BALANCING RADIATION BENEFITS AND RISKS

The Needs of an Informed Public

April 1994

A Report by
the Subpanel on Public Education

Committee on Interagency Radiation
Research and Policy Coordination
(CIRRPC)

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DISCLAIMER

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June 7, 1994

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Dear Dr. Young:

On behalf of the members of the Subpanel on Public Education, I am pleased to submit our report, *Balancing Radiation Benefits and Risks: The Needs of an Informed Public.* This report is the result of the subpanel's efforts to sift through both Federal and private sector information and to identify commonly expressed concerns and solutions in addressing an issue identified by CIRRPC as one of 10 key radiation issues confronting the Federal government.

The principal objective of the subpanel was to develop a coherent and coordinated Federal policy on public information concerning radiation and its health effects. The subpanel was specifically charged to: (1) determine what radiation issues are important to the Federal agencies for public education; (2) determine which Federal agencies are involved in public education about radiation and what role, if any, nongovernment agencies play; (3) collect and evaluate past and current public education programs on radiation from Federal agencies and any nongovernment groups; and (4) determine what role, if any, the Federal government should play in the development and implementation of a unified public education program concerning radiation.

In preparing this report, the subpanel gathered information from CIRRPC member agencies and heard from private and public sector groups representing diverse positions on the balance between the benefits and risks of radiation technologies. In addition, preliminary recommendations generated by subpanel deliberations were presented for discussion and further development at the *Workshop on Federal Agency Radiation Information and Education*, which was attended by representatives from the public affairs/media, policy/management, and education sectors of 13 Federal agencies.

This report was developed and completed with the enthusiasm and hard work of all the subpanel members. I felt privileged to have worked with them, and they have my genuine appreciation.

Sincerely,

Leven B. Gray
Chairman
Subpanel on Public Education

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EXECUTIVE SUMMARY

The American public's perceptions regarding ionizing radiation do not always conform to or correlate with scientific evidence. The ultimate purpose of this coordinated Federal effort and report is to increase the public's knowledge of the benefits and risks associated with ionizing radiation. In the Federal sector, there is currently no consolidated policy on the dissemination of public information regarding the benefits and risks of radiation on health and the environment. Although several Federal agencies have developed substantial public education programs, agency approaches generally have been fragmented, and there is no coordinated Federal public education program on radiation issues.

The lack of a unified Federal effort on public education has been a long-standing concern of the Committee on Interagency Radiation Research and Policy Coordination (CIRRPC). In a 1986 report, CIRRPC identified public education as one of 10 key radiation issues confronting the Federal government. The report revealed that inadequate communications and uncoordinated efforts among the Federal agencies, the scientific community, the public, and various segments of the popular media have contributed to problems associated with public knowledge and understanding of radiation issues. In 1989 CIRRPC established the Subpanel on Public Education to address public education on radiation issues. While this report embodies the Subpanel's findings and recommendations, it does not purport to represent the positions of individual agencies.

The Subpanel was established to:

- ▲ determine what radiation issues are important to the Federal agencies for public education;
- ▲ determine which Federal agencies are involved in public education about radiation and what role, if any, nongovernment agencies play;
- ▲ collect and evaluate past and current public education programs on radiation from Federal agencies and any nongovernment groups; and
- ▲ determine what role, if any, the Federal government should play in the development and implementation of a unified public education program concerning radiation.

To address these charges, the Subpanel used a three-pronged approach to gather information. First, the Subpanel requested each CIRRPC member agency or department to provide information on its policy regarding public education, its efforts in education on radiation issues, and its current and future radiation-related issues of concern. Second, oral presentations were made by private and public sector groups representing diverse positions on the balance between the benefits and risks of radiation technologies. Third, the Subpanel conducted a three-day workshop in May 1991 to further solicit ideas about public education issues and to develop preliminary recommendations.

This report is divided into five sections. The first section, *Introduction*, discusses the public's knowledge of radiation, their perceptions of benefits versus risks, and the Federal government's role in public education. The section also outlines the charge to the Subpanel. *Radiation Issues and Public Reactions* discusses several radiation issues important to Federal agencies for which public education programs need to be established or enhanced. *Federal Programs* describes Federal agencies with public education programs on radiation and the nature of the programs they support. *Education Issues and Federal Strategies* explores the elements identified by the Subpanel as critical to the development and implementation of an effective Federal program in the area of public education on radiation issues and nuclear technologies. An important issue repeatedly brought up during the public sector presentations to the Subpanel was the perceived lack of Federal credibility on radiation issues in the eyes of the public. To some degree, this concern was factored into all of the recommendations developed by the Subpanel. The issues discussed in this section include the fragmented nature of Federal radiation programs and the need to improve credibility, promote agency responsiveness, and support the enhancement of scientific literacy. Finally, under *Recommendations*, the Subpanel discusses its overall findings and conclusions.

The principal objective of the Subpanel was to develop a coherent and coordinated Federal policy on public information concerning radiation and its health effects. The Subpanel believed that the purposes of such a policy should be to increase public understanding of the potential for radiation exposure from various sources and to increase public understanding of the basic concept of relative risk as part of the broader Federal effort to enhance scientific literacy. The following recommendations, as described in the final section of the report, are proposed as strategies to specifically address these education issues.

ESTABLISH A NATIONAL RADIATION INFORMATION CENTER

A Federally sponsored, independent National Radiation Information Center (NRIC) should be created to communicate information on radiation issues to the general public. An administrative board of government and nongovernment personnel, with wide representation, should oversee the center's activities. To enhance its credibility, the center should be independent of any agency with a vested interest in radiation technologies. The NRIC should be a repository for technical and factual information on radiation and should efficiently and effectively interact with both the public and various government agencies on specific radiation issues. However, matters involving individual agency policies should be referred back to the appropriate agencies. Initially, the center should be focused on a set of objectives, with a modest coverage of issues related to radiation benefits and risks. This will enable the center and its staff to learn through experience, manage the expense of keeping up with new developments, and build credibility.

ESTABLISH ACADEMIC OUTREACH PROGRAMS

Individual departments and agencies should develop and/or expand outreach programs for students and teachers. These programs may involve workshops, summer laboratory internships, and the development and distribution of educational literature and computer software. To ensure credibility, materials provided by the outreach program should be subject to the highest standards of scientific review. These efforts would not only enhance science and mathematics literacy using radiation issues as examples, but would also encourage students to pursue careers in science, engineering, and technology. In addition, these programs would give teachers renewed enthusiasm and expose them to new educational ideas and materials they can share with students and fellow teachers. To encourage participation in these programs, awards to recognize teacher and student excellence at the national (e.g., a "President's Science Award") and regional levels should also be implemented.

ENHANCE COMMUNICATIONS INFRASTRUCTURE IN AGENCIES

Federal departments and agencies should review their current public education and information programs on radiation issues. Efforts should focus on the development of a coordinated and comprehensive program, in accordance with individual department or agency mandates. If not already in place (e.g., an Office of Public Relations), each department or agency should designate a primary point of contact to respond to public inquiries on radiation issues and to interact with other Federal agencies and the NRIC. The point of contact should provide access to the agency's communications infrastructure, or network, of "user-friendly" resource persons who can be readily contacted to address specific inquiries. Credibility is undermined when responses to inquiries are delayed or inaccurate. Thus, it is important to have a planned method in place for directing public queries to the appropriate resource person(s), particularly for providing quick, accurate responses to inquiries on radiation issues currently in the news.

ENCOURAGE CURRICULUM REFORM IN MATHEMATICS AND SCIENCE EDUCATION

Curriculum reform in mathematics and science for students in grades K through 12 should be initiated to improve their understanding of science in general and radiation issues in particular. Efforts to enrich the curriculum should be coordinated with teachers, local school boards, parent-teacher associations, professional societies of science and mathematics teachers, and State and local government representatives. Radiation technologies are regularly used in society, and the incorporation of curricula based on radiation issues should be encouraged and supported. This effort should be part of a generalized curriculum reform strategy to help spark student interest in mathematics and science concepts applicable to significant societal issues. The relevance of the energy and environmental issues associated with radiation benefits and risks should be used as one of the tools to enhance mathematics and science education in elementary and secondary schools. With the assistance of technical experts in the radiation field and the Federal agencies, educational materials (e.g., books, videos, and computer games on radiation issues) should be developed to enhance the curriculum at all grade levels and to make the students' learning experience fun, informative, and useful to their development as involved citizens. To ensure credibility, all materials and information presented in the curriculum should be subject to the highest standards of scientific review and accuracy.

INTRODUCTION

PUBLIC KNOWLEDGE OF RADIATION AND PERCEPTION OF RISK

The general public has come to rely heavily on the uses and benefits of ionizing radiation[1] technologies in almost every aspect of daily life. Nuclear power now generates about 20% of the electricity in the United States. Many people take for granted that radiation from x-ray machines, other radiation-producing equipment, and radioactive materials now plays an important and indispensable role in the early detection, diagnosis, and treatment of diseases. The medical uses of radiation also offer benefits to patients by replacing or enhancing other medical procedures to make them more accurate and effective. Approximately two out of every three Americans receive medical or dental x rays annually.[2] In another example of the applications of radiation technology, many lives have been saved by home and institutional smoke detectors, which contain small radioactive sources.

Despite the role of radiation technologies in everyday life, however, public reaction to radiation risks are often not in agreement with the scientific understanding of these risks. One of the main reasons for this reaction is concern about public health and environmental risks, which are often perceived as being much greater than they really are.[3, 4] This underscores the importance of increasing the public's understanding of radiation risks, relative to other hazards.

The health and environmental effects of exposure to ionizing radiation and radioactive materials are better known than the effects of most other hazardous materials. The harmful effects of high doses of radiation (above 0.5 sievert or 50 rem) delivered at high dose rates (greater than 0.1 sievert per day or 10 rem per day) have been documented from studies of Japanese atomic bomb survivors. Evidence of harmful effects is also apparent in studies of radium dial painters, radon-exposed workers in underground mines (e.g., uranium mines), radiologists, and other similarly exposed groups. There is very little controversy

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[1] For the purposes of this report, radiation is considered to be ionizing radiation, such as x rays and gamma rays, which may be emitted by radioactive materials or radiation-producing equipment.

[2] National Research Council, *The Effects on Populations of Exposure to Low Levels of Ionizing Radiation: 1980 (BEIR III)* (Washington, D.C.: National Academy Press, 1980). The BEIR III Committee reported that the Food and Drug Administration estimated that 65% of the U.S. population was exposed to medical and dental x rays in 1970.

[3] Daniel L. Collins and Ana Bandeira de Carvalho, "Chronic Stress From the Goiania ^{137}Cs Radiation Accident," *Behavioral Medicine* 18 (1993): 149-157.

[4] Daniel L. Collins, "Behavioral Differences of Irradiated Persons Associated with the Kyshtym, Chelyabinsk, and Chernobyl Nuclear Accidents," *Military Medicine* 157 (October 1992): 548-552.

regarding the effects of high doses of radiation because clear evidence of these effects has been demonstrated in epidemiological studies of these exposed populations.

At low radiation doses and dose rates, such as those associated with natural background radiation and most radiation applications, the risk of health effects is generally so small that it cannot be distinguished from the natural incidence of cancers, birth defects, and other effects not caused by radiation. At these low levels, estimates of the risk must be obtained by extrapolation from the risks found at high doses and high dose rates. Because this extrapolation process requires the assumption of a risk model (e.g., the linear nonthreshold, dose rate independent model), there is a degree of uncertainty in the predicted risk. Much of the public debate centers on the effects of exposure to low levels of radiation.

The study of how individuals perceive technological risks is a rapidly evolving discipline that has been applied extensively to radiation technologies.[5] Slovic and his colleagues[6] identified several qualitative characteristics of risk that may influence an individual's perception of, and reaction to, a risk and its potential danger. These characteristics include:

- the voluntariness of the risk (whether or not taking the risk is voluntary on the part of the individual);
- knowledge about the risk (what, and how much, the individual knows about the risk);
- control over the risk (how much control, if any, the individual has over the risk);
- the newness of the technology creating the risk;
- the catastrophic potential of the risk; and
- the degree of the individual's fear or anxiety.

An evaluation of these characteristics, through population surveys, indicates that some radiation technologies, especially nuclear power, have highly negative risk profiles. These characteristics of risk that influence perception are particularly relevant to radiation technologies.

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[5] For a discussion on risk perception as it pertains to radiation technologies, see P. Slovic, J.H. Flynn, and M. Layman, "Perceived Risk, Trust, and the Politics of Nuclear Waste," *Science* 254 (1991): 1603-1607.

[6] P. Slovic, B. Fischhoff, and S. Lichtenstein, "Rating the Risks," *Environment* 21 (1979): 14-20, 36-39.

Risk Perception

Information on radiation risks exists in a number of reports from expert committees and organizations such as BEIR,[7] UNSCEAR,[8] NCRP,[9] ICRP,[10] and IAEA.[11] These highly technical reports are primarily for experts and are not usually read, or readily comprehended, by members of the general public. Some less technical documents have been published in the past by the Federal government and by various industrial organizations. The former Atomic Energy Commission (AEC), for example, spent several million dollars a year during the 1950s and 1960s on the publication and dissemination of information on atomic energy.

