

# Appendices

## Appendix A

# Nuclear Waste Technical Review Board

## Members: Curricula Vitae

### **Jared L. Cohon, Ph.D.; Chairman**

On June 29, 1995, President Bill Clinton appointed Jared Cohon to the Nuclear Waste Technical Review Board. President Clinton appointed Dr. Cohon chairman on January 17, 1997.

Dr. Cohon is president of Carnegie Mellon University in Pittsburgh, Pennsylvania. He has more than 25 years of teaching and research experience, has written one book, and is author, coauthor, or editor of more than 80 professional publications. Among other awards, Dr. Cohon received the 1996 Joan Hodges Queneau Medal for outstanding engineering achievement in environmental conservation, awarded jointly by the American Association of Engineering Societies and the National Audubon Society. He is a member of Tau Beta Pi, the National Engineering Honor Society, and of Sigma Xi, the Scientific Research Society. Dr. Cohon is a registered Professional Engineer.

Dr. Cohon brings to the Board special expertise as a national authority on environmental and water resource systems analysis. His research interests focus on multiobjective programming, a technique for decision-making in situations with multiple conflicting objectives. He also has focused on water resources planning and management in the United States, South America, and Asia and on energy facility siting, including nuclear waste shipping and storage. In addition to his academic experience, he served as legislative assistant for energy and environment to the Honorable Daniel P. Moynihan, United States Senator from New York, from 1977 to 1978.

Dr. Cohon is a member of the American Geophysical Union, the Institute for Operations Research and Management Science, the American Water Resources Association, and the American Society of Civil Engineers. He has served on several committees for the National Research Council, chairing the studies on the probabilities of extreme floods and on measuring and improving infrastructure.

In 1969, Dr. Cohon earned a bachelor of science degree in civil engineering from the University of Pennsylvania. He worked as a construction inspector in Philadelphia and as an engineering assistant for the Philadelphia Water Department before attending the Massachusetts Institute of Technology, where he earned a master's degree in civil engineering in 1972 and a Ph.D. in civil engineering in 1973. Dr. Cohon began his teaching career in 1973 at Johns Hopkins University, where he served as assistant, associate, and full professor in the Department of Geography and Environmental Engineering and as Assistant and Associate Dean of Engineering and Vice Provost for Research. In 1992, he became dean of the School of Forestry and Environmental Studies and professor of environmental systems analysis at Yale University. Dr. Cohon assumed his duties as president of Carnegie Mellon University in July 1997.

Dr. Cohon resides in Pittsburgh, Pennsylvania.

## **John W. Arendt, P.E.**

On June 29, 1995, President Bill Clinton appointed John Arendt to the Nuclear Waste Technical Review Board.

John W. Arendt is senior consultant and founder of John W. Arendt Associates, Inc. Created in 1986, the firm offers consultation on program and project management, safety assessments and investigations, quality assurance, standards and regulations for uranium handling and processing, chemical safety audits, and safeguards and accountability. Mr. Arendt is a registered Professional Engineer and a certified nuclear materials manager.

Mr. Arendt brings to the Board five decades of experience in various phases of the nuclear fuel cycle, especially uranium processing, handling, safeguards and accountability, packaging, and transportation. He has extensive experience in the management of engineering projects, including uranium processing facilities and their quality assurance, quality control, and inspection. He is chairman of American National Standards Institute (ANSI) Accredited Standards Committee N14 on packaging and transportation of radioactive materials and nonnuclear hazardous wastes.

Mr. Arendt earned a bachelor of science degree in chemical engineering from Marquette University in 1943 and was a research engineer for the Manhattan Project at the University of Chicago from 1943 to 1945. He gained the bulk of his experience with Union Carbide Corporation's Nuclear Division in Oak Ridge, Tennessee, where he began as a production supervisor in 1945 and served in various department and project management positions through 1984. Before founding John W. Arendt Associates, Inc., in 1986, Mr. Arendt was a senior engineer with JBF Associates, Inc., where he provided technical and management assistance in uranium enrichment, standards and regulations, waste management, packaging and shipping, reactor activities, quality assurance, and safety.

Mr. Arendt resides in Oak Ridge, Tennessee.

## **Daniel B. Bullen, Ph.D.**

On January 17, 1997, President Bill Clinton appointed Daniel Bullen to the Nuclear Waste Technical Review Board.

Dr. Daniel B. Bullen is director of the Nuclear Reactor Laboratory and associate professor of mechanical engineering, Department of Mechanical Engineering, at Iowa State University in Ames, Iowa. He has been teaching since 1989, served as Nuclear Engineering Program Coordinator at Iowa State University from 1993 to 1996, and has 11 years of industry experience in nuclear engineering and materials science. He has edited and reviewed articles for such professional publications as Nuclear Technology, Journal of the American Ceramic Society, American Nuclear Society Transactions, and Encyclopedia of Chemical Technology. He has written or co-written more than 50 technical publications and reports and has contributed to three books. He is a registered Professional Engineer in mechanical, metallurgical, and nuclear engineering. Dr. Bullen's honors and awards include Tau Beta Pi (National Engineering Honor Society), Phi Kappa Phi, Sigma Xi (The Scientific Research Society), Alpha Nu Sigma (Nuclear Engineering Scholastic Honor Society), a Lilly Teaching Fellowship to the Georgia Institute of Technology (1991), and two Outstanding Professor awards. He has appeared in *Who's Who in California*, *Who's Who in Technology*, and *Who's Who in Science & Engineering*.

Dr. Bullen brings to the Board special expertise in performance assessment modeling of radioactive waste disposal facilities, performance assessment of engineered barrier systems, radiolysis effects in spent-fuel dry casks in storage environments, radiation effects on materials, and materials degradation in severe service environments.

Dr. Bullen is a member of the American Nuclear Society; the American Ceramic Society; ASM International; the Materials Research Society; the American Society of Mechanical Engineers; the National Society of Professional Engineers; the Minerals, Metals & Materials Society; and the American Society for Engineering Education.

In 1978, Dr. Bullen earned a bachelor of science degree in engineering science from Iowa State University. He was a research assistant at the University of Wisconsin-Madison while earning master of science degrees in nuclear engineering in 1979 and materials science in 1981 and a Ph.D. in nuclear engineering in 1984. He then worked for Lawrence Livermore National Laboratory as an engineer until 1986, when he became senior engineer for Science & Engineering Associates, Inc., in Pleasanton, California. In 1988, he became president of DG Engineering Associates, providing technical consulting services to Lawrence Livermore National Laboratory. Dr. Bullen moved to North Carolina State University in 1989 as an assistant professor of nuclear engineering and to the Georgia Institute of Technology in 1990 as an assistant professor of mechanical engineering. He moved to Iowa State University in 1992 as an associate professor of nuclear engineering and assumed his current duties in 1993.

