

2008–2010

Strategic Program Plan



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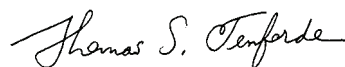
Introduction

Many of the goals established in the Strategic Program Plan of the National Council on Radiation Protection and Measurements (NCRP) for the 2005–2007 triennium were successfully accomplished, and NCRP remains a scientifically productive and financially stable organization. In looking to the future, the leadership of NCRP foresees an increasing need for its technical reports, conferences and advisory services in the areas of radiation protection and measurements. The objectives of this document are to describe the primary strategic goals of NCRP over the 2008–2010 triennium, which are intended to meet both national and international needs for guidance in these areas.

The past decade has been marked by an increase in the applications of radiation in medicine, industry, and in the public domain (for example, in security surveillance systems). The commitment of the U.S. government to the cleanup and remediation of contaminated nuclear waste sites has also grown. Major concerns about the risk of potential acts of nuclear and radiological terrorism have arisen, thereby creating an urgent need for preparation on a local, state and national scale to counteract and mitigate the health effects of such actions should they occur. Finally, a major effort is underway to achieve advances in nuclear fuel-cycle technology and to develop operationally safe power reactors that can meet the world's growing need for energy with a minimal impact on the environment and global climate. All of these developments set the stage for expanded activities by NCRP in providing guidance on health and environmental radiation protection, and on radiation measurements and the safe operation of radiation sources.

The Strategic Program Plan for 2008–2010 provides an overview of the primary goals of NCRP in fulfilling its mission as a leader in radiation protection and measurements over the coming triennium. The specific activities to be undertaken in meeting these goals, and the procedures to be used in their implementation, are also described in this document. Although the focus is on meeting national needs in the United States, NCRP will continue to place an increasing emphasis on obtaining international recognition and stature as a valuable resource for guidance in the fields of radiation protection and measurements.

The preparation of this Strategic Program Plan was a collective effort by the Officers of NCRP, the Vice Presidents who lead Program Area Committees, and members of the Board of Directors. The primary intent of the Strategic Plan is to apprise NCRP's sponsors, members, and other individuals and organizations interested in the work of NCRP on the future areas of emphasis in NCRP's activities. NCRP welcomes suggestions and the participation of Council members and others in the continuous effort to broaden NCRP's activities into all aspects of radiation protection and measurements in medicine, industry, research, public venues, and the natural environment.



Thomas S. Tenforde
President

History & Mission

NCRP's original predecessor organization, the U.S. Advisory Committee on X Ray and Radium Protection, was founded in 1929. Following the atomic-bomb detonations in Japan near the end of World War II, the scope of work of NCRP was expanded to include measurements and estimates of health effects of neutrons, charged particles, and other types of radiation that had not previously been of concern. In 1964 the modern NCRP was formally chartered by Congress under Public Law 88-376 as an independent, nonprofit corporation. The full text of Public Law 88-376 is contained in Appendix A. The Charter of NCRP specified that its primary responsibilities are:

1. Collect, analyze, develop and disseminate in the public interest information and recommendations in the public interest about:
 - b. protection against radiation; and
 - c. radiation measurements, quantities and units, particularly those concerned with radiation protection.
4. Provide a means by which organizations concerned with the scientific and related aspects of radiation protection and of radiation quantities, units and measurements may cooperate for effective utilization of their combined resources, and to stimulate the work of such organizations.
5. Develop basic concepts about radiation quantities, units and measurements, about the application of these concepts, and about radiation protection.
6. Cooperate with the International Commission on Radiological Protection, the International Commission on Radiation Units and Measurements, and other national and international organizations, governmental and private, concerned with radiation quantities, units and measurements and with radiation protection.

The Congressional Charter of NCRP has formed the foundation of its report and conference activities for more than four decades. A complete list of NCRP's publications is provided in Appendix B. An area of emphasis in the strategic planning for the coming triennium will be to further strengthen the second and fourth elements of the Charter involving collaborations at the national and international levels with organizations that have interests similar to those of NCRP. Collaborative efforts of this nature are expected to complement the capabilities of NCRP and to increase the worldwide dissemination of information contained in NCRP's publications.

Vision

NCRP must continue to extend its role as a Congressionally chartered organization with the primary responsibility in the United States for providing guidance on radiation effects, human health, and environmental protection, and radiation measurements, quantities and units. Members of the Council and other participants in NCRP report preparation and conferences represent the leading scientists, engineers and medical professionals with expertise in these areas. NCRP will continue to provide authoritative information on the sources and health implications of exposure of the public and workers to radiation, both from beneficial applications such as medical diagnostic and therapeutic procedures and from uses of radiation sources and radioactive materials in industry, research, public venues, and in possible future acts of terrorism. It is the vision of NCRP to be regarded not only as a national leader, but as an international authority, in providing scientific insights and recommendations on radiation effects, health and environmental radiation protection policies and practices, and radiation measurement technology.

Goals

During the 2008–2010 triennial period NCRP will perform work related to the following set of goals that are consistent with its charter, mission and vision:

- collect, analyze and develop basic scientific information related to the interaction and biological effects of radiation and the implications for human health;
- develop basic concepts of radiation dose quantities and units, and collect the information necessary to determine relevant radiation dose quantities from measured quantities;
- analyze basic concepts and techniques for the accurate measurement of radiation exposures, and analyze the bounding uncertainties associated with the measurement and dosimetry of radiation from external and internal sources;
- collect information about sources of exposure of the public and workers, and describe methods for detecting and deterring sources of unnecessary or inadvertent exposures and procedures for mitigating their health consequences;
- recommend policies and practices for radiation protection of workers, the public, medical patients, and the environment from the use of radiation sources and radioactive material in industry, medicine, scientific research and space exploration;
- assist in the development of local, state and federal strategic plans for counteracting potential acts of nuclear and radiological terrorism;
- recommend policies and practices for the proper remediation of contaminated sites and management of radioactive waste materials; and
- broaden efforts to cooperate with scientific organizations in the United States and internationally in meeting the above goals.

To meet these goals NCRP has developed a set of strategic initiatives that form the basis for its planned activities during the coming triennium. This set of initiatives, described in the following section of this Strategic Plan, is accompanied by a detailed implementation strategy described in the section on *Implementation of Strategic Program Plans Over the Coming Triennium*.

Critical Issues & Strategic Program Plan

In preparing this Strategic Program Plan, the leadership of NCRP carefully reviewed the world's literature on radiation protection and measurements, and the recent and ongoing activities of other organizations in the United States and worldwide in these areas. From this analysis several major initiatives for NCRP's activities during the coming triennium have been identified. In this section these initiatives are discussed in terms of the ways they address critical issues and their national and international importance. General strategies for addressing these initiatives are discussed, with a more detailed implementation plan presented in the following section on *Implementation of Strategic Program Plans Over the Coming Triennium*.

Strategic initiatives in five major areas of radiation science, medical applications of radiation, homeland security, radiation health and environmental protection, and radiation measurements and dosimetry will be the focus of NCRP's activities during the coming triennium. These five areas are the following:

Strategic Initiative 1: *Low Dose and Low Dose-Rate Biological Effects and Implications for Human Health*

A subject of great contemporary interest in the field of radiological health is the analysis of potential human health effects of low doses of ionizing radiation at levels below 0.1 Sv. The applicability of the linear nonthreshold dose-response model in the low-dose range has been a subject of considerable debate and major research programs such as the one supported by the U.S. Department of Energy (DOE) over the past decade. NCRP Report No. 136, *Evaluation of the Linear-Nonthreshold Dose-Response Model for Ionizing Radiation* (2001) and the National Academy of Sciences report, *Health Risks from Exposure to Low Levels of Ionizing Radiation, BEIR VII* (2006) concluded that available data on biological effects of low radiation doses are not inconsistent with the linear nonthreshold model, but a report of the French Academy of Sciences on *Dose-Effect Relationships and Estimation of the Carcinogenic Effects of Low Doses of Ionizing Radiation* (2005) reached a different conclusion. A related subject of importance and conflicting views is the dose and dose-rate effectiveness factor for radiations of differing quality. From both scientific and regulatory policy perspectives, it is therefore a major objective of NCRP during the coming triennium to undertake two activities that address these issues in a definitive manner. The first of these activities will be the 2008 NCRP Annual Meeting on *Low Dose and Low Dose-Rate Radiation Effects and Models*, which will involve in-depth presentations on dose-response information obtained both from laboratory and human epidemiology studies. The second planned undertaking by NCRP is a major report on the subject of low-dose radiation effects, response models, and implications for human health and regulatory policy. Other activities that are planned in basic radiobiology include reports on uncertainties in radiation risk estimation and the biological effectiveness of photon and particle radiations of differing qualities. It is anticipated that this effort will receive cosponsorship by several federal agencies, including DOE, the U.S. Nuclear Regulatory Commission (NRC), and the U.S. Environmental Protection Agency (EPA).

Strategic Initiative 2: *Radiation Protection in Medicine*

With primary support from a five-year grant awarded by the National Cancer Institute (NCI), NCRP will be preparing four new reports on cancer radiobiology and health protection issues related to the increasing use of radiation in medical diagnostic and therapeutic procedures. The basic radiobiology reports will be on the topics of “Genetic Susceptibility to Cancer” and “Second Cancers and Cardiopulmonary Effects After Radiotherapy or Other Medical Exposures.” New reports related to medical radiation safety and health protection will be on “Radiation Safety Issues in Image-Guided Interventional Medical Procedures” and “Diagnostic Reference Levels in Medical Imaging with Recommendations for Application in the United States.” In addition, NCRP plans to organize a major conference on patient doses in diagnostic medical procedures, primarily computed tomography (CT), and the need for training and credentialing of medical staff ordering and performing these procedures in hospitals, outpatient facilities, and emergency rooms. This conference will build on the successful 2007 NCRP Annual Meeting on *Advances in Radiation Protection in Medicine*, and will be cosponsored by the American College of Radiology (ACR) and other scientific organizations such as the American Association of Physicists in Medicine. With support from the Centers for Disease Control and Prevention (CDC), NCRP will also be preparing a report on “Risks of Radiation to the Developing Embryo, Fetus, and Nursing Infant.”

Strategic Initiative 3: *Preparation for and Response to Possible Acts of Nuclear or Radiological Terrorism*

Subsequent to the tragic events of September 11, 2001 NCRP has published several reports and commentaries, and conducted an annual meeting in 2004, on important steps to be taken in the interdiction of, preparedness for, and effective responses to possible acts of nuclear or radiological terrorism. During the coming triennium, NCRP will continue to provide recommendations and guidance to authorities at the regional, tribal, state and national levels on responses to potential acts of terrorism. The following is a summary of the areas in which NCRP reports and commentaries will be focused: (1) operational strategies and decision making in the aftermath of a nuclear or radiological terrorism incident; (2) performance requirements and testing criteria for security surveillance systems at ports-of-entry into the United States; (3) protecting against, mitigating, and treating traumatic injuries and long-term health and psychological effects of radiation exposure and other immediate stress effects such as thermal burns, shock, and contaminated shrapnel wounds resulting from a nuclear explosion; and (4) optimizing the cleanup and disposition of contaminated materials resulting from a nuclear or radiological terrorism incident. Primary support for reports in the first three of these areas has been requested from the U.S. Department of Homeland Security (DHS), and from EPA in the fourth area.

Strategic Initiative 4: *Worker, Public Health, and Environmental Radiation Protection*

Governmental agencies and their contractor organizations have made significant progress during the past decade in the improvement of worker health and in facilitating the cleanup of legacy nuclear

wastes and remediation of the affected environment. However, a number of operational and strategic goals in fully meeting the ultimate objectives of DOE and other government agencies remain to be addressed. NCRP plans to prepare several reports and commentaries that address these issues, including the following. In the area of worker health, NCRP plans to prepare publications on: (1) response to, and investigation of, radiological accidents and incidents; (2) self-assessment procedures for radiation safety programs; and (3) mechanisms for reaching an acceptable compromise between safe operations with radioactive materials and radiation sources and maintaining a high level of security. In the area of environmental protection and waste management, NCRP plans to prepare publications on: (1) design of effective effluent and environmental monitoring systems, (2) environmental management of lands contaminated with naturally-occurring radioactive material (NORM), (3) performing environmental remediation at nuclear waste sites without destruction of natural resources and ecosystems, and (4) development of cost-effective strategies for cleanup and restoration of nuclear waste sites and facilities formerly used for weapons production. The primary sponsor for reports in this area will be DOE, with additional support of reports on operational radiation safety and environmental management from the Health Physics Society (HPS) and EPA.