Despite the extensive accumulation of technical information on radiation effects and risks and the extensive dissemination of this information by governmental agencies, industrial firms (such as utilities), and technical and trade associations, concerns about the health and environmental consequences of exposure to radiation from nuclear power and medical applications have not lessened. The controversy often focuses on what is not known, rather than on what is known, such as the existing epidemiological data for predicting the harmful health effects of exposure to radiation.[12]

The health and environmental effects of low doses of radiation are not easily evaluated with certainty because the estimated probability is low enough that the predicted number of effects cannot be distinguished from the larger (and variable) number of effects from other causes. Because extrapolation models must be used to go from the known risks at high radiation doses to low-level exposures, there are different opinions regarding the models and the predicted level of harm. Public awareness and perception has tended to focus on the existence of scientific uncertainty and not on the achievement of a balance between the overall benefit and risk.

The general public relies primarily on the print and broadcast media for information on technological advancements and the impact of technologies on society. Journalists rely on a variety of sources for technical information, including technical experts (e.g., scientists) and public policy professionals. Science writers rely more on technical publications (e.g., reports of the National Research Council) and articles appearing in scientific or technical journals. Thus, reporters not only focus on emerging information and discoveries that may have short-term or long-term impacts on society (e.g., the discovery of a potentially effective

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[7] Committee on Biological Effects of Ionizing Radiation (BEIR), National Academy of Sciences, Washington, D.C.

[8] United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), United Nations, New York.

[9] National Council on Radiation Protection and Measurements (NCRP), Bethesda, Maryland.

[10] International Commission on Radiological Protection (ICRP), New York.

[11] International Atomic Energy Agency (IAEA), Vienna, Austria.

[12] Kenneth L. Mossman, "Low-Dose Ionizing Radiation: The Question of Cancer," *The Journal of NIH Research* 4 (1992): 51-53.

treatment for a fatal disease), but also on controversial issues because these sustain public interest.

Reporting on nuclear issues is particularly attractive to the news industry, perhaps because of its link with catastrophic events (such as the explosion of nuclear weapons), with the publicized controversy surrounding radiation effects, or with the perceived mysterious nature of radiation. The U.S. public's long-term fascination with nuclear radiation has generated a wide spectrum of emotions. In one form, nuclear radiation is accepted as an important tool in the medical diagnosis and treatment of human diseases, but in other forms, nuclear radiation is associated with the loss of life and destructive environmental consequences.

Some media treatment of radiation or nuclear technology information tends to be overdramatized, particularly in reference to nuclear power generation and the health impacts of the nation's nuclear weapons development programs. These reports often contain messages that serve to heighten the public's uncertainty, anxiety, and negative attitudes toward nuclear technologies. Biased and negative information from news reports and entertainment programs often lead to confusion and inaccurate perceptions regarding the health effects of radiation and the controls and precautions taken in the use of nuclear technologies.

An inadequate understanding of the technology and the current knowledge about radiation risks prevents people from evaluating the credibility and content of the information they receive and from making informed independent judgments. The public is a critical stakeholder and plays an important role in decision making concerning radiation issues. Public perceptions regarding the balance between benefits and risks influence the formulation of government policies that affect access to these benefits and exposure to these risks. The Federal government should work to ensure the public's understanding of, and access to, this decision-making process.

The Emotional Component

The wide spectrum of emotional reactions evoked by the idea of "radiation" ranges from positive to negative. For example, although radon gas is now recognized by experts as the major source of radiation exposure for the U.S. population, accounting for approximately 55% of the total radiation dose everyone receives,[13] much of the U.S. population has shown apathy toward their exposure to radon from indoor air. This is so, in spite of the media attention and public education efforts by the Environmental Protection Agency (EPA) and other national health organizations on the potential risk of lung cancer resulting from such exposures.

Meanwhile, the Department of Energy's (DOE) high-level radioactive waste disposal program encounters resistance and political opposition in its search for an acceptable

[13] National Council on Radiation Protection and Measurements (NCRP), *Ionizing Radiation Exposure of the Population of the United States*, NCRP Report No. 93 (Bethesda, MD: NCRP, 1987).

technology and a suitable disposal site. This situation is influenced by public perceptions of risks closely associated with images of fear and dread.[14, 15] These public risk perceptions persist even though the individual lifetime risk (10^{-2}) associated with elevated indoor radon exposures is ten to a hundred times higher than that associated with radioactive waste disposal sites (10^{-3} to 10^{-4} individual lifetime risk for maximally exposed individuals).

Public education programs on radiation can vary considerably, depending on the circumstances of the radiation exposure, the public or education program's perceptions related to the radiation exposure, and the level of understanding desired. The public's reaction to such information and society's acceptance or nonacceptance of a technology are both individual and societal questions based on an assessment of the balance between the benefits received and the risks (the probability of loss or harm) incurred. This assessment can be very deliberate and methodical; one not easily made because of the close balance between the benefit and the risk. This assessment can also be easy, with one side obviously outweighing the other (i.e., the benefit far outweighing the risk, or the risk far outweighing the benefit). In either case, regardless of existing scientific evidence, the perceptions of individuals and society will play a key role in the assessment process, as well as in future decision-making situations.

Aspects of benefit assessment may lie simply in the recognition of benefit. In some activities, such as the use of radioactive materials in consumer products or the use of radiation in medicine, the person who benefits from the use is also the one subject to its risks. In other activities, such as the generation of electricity by nuclear power or the use of radiation in medicine, a large segment of the population benefits, and only a small part of the population may be subjected to the technological risks involved (e.g., radiation exposure due to the release of radionuclides into the environment, or risks to workers exposed in hospitals).

The recognition of benefits can be subjective and emotional, and it may include one or a combination of judgments about whether or not the technology represents a new technology; saves money; improves health; gives emotional satisfaction; solves problems; is preferable to the alternative; makes life more pleasant; makes life easier; or saves lives.[16] The judgement of the acceptability of risk can also be influenced by emotion. Aspects of this judgement may hinge on the question of whether or not the risk is taken voluntarily or involuntarily, or on perceptions associated with the end result (e.g., slow death from cancer or catastrophic events, such as airplane crashes, versus diffuse events, such as multiple automobile deaths). Risk assessment based solely on emotion, however, may itself present a risk, if the emotions block the recognition of other possibilities of even greater risk.

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[14] Slovic, et al., "Perceived Risk, Trust, and the Politics of Nuclear Waste."

[15] S. Weart, *Nuclear Fear: A History of Images* (Cambridge, MA: Harvard University Press, 1988).

[16] Elyse M. Rogers, *Life is in the Balance—Weighing the Questions of Risk and Benefit in Today's World* (Midland, MI: Dow Chemical U.S.A.: n.d.).

Three questions important to the process of analyzing risk include:[17]

- What potentially can go wrong?
- How likely is it to happen?
- If it does happen, what will the consequences be?

Questions of how risks can be controlled or minimized, and how much this control will cost, may also be incorporated into this judgement.

Although the Federal government has been active in public education regarding radiation technologies since the end of World War II, the social and intellectual climate in which these programs were launched has changed dramatically from the public's acceptance of the peaceful applications of atomic energy to the "not in my backyard" (NIMBY) attitude in relation to radioactive waste disposal. Consequently, the Federal government needs to seriously evaluate the present state of its information and education efforts on radiation issues and determine how these can be improved to meet the changing climate and to increase public confidence. The development of a clear message on what we know about radiation effects and risks, and what nearly 50 years of experience has taught us, is critical to the achievement of increased public confidence.

THE FEDERAL GOVERNMENT'S ROLE IN PUBLIC EDUCATION

Does the Federal government have a responsibility to enhance public understanding of issues surrounding specific technologies used by society? If the answer is "yes," then the purpose of any government education program should be to provide reliable, accurate, and understandable information to enable individuals and groups to make informed decisions, based on their accurate knowledge of the issues involved. It is not the purpose of such a program to persuade the public to accept or reject a specific technology.

In the early 1950s, the Federal government recognized that if activities in nuclear technologies were to be advanced and sustained, then public education and information programs would have to be implemented.[18] Accordingly, the Atomic Energy Act of 1954 authorized AEC to implement information and education programs to improve public understanding of nuclear energy.[19] At present, there is no clearly articulated policy in the Federal sector on the dissemination of public information on the uses and the effects of radiation on health and the environment. Although several Federal agencies have developed substantial public education programs, agency approaches have been fragmented, and there is no coordinated Federal public education program on radiation issues.

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[17] Rogers, *Life is in the Balance.*

[18] G.T. Seaborg and D.M. Wilkes, *Education and the Atom* (New York: McGraw-Hill, Inc., 1964).

[19] The Atomic Energy Act of 1954 (P.L. 83-703), 68 Stat. 919.

The need for the Federal government to provide opportunities and tools to improve public knowledge of radiation sources and their risks, applications, and associated social and political issues has been a continuing topic of interest and concern to the Committee on Interagency Radiation Research and Policy Coordination (CIRRPC).[20] In a 1986 report, CIRRPC identified public education as one of 10 key radiation issues confronting the Federal government.[21] The report revealed that inadequate communications and uncoordinated efforts among the Federal agencies, the scientific community, the public, and various segments of the popular media have contributed to problems associated with the public's knowledge and understanding of radiation issues. In 1989 CIRRPC established the Policy Subpanel on Public Education to address concerns regarding Federal efforts in public education on radiation issues.

The Subpanel's membership was made up of representatives from 13 Federal departments and agencies with one or more relevant areas of interest and concern about radiation affecting their mission and policies. Social and political attitudes toward radiation, along with the public's opinion of the agencies and their programs, influence the establishment of radiation policies that affect the use, control, and costs associated with radiation technologies and issues.

In examining public education issues, the Subpanel was charged to:

- ▲ determine what radiation issues are important to the Federal agencies for public education;
- ▲ determine which Federal agencies are involved and what role, if any, nongovernment agencies play;
- ▲ collect and evaluate past and current public education programs on radiation from Federal agencies and any nongovernment groups, as well as determine the focus and general content of public education programs, the target audiences, the mechanisms of information dissemination, and how programs have been evaluated; and
- ▲ determine what role, if any, the Federal government should play in the development and implementation of a public education program concerning radiation.

The complete text of the Subpanel's charter is given in Appendix A. A list of the Subpanel members and their respective departments or agencies is provided in Appendix B.

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[20] CIRRPC was chartered on April 9, 1984 through the Federal Coordinating Council for Science, Engineering, and Technology. It was established to identify radiation issues of concern to the Federal agencies, to develop initiatives for proposed solutions, and to coordinate radiation research programs. CIRRPC is currently made up of 18 Federal departments and agencies.

[21] Committee on Interagency Radiation Research and Policy Coordination (CIRRPC), *Report on the Identification of Federal Radiation Issues* (Washington, D.C.: CIRRPC, 1986).

The Subpanel used a three-pronged approach to gather information related to its tasks. First, it requested the member departments or agencies to provide information on their policy regarding public education, their efforts in providing public education, and their current and future radiation-related issues of concern. Second, oral presentations were given by private and public sector groups representing diverse positions on the benefits and risks of radiation technologies. Third, the Subpanel conducted the three-day *Workshop on Federal Agency Radiation Information and Education* in May 1991 to solicit ideas and to develop preliminary conclusions and recommendations. The workshop attendees represented the public affairs/media, policy/management, and education sectors of 13 Federal departments and agencies. A summary of findings and conclusions from the workshop is provided in Appendix C. The information gathered through these measures and the identification of education needs are the focus of this report.

The remainder of this report consists of four sections. *Radiation Issues and Public Reactions* discusses several radiation issues important to the Federal agencies and for which public education programs need to be established and enhanced (charge #1 to the Subpanel). *Federal Programs* deals with Federal agencies involved in public education on radiation and the nature of the programs they support (charges #2 and #3 to the Subpanel). *Education Issues and Federal Strategies* explores elements and strategies identified by the Subpanel as critical to the development and implementation of an effective Federal public education program on radiation issues and nuclear technologies. The *Recommendations* section outlines several recommendations for coordinating the Federal government's role in the development and implementation of a comprehensive public education program (charge #4 to the Subpanel).

RADIATION ISSUES AND PUBLIC REACTIONS

Public education programs on radiation issues have produced a variety of public reactions. Environmental radon; the uses of radiation in medical research, diagnosis, and therapy; nuclear power generation; the cleanup and restoration of contaminated areas; and food irradiation are all examples of broad radiation issues with far-reaching impacts and for which public education and information programs have been developed by various Federal agencies.

This section intends to show, by example:

- ▲ the impact that public perception can have on the effectiveness of radiation programs;
- ▲ the need for public education and involvement in the development of radiation programs; and
- ► ways in which agencies have tried to promote public understanding based on our best, but still evolving, knowledge of available science.