Dr. Bullen resides in Ames, Iowa.

## **Norman L. Christensen, Jr., Ph.D.**

On January 17, 1997, President Bill Clinton appointed Norman Christensen to the Nuclear Waste Technical Review Board.

Dr. Norman L. Christensen, Jr., is professor of ecology and dean of the Nicholas School of the Environment at Duke University in Durham, North Carolina. He has been teaching for more than 27 years and has more than 80 scientific articles and books to his credit. Dr. Christensen is the recipient of the 1977 Duke Endowment Award for Teaching Excellence, the 1991 Distinguished Teaching Award for Trinity College of Arts and Sciences at Duke, and the 1994 Distinguished Scholar-Alumni Award from California State University-Fresno. He was the E.V. Komarek Lecturer at the 1989 Tall Timbers Fire Ecology Conference, a Fellow of the American Association for the Advancement of Science in 1993, and a recipient of the National Park Service's A. Starker Leopold Award for distinguished service. Dr. Christensen has served on more than 25 national and regional panels and commissions and on the editorial boards of *American Midland Naturalist*, *Journal of Vegetation Science*, and *Journal of Wildland Fire*.

Dr. Christensen brings to the Board special expertise in biology and ecology. His research interests include the effects of disturbance on structure and function of populations and communities; comparative biogeochemical and community responses to varying fire regimes; use of remote sensing systems (such as synthetic aperture radar) to evaluate long-term changes in forest ecosystems; and pattern analysis of forest development following cropland abandonment as affected by environment, stand history, and plant demographic patterns. He has written widely on the importance of natural disturbance in the management of forests, shrublands, and wetlands, and he is interested in applying basic ecological theory and models to ecosystem management.

Dr. Christensen is a member of the American Association for the Advancement of Science, the British Ecological Society, the Ecological Society of America, Sigma Xi, the Society of American Foresters, and the National Association of Environmental Professionals.

In 1968, Dr. Christensen earned a bachelor's degree in biology from Fresno State College. He earned a master's degree in biology from Fresno State College in 1970 and a Ph.D. in biology from the University of California-Santa Barbara in 1973. He began his teaching career as an assistant professor in the Department of Botany at Duke University in 1973. He became an associate professor in 1979 and was elevated to full professor in 1987. He became dean of the Nicholas School of the Environment in 1991.

Dr. Christensen resides in Chapel Hill, North Carolina

## **Paul P. Craig, Ph.D.**

On January 30, 1997, President Bill Clinton appointed Paul Craig to the Nuclear Waste Technical Review Board.

Dr. Paul P. Craig is Professor of Engineering Emeritus at the University of California, Davis, and is a member of the university's Graduate Group in Ecology. He has more than 21 years of teaching experience and more than 100 refereed publications to his credit. Dr. Craig is a member of the Sierra Club's Global Warming and Energy committees and of the American Association for the Advancement of Science and is a Fellow of the American Physical Society. His awards include a John Simon Guggenheim Memorial Foundation Fellowship and a National Science Foundation Meritorious Service Award. He is a member of Phi Beta Kappa.

Dr. Craig brings to the Board special expertise and research interest in energy policy issues associated with energy system responses to global environmental change.

In 1954, Dr. Craig earned a bachelor's degree in mathematics and physics from Haverford College. He earned a Ph.D. in physics from the California Institute of Technology in 1959. He began his career as a staff scientist at Los Alamos National Laboratory in 1959 and moved to Brookhaven National Laboratory in 1962 as a physicist and a group leader. In 1971, he became deputy and acting director of the Office of Energy Research and Development Policy of the National Science Foundation, where he provided policy analysis support to the President's science advisor and to the Office of Management and Budget. Dr. Craig became director of the University of California Council on Energy and Resources in 1975 and professor of engineering at the University of California, Davis, in 1977. He received his emeritus standing in 1994.

Until his appointment to the Nuclear Waste Technical Review Board, Dr. Craig was a Lawrence Berkeley National Laboratory Participating Guest Scientist (beginning in 1976) and a member of the National Academy of Sciences–National Research Council Board on Radioactive Waste Management.

Dr. Craig resides in Martinez, California.

## **Debra S. Knopman, Ph.D.**

On January 17, 1997, President Bill Clinton appointed Debra Knopman to the Nuclear Waste Technical Review Board.

Dr. Debra S. Knopman is the director of the Center for Innovation and the Environment of the Progressive Policy Institute in Washington, D.C. She has more than 24 publications in scientific and technical journals to her credit. Dr. Knopman is a member of the National Research Council's Commission on Geosciences, Environment, and Resources, and she served briefly on the Board on Radioactive Waste Management and the Panel for the Review of the DOE Environmental Restoration Priority System before accepting a position in the Clinton administration in 1993. She is a member of the American Geophysical Union. Dr. Knopman was a 1978-1979 Henry Luce Foundation Scholar.

Dr. Knopman brings to the Board special expertise in hydrology, environmental and natural resources policy, systems analysis, and public administration.

In 1975, Dr. Knopman earned a bachelor's degree in chemistry from Wellesley College. She completed a master of science degree in civil engineering from the Massachusetts Institute of Technology in 1978 and earned a Ph.D. from the Department of Geography and Environmental Engineering at Johns Hopkins University in 1986. Dr. Knopman began her career as a freelance science writer and editor in Israel and the United States in 1975. Following her Luce Scholar fellowship, which she served in Taiwan from 1978 to 1979, she served as legislative assistant for energy and environmental issues to Senator Daniel P. Moynihan in Washington, D.C., from 1979 to 1980. She served as a professional staff member of the U.S. Senate Committee on Environment and Public Works from 1980 to 1983. She moved to the U.S. Geological Survey in 1984, beginning as a student assistant and progressing through being a research hydrologist to becoming chief of the systems analysis branch. In 1993, Dr. Knopman was appointed Deputy Assistant Secretary for Water and Science, Department of the Interior. She became director of the Center for Innovation and the Environment in 1995.

Dr. Knopman resides in Washington, D.C.

## **Priscilla P. Nelson, Ph.D.**

On January 17, 1997, President Bill Clinton appointed Priscilla Nelson to the Nuclear Waste Technical Review Board.

