a review should be conducted to select sites at which major components of models could be validated. This would assist in reducing many of the uncertainties in the existing models.

c. The Aquatic Ecosystem Effects subgroup was basically concerned with the assessment of the impact of nonradiological, physical and chemical materials. The subgroup concluded that present monitory programs are deficient in terms of direction of effort, quantification of information, and ability to detect ecological changes in the receiving water body. As presently applied the existing program could only detect acute catastrophic effects, while the more insidious effects from short- or long-term chronic releases will not be detected. It is the latter, of course, which are of major concern. The statement made by NRC in the opening session that no important effects on aquatic ecosystems have occurred seemed to be based on the most simplistic and unverified considerations. The recommendations of the subgroup are directed toward overcoming such deficiencies and include improved statistical designs for monitoring, evaluation of the role of compensation, and methods for the control of fouling by orbicula.

It should be noted that these research needs are presented as consensus opinions of experts with many years experience in the field. The priorities are those perceived by the group as needing the attention of NRC and are presented irrespective of the perceived needs by NRC.

3. Aquatic Pathways - Radiological Subgroup

B. G. Blaylock
Y. C. Ng
R. B. Samworth
W. L. Templeton

Introduction

In general, the dose contribution to man through aquatic pathways is a relatively small percentage of the overall doses resulting from releases of radioactivity from nuclear facilities. Of course there are exceptions, depending on source term and use of the environmental resources, and in certain cases critical pathways have been identified as contributing a substantial percentage of the dose to man. For example, the small populations that consume and fish from the N.E. coast of the Irish Sea near the U.K. fuel reprocessing plant at Windscale (Hunt and Jeffries 1980).

However, since in most cases the percentage of the dose to man from aquatic pathways is relatively small and adequate methodologies are available for predicting dose to man, most of the groups recommendations are in terms of confirming or refining methodologies or evaluation of existing data bases. With the exception of validation studies, most of the recommendations are for research that can be accomplished in the 1-3 year time frame. While all the proposed research is cost/effective, the development and application of screening models coupled with de minimis levels would appear to be the most cost/effective.

Objectives of Assessment Programs

An aquatic radiological environmental assessment program is adequate if it accomplishes two objectives. First it should establish and quantify the relationships between the rate of radionuclide input to a water body and/or the resulting radiation doses to man as a result of consumption of water and aquatic food, and through recreational and other uses. The dose to the maximum exposed individuals in the local population should be considered as well as the population dose. The second objective is to establish whether radiation exposures through the aquatic pathways are within the exposure limits set forth in regulatory guides.

Adequacy of Assessment Programs

An aquatic radiological environmental assessment program consists of the literature data bases, preliminary site-specific data, dispersion models, analytical methodologies such as concentration factors and dispersion pathway models. An aquatic environmental assessment program is adequate when it identifies critical pathways and radionuclides and uses realistic parameters to predict concentrations in aquatic environments and hence the dose to man. The methodologies used in the assessment must follow those prescribed in current regulatory guides. However, the legal nature of the licensing process often appears to demand a greater degree of scientific understanding of the underlying processes and mechanisms than is necessary for effective decision making.

Assessment methodologies developed initially for studies of power reactor effluents should also apply equally well to other liquid releases from other stages of the fuel cycle. The only difference will be in the relative importance of applicable source terms and associated bioaccumulation factors.

Accidents

The models used to predict aquatic pathway doses for routine releases are also sufficient for predicting the potential consequences of hypothetical accidents and should be of value in determining protective action and health implications during and after a contaminating event.

During an actual accident more emphasis should be placed on actual monitoring than on the model predictions to overcome the potentially large uncertainties associated with modeling short-term, transient events.

Adequacy of Models

Transport models are available which can be used in radiological assessments to calculate dose to man from radionuclides released into the aquatic environment. Models are currently available to address all significant environmental pathways of potential importance to the radiological exposure of human populations. The use of models is the only mechanism by which an evaluation can be made to determine the acceptability of planned releases of radioactivity. Models must be relied upon to estimate radiological exposures in the environment when actual releases produce concentration in the environmental media that are below limits of detection. The accuracy required of environmental transport models will be dictated by the accuracy with which release rates, dose equivalent, and health risks can be estimated and by the level of uncertainties that can be accepted when model predictions approach prescribed exposure limits.

Recommendations

a. Bioaccumulation and usage factors presently defined in Reg. Guide 1.109 should be updated.

In general terms the basic model for the dose from the ingestion of radionuclides in aquatic foods can be written:

$$D = BFxCWxUxF$$

where

D = dose to man

BF = bioaccumulation factor, the ratio of the radionuclide concentration in the organism or tissue to that in water

CF = radionuclide concentration is water

U = usage (intake rate) of aquatic food

F = dose conversion factor

Default values of elemental BF values are listed in Regulatory Guide (R.G.) 1.109 for algae, invertebrates and fish of both freshwater and marine systems.

Research and/or efforts to improve current programs (i.e., to better meet the objectives or to be more efficient by returning more effective information at a reasonable cost).

(1) Bioaccumulation Factors

Current values of BF in R.G. 1.109 tend to be conservative values largely derived from a publication by Thompson, et al. (1977). Much field data on bioaccumulation factors have been accumulated from a variety of sites since the study by Thompson was published.

These more recent data should be used to correct and update the BFs. For example, the BF for niobium in freshwater fish is about 100-200 rather than the currently listed value of 3×10^4.

Field or experimental studies for additional BF values should be performed only if calculations using screening models with reasonable source terms reveal that a nuclide is potentially significant when the current BF value is assumed.

Bioaccumulation factors may span several orders of magnitude depending on measurement techniques, species of organism, water quality and water chemistry. The available data on BF should also be reexamined from the standpoint of establishing correlation with environmental factors, such as water concentration of the related stable element, water concentration of an analogue element, suspended matter, nutrient levels, etc. Thus, BF values for strontium in freshwater fish flesh were inversely correlated with the calcium concentration in water, while those for cesium in freshwater fish flesh were inversely correlated with the potassium concentration in water. Reevaluation of BF values can be expected to reduce the overall variability of BF values for site-specific assessments when characteristics of the site are taken into account. Furthermore, reducing the variability of BF values is desirable from the standpoint of reducing the overall uncertainty in the predicted dose from the ingestion of aquatic foods (see below), particularly when dose estimates approach allowable limits.

(2) Usage Factors

Default values of dietary intake rates for aquatic foods are listed in R.G. 1.109. A recent report on fish consumption by children, teenagers, and adults in various regions of the U.S. listed percentile values for intakes of freshwater finfish, saltwater finfish and shellfish. These data provide a basis for updating the usage factors for aquatic-food ingestion in R.G. 1.109 and for choosing appropriate intake rates for assessing the dose via aquatic food chains. It is interesting that the current default value for the maximum intake rate of fish corresponds to the 99th percentile and is about one-third the maximum of the distribution of marine-fish intakes.

b. The uncertainty in aquatic dose prediction models should be evaluated by 'imprecision analysis'

The potential distribution of the intakes or doses via ingestion of nuclides in aquatic foods can be evaluated by 'imprecision analysis.' In this approach the potential distribution of the predictions from a model is determined from the estimated distributions of the input parameters. Imprecision analysis was used to evaluate the potential variability of the thyroid dose from ^{131}I via the air-pasture-cow-milk pathway. Imprecision analysis has been applied to study the transport of ^{137}Cs and ^{90}Sr via aquatic pathways and can readily be extended to evaluate the intake and dose from the ingestion of other nuclides in aquatic foods.

Based on the distribution of BF values for cesium, strontium and iodine in freshwater fish, BF values can be assumed to be lognormally distributed. Similarly, usage factors for aquatic-food ingestion can be assumed to be lognormally distributed. It is implicit that the variability in the nuclide concentrations in water and t in the dose factors will be characterized.

None of the aforementioned is regarded as being of extremely high priority. On the other hand, much benefit can be derived for relatively little monetary cost.

c. Simplistic screening models should be developed for preoperational assessments.

Models are currently available to address all significant environmental pathways of potential importance to the radiological exposure of human populations. Simplistic models should be used for screening purposes for determining potential critical nuclide exposure pathways and population groups. For assessment purposes, simple models should be sufficient to determine an approximate level of exposure to assist in the decision-making process, especially when risks associated with uncertainties are relatively small.

d. De minimis levels should be established as a decision-making tool for screening models.

Presently the same degree of rigor is applied to environmental radiological assessments regardless of the source term quantities. However, except in a very few cases, estimated exposures from nuclear facilities appear to be a small percentage of the allowable limits. With the implementation of simple screening models it will be extremely cost-effective to establish de minimis levels or limits below which further assessment or monitoring would be required. Compliance would be demonstrated at the point of release.

e. Model Validation

One of the factors contributing to the degree of uncertainty is that few efforts have been made to validate with field data the transport and pathways models, submodels, or even the basic environmental parameters used in the models. In addition, to improve the quality of the existing models by confirming the accuracy or predicted values, validation studies could be designed that would include identification of those pathway submodels that could be simplified. Priorities for validation should be based on either an increased risk to human health or an encroachment upon decision-making levels prescribed by regulatory authorities. Priorities are needed because in most cases validation experiment will require a considerable commitment of time and financial resources. However, validation of basic parameters such as bioaccumulation may be accomplished through the use of monitoring data or through relatively short-term experiments.

f. Archived and current radiological aquatic monitoring data should be evaluated to determine its usefulness.