Strategic Initiative 5: Analysis of Uncertainties in Radiation Measurement and Dosimetry and Basic Principles and Practices in Radiation Dose Reconstruction

Since 2004 NCRP has been providing technical and administrative support to the Veterans' Advisory Board on Dose Reconstruction (VBDR), which was formed under Public Law 108-183 to provide review and oversight of procedures used in radiation dose reconstruction and claims adjudication for atomic veterans who occupied Hiroshima and Nagasaki, Japan following the atomic-bomb detonations in 1945, were prisoners of war at those locations in Japan at the time of the A bombs, or participated in atmospheric nuclear tests from 1945 to 1962. The technical component of NCRP's services to VBDR includes the preparation of three major reports on uncertainties in external and internal radiation measurements and dosimetry, and the fundamental principles of radiation dose reconstruction. The first of these three reports, *Uncertainties in the Measurement and Dosimetry of External Radiation*, was completed in 2007. A high priority is being placed on completing the second report on *Uncertainties in Internal Radiation Dosimetry* and the third report on *Basic Principles and Practices in Radiation Dose Reconstruction* in the 2008 to 2009 time frame. These three reports are expected to serve as definitive documents for assessing uncertainties in radiation dosimetry and performing dose reconstruction procedures in several important areas of human exposure, including atomic veterans, workers who participated in nuclear weapons production, medical exposures, astronaut space missions, public exposures from nuclear accidents and fallout from past nuclear weapons tests, and other situations involving the exposure of a large number of individuals to radiation (e.g., following possible future acts of nuclear or radiological terrorism). Support for the preparation of these reports is being provided by the Defense Threat Reduction Agency (DTRA) and the U.S. Department of Veterans Affairs (VA).

Strategic Initiative 6: Safety, Health and Environmental Protection Issues in Advanced Reactor Design and Spent-Fuel Processing

Two areas of great interest and possible major report activities by NCRP in the future are the effort in the United States and worldwide to develop advanced nuclear power reactors and to reprocess spent nuclear fuels. A major initiative of DOE and the nuclear power industry has been the design of Generation-3+ and Generation-4 reactors that will incorporate inherently safe operating features to minimize the possibility of uncontrolled fission events, reduce the production of nuclear wastes, reduce life-cycle operational and energy production costs, and limit the use of plutonium-based fuel and achieve proliferation resistance. Several designs of these advanced power reactors have been proposed that utilize a closed fuel cycle to efficiently manage spent nuclear fuel for support of continued and expanding nuclear energy production. To foster international cooperation in the design and production of advanced nuclear reactor and fuel technology, the United States has supported the formation of a Global Nuclear Energy Partnership (GNEP) involving several nations worldwide, including China, France, Japan, Russia, and the United Kingdom, that will participate in the development of promising new nuclear technologies. NCRP will be looking for opportunities to assist the leaders of the GNEP initiative in the United States, namely, DOE and NRC, in evaluating the safety, nuclear waste, and health and environmental protection issues associated with the design and deployment of advanced power reactor systems and management of spent nuclear fuel. These subjects will be major topics in the 2009 NCRP Annual Meeting on *Future of Nuclear Power Worldwide: Safety, Health and Environment*. It is anticipated that the primary sponsors of future NCRP report activities related to this strategic initiative will be DOE and NRC.

Implementation of Strategic Program Plans Over the Coming Triennium

The operational framework of NCRP is built upon six Program Area Committees (PACs) that provide oversight and guidance for the preparation of new reports, commentaries, and annual meeting programs that address critical issues and NCRP's strategic goals in radiation protection and measurements. These PACs and the Vice Presidents that lead them are:

- PAC 1: Basic Criteria, Epidemiology, Radiobiology and Risk (William F. Morgan)
- PAC 2: Operational Radiation Safety (David S. Myers)
- PAC 3: Nuclear and Radiological Security and Safety (John W. Poston, Sr.)
- PAC 4: Radiation Protection in Medicine (Jerrold T. Bushberg)
- PAC 5: Environmental Radiation and Radioactive Waste Issues (S.Y. Chen)
- PAC 6: Radiation Measurements and Dosimetry (Thomas F. Gesell)

In response to the increase in NCRP's efforts related to homeland security, primarily in counteracting potential incidents of nuclear and radiological terrorism, PAC 3 was formed in 2007. The members of PAC 3 will provide oversight of new reports related to nuclear and radiological safety and security beginning in 2008. Several reports in the area of counteracting nuclear and radiological terrorism are currently underway with oversight by PACs 2, 4 and 6. These reports will remain within the PACs to which they are currently assigned, but critical peer reviews of draft reports will be coordinated with PAC 3. As a result of the fact that NCRP's current and planned future reports related to homeland security span a broad range of areas in operational safety, medical countermeasures, and radiation dosimetry, liaison members from each of the other five PACs have been appointed as members of PAC 3.

PAC 3 was originally formed in the 1990s as Scientific Committee 89 and was focused on oversight of NCRP reports in the field of nonionizing radiation. Although NCRP has retained expertise in this area, activities related to the preparation of publications in this area have declined in recent years. As a result, the status and membership of the former PAC 3 have been changed to an advisory role and will be involved should new opportunities for funding of reports on subjects related to nonionizing radiation become available. The former PAC 3 has been renamed as the Nonionizing Radiation Advisory Panel.

The scientific committees operating under the six PACs are listed in Appendix C. In addition to the PACs, an "Advisory Panel on Public Policy" was formed in 2006. To an increasing extent the content of publications and annual meetings of NCRP relate to issues that involve radiation risks and potential impacts on members of the public. The Advisory Panel consists of scientists with experience and expertise in public policy and is called upon to advise NCRP on the content of proposed new reports and to recommend members of new scientific committees who can provide guidance on issues related to public policy.

The strategic goals and programmatic plans of NCRP for 2008–2010 have been formulated within this operational framework. It should be noted at this point that all of the six major strategic initiatives that form the focus of NCRP's activities during the coming triennium, as described in the preceding section, fall within the oversight of specific PACs. Operationally, when new strategic initiatives and

reports of a scientifically crosscutting nature are undertaken by NCRP, the report activities and progress are jointly reviewed by all pertinent PACs. New report activities related to nuclear and radiological terrorism will be within PAC 3, while ongoing activities in this area will remain within the purview of PACs 2, 4 and 6. In the case of Strategic Initiative 4 on radiation protection of human and environmental health, the planned new report activities fall within PAC 2 and PAC 5. Several PACs, specifically 1, 2, 3 and 5 are expected to participate in planning the 2009 NCRP Annual Meeting and preparing new reports related to Strategic Initiative 6.

The *Strategic Program Implementation Plan* that follows is organized on the basis of key functions, recent accomplishments, and plans for new activities in each of the PACs over the period 2008–2010. Recent accomplishments in each Program Area are briefly described because, in many instances, they have set the stage for future report and conference activities to be undertaken by NCRP. The Strategic Program Plans for NCRP’s six Program Areas form the foundation for implementation of strategic initiatives and related activities during the coming triennium.

Program Area Committee 1: *Basic Criteria, Epidemiology, Radiobiology, and Risk*

Key Functions

PAC 1 has existed since the formation of NCRP's original predecessor organization, the U.S. Advisory Committee on X-Ray and Radium Protection, in 1929. Initial efforts involved the preparation of a series of reports on protection against x-ray and radium health effects that were published in the 1930s. In more recent years PAC 1 has produced several NCRP reports, commentaries and statements on limits of exposures of workers and members of the public to all forms of ionizing radiation. NCRP's last major report on radiation exposure limits was published in 1993 (Report No. 116, *Limitation of Exposure to Ionizing Radiation*). In addition to evaluating and updating exposure limits, PAC 1 reviews on a continuing basis new radiobiological and epidemiological data, and determines the potential implications of this information for human risk coefficients used in formulating radiation protection guidance. The implementation of new activities related to Strategic Initiative 1 on low-dose radiation effects will be carried out under the oversight of PAC 1. In reports involving both basic radiobiology and medical implications (*e.g.*, genetic susceptibility to radiation-induced cancer), close coordination and joint oversight will be maintained between PAC 1 and PAC 4.

Recent Accomplishments

Recent activities of PAC 1 related to assessment of radiation health risks and recommendations of exposure limitations have been the following:

- Two NCRP annual meetings have focused on future radiation protection guidance (2003) and a retrospective evaluation of human health effects resulting from the Chernobyl accident (2006). The 2003 meeting peer-reviewed proceedings were published in *Health Physics* [Vol. 87(3), 2004], and featured papers on future directions in developing radiation exposure limits based on new radiobiological and epidemiological information. The 2006 meeting peer-reviewed proceedings were published in *Health Physics* [Vol. 93(5), 2007], and contained a comprehensive epidemiological analysis of health effects among liquidators, cleanup workers, and members of the public exposed to radiation released from the Chernobyl power reactor accident.
- NCRP Statement No. 10 was published in 2004 to reaffirm and clarify recommendations on public exposure limitations.

- Report No. 150 on *Extrapolation of Radiation-Induced Cancer Risks from Nonhuman Experimental Systems to Humans* was published in 2005. This report provided a comprehensive review of experimental laboratory data at the molecular, cellular, organ, and whole-animal levels in relation to the estimation of radiation-induced cancer risks in humans.
- Report No. 153 on *Information Needed to Make Radiation Protection Recommendations for Space Missions Beyond Low-Earth Orbit* was published in 2006. Report No. 153 analyzes the unique radiation environment that will be encountered by astronauts during interplanetary missions and the information needed to evaluate potential health risks and implement effective methods of radiation protection.
- NCRP will complete Report No. 159 on *Risk to the Thyroid from Ionizing Radiation* in 2008. This report presents an analysis of benign and cancerous conditions of the thyroid and mortality risks from radiation exposure of the thyroid from external and internal sources.

Strategic Goals for 2008–2010

During the coming triennium PAC 1 will undertake several new conference and report activities of great importance in analyzing the response of humans to low doses of radiation of differing qualities. The focal areas of work by scientific committees operating under PAC 1 are the following:

- A major planned effort will be the preparation of a comprehensive report on the “Biological Effects of Low Radiation Doses and the Implications for Human Health.” As discussed in the preceding section of this Strategic Plan, the preparation of this report will be preceded by the 2008 NCRP Annual Meeting on *Low Dose and Low Dose-Rate Radiation Effects and Models*. Requests for funding of the report have been submitted to several federal agencies with a direct interest in the preparation of a definitive report on low-dose radiation biological and health effects.
- Another major report to be undertaken in 2008 will be on the topic of “Uncertainties in the Estimation of Radiation Risks and Probability of Disease Causation.” This report will provide an authoritative analysis of all major aspects of uncertainty in relating radiation doses to the risk of contracting diseases, including cancer, noncancer health effects, and genetic defects. The report will provide a definitive basis upon which estimates of exposure to external and internal sources of radiation can be related to the probability of contracting these diseases. The report will be of long-term value to various government agencies that are analyzing radiation-related health effects among populations of exposed individuals, including energy workers previously involved in nuclear weapons production, atomic veterans exposed to radiation from atmospheric nuclear testing or who were prisoners of war in Hiroshima and Nagasaki, Japan, at the time of detonation of atomic bombs in 1945 or who occupied those locations after the atomic bombs were detonated, members of the public exposed to radiation releases from nuclear power plants and fallout from nuclear accidents and weapons testing, and individuals exposed to radiation during widely used medical diagnostic and therapeutic procedures. It is expected that the preparation of this report will be sponsored by CDC’s National Institutes of Occupational Safety and Health.

- One of the goals of NCRP during the 2008–2010 period will be to undertake a new report on the “Biological Effectiveness of Photons and Particle Radiations Over a Broad Range of Energies and Dose Rates.” Over the years the International Commission on Radiological Protection (ICRP) has proposed several sets of values for the quality factors (and, more recently, for the radiation weighting factor values) for neutrons and charged particle radiations. The most recent recommendations are contained in ICRP Publication 92 (2003) and the 2007 ICRP recommendations. Because of the importance of these factors in calculations of equivalent dose and effective dose, which are fundamental quantities in radiation protection, it is important at this time to prepare a report that comprehensively analyzes the basis and most appropriate values for radiation weighting factors. A comparison will be made between the use of quality factors, which are related to the linear energy transfer (LET) values as a function of energy for various particle radiations, and the radiation weighting factors. An important factor in this analysis will be the evaluation of relative biological effectiveness (RBE) values for high-LET radiations which underlie the recommended values of quality and radiation weighting factors. Many of the neutron RBE values used for this purpose are based on data from radiation experiments with small animals, and it is generally accepted that interactions of high-LET neutron radiations with tissue are dependent on animal size and therefore differ for laboratory rodents and humans. The analysis will also be extended to the RBE and dose and dose-rate effectiveness factor for stochastic health effects of low-energy x rays. A quantitative determination of these variations with x-ray energy is necessary for establishing radiation weighting factor values at low energies, and for calculating effective doses and cancer risks from exposure to low doses of low-energy x rays in mammography, other medical imaging procedures, and from various occupational and public radiation sources. This report will be undertaken as a joint activity of PAC 1 and PAC 6, and collaborations with ICRP and the International Commission on Radiation Units and Measurements are anticipated. Requests for sponsorship of this report have been made to several federal government agencies.