Dr. Priscilla P. Nelson is program director and senior engineering coordinator for the Directorate for Engineering at the National Science Foundation. She formerly was professor of civil engineering at The University of Texas at Austin. Dr. Nelson has more than 13 years of teaching experience and more than 100 technical and scientific publications to her credit. She has served as a member of the U.S. National Committee for Rock Mechanics, the U.S. National Committee for Tunneling Technology, and the Board on Radioactive Waste Management, all activities of the National Research Council. She is a member of the American Rock Mechanics Association, the American Society of Civil Engineers (ASCE), the International Tunnelling Association, the American Underground Construction Association, the Association of Engineering Geologists, the British Tunneling Society, and other professional organizations. She serves as vice president and president-elect of the Geo-Institute of ASCE. Her honors and awards include the Lattimore Prize for Field Study from the University of Rochester (1969), an Exxon Teaching Fellowship at The University of Texas at Austin (1985-1987), the Case Studies Award from the U.S. National Committee for Rock Mechanics (1988), the Haliburton Education Foundation Award of Excellence (1991), the Basic Research Award from the U.S. National Committee for Rock Mechanics (1993), and election to The Moles, an association for the heavy construction industry (1995). At the National Science Foundation, she twice has received the Director's Award for Integrative Collaboration, and she received the Director's Award for Meritorious Service in 1997.

Dr. Nelson brings to the Board special expertise in rock engineering and underground construction. Her current research interests are development of a probabilistic risk analysis approach to prediction of underground construction project performance.

In 1970, Dr. Nelson earned a bachelor's degree in geological sciences from the University of Rochester. She earned master's degrees in geology from Indiana University in 1976 and in structural engineering from the University of Oklahoma in 1979. She was awarded a Ph.D. in geotechnical engineering by Cornell University in 1983. Dr. Nelson's career has included service as a Peace Corps volunteer and employment as a field engineer for the Alaskan Resource Sciences Corporation from 1975 to 1977. She joined the faculty of The University of Texas at Austin in 1983 and became full professor and holder of the John Focht Teaching Fellowship before joining the National Science Foundation in 1996.

Dr. Nelson resides in Arlington, Virginia.



## **Richard R. Parizek, Ph.D.**

On February 11, 1997, President Bill Clinton appointed Richard Parizek to the Nuclear Waste Technical Review Board.

Dr. Richard R. Parizek is a professor of geology and geoenvironmental engineering at The Pennsylvania State University; president of Richard R. Parizek and Associates, consulting hydrogeologists and environmental geologists; and a registered Professional Geologist. He has more than 37 years of teaching experience and numerous journal publications to his credit. His awards include a cooperative fellowship from the National Science Foundation (1960), a superior achievement award from the U.S. Environmental Protection Agency (1976), the Clearwater Conservancy Award (1985), the Matthew J. and Anne C. Wilson Teaching Award (1986), and the medal for distinguished service to environmental science and engineering of the Institute of Meteorology and Water Management, Warsaw, Poland (1991). Dr. Parizek was appointed an administrative law judge of the Atomic Safety and Licensing Board Panel of the U.S. Nuclear Regulatory Commission in 1990, a position he left upon appointment to the Nuclear Waste Technical Review Board.

Dr. Parizek brings to the Board special expertise in hydrogeology and environmental geology. His research interests include the hydrogeology of karst, fractured rock, and glaciated terranes; factors controlling groundwater occurrence and movement; and the relationship between land use and groundwater pollution resulting from disposal of nuclear waste and other hazardous substances.

Dr. Parizek is a member of the American Association for the Advancement of Science, the American Geophysical Union, the American Institute of Hydrology, the Geological Society of America, and Sigma Xi.

In 1956, Dr. Parizek earned a bachelor's degree in geology from the University of Connecticut. He earned a master of science degree in geology in 1960 and a Ph.D. in geology in 1961, both from the University of Illinois. Dr. Parizek began his career as research assistant with the Illinois State Geological Survey in 1956 and began teaching in 1961 as assistant professor of geology and geophysics at The Pennsylvania State University. He became a full professor in 1971 and continues to teach in the Department of Geosciences. Dr. Parizek also has been a visiting scientist with the U.S. Geological Survey and a visiting scholar at Stanford University, the Desert Research Institute, Changchun College of Geology and the Institute of Karst Geology in the Peoples' Republic of China, and National Cheng Kuug University in Taiwan.

Dr. Parizek resides in State College, Pennsylvania.

## **Donald D. Runnells, Ph.D.**

On June 23, 1998, President Bill Clinton appointed Donald Runnells to the Nuclear Waste Technical Review Board.

Dr. Donald D. Runnells is professor emeritus in the Department of Geological Sciences at the University of Colorado. He also is vice president of Shepherd Miller, Inc., a firm providing environmental and engineering consultation primarily to the mining industry and to government agencies and other concerns. He has more than 27 years of teaching experience and numerous journal publications to his credit. Dr. Runnells is a Fellow of the Geological Society of America. His awards include selection as a National Science Foundation Graduate Fellow, election to Phi Kappa Phi Honorary Scholastic Fraternity, and selection as a Fellow of the Cooperative Institute for Research in the Environmental Sciences at the University of Colorado. Dr. Runnells has been an editor or on the editorial board for *Journal of Geochemical Exploration*, *Interface*, *Science of the Total Environment*, *Chemical Geology*, and *Journal of Applied Geochemistry*. He has been a member of the Colorado Governor's Council on Science and Technology, the Review Board on Disposal and Permanent Storage of Inactive Uranium Tailings at Sandia National Laboratory, the Materials Review Board at Argonne National Laboratory, the Scientific Advisory Board on Toxics in Water for the Electric Power Research Institute, and several boards and panels of the National Research Council of the National Academy of Sciences.

Dr. Runnells brings to the Board special expertise in geochemistry, hydrochemistry, and mineral deposits.

He is a member of the Geochemical Society, the Society of Economic Paleontologists and Mineralogists, the Association of Exploration Geochemists, the Association of Ground Water Scientists and Engineers, and the American Chemical Society.

In 1958, Dr. Runnells earned a bachelor's degree in geology from the University of Utah. He earned a master of arts degree in geology in 1960 and a Ph.D. in geochemistry and geology in 1964, both from Harvard University. Dr. Runnells began his career as a teaching assistant at Harvard University in 1961. In 1963, he began working with Shell Development Company as a geochemist. He returned to teaching in 1967 as an assistant professor at the University of California. He moved to the University of Colorado in 1969. He was appointed full professor and chairman of the Department of Geological Sciences in 1975 and continued until 1993, when he became vice president of Shepherd Miller, Inc.

Dr. Runnells resides in Fort Collins, Colorado.

## **Alberto A. Sagüés, Ph.D.**

On January 17, 1997, President Bill Clinton appointed Alberto Sagüés to the Nuclear Waste Technical Review Board.

Dr. Alberto A. Sagüés is professor of materials engineering in the Department of Civil and Environmental Engineering at the University of South Florida and is a registered Professional Engineer. He has 20 years of teaching experience and 120 technical publications to his credit. From 1988 to 1992, Dr. Sagüés served as an expert task group member of the Strategic Highway Research Program of the National Research Council. He has made technical presentations to professional and scientific audiences across the United States and Canada and throughout Europe and Central and South America. He holds three patents related to corrosion control.