A substantial amount of radiological data has been collected as the result of monitoring programs at nuclear facilities. There is a lack of quality control in the collection of these data, and it may be of limited value. However, insofar as it is known, the data have been stored with no attempts at data reduction or analysis. This information should be evaluated to determine the value of the monitoring program and whether the data could be used for the validation of models. If preliminary evaluation of the data indicates that it would be useful in model validation, then it should be made available for such purposes. If it is not useful, then the objectives of the monitoring programs should be reevaluated.

g. Pathways monitoring at sites which operate at or approach ALARA levels to be evaluated for cost effectiveness

Improvements in engineering designs have enabled the release rates from reactors to approach the ALARA levels; hence, the need for pathway monitoring at such sites should be reevaluated and reduced to an appropriate level. At the front end of the nuclear fuel cycle there is still a need for improved radiological monitoring of aquatic pathways.

Priorities

Ranking	Title	Justification	Research Duration	Cost/ Effective
1(a)	Update bio-accumulation factors	Increased confidence in dose estimations	1-2 years	XX
1(b)	Update usage factors			XX
2	Uncertainty analysis	(as above)	(as above)	XX
3	Screening models	Reduction in NRC and utility effort for licensing	1-3 years	XXX
4	De minimis dose limits			XXX
5	Validation of existing models	Increased confidence in dose estimation. Highlight areas for research implementation.	1-5 years	XX
6	Evaluation of archived and current aquatic radiological data	Determine usefulness of existing information for impact assessment and validation	2-5 years	X
7	Evaluation of existing pathway monitoring	Determine cost effectiveness	1-2 years	XX

4. Aquatic Ecosystem Effects

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Method of Approach

The subgroup approach was to discuss the major issues presented by the Workshop organizers (Appendix V-A), construct a diagram of areas of concern in nuclear facility construction and operation, and to identify areas of needed research. Research needed was based on the above process as well as on an evaluation of results from previous aquatic assessments which were based on the experience of subgroup members.

After considerable discussion, the subgroup decided that consensus research projects should be presented, irrespective of perceived needs by the NRC. Even though NRC currently makes preoperational predictions of ecosystem changes due to facility construction and operation, we assumed that their responsibility and goal is to conduct research that will detect and evaluate changes occurring in components. Our suggested research should support that goal. Suggested research projects arrived at by consensus are prioritized in Appendix B.

Subgroup Scientific Statement

The position that construction and operation of nuclear facilities has caused no important effects on aquatic ecosystems seems to be based on the fact that few acute catastrophic events have been observed. Such a position is generally without a quantitative basis. The subgroup believes that nearly all monitoring studies conducted so far have not been based on statistical designs, which could detect impacts if impacts are occurring, or did, in fact, occur. We believe that monitoring programs, as presently designed, can detect only acute catastrophic impacts, but that long-term effects cannot be detected using current designs, methodologies and data evaluation procedures. We suspect, but cannot substantiate without further research, that chronic effects may have occurred. It seems imperative that NRC be in a position whereby the data are available to evaluate their preoperational/preconstruction assessments and that the methodology for those be improved. Such improved field designs should stress detecting population change since detecting modest changes in ecosystems is beyond the state-of-the-art.

Aquatic Ecosystem Issues

a. Can important components of aquatic ecosystems be identified, considering potential for effects, importance to the ecosystem and economic role?

The subgroup believes that the ability to identify important aquatic ecosystem components depends primarily on the definition of important. If importance is defined to be those components that have high economic or recreational value, then component identification is relatively simple. When importance is considered in an ecological context, however, identification can be more difficult. For most nuclear power plant sites, a consensus on what constitutes important ecological components is uncommon. For example, important ecological components could be those that are responsible for a large portion of energy flow in an ecosystem, are important links in the food chain, or are sensitive indices or integrators of ecosystem conditions. Micro-habitats involved in shaping ecosystem structure and function may also be considered important components. In most cases, important ecological components can be identified when food web structure of the ecosystem is known. Pertinent information needed to construct simple food chains may be found in the literature, based on data from prior surveys, or obtained from an intensive short-term (less than one year) surveillance program. In addition to the above, it may be possible to identify other structural or functional aspects of higher trophic level groups (e.g., predators) that are relatively simple to enumerate or measure, yet reflect ecosystem condition via their capacity to integrate changes in lower trophic levels. For example, growth or reproductive potential of upper trophic level organisms may reflect the status (acceptable or not acceptable) of lower trophic levels or other system processes (although this has yet to be proved).

b. Are sampling schemes and modeling methods designed to provide a defendable descriptions of important components of the ecosystem within the zone of influence of the plant?

In general, most sampling schemes can identify important economic or recreationally important components, but may be deficient in their ability to identify other important ecological components. Basic food web structure could be determined from the data of many monitoring programs, but critical microhabitats and/or functional integrative indices in general can not be identified. An important issue in this context is defining the "zone of influence" of the plant. Sampling schemes related to potential discharge impacts (thermal, chemical) have a better chance to describe important components in the discharge effects zone because the area of concern is relatively small and monitoring can be focused without dilution of sampling effort. Sampling schemes related to intake issues (impingement and entrainment) are not, in most cases, designed to describe important components because the sampling effort has to consider ecosystem level effects; this problem is complicated by immigration and/or emigration of organisms on a large geographical scale.

c. Can changes in ecosystem components be detected with sufficient resolution to describe effects of plant operation? Can such changes be related to plant operation?

The subgroup members recognize that four problems must be addressed in order to answer this question. As assessment of change implies that at least two measurements of an ecosystem component be compared. The first problem is an ability to detect change. This ability depends on the magnitude of change to be detected which in turn is affected by sampling variability for the ecosystem component. A second problem which logically follows is the ability of a monitoring program to separate apparent changes from natural variability, i.e., changes that naturally occur within the ecosystem. The third problem involves identification of changes resulting specifically from facility construction or operation, as opposed to changes resulting from other causes, i.e., fishery, other pollutants and stressors, and possible synergetic affects. Finally, assessment of changes resulting from specific facility operations, i.e., construction, impingement, entrainment, thermal, etc., must be made.

The subgroup believes that assessment programs have rarely been directed toward providing ecosystem measurements accompanied by estimable levels of detectability. Efforts to quantify changes in ecosystem component(s) which do not account for environmental variability (Eberhardt 1978) have resulted in studies where only large fractional changes could have been detected. With the exception of a few fish populations, the degree of natural variability is unknown for most ecosystem components (some estimates are in Eberhardt, 1978). Thus, the statistical significance of changes detected in past programs cannot be quantitatively assessed. The subgroup believes that separation and assignment of nuclear facility-related changes is currently beyond the state-of-the-art of aquatic ecosystem assessments but not necessary at the population level. Some alternative views are expressed in Green 1979, Fritz et al. 1980, Alevras et al. 1980, and Holling 1978.

While the subgroup agrees that serious environmental impacts have not been demonstrated, we do not agree that serious impacts (undetected) will or have not occurred (long-term). Thus, it is our position that ecosystem changes cannot (at present) be detected with sufficient resolution to describe effects of plant operation on aquatic populations quantitatively.

d. <u>Are sampling methods, data collection, and modeling techniques adequate and quantifiable?</u>

The subgroup believes that data collection and sampling are adequate and quantifiable for some specific circumstances (i.e., benthic organisms in some water bodies) but not in others. Methods for sampling fish population fall in the latter category because concomitant variance estimates are often large. Such abundance estimates are useful only in detecting large, nearly catastrophic changes. Because of this, resource managers utilize long-term data sets, usually longer than ten years, and frequently with large numbers of samples, to assess population changes. The subgroup believes that research to develop new or improved methods for obtaining more reliable population estimates is needed. This need is independent of questions like compensation.

The subgroup consensus on models, at least those generally thought of as simulations of real systems, is that they are generally not adequate for predicting population changes resulting from facility construction and operation. Reasons include a lack of parameter estimates, a poor understanding of the mechanisms for population regulation in aquatic populations, and lack of validation.

e. <u>Are data interpretation, analysis, archiving and modeling adequate to provide ready access to useful and reliable information? Are the data used to describe plant effects on important aquatic ecosystem components in a meaningful way?</u>

The subgroup concluded that most reports of environmental monitoring efforts are not very useful in evaluating the effects of facility construction and operation on biota. Aside from the problems of adequate field designs and the collection of data over long time frames (i.e., personnel, gear and frequency of sampling changes, etc), experience of subgroup members indicates that yearly printed compendia of either summarized or raw data sets (usually accompanied by a discussion of questionable relevancy) are not adequate to a quantitative and in some cases, even qualitative assessment of aquatic effects caused by nuclear facility construction or operation. Reasons for this include either inappropriate or lack of statistical analyses vis-a-vis the impact question. Moreover, even when yearly reports include a valid statistical evaluation of data, the conclusions are generally restricted to data collected during that year; again not very useful in assessing the impact hypothesis. Several extant reports and papers discuss and amplify on these points (i.e., Gore et al. 1976, 1977, 1977a, 1977b, 1979; Adams et al. 1977a, 1977b, 1977c, 1977d; Murarka et al 1976a, 1976b, 1976c, 1976d, 1976e; Eberhardt 1976; Thomas et al. 1978; Thomas and McKenzie 1979; and Skalski and McKenzie 1982). The subgroup believes, however, that there have been, and may still be some exceptions to the generalizations above.