It is a goal of NCRP to complete three publications in the coming triennium that were brought to the point of Council review in 2007. These are the following:

- An update of Report No. 78, *Evaluation of Occupational and Environmental Exposures to Radon and Radon Daughters in the United States*, published in 1984, has been extensively revised following Council review and a second Council review is planned for 2008. This report presents an extensive evaluation of the dosimetry of radon and radon progeny, epidemiology studies on lung cancer risk in underground miners, animal studies to characterize risks of both lung cancer and nonrespiratory neoplasms resulting from radon exposure, epidemiological studies on cancer risk associated with residential radon exposure, and laboratory studies to characterize deoxyribonucleic acid (DNA) damage and repair in cells exposed to radon. Initial sponsorship of this report was received from EPA, and a request will be made for supplemental funding to complete the report.
- A report entitled “Impact of Individual Susceptibility and Previous Radiation Exposure on Radiation Risk for Astronauts” is planned for Council review in 2008. Advances in genetic techniques have made it possible to define large numbers of radiation-induced

gene modifications that may increase an individual's risk for cancer. An analysis of the impact of genetic background on risk and the future potential to use this information is a major thrust of this report. The report also evaluates the extent to which biological damage induced by past radiation exposures may be additive or interactive with cellular and tissue alterations produced by radiation exposure during space exploration by astronauts. The report discusses the regulatory, legal and ethical issues associated with radiation-related genetic sensitivity and previous radiation exposure on the magnitude of an astronaut's radiation risk from prolonged space missions. Initial funding was received from the National Aeronautics and Space Administration (NASA), and supplemental funds have been received for completing the report.

- A commentary on "Radiation Protection and Science Goals for Short-Term Lunar Missions" provides a critical review and suggestions for changes in a draft NASA document on permissible exposure limits for astronauts during short-term lunar missions. The major issues addressed in this commentary are short-term and career dose limits for astronauts in lunar missions of up to 180 days duration, and application of as low as reasonably achievable (ALARA) principles in shielding designs for Earth-to-moon transfer vehicles, lunar habitats, and extravehicular activities in space or on the moon's surface.

Program Area Committee 2: *Operational Radiation Safety*

Key Functions

The primary functions of PAC 2 are to prepare reports that serve as a national resource for information on operational radiation safety, and to formulate guidance regarding the application of operational radiation safety principles.

Recent Accomplishments

NCRP has made many important contributions on the scientific basis and implementation of operational safety programs in industry, medicine, research facilities, universities, homeland security, and space exploration. Noteworthy recent accomplishments by scientific report committees operating within PAC 2 include:

- NCRP recently published four reports on radiation shielding in medicine, dentistry and veterinary facilities: Report No. 145 on *Radiation Protection in Dentistry* (2003), Report No. 147 on *Structural Shielding Design for Medical X-Ray Imaging Facilities* (2004), Report No. 148 on *Radiation Protection in Veterinary Medicine* (2004), and Report No. 151 on *Structural Shielding Design and Evaluation for Megavoltage X- and Gamma-Ray Radiotherapy Facilities* (2005). These reports provide extensive recommendations and detailed technical information on the design, construction, and radiation protection requirements for x-ray imaging facilities used in both diagnostic and therapeutic medical, dental and veterinary facilities.
- NCRP Report No. 144 on *Radiation Protection for Particle Accelerator Facilities* (2003) provides definitive guidance on radiological safety aspects of the design and operation of particle accelerators with energies above 5 MeV up to the highest available energies.
- In 2005 NCRP published Commentary No. 19 on *Key Elements of Preparing Emergency Responders for Nuclear and Radiological Terrorism*. This publication provides important information on radiation detection and personal protection equipment for emergency responders, management of radiation exposures for emergency responders involved in life-saving and other critical actions, advice regarding decontamination of equipment and individuals, and training exercises for emergency responders.

- NCRP Report No. 157 on *Radiation Protection in Educational Institutions* was issued in 2007. The report provides radiation protection guidance for educational institutions that use radioactive materials or radiation-producing equipment for training and research, or for other purposes such as radiation applications in the student health clinic. Guidance is provided both for ionizing radiation and nonionizing radiation sources such as lasers and microwave-producing equipment.

Strategic Goals for 2008–2010

Several major report activities will be carried out under PAC 2 as an integral part of NCRP's strategic initiatives during the coming triennium described in the preceding section of this Strategic Plan.

- A report sponsored by DHS will be completed and published by 2010 on “Key Decision Points and Information Needed by Decision Makers in the Aftermath of a Nuclear or Radiological Terrorism Incident.” The report will summarize the roles and responsibilities of decision makers at the local, regional, state and federal levels, and will describe the information that must be acquired and communicated as a basis for the decision-making process. The resulting document will be useful both for training purposes and for deployment in the field in the aftermath of an act of nuclear or radiological terrorism. The report will be valuable as supplementary information in support of the U.S. National Response Plan, the National Incident Management System, and other federal and state guidance. The report will provide a framework for pre-event planning and training processes, essential policy recommendations, issues to be addressed and key decision points, actions to be taken to protect public health, safety and security, and information needed by decision makers to initiate appropriate actions during all phases of response to an act of nuclear or radiological terrorism. The completion of this report will be under the joint oversight of PAC 2 and PAC 3.
- NCRP plans to prepare a report on “Balance Between Safe Operations with Radioactive Materials and Radiation Sources and Their Security.” As a result of increased concerns over acts of nuclear or radiological terrorism, there is a need to evaluate the extent of information made available in the public domain about the types of radioactive materials and radiation sources used in easily accessible locations within, for example, universities, government laboratories, research organizations, and industrial facilities. Concerns also exist about the safety and security of transporting radioactive materials. It is a common practice to post information on radioactive materials and radiation sources at the entrance to laboratories or other radiation facilities, and the types of work done with these materials and sources are often described in statements of research activities and capabilities of various organizations that use them for training, research, or the production of products. These postings are frequently made in response to operational or regulatory requirements, but can also create vulnerability to misuse or acts of terrorism. This report will evaluate the appropriate compromises that should be considered while meeting safety requirements and protecting radioactive materials and radiation sources from threats of inappropriate uses or terrorist actions. DOE sponsorship has been requested for preparation of this report.
- In 2007 NCRP initiated a commentary on “Self-Assessment of Radiation Safety Programs” that will be completed during the coming triennium. A self-assessment is a

proactive component of an effective management plan for a radiation safety program. This commentary will describe the types of self-assessments, their purposes, and the techniques for conducting them. It will also cover the frequency, the program areas to be assessed, the documentation, and the follow-up actions to be taken in self-assessment procedures. The commentary will consider multiple self-assessment program elements, including the ALARA principle, engineered and administrative controls, posting of hazards, personnel protective equipment, internal and external dosimetry, radiation safety training, radioactive materials management, radiation safety procedures and work permits, workplace monitoring, radiation instrumentation, contamination control, effluent monitoring, radioactive waste handling, storage and disposition, and emergency procedures. The commentary will discuss the documentation, reporting, and tracking of the findings of self-assessments, and provide guidance for corrective actions. Funding to initiate this report has been received from HPS, and cosponsorship has been requested from DOE.

- As a component of NCRP's medical radiation protection initiative, a report will be published on "Radiation Safety Issues for Image-Guided Interventional Medical Procedures." Preparation of this report was initiated in 2007, and it will be completed and published during the coming triennium. NCRP will review the existing literature on image-guided interventional procedures (IGIPs), and evaluate the most common high-dose IGIPs with regard to radiation dose and safety issues. The report will provide recommendations on (1) optimizing imaging protocols, (2) managing procedures time, (3) available radiation protection equipment and dose-reduction features, (4) tracking and trending patient and physician radiation dose, and (5) physician credentialing for use of IGIP equipment for these specialized procedures. Emphasis will be placed on the more complex IGIPs that have the highest potential for long duration and have previously led to significant radiation injuries to patients or clinical staff. The preparation of this report is being supported by NCI, and it will be prepared under the joint oversight of PAC 2 and PAC 4.

Program Area Committee 3: *Nuclear and Radiological Security and Safety*

Key Functions

The primary goals of PAC 3 are to provide guidance and recommendations for response to nuclear and radiological incidents of both an accidental and deliberate nature. The major elements of reports under the oversight of PAC 3 will include: (1) identify important steps to be taken in the interdiction of, preparedness for, and effective responses to possible acts of nuclear and radiological terrorism; (2) define performance requirements, instrumentation, and testing criteria for security surveillance systems; (3) develop operational strategies and optimization procedures for early, intermediate and late-phase responses to a nuclear or radiological incident; (4) recommend effective methods for protecting against, mitigating, and treating traumatic injuries and long-term health and psychological effects of radiation exposure; and (5) analyze methods for optimizing the cleanup, site restoration, and disposition of contaminated materials resulting from a nuclear or radiological incident.

Recent Accomplishments

One month after the tragic events of September 11, 2001, NCRP issued its landmark Report No. 138 on *Management of Terrorist Events Involving Radioactive Material*. NCRP has subsequently issued several publications of relevance to counteracting potential acts of nuclear and radiological terrorism. These publications are:

- Commentary No. 19 (2005) on *Key Elements of Preparing Emergency Responders for Nuclear and Radiological Terrorism*; a PowerPoint presentation that summarizes the recommendations of the commentary is available on the NCRP website at http://www.ncrponline.org/PDFs/Congressional_testimony_11-15-07.pdf. Additional discussion of the contents of this commentary is contained under the PAC 2 *Recent Accomplishments*.
- Peer-reviewed articles in the proceedings of the 2004 NCRP Annual Meeting on *Advances in Consequence Management for Radiological Terrorism Events* were published in *Health Physics* [Vol. **89**(5), 417–588 (2005)];
- Three publications have been issued on operational safety and radiation exposure limitations in new technologies being developed for detection of weapons and nuclear materials:

- Commentary No. 16 (2003) on *Screening of Humans for Security Purposes Using Ionizing Radiation Scanning Systems*;
- Commentary No. 17 (2003) on *Pulsed Fast Neutron Analysis System Used in Security Surveillance*; and
- Commentary No. 20 (2007) on *Radiation Protection and Measurement Issues Related to Cargo Scanning with Accelerator-Produced High-Energy X Rays*.

Strategic Goals for 2008–2010

As discussed in the *Strategic Program Plans* section of this report, additional reports by NCRP in the areas of nuclear and radiological security and safety are expected to be undertaken in the coming triennium with support from DHS and other agencies. Several specific focal areas are the following:

- An important step toward addressing the national need for guidance on key issues in preparing for, and responding to, acts of nuclear or radiological terrorism, has been taken by NCRP in preparing a report with sponsorship of DHS on “Key Decision Points and Information Needed by Decision Makers in the Aftermath of a Nuclear or Radiological Terrorism Incident.” This report is being prepared under the joint oversight of PAC 2 and PAC 3. A discussion of the content of the report is contained in the PAC 2’s *Strategic Goals for 2008–2010*.
- NCRP is in an advanced stage of preparation of two reports that provide recommendations on decontamination and medical management of radioactively contaminated individuals. These reports, which have been supported by the U.S. Navy and CDC and will be completed in 2008, are:
 - *Management of Persons Contaminated with Radionuclides*, and
 - *Population Monitoring and Decontamination Following a Nuclear or Radiological Incident*.

Both reports have been initiated under the purview of PAC 4, but the final stages of review and publication will be under the joint oversight of PAC 3 and PAC 4. A discussion of the content of these reports is contained in the PAC 4’s *Strategic Goals for 2008–2010*.

- NCRP plans to undertake a report with DHS sponsorship on “Contaminated Wounds in Victims of a Radiological Terrorism Incident.” This report will build on information contained in NCRP Report No. 156 (2006) on *Development of a Biokinetic Model for Radionuclide-Contaminated Wounds and Procedures for Their Assessment, Dosimetry and Treatment*. Primary components of the planned report are as follows: (1) dosimetric quantities will be calculated using element-specific biokinetic models for about 300 radionuclides, including absorbed and equivalent doses to tissues and organs from both low- and high-LET radiations, detriment-weighted doses as a measure of risk (using gender-specific tissue weighting factors when appropriate); intake retention fractions for organs in which a deposition of specific radionuclides is expected, and the urinary, fecal and total body excretion fractions; (2) extensive data will be provided on dosimetric parameters, including dose conversion coefficients; and (3) guidance will be provided on medical management of contaminated wounds, including examples using biokinetic models in activities such as surgical excision of radioactive material and

chemical decorporation therapy. This report will be prepared under the joint oversight of PACs 3, 4 and 6.

- NCRP plans to prepare a report on “Recommendations on the Performance Requirements and Testing Criteria for Stationary and Mobile Portal Monitors.” The Domestic Nuclear Detection Office (DNDO) of DHS has undertaken a program to support the design, construction and deployment of portal monitors for the detection of highly enriched uranium and other potentially dangerous nuclear and radiological materials in cargo containers at U.S. ports-of-entry. The monitors will be designed for both stationary and mobile operation, and will function as advanced spectroscopic portals for the dual role of detection of radiation and identifying radiological materials. NCRP will prepare a report that provides a comprehensive analysis and guidance on the design, performance testing, data recording, and deployment of portal monitoring systems with advanced spectroscopic portal capabilities. The primary goals of the guidance will be to assist DNDO with defining testing criteria needed to ensure that portal monitors meet the required performance metrics, development of a database for recording the test results on portal monitors, and establishment of training programs needed to ensure that the operators of portal monitoring systems are capable of deploying them in a manner that acquires and records the necessary data. This report will be prepared under the joint oversight of PAC 3 and PAC 6.
- NCRP plans to prepare a report on “Response to and Investigation of Radiological Accidents and Incidents.” This report, which has been proposed to DOE, will provide an overview of the key elements of mounting an effective response to radiological accidents and deliberate incidents (such as acts of terrorism) ranging in magnitude from small to large. The report will involve the development of a set of health risk-based criteria for evaluating accidents and incidents. These criteria will provide a framework for (1) determining the significance and the reporting thresholds for a broad range of radiological events; (2) carrying out response actions that minimize impacts on human health and the environment; (3) performing appropriate follow-up investigative actions; and (4) developing strategies for future operational improvements and the implementation of more effective safety, security and preventive measures. The report will describe general principles, and provide broad guidance, for the conduct of optimal response actions to radiological incidents of both accidental and deliberate origins. This report will be prepared under the joint oversight of PAC 2 and PAC 3.
- Two other reports related to optimized cleanup and restoration of urban sites contaminated by a nuclear or radiological terrorism incident, and disposition of the resulting contaminated materials, are expected to be undertaken with DHS sponsorship. These report activities will be under the joint oversight of PAC 3 and PAC 5, and are described in more detail under the PAC 5’s *Strategic Goals for 2008–2010*.