Dr. Sagüés brings to the Board special expertise in corrosion and materials engineering, physical metallurgy, and scientific instrumentation. His research interests are in corrosion of reinforcing steel in concrete and durability forecasting of civil infrastructure.

Dr. Sagüés is a member of NACE International (formerly the National Association of Corrosion Engineers), the Electrochemical Society, the American Society for Testing and Materials, the American Concrete Institute, and ASM International (formerly the American Society for Metals).

A native of Argentina, Dr. Sagüés earned his undergraduate degree in physics from the National University in Rosario, Argentina, in 1968. He earned a Ph.D. in metallurgy from Case Western Reserve University in Cleveland in 1972. A citizen of the United States since 1979, Dr. Sagüés began his career as a visiting assistant professor at Columbia University in 1972, performed postdoctoral research in 1973, and was a guest scientist at the Solid State Research Institute of the Jülich Nuclear Research Center in West Germany from 1974 to 1976. He served as a research associate at Argonne National Laboratory from 1976 to 1978 and as senior metallurgist, manager, and associate laboratory director of the Kentucky Center for Energy Research Laboratory from 1978 to 1985. At the same time, he continued his teaching career at the University of Kentucky. In 1985, he moved to the University of South Florida as an associate professor. Dr. Sagüés became professor of materials engineering, Department of Civil and Environmental Engineering in 1991.

Dr. Sagüés resides in Lutz, Florida.

## Jeffrey J. Wong, Ph.D.

On June 29, 1995, President Bill Clinton appointed Jeffrey Wong to the Nuclear Waste Technical Review Board.

Dr. Jeffrey Wong is chief of the Human and Ecological Risk Division of the Department of Toxic Substances Control, California Environmental Protection Agency. Dr. Wong has more than 14 years of experience in toxicology, including assessment of exposure risks at hazardous waste sites, at hazardous waste treatment, storage, and disposal facilities, and at hazardous material spills and accidents. He is an instructor in environmental toxicology at the University of California, Davis, and he has worked with the California Department of Justice in forensic toxicology. Dr. Wong was a National Institutes of Environmental Health Sciences Predoctoral Fellow in environmental toxicology and was the recipient of the American Academy of Forensic Sciences Regional Award in Toxicology in 1984.

Dr. Wong brings to the Board extensive experience in risk assessment and scientific team management. He served as the risk evaluation expert on the external expert review panel to the Consortium for Environmental Risk Evaluation, a program of Tulane and Xavier universities. Dr. Wong also has served on National Academy of Sciences/National Research Council committees relating to remedial action for hazardous waste sites and the U.S. Department of Energy's environmental restoration program. He is a member of the editorial board of *Journal of Contaminated Soils* and is an advisory board member for the Association for the Environmental Health of Soils.

Dr. Wong earned a bachelor of arts degree in bacteriology in 1973, a master of science degree in food science and technology in 1976, and a Ph.D. in pharmacology and toxicology in 1981, all from the University of California, Davis. He worked for the California Department of Justice as a senior forensic toxicologist after his doctoral work. He moved to the California Department of Food and Agriculture as a staff toxicologist before beginning his career with the California Environmental Protection Agency in July 1985.

Dr. Wong resides in Sacramento, California.

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## Appendix B

# Meeting List for 1998

**January 20 and 22****Board Business Meeting**

*Amargosa Valley and Las Vegas, Nevada*

Minutes available

**January 20-21****Full Board Meeting**

*Amargosa Valley, Nevada*

Topics

- Yucca Mountain program updates
- Government Performance and Results Act
- Public comments
- Saturated zone hydrology and expert elicitation
- Thermal testing at Yucca Mountain site

Transcripts available

**March 11-12****Board Business Meeting**

*Santa Fe, New Mexico*

Annotated notes available

**April 23-24****Meeting of Panel on Performance Assessment**

*Albuquerque, New Mexico*

Topics

- TSPA-VA base case and selected sensitivity tests

Transcripts available

**May 18-19****Workshop on Waste Package**

*Falls Church, Virginia*

Topics

- Alternative designs and materials research needs

Transcripts available

**June 22 and 25****Board Business Meeting**

*Las Vegas, Nevada*

Minutes available

**June 23****Board tour of Yucca Mountain facility**

*Las Vegas, Nevada*

**June 24****Full Board Meeting**

*Las Vegas, Nevada*

Topics

- Waste package and repository design alternatives
- Environmental impact statement update
- Nye County drilling program
- Public comments

Transcripts available

**September 15-18****Board Business Meeting**

*Pittsburgh, Pennsylvania*

Annotated notes available

## Appendix C

# Panel Organization

### 1. Panel on Site Characterization

Chairman: Dr. Debra S. Knopman  
 Members: Dr. Priscilla P. Nelson  
 Dr. Richard R. Parizek  
 Dr. Alberto A. Sagüés

Staff: Leon Reiter\*  
 Russell K. McFarland  
 Victor V. Palciauskas

### 2. Panel on the Repository

Chairman: Dr. Priscilla P. Nelson  
 Members: Mr. John W. Arendt  
 Dr. Daniel B. Bullen  
 Dr. Alberto A. Sagüés

Staff: Russell K. McFarland\*  
 Carlos A. W. Di Bella  
 Victor V. Palciauskas

### 3. Panel on the Waste Management System

Chairman: Mr. John W. Arendt  
 Members: Dr. Daniel B. Bullen  
 Dr. Norman L. Christensen, Jr.  
 Dr. Paul P. Craig  
 Dr. Debra S. Knopman

Staff: Michael G. Carroll\*  
 Carlos A. W. Di Bella  
 Daniel S. Metlay

### 4. Panel on the Environment, Regulations, and Quality Assurance

Chairman: Dr. Jeffrey J. Wong  
 Members: Mr. John W. Arendt  
 Dr. Norman L. Christensen, Jr.  
 Dr. Paul P. Craig  
 Dr. Debra S. Knopman

Staff: Daniel J. Fehring\*  
 Daniel S. Metlay

### 5. Panel on Performance Assessment

Chairman: Dr. Daniel B. Bullen  
 Members: Dr. Paul P. Craig  
 Dr. Richard R. Parizek  
 Dr. Alberto A. Sagüés  
 Dr. Jeffrey J. Wong

Staff: Carlos A. W. Di Bella\*  
 Daniel S. Metlay  
 Victor V. Palciauskas  
 Leon Reiter

\*Staff coordinator

## Appendix D

# U.S. Nuclear Waste Technical Review Board Strategic Plan for FY 1998-2003 (Updated) December 1, 1998

### Statement of the Chairman

The U.S. Nuclear Waste Technical Review Board was established as an independent agency of the United States Government on December 22, 1987, in the Nuclear Waste Policy Amendments Act. Congress charged the Board with evaluating the technical and scientific validity of activities undertaken by the Secretary of Energy related to civilian radioactive waste management, including characterizing a site at Yucca Mountain, Nevada, for its suitability as the location of a permanent repository for civilian spent nuclear fuel and high-level radioactive waste and packaging and transporting such waste.