Finally, to our knowledge, only one limited attempt has been made (in computer compatible formats) to archive data collected for future analysis (EPRI Report from Ecological Analysts).

f. Has the potential for synergistic effects been considered?

Because few studies have been conducted to examine the existence or magnitude of synergistic interaction of chemicals or chemicals and heat, it is currently not possible to predict the effects of such interactions on aquatic biota. Potential interactions of importance include temperature, chlorine, copper and corrosion inhibitors (e.g., chromate, sulfuric acid, etc.).

Several studies have indicated that sensitivity of aquatic biota generally increases with temperature (see reference in Cairns et al. 1975) and for the biota tested, sensitivity can vary severalfold. Even so, most toxicity studies have been conducted at 18-20°C. The problem is further complicated by the fact that the degree of sensitivity (compared to normal temperature ranges) appears to vary among species. In addition, currently available data are insufficient to evaluate the effect of chemical species of chlorine (i.e., hypochlorous acid, hypochlorite ions, inorganic chloramines, organic chloramines) on the magnitude of the shift in sensitivity. Studies of temperature and chlorine interactions and their effects on sublethal effect endpoints have not been conducted.

Only a single study (Tsai and Mattice 1980) has been conducted which has potential application for assessment of the interactions of chemicals in power plant effluents. Copper and monochloramine (NH_2Cl) were found to be additive or synergistic, depending on the relative proportions of the two chemicals in the mixture. Since exposure was 96 hours, the application of such results to power plant effluents is tenuous since neither exposure temperatures nor exposure duration mimics conditions at power plant sites.

Needed Research

Consideration of the issues in the preceding section and Table 2 led directly to formulation of research recommendations. These primarily related to past sampling programs conducted for both preoperational environmental assessments and operational monitoring at nuclear power plants. As indicated in discussion of issues, the general subgroup conclusion was that these programs have been deficient in terms of direction of effort, quantification of information, and ability to detect change in the receiving water body biota. Additionally, environmental assessments have been based largely on independent consideration of the various stressors without regard for the possible modification of effects resulting from stress or interaction and/or coincident contact with biota. Several of the research projects presented below are directed toward overcoming these deficiencies.

A workshop was suggested as a result of constructing Table 2. The objective of this workshop would be to assess the area of cooling system fouling by the Asiatic clam *Corbicula*. Recent findings at Arkansas Power Unit II indicate that this species has become an important safety issue for nuclear power plants, as well as an economic issue for all power plants with freshwater cooling systems. The project (workshop) advocated by the subgroup is specifically directed toward efficient development of control procedures.

a. Statistical Design(s) for Monitoring

Research Recommendation

Field designs and methods for statistical analyses that will provide guidance for aquatic monitoring programs assessing the impact of construction and operation should be provided to licensees. Estimates of detectable population change are needed, expressed in terms of the size of difference which could be detected by the study. Results would allow NRC to quantify an expression of "no important effects of operations" and permit an evaluation of the adequacy of

TABLE 2. Diagram of Aquatic Ecological Monitoring Programs, Possible Research Needed for Improvement

Objective: Detect and Evaluate Change in Components of Aquatic Ecosystems Due to Facility Construction and Operation

Monitoring Purpose	Monitoring Programs	Monitoring Decisions
	Pre-Operational Prediction(NRC)	
1. Detect catastrophic events	A. Designs	
	B. Statistical and field methods	
2. Detect long term cause and effect	C. Adequate valid data	
3. Validate models		How often, which...where
		1. Population(s)
		2. Key components and/or function
	Operational	
	Other agencies (EPA, States)	
	A. Designs	
	B. Statistical and field methods	
	C. Adequate valid data	

TABLE 2. (continued)

Causatine Agents of Effects

Non-Specific	Chemical	Safety or Public Concerns	Kinds of Facilities	Scope of Studies	Condition Studied
Heat	Chlorine	Microbes Viruses	Nuclear Power Reactors	Site specific	Normal operation
Impingement	Copper				
Entrainment	Chromates	Corbicula			
Periodic Conditions		Endangered Species			
Cold Shock	Organics in Cooling Towers				
			Total Fuel Cycle	Regional	Accident (class)

these statements. In addition, a quantitatively valid means for assessing the cost-benefit of field studies would be provided.

Rationale

Since NRC's responsibility is to make preconstruction/preoperational predictions of potential changes in ecosystem components due to facility construction and operation, a quantitative basis for these predictions is needed. Even though other agencies (EPA, state government) are subsequently involved in requiring operational data to satisfy their particular requirements, data collected by other agencies should be used by NRC to verify their preoperational predictions.

At this time, the quantitative basis for designing monitoring programs (based on statistical criteria) required of licensees is insufficient. Field designs and methods of statistical analysis with estimable a priori power and reliability (e.g., a 20% change can be detected 80% of the time at an estimable level of labor effort) are not available. In order to obtain valid designs, the subgroup believes a two- or three-year program should be initiated to collect the needed data or, if possible, to use available data to obtain and promulgate designs and methods for statistical analysis. However, the subgroup favors the concept of short-term pilot studies to estimate natural variability among and within sampling locations. Studies at plants under construction as well as operating plants are encouraged. These can be used to estimate the number of samples needed to verify impact with known statistical reliability. The subgroup suggests efforts using population abundance estimators. Measures of ecosystem function are suggested as an additional research task below.

The subgroup believes that the field use of the designs developed will allow NRC to make quantitative statements about nuclear construction and operation effects on aquatic ecosystem components. Currently the commission is in the unenviable position of communicating to the public that insofar as they know, effects have not been observed. Such statements are without scientific credibility when the size of differences which could be detected are unknown.

b. Compensation

Research Recommendation

The subgroup recommends NRC participation in an EPRI-funded compensation workshop (February 9-11, 1982). This could provide a basis for NRC decisions regarding research funding on compensation questions most relevant to their needs.

Rationale

As evidenced by controversies at Indian Point regarding the impacts on striped bass, compensatory mechanisms in fish populations are important for interpreting direct effects of power plant operation (e.g., impingement-entrainment) at the population level. Because empirical data upon which to evaluate the existence of compensation are largely nonexistent, predictions of impacts, particularly on fisheries at the population level have diverged widely without any reliable basis for deciding which prediction is accurate. Provision of such data is critical to assessment in situations where the significance of power plant impacts is in question.

c. Control of Corbicula

Research Recommendation

The subgroup recommends a workshop to: 1) summarize past and potential problems at power plants caused by Corbicula fouling; 2) review current control practices and their efficacies; and 3) propose control procedures which appear feasible considering the life cycle characteristics, physiology, tolerance, etc., of Corbicula and the likely responses of nontarget organisms.

Rationale

Because of past shutdowns of power plants due to Corbicula fouling of service and emergency cooling systems and the prospect that populations will increase in the future, it is time to synthesize present information on Corbicula and to assess control methods at power plants. A number of utilities have had to contend with and combat Corbicula fouling, generally at significant cost. Some mitigation methods have apparently been at least partly successful while others have not. The rapid growth of research on Corbicula since the early 1970's has also provided a large informational base on the organisms biology. However, communication between researchers and utilities, as well as among utilities has been almost nonexistent. Information exchange between utilities addressing the problem and those with an understanding of the organism offer the best chance for evaluating the most likely procedures/methods for Corbicula control. In addition, since the subgroup believes that is essential that nontarget species in the receiving water body be unaffected, workshop participants should include experts in aquatic toxicology.

d. Evaluation of Synergism

Research Recommendation

Research designed to determine the toxicity and interaction(s) of hat, chlorine, copper, and standard corrosion inhibitors should be initiated. Combinations should include those likely to be released during power plant operations. Several representative fish species (a minimum of three each from marine and freshwater) should be studied. Exposure times should be similar to those found at power plants (e.g., 2 hours for combinations including chlorine, and approximately 96 hours for other compounds). Chemical speciation should be determined and should simulate actual conditions. Additive equations are recommended to determine the types of interaction(s) occurring at various relative concentrations of chemical species in test systems. Follow-up studies could be conducted to estimate effects at other combination levels.

Rationale

Conclusions regarding possible effects of toxicants released at power plants have depended on comparing effluent concentrations with toxicity thresholds for each sep[illegible] chemical. Inherent in this treatment are the assumptions t[illegible] toxicity of each chemical is independent and that the thresho[illegible]s are valid for all effluent temperatures. Both appear unlikely based on present data, but further work is needed for verification. Without data on the interaction of various chemical/physical factors on toxicity, valid questions may be raised regarding conclusions about the occurrence or magnitude of possible environmental impact(s).

e. Preoperational Impact Prediction Methodology

Research Recommendation

A research effort should be undertaken to design improved preoperational impact prediction methodologies. Initial work should review and improve on current impact predictions included in environmental impact statements for nuclear facilities. The objective would be to devise research methods and guidelines that lead to environmental assessments with more explicit (quantitative) impact predictions and associated uncertainty measures. These guidelines should address the levels of predictability in aquatic systems, levels of natural variability, and factors thought to influence the direction and magnitude of potential impacts. The ability to integrate the effects from multiple stressors that are facility related, as well as with others within aquatic systems, is anticipated as an important issue to be addressed. A major objective should be the development of impact predictions which can be subsequently tested and evaluated during facility operation.