Program Area Committee 4: *Radiation Protection in Medicine*

Key Functions

PAC 4 provides recommendations on methods for reducing or eliminating unnecessary radiation exposures of patients and medical practitioners in diagnostic and therapeutic procedures. Evaluation is made of potential secondary effects on patients of radiological medical procedures. PAC 4 also develops recommendations on effective radiation protection training and credentialing requirements for medical personnel. In addition, reports being prepared under the joint oversight of PAC 3 and PAC 4 provide guidance on the management and medical treatment of persons exposed to radiation through possible future acts of nuclear or radiological terrorism.

Recent Accomplishments

Notable recent accomplishments by NCRP in the area of radiation protection in medicine include:

- A major recent accomplishment was the successful 2007 NCRP Annual Meeting on *Advances in Radiation Protection in Medicine*. In the 2007 Annual Meeting, prominent physicians, medical physicists, and experts in radiation health effects addressed key questions about how to maximize medical benefits to patients while controlling and minimizing their risks from exposure to ionizing radiation. Topics discussed at the meeting included patient doses and associated health risks in diagnostic radiology, nuclear medicine, and interventional radiology. The peer-reviewed proceedings of the meeting will be published in *Health Physics* in 2008.
- NCRP continued its long tradition of providing guidance on the safe use of ultrasound in medicine with the publication in 2002 of Report No. 140 on *Exposure Criteria for Medical Diagnostic Ultrasound: II. Criteria Based on All Known Mechanisms*. This report provides an update and extension of earlier NCRP Reports No. 74, *Biological Effects of Ultrasound: Mechanisms and Clinical Implications* (1983) and No. 113, *Exposure Criteria for Medical Diagnostic Ultrasound: I. Criteria Based on Thermal Mechanisms* (1992) that considered primarily thermal mechanisms of ultrasound interactions with tissue.
- An important medical report published by NCRP in 2004 is Report No. 149 on *A Guide to Mammography and Other Breast Imaging Procedures*. This report is an update of

Report No. 85 (1986) on *Mammography – A User’s Guide*, and provides state-of-the-art information on the equipment and imaging techniques for obtaining optimum mammograms. The report provides an analysis of factors that influence image quality and the relationship between image quality and patient dose and long-term cancer risk.

- Report No. 155 on *Management of Radionuclide Therapy Patients* was issued in 2006, and supersedes Report No. 37, *Precautions in the Management of Patients Who Have Received Therapeutic Amounts of Radionuclides*, that was published in 1970. The report provides radiation protection guidance for physicians, medical physicists, healthcare professionals, visitors to medical facilities, family members of radionuclide therapy patients, and members of the general public who may be in the proximity of, or involved in the care of, persons treated with therapeutic quantities of radioactive material.

Strategic Goals for 2008–2010

During the 2008–2010 triennium scientific committees operating under PAC 4 will be working on several reports and conferences related to radiation protection in medicine and topics associated with the management and treatment of contaminated individuals. These activities will be of direct significance in meeting the goals of Strategic Initiatives 2 and 3 described in the preceding section of this Strategic Plan.

During the 2008–2010 triennium PAC 4 scientific committees will prepare with support from an NCI grant three reports in the areas of basic cancer radiobiology and operational radiation safety and dose controls in medicine. A related report on “Radiation Safety Issues for Image-Guided Interventional Medical Procedures,” discussed above under the PAC 2’s *Strategic Goals for 2008–2010*, will be prepared under the joint oversight of PAC 2 and PAC 4. A concise summary of the content of the new PAC 4 reports, all of which will be completed in the coming triennium, follows:

- A report will be prepared on “Genetic Susceptibility to Cancer,” which will provide recommendations on radiation protection in medicine related to genetic predisposition to cancer. This report will build on recent advances in understanding the molecular mechanisms in genetic diseases that involve defects in DNA repair and replication, and increases in the knowledge of biomarkers and polymorphic DNA repair genes associated with susceptibility to radiation-induced cancer. The NCRP report will include an assessment of the impact of the current state of knowledge of genetic susceptibility on staging radiotherapy or multimodality therapy regimens. The preparation of this report is under the joint oversight of PAC 1 and PAC 4.
- A report will be prepared on “Second Cancers and Cardiopulmonary Effects After Radiotherapy,” which will provide a focused review of the present state of knowledge on the incidence of second cancers after medical exposures to ionizing radiation or combined radiotherapy and chemotherapy. Second malignancies frequently occur following high-dose chemotherapy or radiotherapy of primary cancers in many tissues, especially those treated in pediatric patients. The report will address the organs demonstrating heightened sensitivity to second cancers and late effects such as elevated cardiopulmonary diseases. Genetic factors that influence second cancer incidence and other factors such as age at exposure that modulate the risk of second tumors will be discussed. The current state of knowledge on the cellular and molecular bases of second

cancer formation will be evaluated. The preparation of this report is under the joint oversight of PAC 1 and PAC 4.

- NCRP will prepare a report on “Diagnostic Reference Levels in Medical Imaging and Recommendations for Applications in the United State,” which will provide a practical tool in diagnostic radiology and nuclear medicine for managing the radiation doses received by patients in medical imaging procedures. This report will provide recommendations on: (1) optimizing imaging protocols, (2) managing procedure time, (3) available radiation protection equipment and dose-reduction features, (4) tracking and trending patient and physician radiation doses, and (5) physician training and credentialing in the use of IGIP equipment for these specialized procedures.

During the current triennium NCRP has undertaken several reports within PAC 4 that involve an analysis of medical exposures of members of the U.S. population and the monitoring, decontamination and treatment of individuals contaminated with radionuclides. A high priority will be placed on completion of the following two reports under the joint oversight of PAC 3 and PAC 4:

- A report on “Management of Persons Contaminated with Radionuclides” was initiated in 2005 and will be completed in 2008. This report will be both an update and an extension of NCRP Report No. 65, *Management of Persons Accidentally Contaminated with Radionuclides*, that was published in 1980. The original report was focused primarily on individuals contaminated with one or more radionuclides at a nuclear facility. However, a broader range of contamination events has occurred in subsequent years, and there is now significant concern about deliberate releases of radionuclides through an act of terrorism. Accordingly, the new report will consider a larger number of radionuclides, including many that are considered primary candidates for possible radiological terrorism incidents. The report will be a multipurpose handbook that provides quick reference information for early post-exposure actions, as well as guidance for longer-term management and treatment of exposed persons. Preparation of this report has been cosponsored by the U.S. Navy and CDC.
- A report on “Population Monitoring and Decontamination Following a Nuclear or Radiological Incident” was initiated in 2006 with sponsorship by CDC and publication is expected by 2009. This report will provide a comprehensive set of recommendations on the monitoring and decontamination of members of the public who may be internally contaminated as a result of a nuclear accident or an act of nuclear or radiological terrorism. These recommendations will be directed to responders at the federal, state and local levels. Consideration will be given to the breadth of information, procedures and facilities necessary to respond effectively to the possible exposure of a general population of victims comprised of persons of different ages and health status.

During the coming triennium NCRP also plans the preparation of another report and organizing a conference related to radiation protection in medicine. These planned activities are described below.

- NCRP plans to prepare a report with CDC sponsorship on “Risks of Radiation to the Developing Embryo, Fetus, and Nursing Infant,” that will significantly update and extend information contained in Report No. 54, *Medical Radiation Exposure of Pregnant and Potentially Pregnant Women* (1977) and Commentary No. 9, *Considerations*

Regarding the Unintended Radiation Exposure of the Embryo, Fetus or Nursing Child (1994). Subsequent advances have been made in determining the potentially adverse effects of both pre- and postconception maternal irradiation, as well as irradiation at various stages of pregnancy and of newborn children. In addition, there have been significant increases in recent years in the use of diagnostic radiological procedures such as CT to which pregnant or potentially pregnant women are exposed. The report will provide a comprehensive discussion of birth defects and developmental abnormalities that can result from irradiation of an embryo, fetus, or nursing child based on information gained from studies on *in utero* and postnatal exposures of atomic-bomb survivors and inadvertent medical or occupational exposures of pregnant and nursing women. Quantitative estimates will be made of doses to embryos, fetuses, and nursing children from external radiation sources or radionuclides administered to the mother. The report will also present information on effective methods of communicating the risks of radiation exposure to pregnant women, and conveying to them the scientific basis for decisions of whether and when diagnostic or therapeutic radiological procedures should be performed with minimal risk to the developing embryo or fetus. Preparation of the report will be under the joint oversight of PAC 1 and PAC 4 since it relates both to radiation exposure guidance and to assessing potential risks of maternal radiation in medical procedures on the developing embryo or fetus and the nursing infant.

- NCRP is planning a conference on “Patient Doses in Medical Imaging Procedures,” with a focus on the use of CT in emergency room situations. It is anticipated that this conference will be cosponsored by ACR and other scientific organizations, and will provide a comprehensive review of CT doses received by patients, including children, operational controls on doses, the importance and optimum use of CT in emergency rooms, and the importance of adequate training and credentialing of medical staff ordering and administering CT and other radiological imaging procedures.

NCRP is also giving consideration to the preparation of a statement on “Ethical and Radiation Protection Recommendations for Studies on Human Subjects.” Although ethical principles have been codified internationally in the Declaration of Helsinki (1975) and in the United States by the National Institutes of Health (1997), neither address the radiation exposure standards to be followed in research studies involving radiation exposures of humans. The proposed statement will provide specific guidance on this subject. The statement will provide recommendations on performing individual-specific risk/benefit analyses; guidelines for minimizing radiological risks without compromising scientific objectives; the scope of information to be provided to potential research subjects as part of the informed consent process; and will provide guidance on procedures involving children or persons of diminished mental capacity. It is anticipated that this statement will represent an important extension of existing national and international guidance on the ethical conduct of radiation studies with human subjects. In the preparation of the statement, NCRP will utilize the experience and insights of members of its Advisory Panel on Public Policy.

Program Area Committee 5: *Environmental Radiation and Radioactive Waste Issues*

Key Functions

The primary function of PAC 5 is to prepare definitive reports that serve as a scientific foundation for assessing the health risks of, and mitigation procedures for, environmental sources of radiation and radioactive and mixed wastes. PAC 5 also provides technical guidance on nuclear waste cleanup and environmental restoration, and on managing the disposition of radioactive and mixed wastes. In addition, PAC 5 will provide joint oversight with PAC 3 of planned new reports on the cleanup and restoration of urban sites contaminated as the result of a possible future act of nuclear or radiological terrorism.

Recent Accomplishments

NCRP has conducted an annual meeting and published several important reports in recent years on management and disposition of radioactive materials, releases of these materials to the environment, and the cleanup of nuclear facilities. Specific accomplishments include:

- The successful 2005 NCRP Annual Meeting was on the topic *Managing the Disposition of Low-Activity Radioactive Materials*, and the proceedings were published in 2006 in *Health Physics* [Vol. 91(5)]. Papers presented at the meeting discussed regulatory, commercial and social aspects of developing methods for the disposal or reuse of low-level radioactive materials in a cost-effective manner that is protective of human health. The 2005 Annual Meeting provided additional information on the disposition of low-activity radioactive wastes to that contained in NCRP Report No. 141 (2002) on *Managing Potentially Radioactive Scrap Metal*.
- Report No. 143 on *Management Techniques for Laboratories and Other Small Institutional Generators to Minimize Off-Site Disposal of Low-Level Radioactive Wastes* was published in 2003, and addresses the problems encountered by small organizations that generate low-activity wastes. The report evaluates all aspects of process refinements and waste reduction techniques that can reduce the quantity of low-level wastes generated by laboratories and other organizations that utilize relatively small amounts of radioactive materials.

- Report No. 146 (2004) on *Approaches to Risk Management in Remediation of Radioactively Contaminated Sites* analyzes current policies and practices used by NRC under the License Termination Rule and by EPA under the Comprehensive, Environmental Response, Compensation, and Liability Act (1980) (Superfund) regulations and the National Oil and Hazardous Substances Pollution Contingency Plan in the remediation of radioactively contaminated sites. The report delineates the similarities and differences in the regulatory approaches of NRC and EPA in remediating contaminated sites.
- Report No. 154 (2006) on *Cesium-137 in the Environment: Radioecology and Approaches to Assessment and Management* summarizes the current state of knowledge on radiocesium in the environment and identifies future management issues concerning ¹³⁷Cs-contaminated ecosystems. It provides a review of knowledge of the sources and levels of radiocesium worldwide, natural processes that underlie highly varied behavior of cesium in aquatic and terrestrial ecosystems, transport parameters for dose and risk assessment models, and practical approaches to mitigating the environmental and health impacts of radiocesium contamination.