In creating the Board, Congress recognized that an unbiased technical and scientific evaluation of the credibility of site-evaluation and other waste-management activities would be crucial to public acceptance of any approach for disposing of high-level radioactive waste. The Board takes very seriously its role as the main source of ongoing technical and scientific review of the Department of En-

ergy's civilian radioactive waste management program. The Board strives to provide Congress and the Secretary of Energy with timely, independent, and credible technical and scientific program evaluations and recommendations achieved through peer review of the highest quality. The Board's technical and scientific findings and recommendations are included in reports that are submitted at least twice each year to the Secretary of Energy and the Congress. The Board can make recommendations but cannot compel the Department of Energy to comply.

The attached strategic plan includes the Board's goals and objectives for 1998 through 2003. These years will be critical to the success of waste management initiatives in the United States. Because many critical activities will be undertaken throughout this period, we believe that the Board's ongoing review of these efforts will be especially important.

On behalf of the Board,  
Jared L. Cohon, Chairman

## Mission

The Board's mission, established in the Nuclear Waste Policy Amendments Act of 1987 (Public Law 100-203), is to "evaluate the technical and scientific validity of activities undertaken by the Secretary of Energy, including site-characterization activities; and activities related to the packaging or transportation of high-level radioactive waste and spent nuclear fuel."

## Vision

To make a unique and essential contribution to the success of the nation's efforts in the safe disposal of spent nuclear fuel and high-level radioactive waste by providing ongoing technical and scientific peer review of the highest quality.

## Values

To achieve its goals, the Board conducts itself according to the following values:

- The Board's practices and procedures are open and conducted so that its integrity and objectivity are above reproach.
- The Board's findings and recommendations are technically and scientifically sound and based on the best available technical analysis and information.
- The Board communicates its findings and recommendations clearly and in a timely manner that is most beneficial to Congress, the Department of Energy (DOE), and the public.

## General Goals and Objectives

The overarching goal for national radioactive waste management established by Congress is to ensure that civilian spent nuclear fuel and high-level radioactive waste are safely packaged, transported, and disposed of in a permanent repository at a suitable site. The Administration, state and local governments, and the public all have important parts to

play in achieving a safe waste-management program. Federal agencies with important, often cross-cutting, roles include the DOE, the Nuclear Regulatory Commission (NRC), the Environmental Protection Agency (EPA), the Department of Transportation (DOT), the United States Geological Survey (USGS), and the Board. (See discussion under "Key External Factors.")

## NWTRB General Goals

As a key contributor to this national waste-management effort, the Board has established two general goals:

- Help ensure that site-characterization activities undertaken at Yucca Mountain, Nevada, establish a sound technical basis for an eventual decision concerning the suitability and licensability of a permanent repository for the disposal of commercial spent fuel and high-level radioactive waste.
- Convey effectively and in a timely manner technical and scientific findings and recommendations that can be used in decision-making related to the management of spent fuel and high-level radioactive waste.

## Objectives

To achieve its general goals, the Board has established the following long-term objectives.

### *Site Characterization*

- Determine the relative importance of the hydrology, radionuclide transport, and other natural processes that establish the foundation for assessing repository performance. Board members will focus their evaluation on the methodologies used (e.g., selection of data, elicitation of expert judgment, and treatment of uncertainties) and on integration of basic science and engineering in the total system performance assessment (TSPA).
- Determine the appropriate program emphasis on repository design activities, plans for repository construction and operation, engineered-barrier design activities, supporting testing activities, and



the source-term and other process models that support an assessment of repository performance.

- Identify key environmental monitoring activities at Yucca Mountain required for preparing an environmental impact statement for the site, evaluate regulations applicable to the program and potential effects of regulatory changes on the program, and monitor the adequacy of the program's quality assurance programs.
- Encourage the DOE to address concerns of the public related to the scientific and technical validity of site-characterization activities.

### *Transportation and Packaging*

- Ensure the accuracy of analyses, methods, and major assumptions used by the DOE and other federal agencies in estimating health and safety risks associated with transporting spent fuel. Assess the reasonableness of the approaches and the assumptions embodied in the analyses.
- Determine the adequacy of plans and requirements for the transportation infrastructure to move significant amounts of spent fuel from individual reactor sites to a DOE storage or disposal site. Compare these requirements with current transportation capabilities, and determine the overall effort needed to bring about a large-scale transportation capability.
- Ensure that the DOE adequately addresses public safety concerns and plans for enhancing safety capabilities along the transportation corridors. This includes activities related to planning and coordination (e.g., route selection), accident prevention (e.g., improved inspections and enforcement), and emergency response.

## **Achieving the Goals and Objectives**

The Board was granted significant investigatory powers by Congress in the Nuclear Waste Policy Amendments Act of 1987. In accordance with the Act, the Board may hold such hearings, sit and act at such times and places, take such testimony, and receive such evidence as it considers appropriate. Sub-

ject to existing law, the DOE is directed to provide all records, files, papers, data, and information requested by the Board, including drafts of work products and documentation of work in progress. According to the legislative history, by providing this access, Congress expected that the Board would review and comment on DOE decisions, plans, and actions as they occurred, not after the fact. The Board believes that it has adequate powers under current law to achieve its goals and objectives.

The Board uses the powers granted to it by the Congress to review the scientific and technical adequacy of the DOE's work. Much of the Board's information gathering is done at meetings, open to the public, where the DOE, its contractors, and other parties make formal presentations of technical information. To help achieve its goals and objectives, the Board has organized itself into five panels to address a variety of critical issues. The full Board meets three or four times each year, and each panel typically meets at least once a year. The Board also gathers information through field trips to the Yucca Mountain site, visits to contractor laboratories and facilities, and informal meetings with individuals working on the project. Although the Board's information-gathering activities are carried out primarily for the Board's benefit, they have the collateral benefit of promoting communication and integration of technical information within the DOE's program and communication with interested parties outside the program.

Analyses of the information gathered by the Board are carried out by its members, the Board's professional staff, and consultants hired to supplement the expertise of the Board and the staff. The Board evaluates whether the DOE's work is of high quality and whether it is focused correctly to achieve higher-level program objectives. The Board also evaluates the processes used by the DOE to reach decisions, especially for assigning priorities to activities and evaluating the results of studies. In the years ahead, assessing the viability of the Yucca Mountain site and then determining whether the site is suitable for development as a repository are major decisions facing the program. The Board expects to review the decision processes, as well as the database of technical information used by the DOE in making these decisions.