A few caveats are in order. The Subpanel does not present a case for or against any particular program or judge its merits. Neither are readers expected to agree completely with the points of view expressed in each example. To the contrary, some readers may perceive a bias, maybe even a hint of advocacy, in one or more of these examples.

The examples were carefully selected by the Subpanel members to present a balanced perspective. However, they have not tried to make each example acceptable to every conceivable reader. The Subpanel members recognize that the issues presented in these examples may be polarized. Even the members themselves were unable to agree unanimously with some of the observations in the examples. Statements perceived by some as simple deductions from fact were perceived by others as biased. That was instructive in itself. The diversity of opinion in these examples shows that "experts" in radiation science have differing views, and this makes the task of communicating to the public all the more difficult.

ENVIRONMENTAL RADON CONTROL

Radon is a common element in our everyday environment. It comes from the breakdown (decay) of natural radionuclides (primarily uranium and radium) in rocks and soils. Radon and its decay products, which can enter and accumulate in buildings, are generally accepted as the largest contributors to background radiation in the world. In the United States, the majority of the radiation exposure received by the public is associated with natural radon exposure.[22] Using the relative risk model developed by the National Academy of Sciences (NAS) and the 1991 NAS report, *Comparative Dosimetry of Radon in Mines and Homes*, EPA estimated that from 7,000 to 30,000 lung cancers annually (about 5% to 20% of the total lung cancer cases) may be caused by breathing indoor radon, either by itself or in combination with smoking. EPA has been given the Federal lead, through legislation, to reduce the public health risk from radon.

Benefits, Risks, and Costs

Numerous studies of underground miners have scientifically shown that exposure to high concentrations of radon and its decay products represents a risk to humans. EPA recommends a level of radon (4 picocuries per liter or 150 Bq/m^3) that should not be exceeded in homes. Lifetime exposure at this level results in a dose (40 working level months) similar to that received by miners who were found, in several studies, to be at increased risk of lung cancer from radon. Despite these findings and EPA's recommendations, the public has shown a disproportionate lack of concern for radon in their homes. Such apathy is principally related to the fact that radon exposure, for the most part, is a natural phenomenon unrelated to any man-made technology. Thus, there is typically no polluter at fault. This, in combination with the expectation that one's home is a safe haven, has resulted in a relatively small fraction of U.S. households having invested minimal resources (tens of dollars) to test their homes to determine if they have a "radon problem." Of the estimated 6 million households expected to be above EPA's radon action level, only about 5% have mitigated these elevated levels (at a typical cost of $500-$2,500).[23, 24]

Education Efforts and Public Reactions

EPA's public information program has attempted to alert the public to radon risks and to convince citizens to take appropriate precautions, based on EPA's recommendations. Early efforts generally represented attempts to provide factual information to the public. These programs were most effective for communities and individuals interested and already concerned enough to seek information. More recently, EPA has been more aggressive in encouraging the public to take action and has instituted a public information program similar to the Public Health Service's antismoking campaign and the National Highway Traffic Safety Administration's seat belt campaign. Since 1988, when EPA and the Office of the Surgeon General issued a public health advisory recommending that homeowners test for radon,

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[22] NCRP, *Ionizing Radiation Exposure of the Population of the United States*. Radon is recognized as the major source of radiation exposure for the U.S. population. It accounts for 55% of the total exposure from all sources, based on the average annual effective dose equivalent.

[23] *A Consumer's Guide to Radon* (Washington, D.C.: EPA, 1992) [Document #402-K92-003].

[24] *National Residential Radon Survey of U.S. Homes: Summary Report* (Washington, D.C.: EPA, 1992) [Document #4402-R-92-011].

public awareness and understanding about radon has increased rapidly. In a 1993 survey of 45,000 randomly selected American households, approximately 70% of those polled had heard of radon. However, only 10% of Americans had tested their homes for radon, and approximately 300,000 homes with elevated levels had been mitigated.

HEALTH AND MEDICINE

Radiation is used in the healing arts for research, diagnostic, and therapeutic applications. The majority of the public is directly affected by diagnostic and therapeutic applications. Diagnostic applications include medical radiography, dental radiography, computerized tomography, nuclear medicine, and mammography. Therapeutic applications include the use of high energy x rays, teletherapy, and intercavitary and interstitial radiation sources that provide high radiation doses for the treatment of diseases, particularly cancer. NCRP estimated that in 1980 there were 440 dental x-ray examinations and 790 medical x-ray examinations for every 1,000 people in the United States.[25] The medical uses of radiation in the United States are thus wide-spread.

Benefits, Risks, and Costs

The medical and dental uses of radiation involve radiation exposure to patients undergoing diagnosis or treatment. These uses constitute the largest man-made, or technology-based, source of radiation exposure in the United States.[26] The magnitude of tissue doses to the patient from the different medical procedures varies greatly and can range from less than 0.1 milligray (or less than 10 millirad, a small fraction of the annual background radiation) for a typical chest x ray, to as much as 100 gray (or 10,000 rad) to a localized area of the body (e.g., a tumor) for cancer therapy. Under certain circumstances, the patient's family or friends may also be exposed as a result of visiting or tending to the patient after a procedure, such as in outpatient nuclear medicine therapy, but these doses are a minuscule fraction of the patient's dose.

In all cases, the use of radiation in therapy or diagnosis is controlled by a physician, and the benefits derived from this use of radiation are generally perceived by the public as being greater than the risk. The personal interaction of the physician with the patient, the public's confidence and trust in the medical profession, and the direct benefits derived from the radiologic procedure all contribute to the public's general acceptance of radiation in medicine. Patients accept the need for x rays or nuclear medicine studies, if such procedures are perceived as beneficial by patients or considered essential by their physician.

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[25] NCRP, *Exposure of the U.S. Population from Diagnostic Medical Radiation*, Report No. 100 (May 1, 1989).

[26] NCRP, *Ionizing Radiation Exposure of the Population of the United States*. Medical x rays and nuclear medicine procedures account for 15% of the total exposure from all sources, based on the average annual effective dose equivalent. This, along with exposure to all the natural sources of radiation, accounts for 97% of the average exposure received by the U.S. public.

Education Efforts and Public Reactions

Professional organizations in the medical community provide numerous programs to educate the public and provide necessary information on the uses, benefits, and risks of radiation in medicine. However, the medical community consensus on the balance between the benefit versus the risk of some medical applications of radiation may still differ from public perception. For instance, mammography is now recognized as an important test in the diagnosis of breast cancer. However, many women are reluctant to undergo this type of x-ray examination, perhaps due to the discomfort they may experience during the procedure, the cost of the procedure, concerns over the quality of the diagnosis, and fear of radiation. Women who refuse mammography may be denying themselves an important medical benefit by compromising early detection and the subsequent management of breast cancer.[27] In 1992 The Mammography Quality Standards Act was passed to establish national uniform quality standards for mammography.[28] The proper utilization of mammography as a screening tool, particularly for women over the age of 50, would increase the early detection of breast cancer and increase the probability of control or cure.

NUCLEAR ENERGY

The United States pioneered the use of nuclear energy, and the technology still represents a vital part of the U.S. energy production system. However, environmental and other special interest groups have long advocated the dismantling of existing plants and the imposition of a moratorium on new plant construction because of perceived safety problems associated with the generation of nuclear power and the disposal of radioactive wastes from nuclear power plants. The Three Mile Island nuclear power plant accident in 1979 and the Soviet Chernobyl accident in 1986 fueled a successful antinuclear power movement and established the safety of nuclear power as an issue of great public concern. In some segments of society, nuclear power is now considered a dangerous and high-risk energy source.

There have been no new nuclear plants ordered in the United States in more than a decade. Although the 1991 National Energy Strategy identified a continuing, and possibly increased, role for nuclear energy well into the next century,[29] there is little public support for nuclear power generation. Deciding whether or not nuclear power is really important to the national energy system is ultimately a public policy decision. Therefore, it is vital that public information and education programs on the benefits, risks, and costs of the nuclear option are available. The public needs reliable and accurate information, if informed decisions are to be made about the future of nuclear power in this country.

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[27] Kenneth L. Mossman, "Nuclear Literacy," *Health Physics* 58 (1990): 639-643.

[28] Public Law 102-539, October 27, 1992, *Weekly Compilation of Presidential Documents* 28 (1992), 106 Stat. 3547.

[29] *National Energy Strategy: Powerful Ideas for America* (Washington, D.C.: U.S. Government Printing Office, February 1991).

Benefits, Risks, and Costs

Between 1980 and 1989, the percentage of electricity generated by nuclear power in the United States increased from 11% to 19%. Of the total 2,779 billion kilowatt-hours (kWh) of electricity produced in 1989, 529 billion kWh were produced by the 110 operating nuclear reactors.

The operation of nuclear reactors can expose the public to small amounts of radiation through several pathways. These pathways may involve direct external exposure to small amounts of gamma radiation or internal exposures following the intake of radionuclides released into the environment. Population exposures to radiation emitted from existing nuclear power plants during normal operations have been estimated to be less than 0.1% of the total exposure from all natural and man-made radiation sources.[30] Accordingly, overall risks to public health and the environment from radiation exposures from nuclear power plants and the associated nuclear fuel cycle are estimated to be extremely low, possibly even zero.[31] Despite these estimates, individuals and groups have continued to express grave concerns over the safety of nuclear plant operations, primarily because of the fear of nuclear accidents and concerns about the ability to safely dispose of spent nuclear fuel.

U.S. nuclear power is a mature industry with an impressive safety record spanning 33 years. Plants have accumulated more than 1,425 reactor-years of safe operation, and new reactors are being designed to be even safer. The underground mining and rail transport of coal for combustion is estimated to cause about 280 illnesses and injuries and 18 deaths per gigawatt-year. In comparison, the use of uranium fuel in nuclear power (mining, processing, transporting, and burning) is estimated to cause about 17 cases of illnesses and injuries and one death per gigawatt-year. Therefore, from a health risk perspective, nuclear power will most likely continue to be a significant current and future source of energy in the United States.

However, despite the reductions in health risks and the environmental advantages of nuclear power generation, the public continues to show considerable concern over the safety of nuclear power facilities and proposed nuclear waste disposal options. These concerns have led to a highly variable, quickly changing, and increasingly restrictive regulatory environment. The continuing change in regulations, standards, and limits leads to a high level of economic unpredictability. This uncertainty has contributed to decisions to abandon plans to construct new nuclear power plants and has led to the premature closing of plants that have already been constructed.

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[30] NCRP, *Ionizing Radiation Exposure of the Population of the United States*. The percentage of exposure attributable to nuclear power operations was determined on the basis of the average annual effective dose equivalent.

[31] National Research Council, *Health Effects of Exposure to Low Levels of Ionizing Radiations: BEIR V* (Washington, D.C.: National Academy Press, 1990).

Education Efforts and Public Reactions

A public information/education program using factual and credible information can provide the public a much-needed overall perspective of the nuclear power option. Education programs need to stress the benefits, as well as the risks and costs, of the nuclear option, in comparison to the benefits, risks, and costs of alternative energy sources.

The need for a reliable and readily available supply of electricity is well recognized by the public. In considering nuclear power versus other options for meeting energy needs, equivalent comparisons need to be made; that is, the benefits, risks, and costs of each option should be examined. Risk comparison may, for example, include the consideration of:

- the reliability of oil supplies from the Middle East;
- the environmental impacts of building a dam or a spill from an oil tanker;
- the probability of long-term contamination resulting from the disposal of radioactive wastes from nuclear power plants;
- the controls needed for hazardous chemicals required in the manufacture of solar energy cells;
- the effects of home energy conservation improvements on indoor air quality;
- the competition for land between the needs of food production and biomass energy production;
- the safety measures needed in the transport of natural gas;
- the radioactive material released during the operation of coal burning plants;
- the effects of wood-burning stoves on air pollution; and
- the risk of reliance on a limited number of energy sources.

For an education program to be effective, a comprehensive presentation of these types of considerations is important to create public awareness of the elements that need to be considered in trying to reach a balanced decision on the use of energy resources.

CLEANUP, RESTORATION, AND WASTE DISPOSAL

The continued use of radioactive materials in biomedical research and health care, electrical energy production, and other industrial applications will be largely dependent on the implementation of an effective radioactive waste disposal program. The choice of sites and the licensing of waste disposal facilities are major problems in the United States. Both low- and high-level waste repositories have faced great local and, in some cases, regional (i.e., State and interstate) opposition.

The intensity of public opposition to the establishment of waste disposal sites is reflected in the large number of legal suits (and counter-suits) among States, between individual (or several) States and the Federal government, and between the government and public interest groups seeking to stall facility-siting efforts. The reasons for this political turmoil are complex, and they involve various perceptions and opinions among scientists, policy makers, and groups affected by the technology and its risks. As a consequence, the critical progress needed to establish a national waste disposal program has come to a halt, not due primarily to scientific or engineering problems, but due to political problems surrounding the issues.