Strategic Goals for 2008–2010

During the coming triennium the areas of emphasis in reports prepared under the oversight of PAC 5 will be on the monitoring, avoidance and cleanup of environmental contamination by radioactive materials, including those produced by potential acts of nuclear or radiological terrorism. Many of these reports will be directly related to NCRP Strategic Initiatives 3 and 4 over the 2008–2010 period described under *Critical Issues and Strategic Program Plans*.

Reports related to the cleanup and restoration of urban areas contaminated by a deliberate act of terrorism are the following.

- NCRP plans to prepare a report on the topic “Approach to Optimizing Decision Making for Late Phase Recovery from Nuclear or Radiological Terrorism Incidents.” A key issue in optimization is the recovery of numerous critical public infrastructures or personal properties in urban areas that may have been contaminated by radioactive materials and deemed to be unfit for reuse or occupancy. The report will be a component of the protective action guidelines originally prepared by DHS and being completed by EPA for response to an act of nuclear or radiological terrorism. The proposed NCRP report will identify key elements and the basic framework for optimization in the late-phase recovery effort following a terrorist act. It will also identify key decision factors involved in restoring or remediating the critical infrastructures (*e.g.*, medical facilities) and the affected components of the community, develop hierarchical parameters for characterizing the priority actions to be taken in returning the community to normalcy, and develop the basis and approach for implementing optimization to support decision making, including the identification of necessary tools and techniques. Sponsorship for the preparation of this report has been requested of EPA, and the report will be under the joint oversight of PAC 3 and PAC 5.
- A related report planned by NCRP with DHS sponsorship is on the topic “Management and Long-Term Safe Containment of Contaminated Materials Generated Following a Nuclear or Radiological Terrorism Incident.” This report will address the many issues in disposition and safe long-term containment of radioactive wastes generated during

the cleanup of a nuclear or radiological terrorism incident. The primary components of the report will include: (1) the description of scenarios and associated levels of radioactivity in possible terrorism acts; (2) the volumes, physical and chemical characteristics, and levels of radioactivity of materials generated by optimized cleanup activities; and (3) the disposition options for managing these contaminated materials, including the separation and possible reuse of minimally contaminated materials, the safe handling and packaging of more highly contaminated materials, and the selection of long-term disposal options that comply with regulatory requirements and expectations on containment stability and public safety over a period of hundreds to thousands of years. The report will also address radiation protection of individuals involved with the preparation, packaging, transport, and final disposition of the more highly radioactive waste materials. The preparation of this report will be under the joint oversight of PAC 3 and PAC 5.

During the coming triennium NCRP plans to prepare five reports related to environmental monitoring, radioactive contamination of land, facilities and commercial products, and the cleanup and environmental restoration of nuclear waste sites and contaminated nuclear facilities. Sponsorship of these report activities has been requested from DOE and other federal government agencies.

- NCRP will publish a report on “Design of Effective Effluent and Environmental Monitoring Programs” by 2009. This report will provide a comprehensive description of the key elements of procedures to be used in establishing an effective radiological monitoring and surveillance program at nuclear facilities. The report will describe the required radiation detection equipment and state-of-the-art modeling approaches for determining radionuclide transport pathways and potential doses to members of the public from releases of radionuclides. The quality control processes that must be integrated into the program, and the applicable regulatory requirements that must be met, will be described in detail.
- NCRP plans to prepare a report on “Developing Cost-Effective Strategies for the Cleanup and Restoration of DOE Nuclear Waste Sites and Facilities Formerly Used for the Production of Special Nuclear Materials and Weapons.” At the present time there are millions of curie of high-level radioactive and mixed wastes stored in tanks at several sites managed by DOE. Many of the facilities that were utilized for the production of nuclear weapons during the Cold War era are still in operation or in early stages of decommissioning. Although extensive planning for the ultimate disposition of stored nuclear wastes (for example, by vitrification and long-term underground storage at Yucca Mountain) has been a priority of DOE for nearly two decades, there are still many unresolved questions about the stability and security of the wastes, as well as the long-term radiological protection of the public should problems with waste containment occur. There are also significant unresolved issues related to the optimal approaches to be taken in the decommissioning and demolition of laboratories used for the production of materials for nuclear weapons, including the cleanup of radioactive waste materials that have escaped into the subsurface environment and are moving through the vadose zone and aquifers toward bodies of publicly accessible water. Other issues of great interest and concern are the appropriate cleanup levels of residual radioactivity and the safe reuse of land for new DOE laboratories or commercial businesses once the former

nuclear facilities have been demolished. The NCRP report will address all of these issues and make recommendations on safe and publicly acceptable targets for cleanup and the reuse of land formerly occupied by nuclear waste sites and production facilities.

- NCRP plans to prepare a critically needed report on “Performing Environmental Restoration at DOE Sites That is Protective of Public Health Without the Destruction of Natural Resources and Ecosystems.” There are many nuclear waste sites that are located on, or near, environmental areas with sensitive, and in some cases unique, natural ecosystems. The planning for cleanup and restoration of nuclear waste sites must take into account the need to preserve these natural resources to the maximum extent possible. The proposed NCRP report will present recommendations on the optimization strategies that can be employed for achieving nuclear cleanup goals while preserving natural terrestrial and aquatic ecosystems. There are several examples of cleanup at DOE nuclear sites that successfully met this goal (for example, at the Savannah River Site, Rocky Flats, and Hanford). The NCRP report will provide generic guidance for planning of cleanup and restoration activities that build upon these examples and are applicable to a wide range of nuclear sites that will be decommissioned and restored in the coming decades. The report will establish metrics for the preservation and long-term viability of natural flora and fauna in terrestrial and aquatic ecosystems, and present the basis for cleanup strategies consistent with these metrics.
- NCRP plans to prepare a report on “Environmental Management of Lands Contaminated with Naturally Occurring Radioactive Materials,” such as the ^{226}Ra present at former phosphate mines in southern Florida. There is a need to address public health concerns and to provide guidance on the cleanup and potential reuse of lands contaminated with NORM or technologically-enhanced NORM (TENORM). The proposed NCRP report will provide recommendations on the development of federal requirements and regulations in the cleanup and restoration of sites contaminated with NORM and TENORM. Although there are environmental cleanup standards in place for man-made radioactive contamination, there are no consistent federal or state regulatory controls or environmental management policies for NORM or TENORM contamination resulting from industrial practices associated with processing natural metal and mineral resources. The NCRP report will evaluate the environmental management issues associated with NORM and TENORM, and provide guidance to federal and state agencies on the scientific basis for establishing future cleanup regulations.
- A major concern of the U.S. government and the International Atomic Energy Agency (IAEA) has been the large number of unregulated and often uncontrolled sealed sources of radiation that exist worldwide and create problems as a result of entry into the metal-recycling and steel-making industries. In the United States the DOE National Nuclear Security Administration has undertaken a major program to recover these so-called “orphan sources” and has already recovered more than 15,000 sources from over 600 sites. IAEA recently held a meeting at its headquarters in Vienna, Austria to discuss the extent and resolution of problems with orphan sources in the scrap metal supply chain worldwide. The proposed NCRP report will provide “Guidance on the Management and Control of Recycled Orphan Radiation Sources,” especially in the steel production industry. The key issues to be addressed are optimal methods for detecting the presence of radioactivity in slag, steel products and baghouse dust, and assessing the potential

impact of exposure to slightly contaminated steel products on public health. This report will be prepared under the joint oversight of PAC 2 and PAC 5.

As described above in *Critical Issues and Strategic Program Plans*, Strategic Initiative 6 is focused on safety, health and environmental protection in advanced reactor design and spent-fuel processing. PAC 5 will have a lead role in developing new NCRP activities related to this initiative since many of the important areas in which NCRP guidance will be valuable involve the role of advanced nuclear technology in minimizing nuclear wastes, enhancing environmental protection against contamination from uncontrolled nuclear incidents, and reducing dependence on carbon-based fuels that are the underlying cause of progressive global climate change.

An initial step in meeting the goals of this new strategic initiative will be the 2009 NCRP Annual Meeting focused on topics related to the safety, health and environmental protection aspects of new nuclear power reactor systems. The design features of Generation-3+ and Generation-4 reactors include the use of closed fuel cycles to efficiently manage spent nuclear fuel, new operational safety features and shielding designs, and reduced dependence on plutonium-based fuel and the utilization of proliferation-resistant fuels. In support of the operation of these reactors, several advanced concepts have been proposed to manage the reprocessing of spent nuclear fuels and utilize the resulting byproducts (for example, advanced uranium separation methods, pyrochemical processing, and the burning of recycled transuranics in “burner reactors”).

It is expected that the 2009 NCRP Annual Meeting on *Future of Nuclear Power Worldwide: Safety, Health and Environment* will be an international conference with participation by representatives of the many nations and scientific organizations and governmental agencies that are engaged in the GNEP initiative. The peer-reviewed proceedings of the NCRP Annual Meeting will be published, and it is anticipated that NCRP will undertake several new report activities over the coming triennium related to the safety, nuclear waste management, and health and environmental protection aspects of the development and deployment of advanced nuclear power reactor systems. Oversight of these activities will include PAC 1 (issues related to the potential health effects of “exotic” fission products), PAC 2 and PAC 3 (operational safety and security of new nuclear power systems), and PAC 5 (environmental protection and potential benefits of expanding the use of inherently safe nuclear power systems and developing advanced fuel design and reprocessing technologies).

Program Area Committee 6: *Dosimetry and Measurements*

Key Functions

The primary functions of PAC 6 are to analyze the current state-of-the-art methods for use in radiation measurements and dosimetry, and applications of new technologies in medicine, industry, responses to radiological emergencies, and homeland security. A current focus of scientific committees operating under PAC 6 is on analyzing uncertainties in the dosimetry of both external and internal radiation, and the implications of these uncertainties in performing dose assessments and dose reconstructions for individuals exposed to radiation in industrial and medical procedures, environmental contamination from nuclear weapons production and atmospheric testing, nuclear accidents, and military operations.

Recent Accomplishments

The following important NCRP publications were completed under PAC 6 during the 2005–2007 triennium.

- Report No. 156 on *Development of a Biokinetic Model for Radionuclide-Contaminated Wounds and Procedures for Their Assessment, Dosimetry and Treatment* was issued in 2007. Report No. 156 uses both human and experimental laboratory data in developing a model of the deposition and retention of radioactive materials in wounds and their release into the systemic circulation, which depend upon the physical and chemical forms of the radionuclides involved, the depth of a wound and the extent of injury, the treatment administered, and the time elapsed between injury and treatment.
- Report No. 158 on *Uncertainties in the Measurement and Dosimetry of External Radiation* was completed by NCRP in 2007. This report discusses in depth the uncertainties associated with data obtained from personal dosimeters and area monitors for gamma, beta, neutron, charged-particle, and mixed radiation fields. The report describes concepts and factors that contribute to uncertainty in converting measurements to estimates of organ radiation doses, including statistical methods for combining the uncertainties associated with measurements and models to calculate the total uncertainty in organ dose estimates.

- NCRP Commentary No. 20 on *Radiation Protection and Measurement Issues Related to Cargo Scanning with Accelerator-Produced High-Energy X Rays* was issued in 2007. This commentary provides a comprehensive analysis of the health protection issues and radiation measurement technology to be utilized with the Cargo Advanced Automated Radiography System. This system is being designed and will be installed at many land and sea ports-of-entry into the United States for detection in cargo containers of special nuclear materials and other high atomic number elements that could be used as shielding for special nuclear materials and other radioactive materials that might be illegally transported into the United States for use in acts of nuclear or radiological terrorism.

Strategic Goals for 2008–2010

NCRP plans to complete several major reports related to radiation measurements, dosimetry, and dose reconstruction during the coming triennium that are essential components of Strategic Initiative 5 in this area.

- A report on “Ionizing Radiation Exposure of the United States Population” was initiated in late 2005 and publication is expected in 2008. This report, the preparation of which has been sponsored by NRC, EPA and CDC, will be an update of NCRP Report No. 93, *Ionizing Radiation Exposure of the Population of the United States*, that was published in 1987, and presents data on all sources of occupational, environmental and public radiation exposure. A primary rationale for undertaking this update was the recognition by NCRP that the number of medical procedures involving radiation, for example CT diagnostic imaging, has increased significantly over the last two decades. As discussed earlier in the description of the 2007 NCRP Annual Meeting, analysis of the current numbers of procedures and doses received by patients in diagnostic radiology, nuclear medicine, and interventional radiological procedures indicates a significant increase in the average medical dose to a member of the U.S. population relative to the 1980s. The average per capita medical dose has increased from about 0.5 mSv y⁻¹ in the 1980s to a current level of about 3 mSv y⁻¹.