The Board formally reports the results of its reviews at least twice each year to Congress and the Secretary of Energy. Additional informal communication occurs as needed. All such communications are available to the public either by request or on the Board's Web site at [www.nwtrb.gov](http://www.nwtrb.gov).

The Board has evaluated its data processing needs and has recently updated its computer hardware and software to achieve its goals and objectives. The Board's data system currently includes no mission-critical or legacy software that will be affected by the Year 2000 changeover. The Board also plans to ensure that all workstations and the network operating system are Year 2000 compliant and will upgrade hardware and software as needed.

## Cross-Cutting Functions

As noted under "Goals and Objectives," a number of entities and agencies share responsibility for the ultimate national goal established by Congress of ensuring that civilian spent fuel and high-level radioactive waste are safely packaged, transported, and disposed of in a permanent repository at a suitable site. Although there may be cross-cutting areas of interest, the Board's role is different from those of others involved in managing high-level radioactive waste. For example:

- **Congress and the Administration, including the Secretary of Energy**, make policy decisions about what the national goals will be and how they will be implemented. *The Board's only role in this process is to provide policy makers with unbiased and credible technical and scientific analyses and information.*
- **State and local governments** comment on and oversee DOE activities. *The Board's oversight activities are different in that they are (1) unconstrained by any stake in the outcome of the endeavor besides the credibility of the scientific and technical activities, confined to scientific and technical evaluations, and (3) conducted by individuals nominated by the National Academy of Sciences and expressly chosen by the President for their expertise in the various disciplines represented in the DOE program.*

- **Other federal agencies** that have roles in achieving a safe waste management program include the DOE, the NRC, the EPA, the DOT, and the USGS. The DOE and its contractors are responsible for developing and implementing the waste management system and planning and conducting research activities related to disposal, packaging, and transportation of spent fuel and high-level radioactive waste. The NRC is the regulatory body authorized to license the construction and operation of the repository to ensure protection of public health and safety and the environment. The EPA is the agency given the responsibility to issue health-based safety standards. The DOT will be involved extensively in planning and regulating the transportation of waste, either to a repository or to a storage facility. The USGS participates in site-characterization activities at the Yucca Mountain site. *The Board's role is unique among these entities: To provide ongoing, independent peer review and oversight of the technical and scientific validity of the Secretary of Energy's activities related to civilian radioactive waste management, including site-characterization and packaging and transportation of spent fuel and radioactive high-level waste, and to communicate its findings and recommendations to Congress and the Secretary.*

The Board's evaluation of the technical and scientific validity of the Secretary's activities related to civilian radioactive waste management complements and enhances the work of other entities involved in achieving the national goal.

## Key External Factors

Some factors beyond the Board's control could affect its ability to achieve its goals and objectives. Among them are the following:

- **The Board has no implementing authority.** Therefore, the DOE is under no obligation to accept any of the Board's recommendations. To increase its effectiveness, the Board has developed procedures for interacting with the DOE that enhance the Board's ability to conduct its independent review and communicate its findings and recommendations in a timely and effective way to Congress, the Secretary, DOE program managers,

and the public. Written DOE responses to Board recommendations are transmitted to the Board and included in Board reports to Congress and the Secretary. If the DOE does not accept a Board recommendation, the Board's recourse is to advise Congress or reiterate its recommendation to the DOE, or both.

- **Legislation could affect nuclear waste policy.** Although nuclear waste legislation was not passed by the 105th Congress, it may be taken up again in 1999. The effects of such legislation on the program or the Board's role are not currently known.

The Board will evaluate the status of these external factors, identify any new factors, and, if warranted, modify the "external factors" section of the strategic plan as part of the annual program evaluation described below.

## Program Evaluation

The Board will conduct an annual review of its actions in achieving its performance goals from the previous year. In evaluating its performance, the Board will consider (1) whether the reviews, evaluations, and other activities included in its performance goals have been completed, (2) whether the results of reviews, evaluations, and other activities undertaken under the auspices of program goals have been communicated in a timely, understandable, and appropriate way to the Secretary of Energy and Congress, and (3) whether the recommendations made by the Board had a positive effect on the program.

The Board believes that it is important to evaluate its effectiveness on the basis of programmatic results as opposed to "output" (e.g., reports, letters, recommendations). It should be noted, however, that be-

cause the Board has no implementing authority, it cannot compel the DOE to comply with its recommendations. Therefore, the judgment of whether a specific recommendation had a positive outcome may, in some cases, be somewhat subjective. To help balance the evaluation, the Board will seek comments from Congress, the Secretary of Energy, and the public on the effectiveness of its recommendations.

The Board will use its evaluation of its own performance from the current year, together with its assessment of current or potential key issues of concern related to the civilian radioactive waste management program, to establish its annual performance goals and develop its budget request for the next fiscal year. The results of the Board's performance evaluation, together with the Board's findings and recommendations related to the civilian radioactive waste management program, will be used to evaluate and, if necessary, to revise the Board's overall goals and objectives and will be included in the Board's annual summary report to Congress and the Secretary of Energy.

## Congressional and Stakeholder Consultations

In developing its strategic plan for 1998-2003, the Board consulted with the Office of Management and Budget, the DOE, congressional staff, and members of the public. The Board solicited public comment and presented its strategic plan at a session held expressly for this purpose during its meeting in Armagosa Valley, Nevada, on January 20, 1998. In addition, the Board made a copy of the plan available on its Web site. A copy of the plan also has been provided to the NRC and to representatives of state and local governments. The Board plans to continue the consultation process throughout fiscal year 1998 and, on the basis of comments received, will submit a revised strategic plan by September 30, 1998.

## Appendix E

# U.S. Nuclear Waste Technical Review Board FY 1999 Performance Plan

### **FISCAL YEAR 1999 PERFORMANCE OBJECTIVES**

As stated in the Board's 1998 - 2003 strategic plan, the overarching goal established by Congress for national radioactive waste management is to ensure that civilian spent nuclear fuel and high-level radioactive waste are safely packaged, transported to, and disposed of in a permanent repository at a suitable site. The Board's general goals are to (1) help ensure that site-characterization activities undertaken at Yucca Mountain, Nevada, provide a sound technical basis for an eventual decision concerning the suitability and licensability of a permanent repository for the disposal of commercial spent fuel and high-level radioactive waste and (2) to convey effectively and in a timely manner technical and scientific findings and recommendations that can be used to inform decision-making related to the management of spent fuel and high-level radioactive waste.

The Board developed its fiscal year 1999 performance objectives based on the general objectives in the strategic plan for site characterization and transportation and packaging. The aim is to ensure that the activities undertaken by the Board in fiscal year 1999 completely support the Board's long-term goals and objectives.