Rationale

It appears to the aquatic subgroup that available quantitative methodology for predicting operational impacts during the preoperational stage at nuclear facilities is inadequate. Our experience leads us to conclude that environmental impact statements are primarily qualitative evaluations of short-term effects from single stressors. While the evaluations have apparently not been contradicted by current operating experience, the subgroup recommends that improved quantitative predictive methodology be developed. One area which needs improvement is the prediction of impacts resulting from an integration of all stresses within aquatic ecosystems. Development of methodology to evaluate long-term effects is recommended. Predictive methodologies should include quantification of impacts and uncertainty measures.

Predicted operational impacts must be testable using data from operational field monitor programs. The subgroup believes that methods of preoperational impact prediction which cannot be tested should be revised or changed or should result in research efforts which provide methods of field validation. In those circumstances where field validations are conducted, results should be used to evaluate and make changes in methods of preoperational predictions.

f. <u>Ecosystem Key Component Research</u>

Research Recommendation

Research should be sponsored to evaluate the key component approach as a method to investigate power plant effects on ecosystems.

Rationale

Monitoring programs, using the concept of important ecological components, have potential for detecting both short- and long-term effects of power plant operation. Possible approaches for investigating ecosystem response to stress are to: 1) intensively monitor all or some components of an ecosystem; 2) predict ecosystem response using mathematical simulation models; and 3) use key components of ecosystems that integrate important structural and functional aspects of ecosystems and thus reflect ecosystem condition. The feasibility of the first approach depends on the number of components studied. When many are studied, there is generally not enough information collected to clearly demonstrate effects/no effects clearly. Moreover, evaluation of preoperational predictions is restricted because of the inordinate requirements of cost, manpower or time. The second approach suffers from a lack of adequate empirical data and a lack of methods for validation.

Examples of key ecosystem components are those that contribute a large proportion of energy flow to a system, are important links in the food chain, are sensitive indices or integrators of ecosystem condition, or are important microhabitats that shape ecosystem structure and function.

Data from recent preliminary studies (Adams et al. 1982, Heidinger and Crawford 1977, Bulow et al. 1978) suggests that several physiological indices of predators (e.g., liver-somatic ratio, fat storage-somatic ratio, and gonadal-somatic ratio) show considerable promise as indicators of ecological change and integrators of processes occurring at lower trophic levels. These methods may be especially useful when power plant operation affects lower trophic levels, i.e., entrainment of phytoplankton and zooplankton. The gonadal-somatic index (as affected by power-plant operation) maybe translated directly into long-term effects on predator population structure by investigating future shifts in the length-frequency distributions of the major age classes of aquatic predators.

g. Other Potential Research Areas

In addition to the discussion of major issues and the research recommendations, the subgroup considered other potential research in its discussion of Table 2. While the overall purpose of the Workshop was to address all aspects of the nuclear fuel cycle (uranium milling, plant construction and operation, and waste disposal) the subgroup focused on generic monitoring methodology useful in quantitatively evaluating aquatic effects of nuclear operations. Some attention was given to the effects of cooling systems, effluents and biocides used at nuclear power plants.

Because of lack of expertise within the subgroup, we elected not to direct our efforts specifically to other components of the fuel cycle. The subgroup did not consider accident scenarios both because of site specificity and the fact that ecological monitoring programs (at least initially) would be short term and probably pragmatic (i.e., presence or absence of important species). Regional monitoring was not considered because of time constraints.

Other areas illustrated in Table 2 and not specifically addressed in the issue or research sections were considered and the subgroup either could not decide on specific new needed research or did not perceive the problem as needing immediate NRC consideration.

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APPENDIX V-B1. AQUATIC ECOSYSTEM ISSUES

Can important components of aquatic ecosystems be identified, considering potential for effects, importance to the ecosystem and economic role?

Are sampling schemes and modeling methods designed to provide a defendable description of important components of the ecosystem within the zone of influence of the plant?

Can changes in populations be detected with sufficient resolution to describe effects of plant operation (including those resulting from water quality changes, impingement, and passage through the plant as well as those from physical structures, water circulation, and other factors)? Can such changes be related to plant operation?

Are sampling methods, data collection, and modeling techniques adequate and quantifiable?

Are data interpretation, analysis, archiving and modeling adequate to provide ready access to useful and reliable information? Are the data used to describe plant effects on important aquatic ecosystem components in a meaningful way?

Has the potential for synergistic effects been considered?

APPENDIX V-B2. RESEARCH PRIORITIES

Priority	Title	Research Duration
1	Sampling Designs for Monitoring	I
1	Compensation	L
2	Control of *Corbicula*	S
2	Evaluation of Synergism (Chemicals, heat)	S
3	Preoperation Impact Predicting Methodology (Multiple Stressors)	I
3	Ecosystem Key Components Research	I
Individual Contribution	Thermal Niche Analysis for Estimating Exposure of Toxicants to Fish (see next page)	

Short: 1-2 years

Intermediate: 2-5 years

Long: Over 5 years

THERMAL NICHE ANALYSIS FOR ESTIMATING EXPOSURE OF TOXICANTS TO FISH

Research Recommendation - Individual Contribution

Research designed to investigate the relationship between fish distribution as dictated by temperature and the distribution of toxicants such as chlorine in the thermal effluent zone of a power plant is needed.

Rationale

Based on the known thermal preferences of various sizes and species of fish, the distribution of fish in the thermal effluent zone of a power plant can be predicted so that fish distribution can be related to toxicant distribution. This information can be used to predict probabilities of toxicant exposure to various species and sizes of fish.

Fish are distributed in aquatic environments according to their temperature preference and food availability. Several studies have shown (references Marshall) that temperature is the dominate environmental factor that influence fish distribution. There is considerable information on the thermal preference of many sizes and species of fish. The distribution of toxicants in the thermal zone of a plant can be predicted based on thermal dispersion models. Thus, using estimates of fish and toxicant distribution, probability and amount of exposure can be estimated.

5. Transport and Fate of Contaminants Subgroup

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In the application of any evaluation methods for environmental assessment, the simplest model which can provide the required sensitivity and level of conservativeness for the application must be chosen. For example, the workshop participants recognized that initial dose calculations should be made using a simple conservative model. If this simple conservative approach indicates non-compliance, then the use of more complicated method should be employed to improve the accuracy of the assessment and to reduce the uncertainty.

The existing methods and models, including those currently under development (e.g., radionuclide transport models including sediment interactions), are generally adequate to describe the physical and chemical behavior of radioactive materials released to aquatic media from fission-derived energy generation, Hunt and Jeffries 1980. Nonradioactive chemicals, however, such as chlorine and copper, have not been developed to the same degree of adequacy.

Although current analytical methods are generally adequate to describe water quality characteristics with sufficient resolution, current sampling schemes are generally not adequate to provide temporal and spacial descriptions of plant effects. Furthermore, models are not validated to provide such information with confidence. Ground-water modeling of fractured media has not been proved adequate nor has it been tested.

Data interpretation, analysis, modeling and archiving are not adequate to provide ready access to reliable information. Nor are the data used to describe effects on water quality in a meaningful way.

Thirteen research areas have been identified as worthy subjects of future research. The goal of such additional research is to improve the accuracy of or to reduce the uncertainty of environmental assessments pertaining to the transport and fate of both radioactive and nonradioactive material. The items that follow are listed in order of perceived importance.

High-level waste management and mining/milling operations have not been considered in arriving at the following list of aquatic transport and fate research needs.

RESEARCH NEEDS ON PHYSICAL AND CHEMICAL PROCESSES IN AQUATIC MEDIA

Priority	Need
1	Source characterization
2	Model simplification and validation.
3	Development of field sampling protocols.
4	Estimation of uncertainty in exposure estimate.
5	Completion of development and testing of transport and fate models for sorbed radioactive and nonradioactive materials and investigation of sorbed containment uptake by biota.
6	Chemical mechanisms in geologic media.
7	Laboratory experiments on fine sediment transport.
8	Feasibility study on application of risk assessment techniques to the environment - NEPA process.
9	Development of multimedia radionuclide transport and fate assessment methodologies.
10	Remedial measures for mitigation of ground-water radionuclide releases to surface water due to a core meltdown.
11	Assessment of chlorine releases from nuclear power plants.
12	Transport and transformation of heavy metals in fresh water.

13 Assessment of ^{32}P and ^{55}Fe releases from nuclear power plant.

14 Portable instruments on radioactivity measurements.

a. Source Characterization

The sources of radioactive and nonradioactive contaminants released from severe power plant accidents have not been well defined. Nor are routine nonradioactive releases well known. Since the accuracy of any further analyses of contaminant transport and fate depends on the accuracy of source characterization, it is essential to have a reasonable characterization of source strength. Unfortunately, source characteristics are too site-specific to be uniformly researched.

b. Model Simplification and Validation

The proper use of models for any application requires the selection of models that can provide required sensitivity and level of conservativeness appropriate to a specific problem. An appropriate model is one that is capable of describing the important physical and chemical processes active in a particular environment at a resolution level consistent with both available data and management needs. It is generally desirable to use the simplest model for a particular application, as long as that model satisfies particular needs for the problem of concern. A rational basis must be developed for selecting the simplest model to a specific application. Validation and comparison of models to identify the accuracy and applicability of each model should also be a part of this study. The study should be tailored to the types of analyses required in assessing the aquatic environment.

Justification: When applying transport and chemical models, an analyst is faced with a number of alternatives. Normally, it is best that he choose the simplest appropriate model because the simple model is:

- easier to use,
- less expensive to use,
- tends to require fewer input data, and
- produces results that are more easily understood.