As discussed in the section on *Critical Issues and Strategic Program Plans*, an important part of NCRP’s program to provide technical and administrative support to VBDR with cosponsorship of DTRA and VA, will be the publication of three major reports on uncertainties in external and internal radiation dosimetry and the basic principles and practices in dose reconstruction. As described above the first of these reports, on uncertainties in radiation measurements and dosimetry for external radiation, was completed in 2007. Other reports in this series that are expected to be published during the coming triennium are the following:

- NCRP initiated a report in 2005 on “Uncertainties in Internal Radiation Dosimetry” that is expected to be published by 2009. This report provides a comprehensive analysis of all sources of uncertainty in the measurements and models used to calculate organ doses from internally deposited radionuclides. Measurement uncertainties are discussed for bioassay data, whole- and partial-body counting, biodosimetry data, and environmental data. An extensive analysis is also made of uncertainties in models used to estimate organ doses, including estimates of intake by all routes, uptake to blood from the lungs,

gastrointestinal tract and wounds, and distributions to bone and soft tissues. An assessment of uncertainty in dose estimation using both Bayesian and non-Bayesian (*e.g.*, Monte Carlo) methods are described. Examples of methods of uncertainty analysis for internal radiation doses are presented for a number of exposure scenarios.

- A report on “Principles and Practices in Radiation Dose Reconstruction” was initiated in 2006 and is expected to be published in 2009. The report focuses on all of the major aspects of radiation dose assessment and reconstruction, including: (1) the establishment of exposure scenarios and pathways of exposure to external and internal sources of radiation; (2) physical principles and calculational methods used to reconstruct radiation doses to specific organs and the whole body; (3) methods used to account for exposure to radiations of differing quality, including mixed radiation fields; (4) analysis of all sources of uncertainty in estimating doses, building on the results of NCRP reports on estimating uncertainties for external and internal sources of radiation, and including uncertainties associated with spatial and temporal variations in the radiation field, shielding by buildings or other structures, and resuspension of deposited radionuclides; and (5) clear methods of presenting exposure data and communicating the results of dose reconstructions to affected individuals. Several examples of dose reconstructions are presented to illustrate the results of this analysis.
- NCRP is also preparing two focused peer-review reports that relate to the dose reconstruction program. These reports are on the topics of “Skin Doses from Dermal Contamination” and “Evaluation of Inhalation Doses in Scenarios Involving Resuspension by Nuclear Detonations at the Nevada Test Site.” These reports involve an evaluation of analyses contained in reports by SENES Consultants, Ltd. (Oak Ridge, Tennessee) and related scientific literature. The reports will be completed in 2008.

NCRP is considering an annual meeting during the coming triennium that will be focused on the many issues associated with accurate estimates of external and internal radiation, the associated uncertainties, the optimum procedures to be used in dose assessments and reconstructions, and the use of this information in acute and retrospective dose reconstructions and compensation programs for occupationally-exposed individuals and members of the general public. This meeting is expected to be of interest and importance for several federal agencies involved in dose reconstruction and claims compensation programs.

Advisory Panel on Public Policy

Key Functions

NCRP is an important national source of information for the development of radiation safety programs and policies by federal, state and local governments, private sector organizations, and the medical community. In 2006 the NCRP Board of Directors completed an evaluation of the importance of NCRP's publications in providing the scientific basis for regulatory and public policy decisions by government agencies and by radiation safety officials in both government and the private sector. As an outcome of this review, the decision was made to form an Advisory Panel on Public Policy, which will have the following primary responsibilities: (1) identify policy implications of NCRP publications; (2) suggest members or serve as members of new NCRP scientific committees whose topics relate to public policy; (3) provide advice and wording on public policy issues when needed for NCRP reports; and (4) ensure that NCRP communications make it clear that NCRP's publications provide scientific information and recommendations to assist policy makers, but that NCRP does not participate directly in policy decisions. The Advisory Panel's activities are expected to be of value in strengthening NCRP's approach to, and management of, new report and conference activities with public policy implications.

Recent Accomplishments

The Advisory Panel has provided advice to the NCRP Directorate on undertaking new report activities on subjects related to exposure of members of the public to ionizing radiation, including recommendations on the use of radiation security screening systems at United States border crossings.

Strategic Goals for 2008–2010

NCRP will continue to request advice from members of the Advisory Panel on new report activities related to the preparation of guidance and recommendations on matters that involve policies on radiation exposure of workers or members of the general public.

Advisory Panel on Nonionizing Radiation

Key Functions

The primary functions of this Advisory Panel are to analyze mechanisms of interaction of nonionizing radiation with biological systems, including humans, and to identify biological responses and potential human health effects. Evaluations are made of both theoretical and applied aspects of dosimetry and exposure assessment of humans to nonionizing radiation, as well as procedures for mitigating exposure in public and occupational settings. Recommendations are also established on acceptable exposure levels for nonionizing radiation in occupational, medical and public environments.

Recent Accomplishments

Reports by NCRP in this area in recent years have focused on the potential health risks and safe operations of wireless telecommunication systems emitting radiofrequency (RF) radiation. An NCRP Presidential report on the topic of wireless telecommunication safety issues for building owners and managers was issued in 2002. This report provided guidance on safety procedures to be followed in placing wireless telecommunication base stations on building rooftops. Commentary No. 18 (2003) on *Biological Effects of Modulated Radiofrequency Fields* provided an in-depth evaluation of the potential biological and health effects of the pulsed and amplitude-modulated RF fields used for wireless telecommunications.

Strategic Goals for 2008–2010

NCRP plans to continue its activities related to the safety of RF radiation in wireless telecommunications and other applications. NCRP is currently exploring opportunities for work related to health protection in the many applications of electromagnetic fields in medicine, including RF ablation of heart arrhythmias, localized therapy of tumors in the liver, breast and other tissues using RF hyperthermia, direct-current electric field therapy of localized tumors, induced current from alternating-current electric and magnetic fields to inhibit cellular regrowth after cancer therapy, and magnetic guidance of chemotherapy agents contained in liposomes to cancerous tissues using strong gradient magnetic fields. In many cases, there is a need for additional analysis of secondary tissue effects and more precise measurements and dosimetry of the applied electric, magnetic and electromagnetic fields.

Summary of Prospective Contributions to Radiation Safety, Health Protection, and Measurement Technology

Consistent with its Congressional Charter, it is the primary objective of NCRP to provide guidance on radiation health protection and measurements in areas of greatest national need. The Strategic Program Plan for 2008–2010 has been developed with meeting that goal as a priority for NCRP’s reports and conferences. The relationship to national needs of NCRP’s strategic initiatives and program objectives for the coming triennium is summarized in the following table.

Activities in Meeting National Needs for Guidance on Radiation Protection and Measurements

Areas of National Priority	NCRP Reports and Conferences	PACs
Radiation Exposure and Health Risks	• 2008 annual meeting on low dose and low dose-rate radiation effects and models ^a	1
	• Low-dose radiation biological and health effects report	1
	• Uncertainties in radiation risk estimates and probability of disease causation	1
	• Biological effectiveness of photons and particle radiations	1 and 6
	• Radon health risks ^a	1
Medical Radiation Protection	• Genetic susceptibility to cancer	1 and 4
	• Second cancers and cardiopulmonary effects after radiotherapy ^a	1 and 4
	• Radiation safety in image-guided medical interventional procedures ^a	2 and 4
	• Diagnostic reference levels in medical imaging and applications in United States	4
	• Management of persons contaminated with radionuclides ^a	4
	• Population monitoring and decontamination following a nuclear or radiological incident ^a	4

Areas of National Priority	NCRP Reports and Conferences	PACs
Homeland Security	• Radiation risks to the developing embryo, fetus, or nursing child	1 and 4
	• Conference on patient doses in medical imaging procedures	4
	• Information for decision makers in a nuclear or radiological terrorism incident ^a	2 and 3
	• Protection against and medical treatment of exposure resulting from a nuclear or radiological terrorism incident	3 and 4
	• Treatment of contaminated wounds in persons exposed in a nuclear or radiological terrorism incident	3, 4 and 6
	• Decision making in late phase recovery from a nuclear or radiological terrorism incident	3 and 5
	• Management and containment of contaminated materials following nuclear or radiological terrorism incident	3 and 5
Operational Radiation Safety	• Response to radiological accidents and incidents (including terrorism acts)	2 and 3
	• Balance between radiological safety and security of materials and sources	2
	• Self-assessment of radiation safety programs ^a	2
Environmental Cleanup and Preservation	• Design of effective effluent and monitoring programs at nuclear facilities ^a	5
	• Cost-effective strategies for cleanup and restoration of DOE nuclear sites	5
	• Environmental restoration of DOE sites with preservation of natural ecosystems	5
	• Environmental management of lands contaminated with naturally-occurring radioactive material	5
	• Management and control of recycled orphan radioactive sources	2 and 5

Areas of National Priority	NCRP Reports and Conferences	PACs
Measurements, Dosimetry and Dose Reconstruction	• Ionizing radiation exposure of the U.S. population ^a	6
	• Uncertainties in internal radiation dosimetry ^a	6
	• Basic principles and practices of radiation dose reconstruction ^a	6
	• Skin doses from dermal contamination ^a	6
	• Inhalation doses from radiation resuspension at Nevada Test Site ^a	6
Astronaut Radiation Safety	• Prior radiation therapy and genetic background effects on astronaut susceptibility to radiation risks ^a	1
	• Radiation protection in short-term lunar missions ^a	1
Advanced Nuclear Power Technologies	• 2009 annual meeting on safety, health and environmental protection in advanced nuclear power reactor systems and fuel technologies	1, 2, 3 and 5

^aNCRP activity that is currently in progress. A complete list of active committees is contained in Appendix C.

Operational Goals & Objectives

During the 2005–2007 triennium NCRP has continued to meet its publication goals, reduce operating costs, and increase its sources of income and assets. An average of four reports have been published each year, along with the proceedings of the previous year’s annual meeting. Operating costs have been reduced by outsourcing NCRP’s information technology support, reducing the cost of maintaining a large archive of old report files, using “desktop publishing” methods, and establishing a “print-on-demand” agreement with NCRP’s printer, Automated Graphics Systems, Inc. New sources of income have been implemented, including making electronic copies of NCRP’s reports and commentaries available on its publications website (<http://NCRPpublications.org>), and establishing agreements for the dissemination of NCRP’s publications and their content with a major data aggregator and web-based information resource, Knovel Corporation, and the eBook distributor NetLibrary. The assets of NCRP have grown by \$1.11 million since 2002 as a result of winning new grants and contracts, coupled with an increase in the margin between income and expenses.

During the coming triennium NCRP will continue to meet its productivity goals and implement its strategic planning initiatives through implementation of the following operational practices:

- develop long-term funding agreements with government sponsors, with a focus on contracts or grants extending for a period of five years or longer;
- use all available sources of information to closely match work by NCRP to important national issues and specific needs of sponsors;
- seek opportunities to present the current work and future plans of NCRP to representatives of government agencies, and to congressional staff and members of Congress with interest in, and direct responsibility for, major areas of national importance addressed in the NCRP Strategic Program Plan, including energy, environment, health, and national security;
- build new avenues of interaction with sponsoring organizations by utilizing knowledge and key contacts developed through relationships with past and present members of Council and collaborating scientific organizations;
- develop new and strengthen existing liaison relationships with scientific organizations that share common interests and goals with NCRP, including international organizations; and
- ensure on-time delivery of NCRP’s products (publications, conferences, advisory statements) to all sponsors.

NCRP staff and technical staff consultants are listed in Appendix D.

Appendix A: Public Law 88-376

CONGRESSIONAL CHARTER



Public Law 88-376
88th Congress, H. R. 10437
July 14, 1964

An Act

To incorporate the National Committee on Radiation Protection and Measurements.

78 STAT. 320.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That—

C. M. Barnes, Rockville, Maryland;
E. C. Barnes, Edgewood, Pennsylvania;
V. P. Bond, Setauket, Long Island, New York;
C. B. Braestrup, New York, New York;
J. T. Brennan, Bethesda, Maryland;
L. T. Brown, Bethesda, Maryland;
R. F. Brown, San Francisco, California;
F. R. Bruce, Oak Ridge, Tennessee;
J. C. Bugher, Rio Piedras, Puerto Rico;
D. R. Chadwick, Upper Marlboro, Maryland;
R. H. Chamberlain, Philadelphia, Pennsylvania;
J. F. Crow, Madison, Wisconsin;
R. L. Doan, Idaho Falls, Idaho;
C. L. Dunham, Washington, District of Columbia;
T. C. Evans, Iowa City, Iowa;
E. G. Fuller, Bethesda, Maryland;
R. O. Gorson, Philadelphia, Pennsylvania;
J. W. Healy, Chappaqua, New York;
P. C. Hodges, Chicago, Illinois;
A. R. Keene, Richland, Washington;
M. Kleinfeld, Brooklyn, New York;
H. W. Koch, Silver Spring, Maryland;
D. I. Livermore, Washington, District of Columbia;
G. V. LeRoy, Chicago, Illinois;
W. B. Mann, Chevy Chase, Maryland;
W. A. McAdams, Schenectady, New York;
G. W. Morgan, Kensington, Maryland;
K. Z. Morgan, Oak Ridge, Tennessee;
H. J. Muller, Bloomington, Indiana;
R. J. Nelsen, Rockville, Maryland;
R. R. Newell, San Francisco, California;
W. D. Norwood, Richland, Washington;
H. M. Parker, Richland, Washington;
C. Powell, Bethesda, Maryland;
E. H. Quimby, New York, New York;
J. C. Reeves, Gainesville, Florida;
R. Robbins, Philadelphia, Pennsylvania;
H. H. Rossi, Nyack, New York;
E. L. Saenger, Cincinnati, Ohio;
T. L. Shipman, Los Alamos, New Mexico;
P. J. Shore, Patchogue, New York;
J. H. Sterner, Rochester, New York;
R. S. Stone, San Francisco, California;
L. S. Taylor, Bethesda, Maryland;
E. D. Trout, Corvallis, Oregon;
R. F. Trum, Boston, Massachusetts;
Shields Warren, Boston, Massachusetts;
E. G. Williams, Jacksonville, Florida;
H. O. Wyckoff, Silver Spring, Maryland;

National Council
on Radiation Pro-
tection and Meas-
urements, incor-
poration.