#### **Site Characterization Performance Objectives**

- Determine what the DOE's viability assessment can and cannot tell us about further activities needed to determine the suitability of the Yucca

Mountain site, and ascertain the extent to which the repository and engineered barrier designs at the time of the viability assessment are likely to support decisions about the suitability of the site.

- Determine the strengths and weaknesses of TSPA-VA, and how they could influence the conclusions to be drawn from the viability assessment.
- Identify and evaluate the technical issues required to make a technically-supportable site-suitability decision. Increase the Board's understanding of the natural processes at work at the Yucca Mountain site by recommending additional studies needed, with particular attention to estimates of infiltration rates and identification of fast pathways for water flow.
- Explore the relationship between science and engineering in the DOE program, especially the way results from site-characterization studies do or do not influence design of the engineered barrier system.
- Monitor the results of ongoing thermal tests, and evaluate DOE plans for using the test results to support models of the thermally disturbed region near a repository.
- Evaluate the DOE's use of risk assessment and quantification of uncertainty and determine whether it is being used appropriately.

- Review the technical basis for the environmental impact statement being prepared for the Yucca Mountain site, issues to be addressed, and the validity of the data used to project potential environmental effects. Advise the DOE and Congress of any weaknesses or shortcomings found.
- Monitor progress being made on the environmental radiation protection standards for a Yucca Mountain repository to be developed by the U.S. Environmental Protection Agency and the implementing regulations to be developed by the U.S. Nuclear Regulatory Commission. Advise the DOE and the Congress of the technical implications (e.g., cost, ability to demonstrate compliance of the standards and regulations).

### **Transportation and Packaging Performance Objectives**

- Evaluate the DOE's plans for enhancing safety capabilities along the transportation corridors by reviewing DOE's planning and coordination activities (e.g., route selection), accident prevention activities (e.g., improved inspections and enforcement), and emergency response activities.
- Determine how the design of the waste package (for disposal) at the time of the viability assessment is likely to influence decisions about the suitability of the site.

## **Performance Measurement**

In measuring its fiscal year 1999 performance, the Board will consider (1) whether the reviews, evaluations, and other activities included in its performance objectives have been completed, (2) whether the results of reviews, evaluations and other activities undertaken under the auspices of program goals have been communicated in a timely, understandable, and appropriate way to the Secretary of Energy and Congress, and most importantly, (3) whether the recommendations made by the Board had a positive effect on the DOE program.

While the Board believes it is important to measure its effectiveness based on programmatic results or

“outcomes” as opposed to “outputs” (e.g., reports, letters, recommendations), it is important to note that because the Board has no implementing authority, it cannot compel the DOE to comply with its recommendations. Therefore, the judgment of whether a specific recommendation had a positive outcome may, in some cases, be somewhat subjective, and makes establishing specific performance measures very difficult.

In addition, the results of many of the Board's recommendations may not be known until the licensing process begins in 2002. To supplement its own evaluation, the Board will seek comments from Congress, the Secretary of Energy, and the public on the timeliness, clarity, and effectiveness of its recommendations and reports.

The Board will use its evaluation of its own performance from the current year, together with its assessment of current or potential key issues of concern related to the civilian radioactive program, to establish its annual performance objectives and develop its budget request for the next fiscal year. The results of the Board's performance evaluation, together with the Board's findings and recommendations related to the civilian radioactive waste management program, will be used to evaluate and, if necessary, to revise the Board's overall goals and objectives and will be included in the Board's annual summary report to Congress and the Secretary.

## **Board Operations**

The Board consists of 11 presidentially-appointed members who serve on a part-time basis, are eminent in a field of science or engineering, including environmental sciences, and are appointed solely on the basis of distinguished service. Because of the comprehensive nature of the program and the part-time availability of the members, Congress authorized the Board to maintain a professional staff of 10 full-time employees. The professional staff support the Board's comprehensive review of the DOE program. In addition to the members and professional staff, the Board maintains a small administrative staff to support its activities.

The full Board meets three or four times each year, and each panel typically meets at least once per year. The Board also gathers information through field trips to the Yucca Mountain site, visits to contractor laboratories and facilities, and informal meetings with individuals working on the project. Based on the information gathered throughout the year, the Board issues its findings in letters and reports.

### **Resource Allocation for Fiscal Year 1999**

The Board's budget request for fiscal year 1999 is \$2,950,000. Of that total, \$1,925,000 will be allocated for activities related to site characterization. These activities will include the salaries and benefits of the Board's members and professional staff. They will

also include the cost of conducting meetings, field trips, and other fact-finding activities, and the production of reports related to these activities. \$545,000 will be allocated for transportation and packaging activities, which will include activities similar to those used to evaluate site-characterization efforts. The balance of \$480,000 will be allocated for the administrative support of the Board's activities in fiscal year 1999.

The Board has made great progress in reducing its administrative support costs. By implementing teaming, reengineering administrative processes, and using technology wherever possible, the Board has reduced its administrative support staff by 50% (from 10 FTE to 5 FTE) in the last two fiscal years. The Board relocated in 1997 reducing its rent by 35%. The Board will continue to strive to reduce administrative support costs and allocate as many resources as possible toward its activities related to the general goals and objectives in the strategic plan.

## Appendix G

# Nuclear Waste Technical Review Board Publications

The following publications are available by mail from the Nuclear Waste Technical Review Board or electronically from our Web site at [www.nwtrb.gov](http://www.nwtrb.gov).

***First Report to the U.S. Congress and the U.S. Secretary of Energy. March 1990.***

The first report sets the stage for the Board's evaluation of the Department of Energy's (DOE) program to manage the disposal of the nation's spent fuel and high-level waste. The report outlines briefly the legislative history of the nation's spent fuel and high-level waste management program including its legal and regulatory requirements. The Board's evolution is described, along with its protocol, panel breakdown, and reporting requirements. The report identifies major issues based on the Board's panel breakdown, and highlights five cross-cutting issues.

***Second Report to the U.S. Congress and the U.S. Secretary of Energy. November 1990.***

The Board's second report begins with the background and framework for repository development and then opens areas of inquiry, making 20 specific recommendations concerning tectonic features and processes, geoengineering considerations, the engineered barrier system, transportation and systems, environmental and public health issues, and risk and performance analysis. The report also offers concluding perspectives on DOE progress, the state of Nevada's role, the project's regulatory framework, the nuclear waste negotiator, other oversight agencies, and the Board's future plans.