How does one know that a simple model is adequate? The model is considered adequate if it describes the relevant physical and chemical processes to a degree that the uncertainty of the simulation results does not affect the assessment of impact on biota and man.

Models are validated by comparing model results with actual data from the system the model is trying to simulate. Criteria for evaluating such comparisons need to be established, however. Simple models may be partially validated by comparing their results with those of more sophisticated models. One-dimensional modeling results, for example, may compare favorably with results from three-dimensional models. Although decisions about model complexity are of necessity highly site- and application-specific, some general guidance must be provided if model results are to become more credible.

c. Development of Field Sampling Protocols

Field sampling protocols should be developed involving the use and development of statistical methods for designing and implementing monitoring requirements at power plants or other nuclear facilities. Data volumes would have to be reduced to a meaningful level for regulatory processes.

Justification: Radiological and nonradiological monitoring requirements under routine operating conditions have increased the cost of monitoring nuclear power plants. It is expensive to buy and install instruments, collect data, and report the results. Unfortunately, the purposes, uses, and the appropriateness of monitoring needs are not well defined or understood. Through research, the NRC should examine the rational and scientific basis of using field sampling protocols for surveillance at nuclear power plants.

The benefits of this research would be twofold: protocols would reduce costs to the NRC and the plant operator, and would provide a better sampling network for surveillance at nuclear power plants.

d. Estimation of Uncertainty in Exposure Estimates

Risk evaluations should include estimates of uncertainty regarding exposure via aquatic pathways. A wide variety of statistical techniques is available for estimating uncertainties of predictions. These methods should be reviewed in relation to the estimation techniques used. For each estimation technique, guidelines specifying uncertainty calculations should be developed. These may range from specification of sensitivity tests for mathematical models to specification of statistical procedures for characterizing the probability of occurrence of rare events based on limited monitoring data.

Justification: The Nuclear Regulatory Commission has expressed a need to have more complete information about risk and aquatic exposure, and about the uncertainty of predicted concentrations and the frequency of occurrences at given concentrations. Statistical methods covering a wide variety of problems are able to perform uncertainty calculations. Consequently, it appears to be feasible to establish guidelines for performing uncertainty calculations.

e. Completion of Development and Testing of Transport and Fate Models for Sorbed Radioactive and Nonradioactive Materials and Investigation of Sorbed Contaminant Uptake by Biota

Development and testing of radionuclide transport/fate with sediment interaction should be completed and the uptake of sorbed radionuclides by aquatic biota should also be investigated as a part of food chain. If the uptake of radionuclides or nonradioactive materials by organic/inorganic matter is found to be important, then a method must be developed to connect the exposure levels of sorbed contaminants to the ecological food chain.

Justification: Transport models for radionuclide/nonradioactive materials for rivers, lakes, estuaries and coastal waters are being developed by several researchers. This effort should be completed so that NRC can use these models so that simpler screening methods could be used to identify possible noncompliance problems under certain conditions. These models with sediment interactions provide more potentially accurate predictions of contaminant concentration levels and durations to reduce the uncertainty. Since these methods provide sorbed containment concentrations, as well as dissolved concentrations, the ecological impact of contaminants in both phases must also be examined.

f. Chemical Mechanisms in Geohydrologic Media

The purpose of this research is to provide a better understanding and a useful data base for a wide range of chemical reactions that occur in ground-water transport applications. The retardation mechanism needs to be validated for a range of contaminants and geologic media. The reactions to be investigated include, for example; chelation sorption, ion exchange, precipitation and dissolution. This research will involve a great deal of time and money. Because of the wide application of this fundamental research, NRC should coordinate its efforts with other agencies and universities that are already doing research in this area.

Justification: Attenuation of radionuclides or other types of contaminants is a major source of uncertainty in many ground-water transport applications. One of the main factors contributing to this uncertainty is a general lack of data to describe reaction mechanisms in geohydrologic media. The credibility of any fate predictions will hinge on the adequacy of the data used. Usually, chemical mechanisms are described by a semi-empirical retardation coefficient in transport models. In model applications, this coefficient is often chosen in an arbitrary manner. Without a more complete data base, predictions will have to rely on overly conservative estimates of retardation parameters.

g. Laboratory Experimentation on Fine Sediment Transport

Laboratory flume experiments to study transport, deposition, and erosion of fine sediments of both organic and inorganic materials must be conducted. Especially, the functional relationship of sediment deposition/erosion and flow/sediment characteristics must be investigated.

Justification: Many radionuclide and nonradioactive materials are absorbed by fine sediment. Hence, transport, deposition, and suspension of sorbed contaminants are directly affected by the movements of fine sediments of both inorganic and organic materials. Unfortunately, functional relationships between erosion/deposition and flow/sediment characteristics are poorly known. To obtain more accurate estimates of contaminant transport, fine sediment transport mechanisms must be identified, especially under what conditions, and at what rates fine sediments are deposited and/or resuspended. This should be examined in laboratory flume experiments under controlled and widely ranging flow and sediment conditions.

h. Feasibility Study on How Risk Assessment Techniques Apply to NEPA

A feasibility study is needed on how risk assessment techniques apply to the NEPA process. The study should examine the probabilistic approach in estimating the environmental impacts of nuclear station operations.

Justification: Justification for this study is described in "Pre-operational Impact Prediction Methodology" under Aquatic Ecosystem Effects. (See page 110)

i. Development of Multimedia Radionuclide Transport and Fate Assessment Methodologies

Methodologies assessing radionuclide transport and fate in multi-media (air, water, and soil) must be developed so that contributions of radionuclides from one medium to another can be correctly incorporated in the dose assessment. Especially the transfer of radionuclides from air to surface water or air to overland to surface water must be assessed. These methodologies may include:

- simple screening methodology, and
- more mechanistic computer-model based methodology.

Justification: Atmospheric releases from severe nuclear accidents consist of gases (e.g., radioiodine, noble gases) and particulate matters. Releases to potential aquatic pathways from severe nuclear accidents have not previously been assessed probably because their impacts are regarded to be small compared to inhalation doses resulting from atmospheric releases of iodine and noble gases. However, these aerosol releases could be an important factor for aquatic pathway assessments, because aerosols can be deposited directly to large surface water bodies (e.g., the Great Lakes) or onto the watershed thereby reaching surface water. Previous studies on pesticides and other contaminants indicated that 1-5% of total deposits on land surfaces may wash off annually from watersheds into receiving surface waters via runoff and soil erosion.

A particularly important case for nuclear power plants might be the Great Lakes, which consists of:

- confined water bodies,
- fresh water,
- relatively large water surface area compared to its watershed, and
- tens of millions of users along the lake shores.

Several useful approaches to this problem are:

- Fallout data can be used to estimate runoff of sediment from watersheds. By estimating radionuclide concentrations per unit weight of sediment, scientists can turn the problem around to directly estimate radionuclides getting into surface water.

- Multimedia models being developed for acid rain runoff or pesticide calculations could be used as a basis for radionuclide atmospheric/ ground-water surface models.

j. <u>Remedial Measures for Mitigation of Ground-water Release to Surface Waters Due to a Core Meltdown</u>

This research addresses several questions simultaneously:

- What measures (grout walls, intercepter wells, drains) can be used to mitigate the ground-water pathways?

- How effective will alternative measures be?

- What are the logistical considerations of implementing remedial measures on an emergency basis?

This research will be generic, but several typical rock, soil, and hydrological conditions should be considered. This effort could later be extended to a specific site for detailed analysis.

Justification: Remedial measures for ground-water pathways have not received much detailed analysis. The analysis can use existing ground-water flow and transport models. However, the need exists to research the effectiveness of alternative measures. The selection of measures for a particular emergency would be based on site-specific information and analysis. A generic analysis at this time would be useful in that it would provide:

- An example of the level of analysis that is required for emergency planning;

- A generic analysis for preliminary guidance in site-specific planning; and

- A document that could be reviewed by the academic and public community. The reviews might indicate areas that have not been adequately addressed.

k. Assessment of Chlorine Releases from Nuclear Power Plants

Source Term Identification of Chloro Compound

A need exists to identify specific halogenated organic compounds, i.e., halorganic, halophenolic and other chlorine by-products released to the environment from operating nuclear power station cooling systems. In cases of nuclear power stations using cooling towers, research is also needed to identify these halogenated organic compounds in the blowdown and releases to the atmosphere.

Methods of Analysis of Chlorinated Hydrocarbons

Analytical methods are needed to analyze for individual halogenated organic compounds in cooling tower releases and in the atmospheric environment surrounding cooling towers.

Human Health Impacts

A need exists to assess individual and population human health impacts from halogenated organic compounds released to the environment from nuclear power stations. To date, health impacts from releases of halogenated organic compounds to the environment have not been assessed.

Model Development and Validation

Models to predict the transport of halogenated organic compounds released to lakes, rivers, oceans and estuaries from nuclear power stations should be developed and validated. Models should initially be developed which take into account chemical reactions, dilution, dispersion, and sediment characteristics in the receiving water body.

Sublethal Impacts on Aquatic Biota

The sublethal impacts of halogenated organic compounds on aquatic organisms exposed to nuclear power station discharges needs to be addressed. Information and data on acute toxicity effects are fairly well known, but information on chronic effects of concentrations of chlororganic compounds in the parts-per-million and parts-per-billion ranges is nonexistent.

Dechlorination

Effects of dechlorination of cooling water releases to the environment must be examined.

Alternative Biocides

Possible environmental impact due to the use of alternatives to chlorination of cooling waters must be studied.