In many instances, States and contractors working on low-level waste facilities are regarded as biased parties, and their motives and information are often seriously questioned. Negative public opinion about nuclear technologies and waste disposal programs is worsened by the NIMBY attitude. This results from the perception that the few who live near nuclear facilities unfairly bear the risks and consequences of a technology whose benefits are received by many. Thus, people oppose the location of nuclear power plants or waste disposal facilities in their "backyard." If these facilities are to be built and accepted by the public, then it is necessary to improve the local residents' knowledge and understanding of all the associated risks and benefits so they can be involved in the assessment and ultimate decision-making process.

In a properly operated, well-designed waste disposal system, the release of radioactive materials can be well within regulatory limits and of minimal environmental significance. Nonetheless, disposal sites contain radionuclides that may exist for centuries. If waste disposal activities are not properly controlled or managed, a potential for exposure can exist as the materials migrate from the sites through water or air to the surrounding population.

To protect against potential exposures, waste facilities have been designed with multiple barriers. A series of events would have to occur, and many safety measures would have to fail, before any radioactive material could be released. Scientists and engineers have developed mathematical models to predict these chances. They have used engineering and environmental information to choose the credible worst cases (those with the highest risk but still considered to be within the realm of possibility) to estimate the possible radiation dose to people.

Mathematical models developed to estimate radiation doses to the public from radionuclides in waste disposal sites indicate that calculated doses are small, when compared to natural background, even when the most conservative modelling or worst case assumptions are used. Nevertheless, waste disposal is a topic of continuing public debate, and many consider the health, environmental, and economic risks associated with waste disposal activities unacceptable.

Benefits, Risks, and Costs

Under the authorities and responsibilities specified by laws such as CERCLA,[32] RCRA,[33] UMTRCA,[34] SARA,[35] and other related regulations, the Federal and State governments and the private sector work to ensure that environmental, public health, and workplace hazards associated with cleanup, restoration, and waste disposal activities are minimized or controlled.

These efforts can be excessively expensive, not only due to the establishment of the process and engineering plan, but also because of changes in criteria that occur between the design and development stages. The type and the level of cleanup or isolation may not have been decided in the regulatory arena, or they may have been set at unrealistic levels because of the many different definitions of what is considered an "acceptable level of risk." As with the economics of nuclear power production, the speculative nature of meeting unknown performance criteria greatly impacts the costs associated with radioactive waste restoration and disposal. For example, the cleanup of 25 inactive uranium mill tailings sites, under current regulations, is expected to exceed $1 billion. If additional ground water restoration requirements are implemented, the cost to the American taxpayer could potentially double to $2 billion.

In 1992, the General Accounting Office (GAO)[36] indicated that while there were no up-to-date estimates on the total cost of DOE's remedial action projects, based on a review of selected projects, the trends suggest that cost estimates are increasing and that they are likely to be higher than previous estimates (in 1988, DOE estimated that costs could be as high as $64 billion, and GAO estimated that overall costs could exceed $100 billion).

Implementing all the requirements may reduce an already small risk to perhaps an even smaller risk, but at considerable cost. The public should decide whether or not the resources spent on a reduction of this risk would be better used to "buy" more effective risk aversion measures in other areas. If the question is whether or not radioactive wastes should be generated at all, then the public will need to balance this with the costs and risks they will have to accept in the generation of electricity using other sources of energy, or in the research, diagnosis, or treatment of diseases using other methods, if any are available.

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[32] Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (P.L. 96-510), 94 Stat. 2726.

[33] Resources Conservation and Recovery Act of 1976 (P.L. 94-580), 90 Stat. 2795.

[34] Uranium Mill Tailings Radiation Control Act of 1978 (P.L. 95-604), 92 Stat. 3021.

[35] Superfund Amendments and Reauthorization Act of 1986 (P.L. 99-499), 29 USC 655.

[36] *Nuclear Health and Safety: More Can be Done to Control Environmental Restoration Costs* (April 20, 1992) [GAO/RCED-92-71].

Education Efforts and Public Reactions

The U.S. government attempted to define what an "acceptable level of risk" is through a 1985 Congressional mandate to the Nuclear Regulatory Commission (NRC) to establish a "below regulatory concern" (BRC) policy.[37] This policy was to establish the framework within which NRC would formulate rules or make licensing decisions to exempt from regulatory control those practices that have such small estimated health or environmental risks that regulatory efforts to further reduce those risks would be unwarranted and, in fact, might detract from NRC's ability to effectively regulate other activities that pose greater health or environmental risks.

In July 1990 NRC issued a BRC policy to establish the mechanism by which NRC could determine at what levels radioactive material may be exempt from regulatory control.[38] The policy established a consistent approach by which NRC could evaluate and approve each type of BRC use requested and was not significantly different from past NRC licensing practices.

Although there was some disagreement about where the BRC risk levels should be set, Federal agencies, and the technical community at large, generally agreed that a BRC-type policy would provide a useful concept for effectively allocating and managing regulatory resources, while protecting overall public health and the environment. However, there was a public outcry against this policy, particularly as it might apply to the disposal or recycling of very low levels of radioactive materials.

Certain public interest groups opposed the BRC policy and presented it as a policy that would lead to the uncontrolled release of large amounts of radioactive material into the environment. This general impression, coupled with the lack of consensus within the Federal government on the definition of an "acceptable level of risk," caused Congress to react to public sentiment and propose several legislative actions to seriously restrict the application of the BRC policy, whose establishment Congress itself had mandated.

NRC published a pamphlet in 1990 to explain the BRC policy to the public.[39] However, it was clear from letters and other public reaction that there was still considerable misunderstanding about the intent of the policy. In June 1991 NRC formally initiated a process for seeking consensus on the full range of issues related to the BRC policy. NRC declared a moratorium on implementation of this policy until the consensus process was completed. However, in November 1991 NRC abandoned its plans for proceeding with the consensus process when it was unable to find any environmental group willing to participate.

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[37] The Low Level Waste Policy Amendments Act of 1985 (Public Law 99-240), Section 10.

[38] U.S. Nuclear Regulatory Commission, "Below Regulatory Concern; Policy Statement," *Federal Register* 55 (July 3, 1990): 27522-27537.

[39] U.S. Nuclear Regulatory Commission, *Below Regulatory Concern: A Guide to the Nuclear Regulatory Commission's Policy on the Exemption of Very Low-Level Radioactive Materials, Wastes and Practices*, NUREG/BR-0157 (Washington, D.C.: U.S. Nuclear Regulatory Commission, 1990).

Subsequently, Congress revoked NRC's BRC Policy Statement,[40] and NRC formally withdrew the statement. Although there were other considerations that contributed to its demise, the ultimate rejection of the BRC policy is an excellent example of the impact that misinformation, misunderstanding, and negative public perception can have on proposed regulatory policy.

Similar impacts occur regularly on regional and local levels when Federal or State organizations attempt to gain consensus on, or even acceptance for, radioactive waste disposal operations in a given area. While such activities do not always receive the same degree of national attention received by the BRC policy, the integrated impact of concerns and anxieties over waste disposal is substantial. The establishment of radioactive waste disposal sites has been slowed and halted, even in cases where it is clear that such facilities can operate safely and are well within health standards. The overall impact has been to force waste managers to employ temporary, and, in some cases, less desirable and more costly approaches to managing radioactive waste. This affects not only the nuclear energy industry, but the public as well through increased costs of nuclear power and other activities (e.g., nuclear medicine and food irradiation) requiring the use of radioisotopes. Options for for cleanup and restoration activities are also made limited.

Many factors influence decisions and public policies concerning radioactive waste disposal. While an informed public may not necessarily welcome or accept waste disposal sites "in their backyard," a process leading to an open exchange of factual information can help resolve concerns about issues such as nuclear waste disposal or BRC. Educational programs are needed to help the public understand not only the benefits and risks associated with these radiation issues, but also the need to balance local concerns with national interests.

Agencies are attempting to better inform the public and get the public more actively involved in the early stages of regulation development. For example, from January through May 1993, NRC conducted a series of workshops throughout the country to obtain early and widespread public participation in its rulemaking on radiological criteria for decommissioning. More than 180 persons participated in these workshops. In addition, NRC established an electronic bulletin board to allow members of the public to access, via personal computers, information on the rulemaking and to comment on NRC staff proposals. Over 700 individuals have used the bulletin board through over 2,000 calls. NRC also made available for public comment an early staff draft of the proposed rule, which was prepared after the workshops, before it was sent to the Commission for its review.

Concurrent with the NRC rulemaking, EPA is proceeding to develop standards and guidance for Federal agencies in the area of radiation protection, including standards for the cleanup of contaminated sites. EPA is also actively seeking early public input. NRC and EPA have coordinated their efforts in this area to ensure that effective and consistent site cleanup standards are established, while minimizing the duplication of efforts.

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[40] Section 2901 of the Energy Policy Act of 1992.

FOOD IRRADIATION

Ionizing radiation can be used to control pests, parasites, microorganisms, and harmful residues in foods. Irradiation can also increase the shelf life of various food products (including some tropical fruits). The safety of irradiated foods has been evaluated for more than 35 years by scientific and medical experts from the Food and Agriculture Organization, the International Atomic Energy Agency, the World Health Organization, the Codex Alimentarius Commission, and the American Medical Association. Scientific data collected for over 35 years indicate that food irradiated under conditions approved by the Food and Drug Administration (FDA) is safe and nutritious. Foods irradiated under these conditions have been thoroughly tested, and no radiolytic products[41] have been identified in irradiated foods that do not occur in other unirradiated foods. The use of irradiation in food processing could benefit U.S. consumers by adding another technique, with benefits over other processing techniques, to provide a safe, wholesome, convenient, plentiful, and diversified food supply.

Food irradiation has been approved in more than 36 countries. To date, this technology has been successfully adopted for a limited number of foods in 21 countries, including technologically advanced countries such as France, the United Kingdom, the Commonwealth of Independent States (the former Soviet Union), Israel, Japan, the Netherlands, Belgium, and the United States. Historically, the food industry has had great difficulty in influencing public opinion regarding new food processing technologies. For instance, the public resisted the use of canned food products for about 50 years after the introduction of the canning process. When such reticence is coupled with the public's negative perceptions of radiation and the misinformation presented about the food irradiation process, there is little wonder that the food industry has been reluctant to invest in and promote food irradiation because of the belief that the public is not yet ready to accept food irradiation technology. Leading government and nongovernment health organizations in the United States and the world have stated that the public should have a choice of food processing technologies. These organizations, however, have carried out only a minor public education effort. As a result, the general public has been more exposed to the wide dissemination of information on food irradiation from special interest groups opposed to the development of nuclear technologies.

Benefits, Risks, and Costs

The principal benefit of food irradiation is the reduction of food-borne bacteria in food products. In every part of the world, a battle is constantly being waged against the spoilage of food through infestation, contamination, and deterioration. There are no exact figures on just how much of the world's food supply is spoiled, but losses are enormous. This is particularly so in developing countries where warm climates favor the growth of organisms that cause spoilage and hasten the deterioration of stored food and where energy

[41] Radiolytic products are chemical products formed as a result of the irradiation process. These products occur in minute concentrations and are not known to be harmful or to affect the nutritional value of the irradiated food.

and technology resources are insufficient to support the extensive use of other processes, such as pasteurization or refrigeration. Treating foods with appropriate doses of radiation reduces the incidence of food-borne, disease-causing bacteria and parasites and reduces food loss from field-to-table due to spoilage. With a rapidly expanding world population, the development of new methods to preserve food and reduce food-borne diseases is a high priority. The technology can also result in a more efficient and productive use of land and energy resources and can reduce the use of chemical preservatives. The cost of irradiation versus alternative methods of preventing food-borne diseases and food loss may thus be justified in many cases.

A food irradiation facility normally requires a large quantity of radioactive material to provide the necessary high dose rates needed to process large quantities of food products in a reasonable period of time. Other radiation sources, such as accelerators, may also be used. All such facilities must be approved by NRC, FDA, and/or the U.S. Department of Agriculture (USDA) to ensure the safety of the food products being processed. The food irradiation facility must also be constructed and operated properly to comply with appropriate requirements from NRC, EPA, and the Occupational Safety and Health Administration (OSHA) that establish the controls necessary to ensure the safety of workers and the public. The required engineering controls and other necessary radiologic protection measures involved are used in industrial irradiation facilities and in other nuclear technologies and are, therefore, not unique to food irradiation facilities.

The failure of food irradiation to gain wide acceptance is not difficult to understand, given the extensive use of pesticides, fumigants, and other food-processing methods that have effectively precluded any critical need for a new technology, especially in the United States. Furthermore, many people confuse irradiated food with radioactive food, and they are genuinely afraid of any technology they believe would increase their risk of exposure to radiation. Opponents of food irradiation technology use this misconception and often overstate the technology's potential environmental and health risks. They discount the benefits of food irradiation and link it with the production of nuclear weapons and the resulting radioactive by-products because a significant source of the radioactive materials used for food irradiation come from nuclear fission and neutron activation. In spite of what some opponents claim, however, eating food irradiated under conditions specified by FDA cannot make a person radioactive.