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and their successors, are hereby created and declared to be a body corporate, by name of the National Council on Radiation Protection and Measurements (hereinafter called the corporation), and by such name shall be known, and have perpetual succession and the powers, limitations, and restrictions contained in this Act.

COMPLETION OF ORGANIZATION

SEC. 2. The persons named in the first section of this Act are authorized to complete the organization of the corporation by the selection of officers and employees, the adoption of bylaws, not inconsistent with this Act, and the doing of such other acts as may be necessary for such purpose.

OBJECTS AND PURPOSES OF CORPORATION

SEC. 3. The objects and purposes of the corporation shall be—

(1) to collect, analyze, develop, and disseminate in the public interest information and recommendations about (a) protection against radiation (referred to herein as "radiation protection"), and (b) radiation measurements, quantities, and units, particularly those concerned with radiation protection;

(2) to provide a means by which organizations concerned with the scientific and related aspects of radiation protection and of radiation quantities, units, and measurements may cooperate for effective utilization of their combined resources, and to stimulate the work of such organizations;

(3) to develop basic concepts about radiation quantities, units, and measurements, about the application of these concepts, and about radiation protection;

(4) to cooperate with the International Commission on Radiological Protection, the Federal Radiation Council, the International Commission on Radiological Units and Measurements, and other national and international organizations, governmental and private, concerned with radiation quantities, units, and measurements and with radiation protection.

POWERS OF CORPORATION

SEC. 4. The corporation shall have power—

(1) To sue and be sued, complain and defend in any court of competent jurisdiction.

(2) To adopt, alter, and use a corporate seal.

(3) To choose such officers, directors, trustees, managers, agents, and employees as the business of the corporation may require.

(4) To adopt, amend, and alter bylaws not inconsistent with the laws of the United States of America or of any State in which the corporation is to operate, for the management of its property and the regulation of its affairs.

(5) To make contracts.

(6) To take and hold by lease, gift, purchase, grant, devise, or bequest, or by any other method, any property, real or personal, necessary or proper for attaining the objects and carrying into effect the purposes of the corporation, subject, however, to applicable provisions of law of any State or the District of Columbia (a) governing the amount or kind of such property which may be held by, or (b) otherwise limiting or controlling the ownership of any such property by a corporation operating in such State or the District of Columbia.

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(7) To transfer and convey real or personal property, and to mortgage, pledge, encumber, lease, and sublease the same.

(8) To borrow money for its corporate purposes and issue bonds or other evidences of indebtedness therefor, and to secure the same by mortgage, pledge, or lien, subject in every case to all applicable provisions of Federal or State law, or of the laws of the District of Columbia.

(9) To do any and all such acts and things necessary and proper to carry out the purposes of the corporation.

PRINCIPAL OFFICE ; SCOPE OF ACTIVITIES ; DISTRICT OF COLUMBIA AGENT

SEC. 5. (a) The principal office of the corporation shall be located in the District of Columbia, or in such other place as may later be determined by the board of directors, but the activities of the corporation shall not be confined to that place and may be conducted throughout the various States, the Commonwealth of Puerto Rico, and the possessions of the United States, and in other areas throughout the world.

(b) The corporation shall maintain at all times in the District of Columbia a designated agent authorized to accept service of process for the corporation, and notice to or service upon such agent, or mailed to the business address of such agent, shall be deemed notice to or service upon the corporation.

MEMBERSHIP ; VOTING RIGHTS

SEC. 6. (a) Eligibility for membership in the corporation and the rights and privileges of members shall, except as provided in this Act, be determined as the bylaws of the corporation may provide.

(b) Each member of the corporation, other than honorary and associate members, shall have the right to one vote on each matter submitted to a vote at all meetings of the members of the corporation.

BOARD OF DIRECTORS ; COMPOSITION ; RESPONSIBILITIES

SEC. 7. (a) Upon enactment of this Act the membership of the initial board of directors of the corporation shall be those persons whose names are listed in section 1 of this Act.

(b) Thereafter, the board of directors of the corporation shall be selected in such manner and shall serve for such term as may be prescribed in the bylaws of the corporation.

(c) The board or directors shall be the governing board of the corporation and shall, during the intervals between corporation meetings, be responsible for the general policies and program of the corporation. The board shall be responsible for the control of all funds of the corporation.

OFFICERS ; ELECTION OF OFFICERS

SEC. 8. (a) The officers of the corporation shall be a president, one or more vice presidents, a secretary, a treasurer, and such other officers as may be prescribed in the bylaws. The duties of the officers shall be as prescribed in the bylaws of the corporation.

(b) Officers shall be elected annually at the annual meeting of the corporation.

USE OF INCOME ; LOANS TO OFFICERS, DIRECTORS, OR EMPLOYEES

SEC. 9. (a) No part of the income or assets of the corporation shall inure to any member, officer, or director, or be distributable to

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any such person during the life of the corporation or upon dissolution or final liquidation. Nothing in this subsection, however, shall be construed to prevent the payment of reasonable compensation to officers of the corporation in amounts approved by the board of directors of the corporation.

(b) The corporation shall not make loans to its officers, directors, or employees. Any director who votes for or assents to the making of a loan to an officer, director, or employee of the corporation, and any officer who participates in the making of such loan, shall be jointly and severally liable to the corporation for the amount of such loan until the repayment thereof.

NONPOLITICAL NATURE OF CORPORATION

SEC. 10. The corporation, and its officers, directors, and duly appointed agents as such, shall not contribute to or otherwise support or assist any political party or candidate for office.

LIABILITY FOR ACTS OF OFFICERS AND AGENTS

SEC. 11. The corporation shall be liable for the acts of its officers and agents when acting within the scope of their authority.

PROHIBITION AGAINST ISSUANCE OF STOCK OR PAYMENT OF DIVIDENDS

SEC. 12. The corporation shall have no power to issue any shares of stock nor to declare nor pay any dividends.

BOOKS AND RECORDS ; INSPECTION

SEC. 13. The corporation shall keep correct and complete books and records of account and shall keep minutes of the proceedings of its members, board of directors, and committees having authority under the board of directors, and it shall also keep at its principal office a record of the names and addresses of its members entitled to vote. All books and records of the corporation may be inspected by any member entitled to vote, or his agent or attorney, for any proper purpose, at any reasonable time.

AUDIT OF FINANCIAL TRANSACTIONS

SEC. 14. (a) The accounts of the corporation shall be audited annually in accordance with generally accepted auditing standards by independent certified public accountants or independent licensed public accountants, certified or licensed by a regulatory authority of a State or other political subdivision of the United States. The audit shall be conducted at the place or places where the accounts of the corporation are normally kept. All books, accounts, financial records, reports, files, and all other papers, things, or property belonging to or in use by the corporation and necessary to facilitate the audit shall be made available to the person or persons conducting the audit; and full facilities for verifying transactions with the balances or securities held by depositories, fiscal agents, and custodians shall be afforded to such person or persons.

(b) A report of such audit shall be made by the corporation to the Congress not later than six months following the close of the fiscal year for which the audit is made. The report shall set forth the scope of the audit and include such statements, together with the independent auditor's opinion of those statements, as are necessary to present fairly the corporation's assets and liabilities, surplus, or deficit, with an analysis of the changes therein during the year, sup-

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plemented in reasonable detail by a statement of the corporation's income and expenses during the year including (1) the results of any trading, manufacturing, publishing, or other commercial-type endeavor carried on by the corporation, and (2) a schedule of all contracts requiring payments in excess of \$10,000 and any payments of compensation, salaries, or fees at a rate in excess of \$10,000 per annum. The report shall not be printed as a public document.

USE OF ASSETS ON DISSOLUTION OR LIQUIDATION

SEC. 15. Upon final dissolution or liquidation of the corporation, and after discharge or satisfaction of all outstanding obligations and liabilities, the remaining assets of the corporation may be distributed in accordance with the determination of the board of directors of the corporation and in compliance with the bylaws of the corporation and all Federal and State laws applicable thereto. Such distribution shall be consistent with the purposes of the corporation.

ACQUISITION OF ASSETS AND LIABILITIES OF THE EXISTING ASSOCIATION

SEC. 16. The corporation may and shall acquire all of the assets of the existing unincorporated organization known as the National Committee on Radiation Protection and Measurements, subject to any liabilities and obligations of the said organization.

RESERVATION OF RIGHT TO AMEND OR REPEAL CHARTER

SEC. 17. The right to alter, amend, or repeal this Act is hereby expressly reserved.

Approved July 14, 1964.

LEGISLATIVE HISTORY:

HOUSE REPORT No. 1252 (Comm. on the Judiciary).
SENATE REPORT No. 1155 (Comm. on the Judiciary).
CONGRESSIONAL RECORD, Vol. 110 (1964):
Apr. 6: Passed House.
July 2: Passed Senate.

Appendix B: Complete List of Publications

No.	Title and Year of Publication
NCRP Reports	
158	Uncertainties in the Measurement and Dosimetry of External Radiation (2007)
157	Radiation Protection in Educational Institutions (2007)
156	Development of a Biokinetic Model for Radionuclide-Contaminated Wounds and Procedures for their Assessment, Dosimetry and Treatment (2006)
155	Management of Radionuclide Therapy Patients (2006)
154	Cesium-137 in the Environment: Radioecology and Approaches to Assessment and Management (2006)
153	Information Needed to Make Radiation Protection Recommendations for Space Missions Beyond Low-Earth Orbit (2006)
152	Performance Assessment of Near-Surface Facilities for Disposal of Low-Level Radioactive Waste (2005)
151	Structural Shielding Design and Evaluation for Megavoltage X- and Gamma-Ray Radiotherapy Facilities (2005)
150	Extrapolation of Radiation-Induced Cancer Risks from Nonhuman Experimental Systems to Humans (2005)
149	A Guide to Mammography and Other Breast Imaging Procedures (2004)
148	Radiation Protection in Veterinary Medicine (2004)
147	Structural Shielding Design for Medical X-Ray Imaging Facilities (2004)
146	Approaches to Risk Management in Remediation of Radioactively Contaminated Sites (2004)
145	Radiation Protection in Dentistry (2003)
144	Radiation Protection for Particle Accelerator Facilities (2003)
143	Management Techniques for Laboratories and Other Small Institutional Generators to Minimize Off-Site Disposal of Low-Level Radioactive Waste (2003)
142	Operational Radiation Safety Program for Astronauts in Low-Earth Orbit: A Basic Framework (2002)

No.	Title and Year of Publication
141	Managing Potentially Radioactive Scrap Metal (2002)
140	Exposure Criteria for Medical Diagnostic Ultrasound: II. Criteria Based on All Known Mechanisms (2002)
139	Risk-Based Classification of Radioactive and Hazardous Chemical Wastes (2002)
138	Management of Terrorist Events Involving Radioactive Material (2001)
137	Fluence-Based and Microdosimetric Event-Based Methods for Radiation Protection in Space (2001)
136	Evaluation of the Linear-Nonthreshold Dose-Response Model for Ionizing Radiation (2001)
135	Liver Cancer Risk from Internally-Deposited Radionuclides (2001)
134	Operational Radiation Safety Training (2000)
133	Radiation Protection for Procedures Performed Outside the Radiology Department (2000)
132	Radiation Protection Guidance for Activities in Low-Earth Orbit (2000)
131	Scientific Basis for Evaluating the Risks to Populations from Space Applications of Plutonium (2001)
130	Biological Effects and Exposure Limits for “Hot Particles” (1999)
129	Recommended Screening Limits for Contaminated Surface Soil and Review of Factors Relevant to Site-Specific Studies (1999)
128	Radionuclide Exposure of the Embryo/Fetus (1998)
127	Operational Radiation Safety Program (1998)
126	Uncertainties in Fatal Cancer Risk Estimates Used in Radiation Protection (1997)
125	Deposition, Retention and Dosimetry of Inhaled Radioactive Substances (1997)
124	Sources and Magnitude of Occupational and Public Exposures from Nuclear Medicine Procedures (1996)
123	Screening Models for Releases of Radionuclides to Atmosphere, Surface Water, and Ground (1996)
122	Use of Personal Monitors to Estimate Effective Dose Equivalent and Effective Dose to Workers for External Exposure to Low-LET Radiation (1995)
121	Principles and Application of Collective Dose in Radiation Protection (1995)
120	Dose Control at Nuclear Power Plants (1994)
119	A Practical Guide to the Determination of Human Exposure to Radiofrequency Fields (1993)
118	Radiation Protection in the Mineral Extraction Industry (1993)
117	Research Needs for Radiation Protection (1993)
116	Limitation of Exposure to Ionizing Radiation (1993)