Justification: The NRC is required to assess the impacts of nuclear power station releases to the environment, as mandated by the National Environmental Policy Act and the Commission regulations, 10 CFR Part 51. A recent Atomic Safety and Licensing Board ruling has indicated that NRC is required, under NEPA, to address the issue of health impacts of chlorine releases to the environment which have not been adequately addressed.

1. Transport and Transformation of Heavy Metals in Fresh Waters

Models and correlations have been developed for predicting the movement of heavy metals in surface water environments. These models and correlations have not attempted to predict species or forms of metals. Building on existing descriptions of commonly occurring chemical reactions and equilibrium distributions, species-specific transport models should be developed for heavy metals. Precipitation and ion-exchange phenomena should be included. Reaction rates should also be included where rates are slow enough to preclude the assumption of local equilibria.

Justification: NRC has encountered a number of problems in which a release of heavy metals from operating plants is a source of concern related to adverse environmental impacts on downstream fisheries. The specific examples cited are the effects of copper on bluegill fisheries downstream of the H. B. Robinson Nuclear Station and the impacts on the abalone following condenser testing in the Diablo Nuclear Station. The form of metal in the water directly affects the metal's rate of movement and availability for uptake. A great deal of information on the equilibrium chemistry of metal compounds is available. And to a lesser extent, on the metal reaction rates under various environmental conditions. Consequently, it appears to be feasible to modify existing models or to develop new transport models to account for chemistry of metal compounds and their reactions.

m. Assessment of ^{32}P and ^{55}Fe Releases from Nuclear-Power Plants

A further assessment of the transport, fate, and ecological impact of ^{32}P and ^{55}Fe releases to the aquatic environment from operating nuclear stations should be performed.

Justification: The regulatory agency is required to assess the environmental impacts of these radionuclides as part of the environmental review process. To date, these radionuclides are not adequately assessed.

n. Portable Instruments for Measuring Radioactivity

More readily usable instruments should be developed for in-situ measurements of radionuclides.

Justification: One of the difficulties of measuring radioactivity in the environment is related to the great length of time it takes to get data back from the laboratory. The delay usually makes it too late to check interesting anomalies or patterns. Simple detection systems having high sensitivity and resolution for field use are needed.

We realize that we are pushing against physical limits, but in view of the great strides made to date, we hope further gains will be made.

Two radionuclides of particular interest requiring simpler analytical procedures for measurements are phosphorus-32 and iron-55. We encourage further research to ease the difficulties involved in measuring these and other radionuclides in the low levels in which they occur in the environment.

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Hunt, G. J., and D. F. Jeffries. 1980. "Collective and Individual Radiation Exposure from Discharges of Radioactive Waste to the Irish Sea." In Symposium on the Impacts of Radionuclide Releases into the Marine Environment, pp. 535-570, IAEA/NEA Vienna, 1981.

C. Atmospheric Pathways

1. Issues

a. Starting at the source and working toward the receptor, what models and monitoring methods are in general use in environmental assessment?

- Are technically better or more realistic models or methods available?
- If so, is their use justified, and what are the impediments to their use?
- Would further development of the models or methods make them useful?
- If not, is there a need for better models or methods?

b. What are the relative uncertainties in the estimation of source terms, the evaluation of atmospheric transport, diffusion and depletion, and the estimation of dose from air and surface concentrations?

- How do these uncertainties propagate in time and space?
- Are there some areas of uncertainty that are more important than others? For example, is the uncertainty in plume position of more, equal or less importance than the uncertainty in dose conversion factors?
- How does the relative importance of the various areas of certainty vary as the aspect of environmental assessment being considered changes?

c. What are the limitations on environmental assessments based on models?

- How and in what level of detail should these limitations be addressed in the assessments?

d. What are the limitations on interpretation of the results of a small set of measurements?

- How does the representativeness and interpretation of the measurements change with changes in sampling duration.

- How reliable are models in working from a measurement backward to the source?

2. Discussion

John P. Bradley, Chairman

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Environmental assessments are prepared for plant construction, routine plant operations, and for decommissioning. They are also required in the event of an emergency. The atmospheric pathway portion of environmental assessments in an emergency is the same as during other conditions except that the response time in an emergency is much shorter. In addition, the uncertainties associated with the assessments during an emergency are greater than those associated with assessments in other conditions. As a result, the atmospheric pathway working group concentrated on evaluation of the status of information available for use in assessments during accidents and on the identification of research needs for that application.

Problems associated with the atmospheric pathway in environmental assessments arise in attempting to answer the basic questions: Where is the material going, when will it arrive at exposed populations, and what will the concentration be when it gets there? The first two of these questions refer to atmospheric transport. The last refers collectively to the process of diffusion and transformation of the material in the atmosphere and to the depletion of the material by deposition. To answer these questions, it is necessary to determine the characteristics of the effluent as it is released, describe the processes that affect the effluent in the atmosphere and characterize the atmosphere.

The working group considered the following components of atmospheric pathway assessments: source term characterization, transport, diffusion, deposition and depletion. In addition, they considered methods for measuring and monitoring the atmosphere and material released to it. These areas clearly overlap. For example, the separation of transport and diffusion depends upon an arbitrary definition of time scales of interest. It is also clear that characterization of the source is a prerequisite to evaluation of transport, diffusion, transformation, and depletion of the effluent.

Source term characterization is important in the evaluation of effluent transport, diffusion and transformation. Specifically, the effective height of release determines the wind regime that will transport the material and affects the initial dilution of the material near the release point. Estimation of the effective release height requires information on the actual release height, the effluent flow, and the effluent temperature. Given this information, existing equations can be used to estimate effective release height (e.g., Briggs 1969). However, these equations may not be accurate for releases that might accompany large breeches of reactor containment.

If the effective release height is low as in vent releases, it is necessary to determine if the effluent becomes entangled in the aerodynamic wake of the releasing facility. If it enters the wake, the release is effectively at ground level, and must be treated as such. If not, the release may be treated as elevated. Research is needed to better define the conditions under which effluents become entangled in wakes and to further quantify the effect of wakes on effluent concentrations near the source. It should concentrate on field studies to verify the results of theoretical and wind tunnel studies.

In addition to a geometric description of the release, a description of the physical characteristics of the effluent is important. Specifically, knowledge of the initial division between gases and particles, and an initial size distribution of particulates are needed to estimate the transformations that occur within the plume and depletion of the plume due to dry deposition and washout by precipitation. Some information exists on the size distribution of particles released during normal operation of nuclear facilities, but little or no information exists for releases during accidents.

Once material is released to the atmosphere, the wind determines where it will go and how fast it will be transported. Winds are not constant in time or space, therefore, a realistic environmental assessment involving the atmospheric pathway should account for this variability. In assessments of the normal releases over a long period of time, the variability is generally ignored under the assumption that averaging will minimize the resultant errors in estimated exposures. For assessments involving accidental releases, the same assumption is not appropriate.

Methods for treating effluent transport in the atmosphere range from simple straight-line diffusion models in which transport is implicit rather than explicit, (e.g. Regulatory Guides 1.111 and 1.145) through Lagrangian puff and segmented plume trajectory models in which transport and diffusion are separate and explicit (e.g. Start and Wendell, 1974; Ramsdell and Athey, 1981; Powell, Wegley and Fox, 1979) to particle-in-cell models in which transport is treated explicitly and diffusion is incorporated in the transport (e.g. Lange, 1978). The significant question related to transport model complexity is: Do the increases in complexity result in better transport estimates? For short ranges and small travel times, it is likely that straight line models, using the observed wind near the release point, will provide usable transport estimates. As effluent travel distance increases, the utility and accuracy of these simple models decrease. This decrease is a function of the atmospheric conditions at the time of release and the complexity of the terrain. In one instance a model may be useful to a distance of 10 miles or more, while in another instance it may fail within a mile of the source.

Research is required to place quantitative limits on the uncertainties associated with the transport models available for environmental assessments for accident response decisions, to determine those atmospheric and topographic conditions in which they can be expected to provide useful results, and to quantify the climatological frequency that they would not provide useful transport estimates. The first two of these research needs require experiments in which the position of tracer gases or other Lagrangian trajectory markers are measured for comparison with positions predicted by model trajectories. The same experiments should also provide information for assessing the meteorological input data requirements of the transport models. When the limits of the various transport modeling approaches are defined, climatological data should be used with topographic information to assess the relative benefits to be realized from added complexity in transport models for specific applications. An initial research effort might be the use of existing data to evaluate the wind field representations used in the transport models.

As effluent is transported away from the source, its concentration is reduced by mixing with the atmosphere. The rate at which mixing occurs depends upon atmospheric turbulence, which is a function of atmospheric conditions such as stability and wind speed, and of terrain features. Estimation of the dilution rate is generally based on the results of relatively short range (less than 5 miles) field experiments. The best methods use atmospheric stability to estimate vertical diffusion and wind direction fluctuations to estimate horizontal diffusion. Extrapolation of these methods to the evaluation of diffusion for distances of 10 miles or more introduces uncertainties in exposure estimates. This is particularly true when the atmospheric conditions are changing either spatially or temporally. The greatest uncertainty is probably associated with atmospheric motions on spatial scales of a fraction of a mile to a few tens of miles. Motions of this scale contribute to diffusion if average concentrations are determined for times significantly larger than the period of the motions, and are properly considered as transport mechanisms for shorter averaging times.