Education Efforts and Public Reactions

If society is to derive full benefit from food irradiation, then public education and information programs must be implemented to increase public awareness of the benefits, costs, and risks of food irradiation, in comparison with alternative food processing methods. A coordinated Federal program that provides credible and reliable information about the benefits and limitations of radiation processing would allow the public to enhance their decision-making ability regarding this technology. The focus of any Federal program, therefore, should be to provide information in a balanced format to enable the public to make informed choices.

FEDERAL PROGRAMS

The various Federal agencies that deal with radiation issues have developed a wide range of educational programs and approaches to disseminate educational materials to the public. Legislative authorities to conduct, or otherwise support, educational programs in science and mathematics also vary widely among CIRRPC member agencies. DOE and EPA, for example, have legislative authorities that provide for educational programs directly involving radiation issues. Other CIRRPC member agencies, such as the Federal Emergency Management Agency (FEMA) and the National Aeronautics and Space Administration, have legislative authorities for educational programs that only indirectly involve radiation.

In addition to CIRRPC member agencies, other Federal departments and agencies, most notably the Department of Education (DoE),[42] have extensive mathematics and science education programs, but none of these directly pertains to radiation. The report of the Federal Coordinating Council for Science, Engineering, and Technology's (FCCSET) Committee on Education and Human Resources[43] provides detailed descriptions of science and mathematics education programs in a number of Federal agencies and departments, including all of the CIRRPC members, except the Department of State, the Office of Management and Budget, FEMA, and NRC.

At present, there are no coordinated Federal programs to provide educational information on radiation issues. A description of legislative authorizations, education programs, resources to support programs, and radiation issues of concern to CIRRPC member agencies is provided in Appendix D.

One of the tasks assigned to the Subpanel was the collection and evaluation of data on public information programs it deemed relevant. It was suggested that this task include a determination of the focus and general content of the public information programs, the target audiences, and the mechanisms of information dissemination, as well as how the programs have been evaluated. The Subpanel felt, however, that a broad-scope application of such a review was beyond its capabilities and that it should, instead, be part of the continuing effort to improve the public's understanding of the benefits, exposure potential, and relative risks of radiation, as described in the Subpanel's recommendations.

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[42] Although DoE is not a member of CIRRPC, the Subpanel invited representatives to brief the Subpanel. Representatives were also invited to participate in the Workshop.

[43] Federal Coordinating Council for Science, Engineering, and Technology (FCCSET), Committee on Education and Human Resources, *By the Year 2000: First in the World* (February 1991).

EDUCATION ISSUES AND FEDERAL STRATEGIES

Radiation-related issues, such as radioactive waste disposal and food irradiation, have often been topics of heated and emotional debates. Inaccurate and confusing generalizations regarding the risks of exposure to ionizing radiation abound, but education programs that can place radiation risks and benefits in perspective by comparing them to the risks and benefits of alternative activities would broaden public understanding. The existing public confusion over the risks and benefits associated with nuclear technologies demonstrates the need to develop information and education programs to provide accurate information in a clear and concise fashion. This section focuses on issues and strategies identified by the CIRRPC Subpanel as critical to the development and implementation of a coherent and coordinated Federal policy on public information on radiation and its health effects.

ISSUES

Lack of Coordinated Public Education Programs

With the exception of a few activities on specific radiation issues, agency approaches to public education and information have generally been fragmented. No agency has taken the lead in developing a coordinated Federal public education program to facilitate information dissemination. Aside from reducing the number of confusing and conflicting statements among agencies, coordinated programs would be effective in enhancing the government's role as a source of reliable information on radiation and in showing that the Federal government's position on specific issues is clearly established and articulated.

A unified Federal policy on public education and information programs on radiation effects is needed to guide and coordinate agency efforts. A unified position on public education and information programs would also enable Federal departments and agencies to pursue programs that continue to take their special goals and interests into consideration. It would ensure that diverse agency efforts are focused on the same goal: the enhancement of public awareness and understanding of the role of nuclear technologies in society. CIRRPC may be the most suitable government entity to propose and encourage such a policy because it was created specifically to coordinate radiation matters among agencies, evaluate radiation research, and provide advice on the formulation of radiation policy.

Credibility

The effectiveness of any public education and information program strongly depends on the perceived credibility of its information sources. The use of sources with questionable credibility seriously undermines the public's assessment of the information's worth.

Credibility should be built on a foundation of clear, concise, and accurate information, and connections to any vested interest should be avoided. Certain operational elements needed to develop and maintain credibility include an emphasis on objective and explanatory information that recognizes all sides of an issue; a capability for quick response to newsworthy events and public inquiries; and a policy not to defend the position of specific Federal agencies on the issues involved.

Agency Responsiveness

Many Federal agencies and departments have public relations offices that deal with queries from the general public, the press, and other interested constituencies on matters pertaining to radiation issues. Quick and accurate responses to requests enhance public confidence in agency activities and reinforce the concept of the Federal government as a reliable source of technical information on radiation issues and the main source of information on facts behind the adoption of specific Federal policies on radiation issues. For questions of a general nature, many Federal agencies can respond quickly with pamphlets and other publications. However, for more detailed and complex requests, the required information may not be readily available because of difficulties in identifying appropriate agency publications on the matter or in identifying agency experts who can readily address the issue. It is important, however, to respond quickly, if nothing more than to acknowledge the request and to inform the person that an answer is forthcoming. This will help more strongly convey the agency's responsiveness to the information needs of the public.

Scientific Literacy

Many studies have been conducted on the quality and quantity of the public's scientific literacy in the United States. Jon Miller has written extensively on this topic and has developed a methodology for measuring, in quantitative terms, the degree of scientific literacy in the population. Miller's studies show that 19 out of every 20 Americans do not have a minimal understanding of the processes or methods of science, do not have a basic vocabulary of scientific and technical terms and concepts, and do not have a minimal understanding of the impact of science and technology on society.[44] Aside from its negative impact on various domestic programs, including basic science research, inadequate scientific literacy can lead to an erosion of the United States' competitive edge[45] in world

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[44] J.D. Miller, "Scientific Literacy," *Daedalus* 112 (1983): 29-48.

[45] L.A. Steen, "Mathematics Education: A Predictor of Scientific Competitiveness," *Science* 237 (1987): 251-252.

technology markets. Even today, the United States is already experiencing significant competitive pressures.[46]

As discussed previously, poor scientific and nuclear/radiation technology literacy in the United States[47,48,49] can have a significant impact on society, perhaps by restricting the use of certain technologies through choices or decisions that may be based on misunderstandings and unsubstantiated fears. The public should have a basic understanding of science and technology, the scientific method, and fundamental scientific terms and concepts because they are absolute requirements for a sustained and meaningful dialogue on scientific or technical issues.

STRATEGIES

National Radiation Information Center

To address the objective of developing a coherent and coordinated Federal policy on public information on radiation and its health effects, the CIRRPC Subpanel proposes the creation of a centralized National Radiation Information Center (NRIC) that would work closely with Federal departments and agencies in responding to public queries about radiation issues and Federal programs. Inquiries involving individual agency policies would be referred back to the appropriate agencies.

The Subpanel proposes that NRIC sponsorship be established within the Executive branch, but outside any particular agency or department. This would prevent any perceived conflicts of interest (e.g., management by a lead agency with promotional or regulatory responsibilities for radiation activities). NRIC should be governed by a board or panel with broad representation and objectivity. This is essential not only because of credibility concerns, but also because it may be important for maintaining professional and agency support. Interagency participation and coordination, as well as connections with levels of government where policy decisions are made, should be established early on. The need for this strategy is a reflection of the special sensitivity of the issues associated with radiation exposure in the public's mind.

NRIC should initially have a limited set of objectives and a modest coverage of issues concerning radiation effects. This will enable the center and its staff to learn through experience, manage up-to-date information gathering and dissemination costs, and build and

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[46] W.E. Massey, "Science Education in the United States: What the Scientific Community Can Do," *Science* 245 (1989): 915-921.

[47] N. Hackerman, "Science Education: Who Needs It?" *Science* 256 (1992): 157.

[48] Mossman, "Nuclear Literacy."

[49] M. Neuschatz, "Teaching the Critical Mass in High School Physics," *Physics Today* 42(8), Part 1 (1989): 30-36.

evaluate credibility. This paced approach should facilitate an active effort to synthesize complex information into understandable language that includes a risk-benefit perspective.

NRIC should be a fully interactive information center, using the most technologically advanced communication techniques and equipment available. Organizing NRIC in a manner similar to other successful Federal information centers (e.g., the National Agriculture Library's information centers, which deal with contentious issues such as animal welfare and water quality) could substantially reduce set-up and operating costs. These centers have proven expertise in information dissemination, and many of them operate with an interactive staff that fields specific inquiries from the general public, including the media, special interest groups, and educators.

NRIC should be able to interact with different public constituencies—a citizen with a routine question, the media, public officials, special interest groups, and educators. Serving the needs of these "customers" may involve a wide spectrum of information material and dissemination techniques including hard-copy documentation from Federal departments and agencies; special-purpose materials prepared by the center; referrals, as required, to available experts; bibliographies; data base access techniques, including interactive "bulletin boards;" and materials in the public domain designed for educational purposes or prepared by special interest groups.

Outreach Programs

Agencies and departments should establish outreach programs to provide public information on specific agency radiation activities. These agency outreach programs may be complementary to the NRIC initiative, and to ensure success, both efforts should address the difficult underlying issues of public apprehension regarding radiation. This means that mere information or textbook tutorials are not enough. Activities must include an in-depth presentation of the fundamentals of radiation and radiation effects as interesting, useful, and even fascinating phenomena of nature, not necessarily related to any specific nuclear technology.

The "At-A-Glance Series," published by the National Radiological Protection Board of the United Kingdom,[50] is an example of a successful outreach program activity. With titles such as *Radiation Doses—Maps and Magnitudes* and *Radiation Protection*, these foldouts are attractive to look at and are multilevel in content. A DOE series, *Science Activities in Energy*, includes interesting and well-planned packets for elementary schools that illustrate principles and problems related to energy development, its use, and conservation. Other Federal departments and agencies should be encouraged to develop similar materials.

Educational software and video games may also be useful media for communicating risk-benefit concepts and radiation information to school-age children. A radiation

[50] These series of leaflets include: "NRPB at a Glance;" "Partners in Protection;" and "Radiation Doses—Maps and Magnitudes." These are available from the National Radiological Protection Board, Chilton, Didcot, Oxon, England, OX11 ORQ.

technology game, for example, that lets the player (the King or Queen) choose between nuclear options or conventional technologies in building his or her video kingdom could be developed. In deciding options for the kingdom, the player would learn about the negative and positive aspects of all the technological possibilities. Imaginative and colorful games based on the balance between risks and benefits, and the use of accurate risk-benefit information to create this balance, could be widely distributed at little or no cost through electronic bulletin boards and shareware or freeware distributors.

Workshops for the media, science educators, curriculum managers, and special interest groups could also be effective, if they are done proficiently and focus on the background, interests, and needs of the target audience.

Points of Contact — Establishing Channels of Communication

The most fundamental outreach elements, of course, are the agencies' own existing channels of communication with the technical community, the news media, and the public. It is critical for Federal agencies to ensure that their technical personnel are capable of effectively communicating with the public.

Agencies already have significant resources for conducting public information and education efforts within their public relations offices. The effectiveness of these assets could be improved considerably by enhancing the direct communications channels between the public and technical experts in the agencies. Two components are involved: the administrative link between the inquiring individual and the knowledgeable expert; and the ability of the expert to communicate effectively with the public. Improving the first component requires the identification of key experts for each specialized area of interest, such as radioactive waste disposal, food irradiation, etc. Then, formalized mechanisms are needed to ensure that all public affairs personnel are aware of who these experts are and how to contact them.

Even if technical experts are easily accessible, they are ineffective unless they are capable of communicating clearly with the public. Credible members of an agency's technical staff should be trained specifically as communicators and encouraged to interact with the public and with members of the media and the academic community. Enhancements to existing public relations efforts could work to improve public understanding of radiation issues.

Curriculum Reform

Any effort to address the public's educational needs in science and technology must involve the consideration of strategies to introduce curriculum reforms in elementary and secondary education settings. Reforms are necessary because the current science and mathematics curricula have been unable to provide people with a scientific knowledge base sufficient for dealing with science and technology issues in general and radiation issues in particular. Increasing public understanding about the potential for radiation exposure from various sources should be part of a broader effort to increase public understanding of science. In a national survey conducted by The Gallup Organization, college graduates had a better grasp of radiation issues than those with less education. This is evidence of the value of education, in general, in helping the public understand science.[51] The introduction of curriculum reforms, starting at the elementary level, should enhance the understanding of science throughout the population.