No.	Title and Year of Publication
115	Risk Estimates for Radiation Protection (1993)
114	Maintaining Radiation Protection Records (1992)
113	Exposure Criteria for Medical Diagnostic Ultrasound: I. Criteria Based on Thermal Mechanisms (1992)
112	Calibration of Survey Instruments Used in Radiation Protection for the Assessment of Ionizing Radiation Fields and Radioactive Surface Contamination (1991)
111	Developing Radiation Emergency Plans for Academic, Medical and Industrial Facilities (1991)
110	Some Aspects of Strontium Radiobiology (1991)
109	Effects of Ionizing Radiation on Aquatic Organisms (1991)
108	Conceptual Basis for Calculations of Absorbed-Dose Distributions (1991)
107	Implementation of the Principle of As Low As Reasonably Achievable (ALARA) for Medical and Dental Personnel (1990)
106	Limit for Exposure to “Hot Particles” on the Skin (1990)
105	Radiation Protection for Medical and Allied Health Personnel (1989)
104	The Relative Biological Effectiveness of Radiations of Different Quality (1990)
103	Control of Radon in Houses (1989)
102	Medical X-Ray, Electron Beam and Gamma-Ray Protection for Energies up to 50 MeV (Equipment Design, Performance and Use) (1989)
101	Exposure of the U.S. Population from Occupational Radiation (1989)
100	Exposure of the U.S. Population from Diagnostic Medical Radiation (1989)
99	Quality Assurance for Diagnostic Imaging (1988)
98	Guidance on Radiation Received in Space Activities (1989)
97	Measurement of Radon and Radon Daughters in Air (1988)
96	Comparative Carcinogenicity of Ionizing Radiation and Chemicals (1989)
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87	Use of Bioassay Procedures for Assessment of Internal Radionuclide Deposition (1987)
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76	Radiological Assessment: Predicting the Transport, Bioaccumulation, and Uptake by Man of Radionuclides Released to the Environment (1984)
75	Iodine-129: Evaluation of Release from Nuclear Power Generation (1983)
74	Biological Effects of Ultrasound: Mechanisms and Clinical Implications (1983)
73	Protection in Nuclear Medicine and Ultrasound Diagnostic Procedures in Children (1983)
72	Radiation Protection and Measurement for Low-Voltage Neutron Generators (1983)
71	Operational Radiation Safety—Training (1983)
70	Nuclear Medicine—Factors Influencing the Choice and Use of Radionuclides in Diagnosis and Therapy (1982)
69	Dosimetry of X-Ray and Gamma-Ray Beams for Radiation Therapy in the Energy Range 10 keV to 50 MeV (1981)
68	Radiation Protection in Pediatric Radiology (1981)
67	Radiofrequency Electromagnetic Fields—Properties, Quantities and Units, Biophysical Interaction and Measurements (1981)
66	Mammography (1980)
65	Management of Persons Accidentally Contaminated with Radionuclides (1980)
64	Influence of Dose and Its Distribution in Time on Dose-Response Relationships for Low-LET Radiations (1980)

No.	Title and Year of Publication
63	Tritium and Other Radionuclide Labeled Organic Compounds Incorporated in Genetic Material (1979)
62	Tritium in the Environment (1979)
61	Radiation Safety Training Criteria for Industrial Radiography (1978)
60	Physical, Chemical and Biological Properties of Radiocerium Relevant to Radiation Protection Guidelines (1979)
59	Operational Radiation Safety Program (1979)
58	A Handbook of Radioactivity Measurements Procedures (1978)
57	Instrumentation and Monitoring Methods for Radiation Protection (1978)
56	Radiation Exposure from Consumer Products and Miscellaneous Sources (1977)
55	Protection of the Thyroid Gland in the Event of Releases of Radioiodine (1977)
54	Medical Radiation Exposure of Pregnant and Potentially Pregnant Women (1977)
53	Review of NCRP Radiation Dose Limit for Embryo and Fetus in Occupationally Exposed Women (1977)
52	Cesium-137 from the Environment to Man: Metabolism and Dose (1977)
51	Radiation Protection Design Guidelines for 0.1-100 MeV Particle Accelerator Facilities (1977)
50	Environmental Radiation Measurements (1976)
49	Structural Shielding Design and Evaluation for Medical Use of X Rays and Gamma Rays of Energies up to 10 MeV (1976)
48	Radiation Protection for Medical and Allied Health Personnel (1976)
47	Tritium Measurement Techniques (1976)
46	Alpha-Emitting Particles in Lungs (1975)
45	Natural Background Radiation in the United States (1975)
44	Krypton-85 in the Atmosphere—Accumulation, Biological Significance, and Control Technology (1975)
43	Review of the Current State of Radiation Protection Philosophy (1975)
42	Radiological Factors Affecting Decision-Making in a Nuclear Attack (1974)
41	Specification of Gamma-Ray Brachytherapy Sources (1974)
40	Protection Against Radiation from Brachytherapy Sources (1972)
39	Basic Radiation Protection Criteria (1971)
38	Protection Against Neutron Radiation (1971)

No.	Title and Year of Publication
37	Precautions in the Management of Patients Who Have Received Therapeutic Amounts of Radionuclides (1970)
36	Radiation Protection in Veterinary Medicine (1970)
35	Dental X-Ray Protection (1970)
34	Medical X-Ray and Gamma-Ray Protection for Energies up to 10 MeV—Structural Shielding Design and Evaluation (1970)
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32	Radiation Protection in Educational Institutions (1966)
31	Shielding for High Energy Electron Accelerator Installations (1964)
30	Safe Handling of Radioactive Materials (1964)
29	Exposure to Radiation in an Emergency
28	A Manual of Radioactivity Procedures (1961)
27	Stopping Powers for Use with Cavity Chambers (1961)
26	Medical X-Ray Protection up to Three Million Volts (1961)
25	Measurement of Absorbed Dose of Neutrons and Mixtures of Neutrons and Gamma Rays (1961)
24	Protection Against Radiations from Sealed Gamma Sources (1960)
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22	Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure (1959)
21	Safe Handling of Bodies Containing Radioactive Isotopes (1958)
20	Protection Against Neutron Radiation up to 30 Million Electron Volts (1957)
19	Regulation of Radiation Exposure by Legislative Means (1955)
18	X-Ray Protection (1955)
17	Permissible Dose from External Sources of Ionizing Radiation (1954)
16	Radioactive Waste Disposal in the Ocean (1954)
15	Safe Handling of Cadavers Containing Radioactive Isotopes (1953)
14	Protection Against Betatron-Synchrotron Radiations up to 100 Million Electron Volts (1954)
13	Protection Against Radiation from Radium, Cobalt-60 and Cesium-137 (1954)
12	Recommendations for the Disposal of Carbon-14 Wastes (1953)
11	Maximum Permissible Amounts of Radioisotopes in the Human Body and Maximum Permissible Concentrations in Air and Water (1953)

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10	Radiological Monitoring Methods and Instruments (1952)
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8	Control and Removal of Radioactive Contamination in Laboratories (1951)
7	Safe Handling of Radioactive Isotopes (1949)
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30	Fifty Years of Scientific Investigation: The Importance of Scholarship and the Influence of Politics and Controversy, Robert L. Brent (2006). <i>Health Phys.</i> 93 , 348–379 (2007)
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28	Radiation Protection in the Aftermath of a Terrorist Attack Involving Exposure to Ionizing Radiation, Abel J. Gonzalez (2004). <i>Health Phys.</i> 89 , 418-446 (2005)
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26	Developing Mechanistic Data for Incorporation into Cancer and Genetic Risk Assessments: Old Problems and New Approaches, R. Julian Preston (2002). <i>Health Phys.</i> 85 , 4–12
25	Assuring the Safety of Medical Diagnostic Ultrasound, Wesley L. Nyborg (2001). <i>Health Phys.</i> 82 , 578–587
24	Administered Radioactivity: <i>Unde Venimus Quoquo Imus</i> , S. James Adelstein (2000). <i>Health Phys.</i> 80 , 317–324
23	Back to Background: Natural Radiation and Radioactivity Exposed, by Naomi H. Harley (1999). <i>Health Phys.</i> 79 , 121–128
22	From Chimney Sweeps to Astronauts: Cancer Risks in the Work Place, by Eric J. Hall (1998). <i>Health Phys.</i> 75 , 357–366
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18	Mice, Myths and Men, by R.J. Michael Fry (1995)
17	Science, Radiation Protection and the NCRP, by Warren K. Sinclair (1993)
16	Dose and Risk in Diagnostic Radiology: How Big? How Little?, by Edward W. Webster (1992)
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13	Radiobiology and Radiation Protection: The Past Century and Prospects for the Future, by Arthur C. Upton (1989)
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7	The Human Environment—Past, Present and Future, by Merrill Eisenbud (1983)
6	Ethics, Trade-Offs and Medical Radiation, by Eugene L. Saenger (1982)
5	How Well Can We Assess Genetic Risk? Not Very, by James F. Crow (1981)
4	From “Quantity of Radiation” and “Dose” to “Exposure” and “Absorbed Dose”—An Historical Review, by Harold O. Wyckoff (1980)
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- 19 Key Elements of Preparing Emergency Responders for Nuclear and Radiological Terrorism (2005)
- 18 Biological Effects of Modulated Radiofrequency Fields (2003)
- 17 Pulsed Fast Neutron Analysis System Used in Security Surveillance (2003)
- 16 Screening of Humans for Security Purposes Using Ionizing Radiation Scanning Systems (2003)
- 15 Evaluating the Reliability of Biokinetic and Dosimetric Models and Parameters Used to Assess Individual Doses for Risk Assessment Purposes (1998)
- 14 A Guide for Uncertainty Analysis in Dose and Risk Assessments Related to Environmental Contamination (1996)
- 13 An Introduction to Efficacy in Diagnostic Radiology and Nuclear Medicine (Justification of Medical Radiation Exposure) (1995)
- 12 Radiation Exposure and High-Altitude Flight (1995)

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11	Dose Limits for Individuals Who Receive Exposure from Radionuclide Therapy Patients (1995)
10	Advising the Public about Radiation Emergencies: A Document for Public Comment (1994)
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8	Uncertainty in NCRP Screening Models Relating to Atmospheric Transport, Deposition and Uptake by Humans (1993)
7	Misadministration of Radioactive Material in Medicine—Scientific Background (1991)
6	Radon Exposure of the U.S. Population—Status of the Problem (1991)
5	Review of the Publication, “Living Without Landfills” (1989)
4	Guidelines for the Release of Waste Water from Nuclear Facilities with Special Reference to the Public Health Significance of the Proposed Release of Treated Waste Waters at Three Mile Island (1987)
3	Screening Techniques for Determining Compliance with Environmental Standards—Releases of Radionuclides to the Atmosphere (1986)
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2	Radioactive and Mixed Waste—Risk as a Basis for Waste Classification, Proceedings of a Symposium held November 9, 1994 (1995)
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Appendix C: Active Committees

PAC 1

Scientific Committee 1-8
 Scientific Committee 1-13
 Scientific Committee 1-15
 Scientific Committee 1-17
 Scientific Committee 85

Basic Criteria, Epidemiology, Radiobiology, and Risk

Risk to the Thyroid from Ionizing Radiation
 Impact of Individual Susceptibility and Previous Radiation Exposure on Radiation Risk for Astronauts
 Radiation Protection and Science Goals for Short-Term Lunar Missions
 Second Cancers and Cardiopulmonary Effects After Radiotherapy
 Risk of Lung Cancer from Radon

PAC 2

Scientific Committee 2-2
 Scientific Committee 2-3
 Scientific Committee 2-4

Operational Radiational Safety

Key Decision Points and Information Needed by Decision Makers in the Aftermath of a Nuclear or Radiological Terrorism Incident
 Radiation Safety Issues for Image-Guided Interventional Medical Procedures
 Self-Assessment of Radiation Safety Programs

PAC 3

Nuclear and Radiological Security and Safety

PAC 4

Scientific Committee 4-1
 Scientific Committee 4-2

Radiation Protection in Medicine

Management of Persons Contaminated with Radionuclides
 Population Monitoring and Decontamination Following a Nuclear or Radiological Incident

PAC 5

Scientific Committee 64-22

Environmental Radiation and Radioactive Waste Issues

Design of Effective Effluent and Environmental Monitoring Programs

PAC 6

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Radiation Measurements and Dosimetry

Radiation Exposure of the U.S. Population
Uncertainties in Internal Radiation Dosimetry
Fundamental Principles of Dose Reconstruction
Skin Doses from Dermal Contamination
Evaluation of Inhalation Doses in Scenarios Involving
Resuspension by Nuclear Detonations at the Nevada Test Site

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