The most pressing diffusion research need is for validation of models under a wide variety of atmospheric and topographic conditions. To assess the validity of diffusion models, or even to evaluate the uncertainty associated with current models, it will be necessary to collect a number of high quality data sets. Once collected, the high quality data can also be used to develop improved models if existing models are found to be inadequate. Specifically, there is a need for direct measurements of the vertical diffusion of material, and for acceptable diffusion estimation methods for very low wind speed (calm) conditions when the current methods break down.

During residence in the atmosphere, the effluents released during an accident may undergo a variety of chemical and physical changes. The initial effluent species may be depleted and new species may be formed; gaseous effluents may form or be adsorbed on particles, and particles may grow through agglomeration. These changes affect the transport, diffusion and deposition of the effluent.

Research on chemical and physical changes of effluents has involved debris from nuclear weapons tests and industrial effluents such as SO_2. There has been little or no research on the chemical and physical changes of radiological effluents from nuclear facilities. This is particularly true for effluents that might be released during an accident. The research needed includes characterization of the initial physical and chemical characteristics of potential accident effluents for various nuclear facilities, comprehensive review of the literature on the physical and chemical changes these effluents can be expected to undergo, and theoretical studies on the potential changes. Of these needs, the source characterization is most pressing. The forthcoming "SUPER-SARA" LOCA experiments

(SUPER-SARA, 1979) are expected to provide data on the initial source characteristics during an accident. As these data become available, theoretical studies should be undertaken to evaluate the effects of transformation on the transport, diffusion and deposition of the effluent.

Wet and dry deposition processes deplete the effluent plume following an accident. They decrease downwind air concentrations at the expense of surface contamination; through surface contamination material initially released to the atmospheric pathway enters both the terrestrial and aquatic pathways. This interface between the three pathways makes understanding of the wet and dry deposition processes particularly important.

A variety of models exist for estimating plume depletion. These models rely on relatively coarse characterizations of the wet and dry deposition processes. Dry deposition is generally characterized by a deposition velocity (e.g., Van der Hoven, 1968), and wet deposition is characterized by a washout coefficient (e.g. Englemann, 1968). These two parameters represent entire complex processes with single numbers, which are often default values (e.g., a deposition velocity of .01 m/s). More sophisticated models are available (e.g., Horst, 1977; Sehmel, 1980; Slinn, 1980). However, they require more information than the simple models and have not been demonstrated to yield better estimates of deposition in large scale applications. It is also highly improbable that the atmospheric and topographic conditions will be known in sufficient detail to permit use of the more complete deposition models in the environmental assessments required by decision makers during the course of an emergency.

Further research is needed to evaluate the deposition models' utility in predicting where deposition will occur and quantitatively estimating the amounts deposited. If deposition can be modeled with an acceptable degree of accuracy, it is important to evaluate the tradeoffs between increasing local surface contamination and reduction of air and surface contamination at distances farther downwind to determine how precipitation should be viewed in considering potential venting of effluents following an accident.

In a related area, research is needed to enhance our understanding of the interaction between plumes and severe storms. In particular, the effects of storms on the formation of "hot spots" at unexpected locations should be studied further.

The proper blending of atmospheric modeling and atmospheric monitoring results is an important practical problem associated with environmental assessments and the atmospheric pathway. During the course of an accident this problem will be of particular concern to those in decision making positions. Atmospheric models are intended to predict, while monitoring is intended to indicate what is. But, neither monitoring nor modeling is perfect. Models are based on assumptions and rely on simplification, while monitoring information is limited to the time and place of the measurements. Research is needed to provide authoritative guidance on the uses of models and monitoring, and how they compliment one another. Additional research is needed to determine the optimum methods of monitoring so that monitoring resources can be deployed in the most effective manner.

Viewing the atmospheric pathway as a whole, the most pressing need is for model evaluation and validation. Model evaluation and validation requires research in two areas: acquiring adequate sets of quality data for comparison with model predictions, and establishing appropriate and acceptable methods for comparing the data with model predictions. Work is underway in both of these areas, with the collection of data being further advanced. Specific areas where additional work is needed are in the evaluation of transport models and in the development of a rigorous theory of model validation. Transport models have historically been neglected in comparison with models of diffusion. Yet, in the case of an accident release from a nuclear facility, effluent transport may be the more fundamental issue. Development of a rigorous theory of model validation is necessary if we are to have confidence in our evaluation of models. It may also give important direction to development of a better understanding of the atmospheric pathway processes.

Following model evaluation and validation in importance is the research related to chemical and physical characterization of effluents that might be released during an accident. The importance of this research is in the pervasiveness of the effluents' chemical and physical form on its transport, diffusion and deposition.

The third research priority is related to the proper interface between atmospheric modeling and monitoring.

Other research needs identified above are important, but they are of lower priority.

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D. Terrestrial Pathways

1. Basic Issues

a. What is currently required in the area of "terrestrial" environmental assessment in terms of sample types, locations, frequencies and analyses to:

- satisfy regulations (state, federal)?
- provide assurance of proper plant operations (especially effluent control)?
- provide input to impact assessments?
- satisfy public relations needs?
- accident vs. routine measurements?

b. What is currently being done in the area of terrestrial environmental assessment?

c. How and why did the current state-of-the-art develop?

d. What are the differences between 1. and 2. and what needs to be done to bridge the gap?

e. What would constitute an ideal terrestrial environmental assessment program considering:

- Required data (legal requirements)?
- Desired data (to aid in impact assessment, P.R., etc.)?
- Cost?
- Statistical reliability?
- Availability of instruments and analytical techniques?
- Accident detection vs. routine measurements?

f. How does one design a terrestrial program for a specific facility at a specific site?

- What parts of the assessment program are generic to all sites; what ones are site/facility specific?

- What are the steps in designing an adequate program?

2. Discussion

G. Bruce Wiersma, Chairman

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Robert Kinnison	Robert Watters
Jerry Laroche	Carl Welty

The Terrestrial Group discussed several issues which the participants believed warranted additional research and development effort. These issues were then grouped into 10 areas of concern.

Priority	Research Effort
1	Improvement of Assessment (Techniques/Models) (a) Evaluation of Uncertainty (b) Improvement of Accuracy (c) Screening and Simplification Techniques (including de minimis) (d) Develop and Simplify Models for User Group Application
2	Rapid Assessment Techniques for Accidents
3	Demonstration Projects to Enumerate and Quantify Sources of Error in Environmental Measurement
4	Review of Existing Facility Monitoring Data and Programs
5	Improved Data Base for Long-Term Behavior of Nuclides in Soil

6 Develop Techniques for Rapid Assessment of Radionuclide Concentrations in Soil Using Field Instruments

7 Study the Feasibility of Using Indicator Organisms and Media to Monitor Releases from Nuclear Facilities

8 Identify the New or Unusual Modes of Environmental Exposure from Emerging Power Generation Techniques

9 Continue Ongoing Research on Effects of Electric Fields from Transmission Lines on Humans and Biota

10 Develop Techniques for Assessing Asthetic Impact of Nuclear Facilities

Some of these areas were deemed to be of more importance than others in improving the state-of-the-art of environmental monitoring and assessment. The list is arranged in approximate order of descending priority. The group believed that the first two are of equal importance and were of higher priority than the other items. Similarly, the next four were of approximate equal priority. The next item was of secondary priority; while the last three were, as a group, of low priority. The rationale behind each of the research efforts is discussed below. We caution the reader that the priorities assigned are influenced by the personal and professional biases represented by the individuals participating in this session of the workshop. These priorities, however, represent those assigned by the majority of the terrestrial pathway group.

a. Improvement of Assessment Techniques and Models

(1) Evaluation of the Uncertainties in Environmental Assessment Predictions

Estimates of uncertainties should accompany any calculations of radiological or ecological impact. Research to identify and quantify uncertainties should include the following:

- In the absence of information on model validation, standard techniques standard techniques should be developed to perform statistical error propagation and sensitivity analysis and to identify parameters and submodels that contribute most to the overall error in model predictions and evaluate the magnitude of their contribution.

- Perform field validation tests of models for important radionuclides and exposure pathways which encompass the range of conditions under which assessment models are intended to be applied.

  Field validation may require a large investment in time and financial resources; however, it is the only method for testing the overall effect of the combined uncertainty associated with model predictions.

(2) Improvement of Predictive Accuracy

The following research should be conducted to improve predictive accuracy.

- Reduce the errors in model parameters by correlating parameter estimates with readily measurable site-specific environmental factors (i.e., soil type, soil amendments, food type, pH, temperature, agricultural practices). Evaluate the dependency of the values of certain parameters (such as fractional interception and retention on vegetation and transfer factors for agricultural products) on the chemical and physical form of specific radionuclides.

- Identify ways to quantify assessment parameters that are site-specific, such as dietary and living habits, sources of water and foods, and local or regional agricultural practices.

- Improve models that predict time-dependent environmental concentrations and subsequent impacts following accident or pulse releases. To enable formulation of such models, model parameters must be identified and determined in terms of rates of transfer for a range of environmental conditions. Most of the dynamic models developed to date derive transfer rates from currently employed steady-state concentration ratios.

- Identify ways to simplify model structure by such means as combining several parameters into a few major transfer factors or coefficients without significantly reducing the accuracy of the predictions.

(3) Develop Screening Techniques to Improve the Establishment of Priorities for Research

Formal screening methods should be developed to identify problem areas requiring further research and separate these areas from trivial problems.