In addition to curriculum reform, the Federal government should also establish programs to develop teacher interest and excellence in the sciences and mathematics and to encourage students to pursue careers in these areas. Local school boards should be challenged to revamp the curriculum to prepare today's students for tomorrow's society. Any attempt at a permanent solution to the scientific literacy question must, first and foremost, concentrate on the educational experiences of students in grades K through 12 because it is at these levels that students are introduced to, and become conversant in, science and mathematics.[52]

Good science and mathematics teachers need to exhibit two major qualities to be effective. First, they must have a comfortable command of the subject material because it is their basic understanding that gives them confidence to teach and continue to build on their knowledge base. Second, they must be able to present this material through interesting, challenging, and enthusiastic approaches. Teachers who create a classroom environment that allows students to "learn" effectively should be rewarded for their excellence. The Federal government should support the organization of summer workshops to provide teachers with additional training in the sciences and mathematics and to furnish them with new ideas for laboratory experiments and classroom demonstrations.

Excellent teachers and methods alone will not be effective unless interest and motivation is present or generated among students. Of four million high school sophomores in the United States in 1977, only about 18% showed interest in the natural sciences and engineering.[53] Interest in majoring in the sciences among college freshmen has also dropped dramatically since 1966. Freshman interest in various careers in technology has experienced a remarkable decline during the last few years. Between 1966 and 1988, the percentage of college freshmen planning to major in the sciences and mathematics fell from 11.3% to 5.8%.[54] Long-term studies of freshmen preferences also suggest that of those who express an intention to major in science or engineering, less than half actually go on to earn degrees in those fields. To ensure America's continued strength in science and engineering, programs in science and mathematics education (in grades K through 12) must be modified

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[51] A.S. Bisconti and R.L. Livingston, *Communicating with the Public About Radiation* (Washington, D.C.: U.S. Council for Energy Awareness [USCEA], 1992). This report transmits the results of a national survey on the public perception of radiation conducted for USCEA by The Gallup Organization.

[52] *Ibid.*

[53] Massey, "Science Education in the United States."

[54] K.C. Green, "A Profile of Undergraduates in the Sciences," *American Scientist* 77 (1989): 475-480.

to encourage students, especially women and minorities with both the interest and the potential, to pursue careers in science, mathematics, and engineering.[55]

[55] Massey, "Science Education in the United States."

RECOMMENDATIONS

The Subpanel offers the following recommendations to improve the public's understanding of the benefits, exposure potential, and relative risks of radiation by disseminating factual information on radiation issues. These recommendations were based on the careful review and analysis of educational and other related materials, provided by various Federal departments and agencies, on the benefits and risks of the use of radiation technologies in our society. Other sources of information and guidance included presentations by a spectrum of nongovernment organizations, such as consumer groups, as well as the Subpanel-sponsored workshop attended by policy, public relations, and technical experts from the Federal government.

These recommendations are founded on the assumptions that any effort to improve public understanding of radiation through government programs must:

- be based on the use of credible and reliable information sources; and
- recognize and address the overall Federal effort to enhance scientific literacy within the general population.

The Subpanel believes that public education on fundamental scientific and mathematical principles would be enhanced by the successful implementation of the following recommendations.

RECOMMENDATION: ESTABLISH A NATIONAL RADIATION INFORMATION CENTER

A Federally sponsored, independent National Radiation Information Center (NRIC) should be created to communicate information on radiation issues to the general public. An administrative board of government and nongovernment personnel, with wide representation, should oversee the center's activities. The center should be a repository for technical and factual information on radiation topics. The center should also efficiently and effectively interact with the public and with various government agencies on specific radiation issues. The staff would be available to collect and catalog complex, and perhaps conflicting, information. The center would act as a central clearinghouse for information, but it would not interpret policy or attempt to speak for any individual agency. Questions concerning agency policies would be referred to the appropriate agencies for response. It is important for the center to initially focus on a set of objectives, with a modest coverage of issues related to radiation benefits and risks. This will enable the center and its staff to learn through experience, manage the expense of keeping up with new developments, and build credibility.

RECOMMENDATION: ESTABLISH OUTREACH PROGRAMS

Individual departments and agencies should develop and/or expand outreach programs for students and teachers. These programs may involve workshops, summer laboratory internships, and the development and distribution of educational literature and software. To ensure credibility, materials provided by the outreach program should be subject to the highest standards of scientific review. These efforts would not only enhance science and mathematics literacy, using radiation issues as examples, but would also encourage students to pursue careers in science, engineering, and technology. In addition, these programs would give teachers renewed enthusiasm and exposure to new educational ideas and high-quality materials they can share with students and fellow teachers. The report of the FCCSET Committee on Education and Human Resources[56] provides descriptions of outreach programs currently sponsored by Federal departments and agencies that could easily be adapted to include experiences in radiation technologies. To encourage participation in these programs, awards to recognize teacher and student excellence at the national (e.g., a "President's Science Award") and regional levels should also be implemented.

RECOMMENDATION: ENHANCE COMMUNICATIONS INFRASTRUCTURE IN AGENCIES

Federal departments and agencies should review their existing public education and information programs on radiation issues. Efforts should focus on the development of a coordinated and comprehensive program, in accordance with individual department or agency mandates. If not already in place (e.g., in an Office of Public Relations), each organization should establish an office to serve as a primary response and resource center for public inquiries on radiation issues. The office should develop a network of "user-friendly" resource persons who can be readily contacted to address specific inquiries. Credibility is undermined when responses to inquiries are delayed or inaccurate. Therefore, it is particularly important to establish a formal mechanism(s) for directing public queries to appropriate resource persons.

RECOMMENDATION: ENCOURAGE CURRICULUM REFORM IN MATHEMATICS AND SCIENCE EDUCATION

Curriculum reform in mathematics and science for students in grades K through 12 should be promoted to improve their understanding of science in general and nuclear technologies in particular. Efforts to enrich the curriculum should be coordinated with teachers, local school boards, parent-teacher associations, professional societies of science and mathematics teachers, and State and local government representatives. Nuclear technologies play a vital role in society, and the incorporation of curricula, based in part on radiation issues, should be encouraged and supported as part of a generalized curriculum reform strategy to spark student interests in mathematics and science concepts applicable to

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[56] FCCSET, *By The Year 2000: First in the World.*

significant societal issues. The relevance of the energy and environmental issues associated with radiation benefits and risks should be used as one of the tools to enhance mathematics and science education in elementary and secondary schools. With the assistance of technical experts in the radiation field and the Federal agencies, educational materials (e.g., books, videos, and computer games) on radiation issues should be developed to enhance the curriculum at all grade levels and to make the students' learning experience fun, informative, and useful to their development as involved citizens. To ensure credibility, all materials and information presented in the curriculum should be subject to the highest standards of scientific review and accuracy.

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APPENDICES

APPENDIX A CHARTER OF THE SUBPANEL ON PUBLIC EDUCATION

INTRODUCTION

Studies of scientific literacy in the United States indicate that only about one in 20 Americans are scientifically literate. This is a sobering statistic and suggests that the general public is unfamiliar with the scientific method, the impact of science and technology on society, and a basic vocabulary of scientific and technical terms and concepts. Scientific illiteracy may have far-reaching technical, sociopolitical, and economic effects. Without a scientific knowledge base, the public (as individual members and as a group with common interests) cannot make informed decisions about the development and implementation of various technologies in society. Besides the negative impact on various domestic programs, including basic science research, the persistence of scientific illiteracy can only lead to an erosion of our competitive edge in world technology markets. The United States is already experiencing significant competitive pressures. Consider, for example, the remarkable gains the Japanese have made in the computer and semiconductor industries.

The scientific literacy question is nowhere more acute than in the nuclear technology arena. Fear of radiation and a lack of understanding of radiation technologies have adversely affected the development and implementation of nuclear technologies in society. Fear of radiation is considered to be a significant factor in patients' refusal of mammographic examinations. As a consequence, only a small percentage of women have undergone mammographic screening. Women who refuse mammography may be denying themselves important medical benefits by compromising the early detection of breast disease.

In the nuclear power sector, misconceptions about nuclear power plant operations may translate into public opposition to the nuclear energy option. In one study, about 60% of people who think a nuclear explosion is likely in a nuclear power plant oppose the development of more plants. Among those aware that a nuclear explosion is not possible, 88% support nuclear power, and 12% oppose it.

Currently, there is no clearly articulated policy in the Federal sector on the dissemination of information on radiation health effects. Although several Federal agencies have developed public information materials, agency approaches have been fragmented and no agency has taken the lead to develop a coordinated Federal program on public information.

Recognizing the public's lack of understanding of radiation and its health effects and the need to develop a coordinated Federal effort, CIRRPC identified public information and education as one of 10 national radiation issues which should be addressed by the various agencies concerned with radiation technologies.

SUBPANEL CHARGE

Therefore, the CIRRPC Executive Committee establishes a combined Subpanel of the Science and Policy Panels to address the question of public education on radiation. The principal objective of the Subpanel is to develop a coherent and coordinated Federal policy on public information on radiation and its health effects. In developing this policy, it is proposed that the Subpanel undertake the following tasks:

- Determine what radiation issues are important to the Federal agencies for public information.
- Determine which Federal agencies are involved and what role, if any, nongovernment agencies (e.g., NCRP, NUMARC, and ORAU) play.
- Collect and evaluate past and current public information programs on radiation from Federal agencies and any nongovernment groups (e.g., IAEA, NUMARC, League of Women Voters, and ORAU), as the Subpanel deems warranted. This activity should include a determination of the focus and general content of the public information programs, target audiences, mechanisms of information dissemination, and how programs have been evaluated.
- Determine what role, if any, the Federal government should play in the development and implementation of a public information program concerning radiation.

APPENDIX B

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APPENDIX C

RESULTS OF THE WORKSHOP ON FEDERAL RADIATION INFORMATION AND EDUCATION

The Workshop on Federal Agency Radiation Information and Education was held at the Federal Emergency Management Agency's training facilities in Emmitsburg, Maryland from May 29 through 31, 1991. The workshop was attended by over 30 representatives from the public affairs/media, policy/management, and education areas of 13 Federal agencies, including members of the Subpanel on Public Education. The workshop was conducted to gather views on the Subpanel's proposed solutions to problems associated with public information and education programs on radiation and its health effects.

The workshop keynote address was presented by Dr. Alicia K. Dustira of the Office of Science and Technology Policy (OSTP). Among other things, she discussed OSTP's Committee on Life Sciences and Health (CLSH) and how it works with the Federal Coordinating Council for Science, Engineering and Technology (FCCSET) to foster interagency communication and cooperation on science and technology. Dr. Dustira also addressed the Administration's renewed emphasis on science and mathematics education by briefly discussing the FCCSET Committee on Education and Human Resources' report, *By the Year 2000: First in the World.*

After the first Plenary Session, the workshop participants were divided, based on their interest and experience, into three groups: public affairs/media, policy/management, and education. The groups were asked to address four major issues from their respective points of view. These issues were Credibility, Short-Term and Long-Term Solutions, Information Clearinghouse (radiation information center), and Education.

CREDIBILITY

During the session on credibility, the participants were asked about their perspectives on credibility and their idea of what is meant by "a credible source." They were also asked to examine what role credibility, or the lack of it, has in implementing proposed long- and short-term solutions.*

The participants concluded that credibility is influenced by three factors: (1) perceived intrinsic Federal trustworthiness; (2) biases and perceptions extant in the public; and (3)

* Short-term solutions are those whose success may be evaluated on a short time scale. Long-term solutions are those that focus on the educational system.

journalistic filtration of Federal communications with the public. Some felt that improvements in credibility will result only from improvements in each of these three areas.

The credibility of proposed solutions may be enhanced by:

- ▲ implementing a positive and proactive, rather than a negative and reactive, approach;
- ▲ using information sources "with no axe to grind" because these are perceived as more credible;
- ▲ acknowledging mistakes;
- ▲ using well-known, knowledgeable individuals to communicate the facts to the public because familiar individuals are usually perceived as more credible than organizations;
- ▲ training and using agency individuals with a talent for communication, rather than relying on the best technical scientist, who may lack communication skills;
- ▲ providing these trained individuals with opportunities to communicate with the public and the media so that close working relationships and trust may be established;
- ▲ keeping science and politics separate;
- ▲ developing trusting relationships with credible individuals within the State and local governments and within the media; and
- ▲ responding quickly to public inquiries because credibility quickly disintegrates with delay.

During discussions on credibility and the proposed radiation information center, the critical issue of the influence of value judgments on the information provided was raised. The participants said that matters such as peer reviews, disclaimers, citations of vested interest, descriptions of policy/science content, and the use of descriptors such as "recommended," "reliable" or "unreviewed" should also be considered. The appropriateness of such value judgments, however, became the subject of debate.

SHORT-TERM AND LONG-TERM SOLUTIONS

During the session on short-term and long-term solutions, it was generally agreed that there was little distinction between efforts under the two time scales. Therefore, very little discussion was held on separating the two. The session instead resulted in suggestions in two areas: individual agency programs and coordinated agency efforts.

For individual agency programs, the participants suggested the continuation of program-specific efforts; the encouragement and enhancement of outreach activities and workshops for schools, teachers and civic leaders; the implementation of internship and fellowship programs for teachers and staff; the development and promotion of exhibits; and the use of communications training for staff.