- Develop a sequence of screening techniques using simple, reasonably conservative models to identify impacts, exposure pathways, radionuclides, and other pollutants which warrant high priority for research. Such screening levels are most effective when de minimis levels have been established.

- Define and establish de minimis levels of radiological and ecological impact. To accomplish this, research is needed to quantify risks and impacts associated with alternative energy systems and to estimate levels of risks and environmental degradation considered by various groups to be de minimis.

(4) Develop and Simplify Models for User Group Application

Assessment methods (models) should be usable by individuals not intimately familiar with their original development. For assessments of the impacts of normal operations and rapid-response assessments during emergencies there is a need to develop techniques which are simpler than existing ones. Simplification of terrestrial food chain pathways models is especially needed for very low-level routine emission of pollutants where the dominant uncertainties are estimates of release rates and subsequent health effects that occur in humans.

The group was of the opinion that, unless model validation has confirmed the accuracy of model predictions, increased mathematical complexity in environmental models will not necessarily result in increased accuracy. Specific approaches to simplification include:

- Changing process-level parameters that are difficult to measure into readily measurable "lumped" or combined parameters such as radionuclide-dependent, air-to-terrestrial food product, or soil-to-terrestrial food product transfer factors. Then simple hand calculations can be used for assessment;

- Combining two or more parameters suspected to be correlated into single "lumped" parameters that are less sensitive to

b. Rapid Assessment Techniques for Accidents

The objective of this task is to identify and/or develop specific rapid assessment methods and techniques that employ in-place capabilities to detect unanticipated releases and characterize resulting environmental conditions. These capabilities should include both remote sensing and tracking devices and devices that can be recovered and evaluated quickly in an emergency.

A systematic and thorough evaluation of rapid environmental assessment techniques, including lessons learned from TMI, should be performed to assure that practical monitoring and assessment capabilities are available at nuclear facilities in order to provide information for critical decisions. It is necessary to develop or modify dynamic models, associated data bases of transfer coefficients, instruments, monitoring procedures, etc., to provide predictive tools that translate measurements to tangible estimates of impact or effect.

c. Demonstration Projects to Enumerate and Quantify Sources of Error in Environmental Measurements

Typically in environmental radionuclide reports, only counting errors are reported. These errors account for only a part of total error, but the magnitude and identity of other major sources of error are usually unknown. Other errors include those associated with sample collection, preservation, and laboratory analysis. In most cases these errors are larger than the counting errors. Knowledge of the total error involved in an environmental measurement will aid administrators in deciding whether unusual results are due to plant operations, influx of material from other sources or normal, statistical fluctuations.

d. Review of Existing Facility Monitoring Data and Programs

Experience gained from several years of operating environmental monitoring programs should be utilized to improve such programs. Standard criteria for evaluating the monitoring programs is needed. The result should be a reduction in monitoring requirements and in administrative paperwork and data handling. There may also be instances uncovered where an increase in monitoring effort is required.

The reevaluation of data will also help to confirm or deny the original environmental assessment used to obtain the construction permit or operating license. This research could also provide a basis for revision of Regulatory Guides to reflect the current experience in environmental monitoring.

e. Data Base for Long-Term Behavior of Radionuclides in Soil

The objective of this task is to improve the data base on soil depletion mechanisms and soil-to-plant concentration ratios for various types of soils contaminated with radionuclides from nuclear facilities. This project should include a literature search, supplemented by laboratory and/or field studies for those radionuclides in which the data base is inadequate for site-specific assessments.

Both NRC and DOE need improved knowledge of soil depletion mechanisms and soil-to-plant concentration ratios for various types of soils contaminated with radionuclides for the purpose of developing criteria for decommissioning and recovery following accidental and routine releases. The consensus of the group was that for certain nuclear facilities (e.g., low level waste burial sites, and fuel reprocessing plants) the soil-to-plant pathway for ingestion of radionuclides is an important exposure pathway. In developing data on soil depletion and soil-to-plant concentration ratios, and/or soil to human exposure coefficients, most emphasis should be placed on those radionuclides that are expected to be important dose contributors. Soil depletion coefficients, soil-to-plant concentration ratios and soil to human exposure factors should be developed for the various soil types expected at nuclear facilities in the U.S. The soil depletion of radionuclides should take into account various depletion mechanisms such as wind and water erosion of radionuclides from soil, leaching and percolation of radionuclides through soil, and removal of radionuclides from soil via crop production.

f. Development of Techniques for Rapid Measurement of Concentrations of Radionuclides in Soil Using Field Instruments

There is a need to provide real-time guidance in decommissioning operations to personnel as to whether soil and structural items need to be removed, decontaminated or left in place. Sites will first be characterized by using sensitive analytical techniques to determine the radionuclides present. Radionuclides can be selected from the mixture that are measurable with field instruments and the ratio to the other radionuclides determined. Portable instruments such as scintillators, G.M. counters, or proportional counters, when properly calibrated, can be used to make rapid field estimates of concentrations. There is a lack of information on calibration techniques, sensitivities and interpretation of the results of these types of measurements. Existing contaminated sites and their radionuclide content could be used to develop monitoring techniques, determine sensitivities and develop calibration curves for portable instruments.

g. Study the Uses of Indicator Organisms and Media to Monitor Releases from Nuclear Facilities

Site monitoring programs generally include sampling abiotic and biotic components. The biotic samples usually emphasize direct food chain components (i.e., grass, milk and meat). Experiences at DOE sites (Hanford, INEL, ORNL) have shown that intrusion into burial grounds (and other facilities) and dispersion of radionuclides often occurs by non-food chain transport mechanisms such as small mammals, invertebrates, weedy plant species, waterfowl and non-game birds. The measurement of dispersion of radionuclides by these organisms is often not included by existing monitoring programs.

These pathways are not usually extensive and resulting impacts are normally "nuisance exposures," however, they may be much more sensitive for indicating environmental levels. In addition, such incidents of contamination found in these organisms are often highly exploited by the press. Therefore, these pathways and organisms should be considered when designing monitoring systems.

The following items must be considered when determining the feasibility of such a biotic sampling scheme:

- applications to the food-chain to man;
- organisms and sample types available;
- basic source terms (shallow-land burial, reactors, fuels reprocessing);
- quantification of relative concentrations in samples of biota and environmental levels; and
- sampling and statistical design requirements.

h. Identification of New or Unusual Modes of Environmental Exposure from Emerging Power Generation Technologies

Emerging technologies for generating power, such as advanced LWR, gas-cooled reactors, breeder reactors, and controlled thermonuclear power reactors, should be examined to identify potential pathways of exposure to the environment and to man which result from the release of new or unusual pollutants, or new modes of release.

A qualitative estimate of the relative significance of these new pollutant and exposure pathways should be made to determine the need for additional research aimed at quantifying those which are potentially significant and determining the possibility of synergetic effects between new and existing pollutant sources.

The group believed that experience over the last three decades has shown that unexpected modes of exposure to man and the environment quite often arise during the initial operation of new types of facilities. Unexpected pathways of exposure can also arise from new facilities such as breeder and fusion reactors. We have time now to perform research in advance of the operation of these new facilities to identify and evaluate potential new pollutants, new forms of familiar pollutants, and new mechanisms for release. Plans can then be made during the design stage to reduce their potential impact. Such studies would significantly reduce the likelihood of unexpected exposure mechanisms from emerging technologies.

i. Continue Ongoing Research on Effects of Electric Fields from Transmission Lines on Biota

Any recommendation for siting nuclear power plants in low population areas implies longer transmission lines with a concomitant increase in voltage of the lines to reduce power loss. While transmission lines are designed to have similar electric fields independent of voltage, the increased voltage has caused some concern about potential long-term health effects on plants and animals in the vicinity of the lines.

There is a need to verify currently used models of biological effects of electric fields as affected by different land use and land cover types. Therefore, research currently funded by DOE (BPA/EPRI/TVA/EPA) should not be terminated solely because of the lack of NRC support.

j. Develop and Evaluate of Techniques for Assessing Aesthetic Impact of Nuclear Facilities

The National Environmental Protection Act requires the evaluation of nuclear facilities' impact on the aesthetic integrity of the environment. Assessment techniques employed today, however, are as varied as are the individuals assigned to address the problem.

Furthermore, most aesthetic evaluations are limited in scope to only the visual impact of the facility on the environment. Aesthetics, however, encompass the entire spectrum of how individuals perceive and react to the environmental quality or beauty of a given location. Research is needed to develop various techniques for assessing impacts on more attributes of the aesthetic quality of the environment than visual perception. This issue is important for proposed sites near state and national natural preserves used by the public for recreation and enjoyment of protected natural landscapes.

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16. ABSTRACT (200 words or less)

The workshop was convened to consider the technical basis and methodology for regulatory environmental assessment in 1981. The findings and recommendations of the participants addressed several research needs common to aquatic, terrestrial and atmospheric sciences applicable to environmental assessment.

- Model validation - The view often expressed was that there simply is no basis in fact for having a high degree of confidence in estimates derived from existing models.
- Source term characterization - The physical state and chemical characteristics of the source term are needed to estimate transformations within the plume, depletion of the plume due to dry deposition, and rainout. Some particle size distribution information applicable to normal operating conditions is available but little or no information exists for releases during accidents.
- Development of screening techniques - Reliable means of identifying and separating trivial matters from important problems. Techniques using reasonably conservative models to identify effects, pathways, nuclides or pollutants warranting high priority research. This would be closely coupled and dependent upon de minimis environmental effects to be established by the regulatory functions.

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