Coordinated interagency efforts should also include special incentive programs such as merit badges and Presidential awards; the development of educational materials to enhance the curriculum; the use of books, video and audio tapes, television, and even video and computer games to augment information and education efforts; the establishment of a radiation information center as a source of unbiased information; the organization of interagency workshops; and the creation of an interagency response team for responding to public inquiries regarding radiation.

INFORMATION CLEARINGHOUSE CONCEPT (Radiation Information Center)

The workshop participants concluded that the creation of a radiation information center was a viable proposal. They added that the developers of such a center would benefit from the U.S. Department of Agriculture's considerable experience in setting up small information centers dealing with focused and sometimes contentious issues. It was also agreed that the center should be interactive (e.g., establish a telephone hotline), be coordinated on an interagency level, and have quick response mechanisms built in.

It would be best to begin with a modest coverage of issues related to radiation risks and benefits to allow the center to initiate and sustain efforts to respond, in understandable language, to academic or basic science questions, while incorporating a risk-benefit perspective. Options for dissemination capability were also outlined but were not prioritized. These options included agency-printed materials; special-purpose, center-prepared materials; publications of all types in hard-copy; bibliographies; modern data-base access techniques; referrals to a member of a preestablished list of experts; and materials geared to specific age-levels or interest groups.

To establish and maintain credibility, some participants recommended that the center be a Federally created and sponsored entity rather than a creation of a lead-agency. They believed that the center should operate under the watchful eye of a governing board or panel with wide representation. The center should stick to objective information, avoid interpreting or defending agency policies (although there was no clarification on how the line on this matter should be drawn), and be unbiased in its coverage of issues. Questions concerning agency policy would be referred to the appropriate agency for response.

The session resulted in active debate over whether only Federal information should be provided at the center, or if outside information should also be made available. If outside information is to be made available, some participants asked whether or not they should be provided to the public with or without comments or disclaimers. These issues were generally left unresolved.

A representative from the Food and Information Center of the National Agricultural Library, gave a brief presentation related to the radiation information center concept. The speaker said that the name "information center" is generally preferred over "clearinghouse" when the operation includes an interactive staff that fields specific questions and inquiries from the general public, including the media, special interest groups, and educators. Any association with the data base acquisition capabilities and hard copy collection of a good library would also benefit the center. The National Agricultural Library operates seven information centers, some of which deal with contentious issues, such as animal welfare and water quality. The information they provide is primarily explanatory. Both sides of an issue are given at the discretion of the center, and agency policy matters are avoided. The operational staff is made up of professionals in the areas of interest. They function as information managers, backed by a set of experts from around the country who can be called upon, as required.

Another participant, a former manager of the Department of Energy's Office of Science and Technology Information, agreed with the use of the term "information center," as opposed to "clearinghouse." He said that information centers provide a sense of expertise and continuity. This distinguishes an information center from a "clearinghouse," which deals passively with large amounts of information on a bibliographic basis, in much the same way that a library would. The center should: (1) be set up in an area or office where similar expertise already exists to reduce the financial burden; (2) develop the capability to synthesize and reduce complex topics to understandable language; (3) look for multiyear funding; and (4) establish early connections at levels where policy and funding decisions are made (e.g., OMB, OTP, OSTP, and Congress).

EDUCATION

The session on education dealt with issues related to the improvement of radiation information efforts through education and curriculum enhancement. The participants expressed general agreement on the need to introduce mathematics and science education at the earliest possible level and the need to increase and continue this effort throughout the elementary and secondary school levels. They also believed that to be effective, radiation materials need to be introduced in the context of an overall mathematics and science program. Parents should also be educated on what their children will need to succeed in the technically complex workplace of the future.

Suggestions for long-term approaches included tapping into existing structures such as the Association of School Boards, State Science Supervisors, and local Parent-Teacher Associations (PTAs); working with State legislators, such as in the State of California where legislation requires the teaching of radiation concepts in schools; and tying in with the FCCSET concept and report, *By the Year 2000: First in the World.*

The participants believed that short-term goals could be met by hosting workshops and outreach programs for school boards, teachers, PTAs, the media, and the general public. Examples of techniques and methods considered useful were discussed, including the creation and use of board, computer, and video games to make learning fun, as well as the sponsorship of poster and essay contests in local communities. It was suggested that special consideration be given to the creation of a President's Science Award, similar to the President's Fitness Award.

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APPENDIX D — FEDERAL INFORMATION AND EDUCATION PROGRAMS

DEPARTMENT OF AGRICULTURE (USDA)

Legislative Authorization

USDA has authority to conduct a wide variety of programs in science education. Sources of this authority include the 1862 Morrill Land Grant College Act, which established land grant colleges in each state, and the Food and Agriculture Act of 1977, which designated USDA as the lead Federal agency for higher education in the food and agricultural sciences. The Farm Bill Authority (Title XVI of the Food, Agriculture and Trade Act of 1990), the Smith-Lever Act of 1914, the Hatch Act of 1887, the Morrill Act of 1890, and the Rural Development Act of 1977 also contain authorizations for educational programs.

DEPARTMENT OF COMMERCE (DOC)

Education Programs

At present, DOC has no major public information responsibility involving radiation.

Radiation Issues in Public Education

Radiation issues of concern to DOC include research, standards, data, and services for accurate and compatible measurements of ionizing radiation (x rays, gamma rays, electrons, neutrons, energetic charged particles, and radioactivity). Applications involve radiation protection of workers and the general public, radiation therapy and diagnosis, nuclear medicine, radiography, industrial radiation processing, nuclear electric power, national defense, space science, and environmental protection.

DEPARTMENT OF DEFENSE (DOD)

Legislative Authorization

DoD has no legislative authority to engage in proactive public education programs on radiation and its health effects.

Education Programs

DoD Public Affairs Offices (PAOs) provide radiation-related information specific to DoD programs in response to queries from the public or the press. Information is provided to the maximum extent possible, within national security guidelines.

Resources

PAOs deal with a multitude of topics in addition to radiation. Since radiation is not broken out separately in the funding of PAOs, information on the level of resources specifically allocated to the dissemination of radiation information is not available.

Radiation Issues in Public Education

DoD is particularly concerned with the biological effects of electromagnetic radiation (in low-frequency to microwave spectral regions), radon, the decommissioning of facilities that housed radioactive materials, and the disposal of equipment that used or contained radioactive materials.

DEPARTMENT OF ENERGY (DOE)

Legislative Authorization

DOE derives its statutory authority from several sources. The general authority to provide educational material and information on radiation and energy-related activities is implicitly derived from the Atomic Energy Act of 1954 (as amended), the Energy Reorganization Act of 1974, and the Department of Energy Organization Act (effective October 1977). Other specific authority to inform the public of the impacts, hazards, and benefits of specific programs, projects, and operations may be provided through other laws, such as the National Environmental Policy Act (NEPA), the Resource Conservation and Recovery Act, and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act.

In a May 21, 1990 Secretary of Energy Notice (SEN-23-90), a departmental policy was established to make education in mathematics and science a primary DOE objective. The DOE Science Education Act of 1990 (P.L. 101-50) expands DOE's authorization to support science education and amends the 1977 Energy Organization Act to make support for science education a major DOE mission.

Education Programs

DOE deals with public information and education in diverse ways. Two major organizations provide funding for various public information/education efforts—one in the

Office of Energy Research (University and Science Education Programs) and the other in the Office of Environmental Restoration and Waste Management. These offices provide general support for many programs, including a few of the Laboratory-Based Science Education Programs, some of which deal directly with radiation. In addition, many of the project or program offices within DOE have education and information programs specific to their programs, such as the public information programs and precollege curricula on radiation and radioactive waste. Some of these activities provide general information, while others fulfill the requirements of NEPA or CERCLA and other laws.

Resources

The estimated DOE budget for science education support is approximately $113 million. This covers activities such as precollege, undergraduate, and graduate degree support programs, as well as general public information activities. About $1.34 million is spent on general public information programs, such as museum and traveling exhibits, and high school or other related presentations. These estimates do not include public information related to fulfilling NEPA or CERCLA, or other statutory requirements to keep the public informed of activities and possible impacts of various specific programs. Public information efforts can range anywhere from a fraction of a percent of the program costs in a year, to several percent of the annual expenditures, depending on the stage of the program and the degree of public concern.

Radiation Issues in Public Education

Issues of concern to DOE include the development of general radiation protection standards and new radiation risk estimates, the need for technical personnel trained in the radiation protection areas, radioactive and mixed waste, release limits for material containing residual radioactive material, public perception of the risks associated with radiation versus nonradioactive hazards, below regulatory concern, and the definition of "acceptable risk."

DEPARTMENT OF HEALTH AND HUMAN SERVICES (HHS) (PUBLIC HEALTH SERVICE)

Public information regarding ionizing and nonionizing radiation associated with electronic products (e.g., diagnostic x-ray machines, tanning booths, microwave ovens, electric blankets, and cellular telephones) is available from the Food and Drug Administration's Center for Devices and Radiological Health. This information is produced in carrying out the functions of the Radiation Control for Health and Safety Act of 1968 (P.L. 90-602).

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT (HUD)

Legislative Authorization

Section 1091(b)(2) of the Stewart B. McKinney Homeless Assistance Act Amendments of 1988 requires HUD to develop a policy for dealing with radon contamination in homes under certain HUD-assisted programs. This policy covers education, as well as research, testing, and mitigation.

Education Programs

HUD's current activities involve the distribution of radon literature provided by the Environmental Protection Agency (EPA).

Resources

The estimated annual research budget for radon testing and mitigation in EPA-defined high radon areas is approximately $400,000.

Radiation Issues in Public Education

HUD's issues of concern include radon standards, radon testing and mitigation in multi-story buildings, the mapping of the geologic radon potential for the entire nation, radon mitigation aspects of new building codes, and the health effects of radon.

DEPARTMENT OF THE INTERIOR (DOI)

Legislative Authorization

As part of its role as the country's principal conservation agency, DOI has responsibility for most of the nationally owned public lands and natural resources. In this role, the public information offices of DOI's various bureaus address questions related to radiation issues, such as the impact of uranium mining on the environment and the siting of nuclear facilities.

Resources

It is difficult to estimate the amount of resources allocated for information and education because DOI's public information offices deal with a wide range of topics other than radiation.

Radiation Issues in Public Education

Areas of interest to DOI include the mining and milling of uranium ores, the storage and disposal of radioactive wastes, radionuclide contamination and transport in soils and waters, and radon measurements in mines and natural systems.

DEPARTMENT OF LABOR (DOL)

Legislative Authorization

DOL derives its authority from the Occupational Safety and Health Act and the Mine Safety and Health Act. Both Acts mandate that workers be protected from all occupational hazards, including those posed by exposures to ionizing and nonionizing radiation. Under these statutes, the Occupational Safety and Health Administration and the Mine Safety and Health Administration have adopted standards designed to protect workers from radiation exposures. Generally, employers also have a duty under these Acts to inform workers of the nature of the hazards to which they are exposed and to train them to deal with those hazards. This training can take any form necessary to apprise workers of the nature of the hazards posed by various forms of radiation exposure.

DEPARTMENT OF TRANSPORTATION (DOT)

Legislative Authorization

As part of DOT's authority for regulating all kinds of hazardous materials in transportation, the Hazardous Materials Transportation Act of 1974 requires DOT to provide State and local governments with information about hazardous materials and guidance in dealing with transportation accidents involving them.

In addition, the Hazardous Materials Transportation Uniform Safety Act of 1990 (HMTUSA) requires DOT to coordinate with all other Federal agencies that have responsibilities in health, safety, and emergency preparedness. These statutes identify special requirements for radioactive materials as one of the many classes of hazardous materials. The HMTUSA also established a registration/fee program for shippers and carriers to fund hazardous materials planning and training conducted by agencies, primarily at the local level.

Education Programs

The Research and Special Programs Administration (RSPA) has primary responsibility within DOT for regulating the transport of radioactive materials and all other hazardous materials by all modes (highway, air, rail, or water). The main focus of activities are regulations for shippers and carriers of hazardous materials. The Federal Aviation Administration, Federal Highway Administration, Federal Railroad Administration, and the United States Coast Guard are also involved in these activities.

Statutes also require DOT to compile information on accidents and other data. DOT is required to provide local governments information about the hazards of such accidents and suggested responses to them. DOT's *Emergency Response Guidebook* (ERG) is probably the most significant source of information for emergency services personnel about the hazards of accidents that may occur in transporting radioactive materials and what they should do during an emergency. The ERG provides guidance on over 2,500 different hazardous materials and includes information on six different methods of transporting or shipping radioactive materials. The ERG is revised every three years, and over a million copies of the 1990 edition have been distributed, providing a copy for every emergency vehicle in the nation.

In addition to conducting a limited number of training classes about hazardous materials regulations, RSPA, in coordination with the Federal Emergency Management Agency (FEMA), maintains a computer bulletin board information system known as HMIX. HMIX has over 10,000 no-cost subscribers and provides current information about training opportunities, meetings, new documents, and regulatory changes related to hazardous materials and emergency responses.

Radiation Issues in Public Education

The transportation of radioactive materials has had an essentially flawless record for nearly 50 years. No deaths or substantive radiation exposure have been known to result from accidents. In spite of this, however, the perception that there is significant risk to the public and to emergency response personnel continues to exist.

Medical, industrial, and energy-producing nuclear programs will continue to require transportation. Low-level and high-level waste and decontamination/decommissioning programs require the "not-through-any-community" transport of publicly objectionable materials.

DEPARTMENT OF VETERANS AFFAIRS (DVA)

Legislative Authorization

DVA is authorized to support educational activities in several ways. Pursuant to chapters 30, 31, 32, 34, and 35 of title 38, United States Code, the Veterans Benefits Administration is authorized to provide monetary benefits to veterans to assist them in their readjustment to civilian life after their separation from military service. It is also authorized to furnish monetary benefits to provide educational or vocational opportunities to children or spouses of certain veterans. The eligible recipient of these benefits may select the educational, vocational, or professional objectives of the educational programs being pursued.

ENVIRONMENTAL PROTECTION AGENCY (EPA)

Legislative Authorization

Under the Atomic Energy Act of 1954, as amended in 1970, and the Reorganization Plan #3 of 1970, EPA is responsible for Federal guidance on: (1) occupational radiation exposure; (2) medical radiation exposure; (3) protective action guides; (4) nonionizing radiation exposure; (5) exposure to transuranic sources of radiation; and (6) sources of airborne radionuclides. EPA is also responsible for generally applicable environmental radiation standards for nuclear fuel-cycle operations and high-level and low-level radioactive waste disposal.

The Public Health Service Act of 1970 mandates EPA to monitor environmental radiation levels, research the effects of radiation, and provide training and technical assistance to States on preventive and remedial actions.

EPA also has a significant role in the Federal Radiological Emergency Response Plan. The Agency leads the Federal response to radiological emergencies in two cases: when the radiological material is not owned or operated by a Federal agency or an Agreement State and when the environmental fallout is from a foreign source. In these cases, EPA will provide the public with information about its emergency response activities.

Radionuclides are on the list of hazardous air pollutants under Section 112 of the Clean Air Act. EPA is responsible for issuing standards for radionuclides under the National Emission Standards for Hazardous Air Pollutants (NESHAPS). EPA is also promoting the delegation of NESHAPS implementation authority to the States by providing guidance in the development of State programs that will enable them to qualify for such authority.

The Indoor Radon Abatement Act (1988) of Title III of the Toxic Substances Control Act (15 USC 2661-2671) authorizes EPA to conduct public education programs on radon. To meet the requirements of this legislation, EPA is currently: (1) revising *A Citizens Guide to Radon* (an informational booklet developed in cooperation with HHS); (2) conducting an Advertising Council media campaign; (3) initiating cooperative efforts with various national organizations; (4) developing other public information materials; (5) providing State Indoor Radon Grants for State programs, including public education efforts; and (6) establishing regional radon training centers.

Radiation Issues in Public Education

The Office of Radiation Programs (ORP) carries out EPA's radiation protection activities. ORP's goal is to protect public health and the environment from avoidable exposures to radiation. Its public information activities include: (1) issuing standards and guidance to limit human radiation exposure; (2) evaluating and assessing the impact of radiation on the public and the environment; (3) distributing public information; (4) working with State and local governments, industry, professional groups, and citizens to promote actions to reduce exposures to harmful levels of radiation; and (5) responding to radiological emergencies. ORP's Policy and Emergency Response Branch also has a Policy and Public Information Section responsible for disseminating information on EPA's radiation programs.

The Indoor Radon Abatement Act has several specific public education provisions:

- ▲ Sec. 303 directs EPA to publish an updated version of *A Citizen's Guide to Radon*.
- ▲ Sec. 305(a) (1) authorizes EPA to establish a clearinghouse of radon-related information, including mitigation studies, public information materials, surveys of radon levels, and other relevant information.
- ▲ Sec. 305(a) (4) authorizes EPA to publish public information materials concerning radon health risks and methods of radon mitigation.
- ▲ Sec. 305(b) (2) authorizes EPA to assist States in the design and implementation of State public information and education programs.
- ▲ Sec. 306(c) (2) authorizes State and public information and education programs and authorizes EPA to issue grants to States for the development of public information and educational materials.
- ▲ Sec. 306(c) (10) authorizes EPA to issue grants to States to establish toll-free hotlines to provide information and technical assistance.
- ▲ Sec. 308(a) and (b) authorize EPA to establish regional radon training centers to develop information and provide training to Federal and State officials, the private sector, and the public regarding radon health risks and measurement and mitigation methods.

Under its Radon Program, EPA is currently involved in the following activities:

- ▲ *A Citizen's Guide to Radon*—revising a public information brochure providing information on radon health risks, measurement methods, mitigation methods, and other sources of information.
- ▲ Advertising Council media campaign—using television, radio, and print public service advertising to increase public awareness of radon.
- ▲ Cooperative efforts with national organizations—working with the American Medical Association, the American Lung Association, and others to educate local officials and the public and to encourage action to address radon.
- ▲ State Indoor Radon Grants (SIRG)—supporting State programs that include public education efforts.

- ▲ Regional Training Centers—providing training and education at four nationally dispersed centers.

- ▲ Developing other public information materials.

- ▲ Providing technical assistance and guidance to States on public information programs.

FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA)

Legislative Authorization

No specific authority for radiation-related education or information programs exists in FEMA. However, under the Federal Civil Defense Act of 1950, as amended, Section 201(f) authorizes the FEMA Administrator to "publicly disseminate appropriate civil defense information by all appropriate means." This may include information on radiation and the protection of individuals from the effects of radiation, especially as it pertains or applies to the Agency's protection programs from the effects of nuclear weapon explosions, terrorist activities, or from a major accident at a commercial nuclear power plant.

FEMA also chairs the Federal Radiological Emergency Preparedness Coordinating Committee (FRPCC), which was established to carry out the December 7, 1979 Directive to FEMA by the President to coordinate the Federal government programs regarding offsite radiological emergency preparedness and response, particularly in the 10- and 50-mile areas surrounding the commercial nuclear power plants in the country.

Education Programs

The Office of Emergency and Public Information is responsible for disseminating information on radiation issues pertaining to the general public. The Preparedness, Training and Exercises Directorate provides technical guidance to State and local governments in connection with offsite planning, preparedness, and response around commercial nuclear power plants. FEMA has also published a document, *Guidance for Developing State, Tribal, and Local Radiological Emergency Response Planning and Preparedness for Transportation Accidents* (FEMA-REP-5, Rev. 1, June 1992), which was prepared by the FRPCC Subcommittee on Transportation Accidents.

Resources

The Office of Emergency and Public Information has a small professional staff with additional support in the areas of graphic arts, design, and publications. FEMA documents are typically printed in relatively large quantities (10s to 100s of thousands) for distribution to emergency management officials and other selected professionals, throughout State and local governments, and the general public. The Preparedness, Training and Exercises

Directorate typically budgets about $60,000 annually for radiological-oriented publications for use by State and local governments.

Radiation Issues in Public Education

FEMA is concerned with accidental radiological releases from large nuclear facilities—primarily NRC-licensed commercial nuclear power plants; transportation accidents; and the protection, survival, and recovery from radioactive fallout following a nuclear weapon detonation or a terrorist activity.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

Legislative Authorization

Under the National Aeronautics and Space Act of 1958, NASA is required "to provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof." In accordance with the Space Act, NASA develops and disseminates education or information materials on NASA's activities to the media and the general public.

Under the Federal Radiological Emergency Response Plan, NASA established public affairs plans to disseminate radiological information to the media and the general public for plutonium-238 (Pu-238)-fueled radioisotope thermoelectric generators used to power the Galileo and Ulysses planetary missions.

Education Programs and Public Affairs

Educational activities are carried out under the Associate Administrator for the Office of Human Resources and Education. Under this office, the Educational Division covers publications, education programs and activities for elementary and secondary schools, higher education, and technology and evaluation. NASA is committed to helping America become a leader in math and science and encourages scientific literacy for all Americans. NASA's education programs exist to inspire students and teachers to reach their full science potential.

The Office of Public Affairs in Washington, D.C., is a multi-faceted organization under the leadership of the Associate Administrator for Public Affairs. It reaches NASA's numerous audiences through various programs and activities undertaken by the Divisions of Media Services and Public Services, an Internal Communications Branch, and Public Affairs officers located in the same program offices at NASA Headquarters (e.g., Space Flight, Space Science, Safety, and Mission Assurance). The Associate Administrator for Public Affairs also exercises functional oversight of public affairs activities at NASA's Centers, each of which has a public affairs organization.

Resources

The Office of Public Affairs employs a wide range of tools and activities including: (1) print materials (news releases, fact sheets, and press kits); (2) audio-visual materials (still photos, videotapes, films, and radio features); (3) a speakers bureau and a program of domestic and international astronaut appearances; (4) guest operations at NASA launches and landings; (5) exhibits at major domestic and international conferences and air shows; (6) fine arts, graphic arts, and artifacts programs; and (7) an internal communications program (newsletter, daily news summaries, and NASA Select).

NASA Select is an internal television system that allows NASA to broadcast past, current, and future NASA activities and events, both internally and externally. The system has proven to be an invaluable resource for supporting the agency's mission requirements and for disseminating information to the media and the general public.

The Education Division also employs a wide range of tools and activities (in coordination with public affairs) including: (1) print materials, posters, lithos, and publications; (2) videos; (3) mobile exhibits; (4) education conferences; (5) NASA Select television; (6) Spacelink (a computer-accessed resource library for educators); and (7) Teacher Resource Centers (located at all NASA Centers and in every State) that provide information on a variety of science, technology, and space programs and activities.

Education programs are a significant part of daily programming on NASA Select. These programs increase public awareness of NASA's commitment to education and the variety of programs available to parents, teachers, and students. Some cable stations, universities, secondary schools, and other organizations carry NASA Select to facilitate a wider distribution for these programs.

Radiation Issues in Public Education

NASA's concerns include: (1) the exposure of astronauts to space radiation and nuclear power sources; (2) terrestrial occupational exposure to radiation sources (normal industrial and laboratory use of ionizing and nonionizing radiation, as well as tracking and data radar); (3) space nuclear power sources (Pu-238-fueled radioisotope thermoelectric generators used to power planetary missions); and (4) the use of nuclear propulsion in space (the development of reactors for space propulsion and power generation for missions to the outer planets and beyond).

NATIONAL SCIENCE FOUNDATION

Legislative Authorization

The Directorate for Education and Human Resources is responsible for the health of the nation's science, mathematics, engineering, and technology education and for providing leadership in the effort to improve education in these areas.

Education Programs

The Foundation has no major public information responsibility involving radiation, but it supports the development of science curricula for grades K-12. In addition, it supports informal science education programs to maintain public interest in and awareness of scientific and technological developments.

NUCLEAR REGULATORY COMMISSION (NRC)

Legislative Authorization

NRC derives its statutory authority from the Atomic Energy Act of 1954, as amended, and the Energy Reorganization Act of 1974, as amended. NRC's principal objective is the regulation of nuclear activities to protect public health and the environment. Any education or information activities would be ancillary to this principal objective.

Education Programs

A small public education program is conducted by the Office of Public Affairs.

Resources

The Office of Public Affairs has 16 employees (13 professionals and three clerical staff) directly involved in providing public information and education.

Radiation Issues in Public Education

NRC's concerns include a major revision to the NRC standards for protection against radiation (10 CFR Part 20), life extension for nuclear power plants, the decommissioning of nuclear facilities, the disposal of radioactive waste, and the licensing of a new generation of nuclear power plants.

APPENDIX E — SOURCES OF INFORMATION

INVITED SPEAKERS

Mr. Steven Aftergood
Federation of American Scientists

Dr. Conrad Katzenmeyer
Director, Division of Schools and School Professionals
Office of Research
Department of Education

Ms. June Kimmel
League of Women Voters
North Carolina Chapter

Mr. Bill Perkins
Potomac Communications Group

Ms. Sherry Saunders
Washington Communications Group

INFORMATION MATERIALS WERE ALSO RECEIVED FROM:

American Nuclear Society
555 N. Kensington Avenue
La Grange Park, IL 60525

Atomic Industrial Forum, Inc.
Public Affairs And Information Program
7101 Wisconsin Avenue
Bethesda, MD 20814-4805

Boston Edison
800 Boylston St.
Boston, MA 02199

Boston Edison
Pilgrim Nuclear Power Station
Rocky Hill Road
Plymouth, MA 02360

Dow Literature Services
Dow Chemical Company
Midland, MI 48674

Edison Electric Institute
1111 19th Street, N.W.
Washington, DC 20036-3691

Epidemiology Resources Inc.
826 Boylston Street
Chestnut Hill, MA 02167

Federation of American Scientists
307 Massachusetts Avenue, N.W.
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