***Third Report to the U.S. Congress and the U.S. Secretary of Energy. May 1991.***

The third report briefly describes recent Board activities and congressional testimony. Substantive chapters cover exploratory shaft facility alternatives, repository design, risk-benefit analysis, waste package plans and funding, spent fuel corrosion performance, transportation and systems, environmental program concerns, more on the DOE task force studies on risk and performance assessment, federal quality assurance requirements for the repository program, and the measurement, modeling, and application of radionuclide sorption data. Fifteen specific recommendations are made to the DOE. Background information on the German and Swedish nuclear waste disposal programs is included in Appendix D.

***Fourth Report to the U.S. Congress and the U.S. Secretary of Energy. December 1991.***

The fourth report provides update on the Board's activities and explores in depth the following areas: exploratory studies facility (ESF) construction; test prioritization; rock mechanics; tectonic features and processes; volcanism; hydrogeology and geochemistry in the unsaturated zone; the engineered barrier system; regulations promulgated by the Environmental Protection Agency, the Nuclear Regulatory Commission (NRC), and the DOE; the DOE

performance assessment program; and quality assurance in the Yucca Mountain project. Ten recommendations are made across these diverse subject areas. Chapter 3 offers insights from the Board's visit with officials from the Canadian nuclear power and spent fuel disposal programs. Background on the Canadian program is in Appendix D.

***Fifth Report to the U.S. Congress and the U.S. Secretary of Energy. June 1992.***

The Board's fifth report focuses on the cross-cutting issue of thermal loading. It explores thermal-loading strategies (U.S. and others) and the technical issues and uncertainties related to thermal loading. It also details the Board's position on the implications of thermal loading for the U.S. radioactive waste management system. Also included are updates on Board and panel activities during the reporting period. The report offers fifteen recommendations to the DOE on the following subjects: ESF and repository design enhancements, repository sealing, seismic vulnerabilities (vibratory ground motion and fault displacement), the DOE approach to the engineered barrier system, and transportation and systems program status.

***Sixth Report to the U.S. Congress and the U.S. Secretary of Energy. December 1992.***

The sixth report begins by summarizing recent Board activities, congressional testimony, changes in Board makeup, and the Little Skull Mountain earthquake. Chapter 2 details panel activities and offers seven technical recommendations on the dangers of a schedule-driven program; the need for top-level systems studies; the impact of defense high-level waste; the use of high capacity, self-shielded waste package designs; and the need for prioritization among the numerous studies included in the site-characterization plans. In Chapter 3, the Board offers candid insights to the high-level waste management program in five countries, specifically those areas that might be applicable to the U.S. program, including program size and cost, utility responsibilities, repository construction schedules, and alternative approaches to licensing. Appendix F provides background on the Finnish and Swiss programs.

***Special Report to Congress and the Secretary of Energy. March 1993.***

The Board's seventh report provides a nontechnical approach for those not familiar with the details of the DOE's high-level nuclear waste management program. It highlights three important policy issues: the program is driven by unrealistic deadlines, there is no integrated waste management plan, and program management needs improvement. The Board makes three specific recommendations: amend the current schedule to include realistic intermediate milestones; develop a comprehensive, well-integrated plan for the overall management of all spent nuclear fuel and high-level defense waste from generation to disposal; and implement an independent evaluation of the Office of Civilian Radioactive Waste Management's organization and management. These recommendations should be implemented without slowing the progress of site-characterization activities at Yucca Mountain.

***Underground Exploration and Testing at Yucca Mountain A Report to Congress and the Secretary of Energy. October 1993.***

This report (eighth in the NWTRB series) focuses on the exploratory studies facility at Yucca Mountain, Nevada: the conceptual design, planned exploration and testing, and excavation plans and schedules. In addition to a number of detailed recommendations, the Board makes three general recommendations. First, the DOE should develop a comprehensive strategy that integrates exploration and testing priorities with the design and excavation approach for the exploratory facility. Second, underground thermal testing should be resumed as soon as possible. Third, the DOE should establish a geoengineering board with expertise in the engineering, construction, and management of large underground projects.

***Letter Report to Congress and the Secretary of Energy. February 1994.***

This report is issued in letter format due to impending legislative hearings on the Department of Energy's fiscal year 1995 budget and new funding mechanisms sought by the Secretary of Energy. The



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8-page report (ninth in the NWTRB series) restates a recommendation made in the Board's Special Report, that an independent review of the Office of Civilian Radioactive Waste Management's management and organizational structure be initiated as soon as possible. Also, it adds two additional recommendations: ensure sufficient and reliable funding for site characterization and performance assessment, whether the program budget remains level or is increased, and build on the Secretary of Energy's new public involvement initiative by expanding current efforts to integrate the views of the various stakeholders during the decision-making process—not afterward.

***Report to The U.S. Congress and The Secretary of Energy: January to December 1993. May 1994.***

This report summarizes Board activities primarily during 1993. It reviews the nuclear waste disposal programs of Belgium, France, and the United Kingdom; elaborates on the Board's understanding of the radiation protection standards being reviewed by the National Academy of Sciences; and, using "future climates" as an example, examines the DOE's approach to "resolving difficult issues." Recommendations center on the use of a systems approach in all of OCRWM's programs, prioritization of site-suitability activities, appropriate use of total system performance assessment and expert judgment, and the dynamics of the Yucca Mountain ecosystem.

***Report to the U.S. Congress and the Secretary of Energy: 1994 Findings and Recommendations. March 1995.***

This report summarizes Board activities during 1994. It covers aspects of the DOE's Program Approach, their emerging waste isolation strategy, and their transportation program. It also explores the Board's views on minimum exploratory requirements and thermal-loading issues. The report focuses a chapter on the lessons that have been learned in site assessment from projects around the world. Another chapter deals with volcanism and resolution of difficult issues. The Board also details its observations from its visit to Japan and the Japanese nuclear waste disposal program. Findings and

recommendations in the report centered around structural geology and geoengineering, hydrogeology and geochemistry, the engineered barrier system, and risk and performance analysis.

***Report by letter to the Secretary of Energy and the Congress, December 13, 1995.***

This report, in the form of a letter, addresses the DOE's progress in underground exploration with the tunnel boring machine, advances in the development of a waste isolation strategy, new work on engineered barriers, and progress being made in performance assessment.

***Disposal and Storage of Spent Nuclear Fuel – Finding the Right Balance. March 1996.***

This special report caps more than two years of study and analysis by the Board into the issues surrounding the need for interim storage of commercial spent nuclear fuel and the advisability and timing of the development of a federal centralized storage facility. The Board concludes in the report that the Department of Energy's efforts should remain focused on permanent geologic disposal and the site investigations at Yucca Mountain, Nevada; that planning for a federal centralized spent fuel storage facility and the required transportation infrastructure be begun now, but actual construction delayed until after a site-suitability decision is made about the Yucca Mountain site; that storage should be developed incrementally; that limited, emergency backup storage capacity be authorized at an existing nuclear facility; and that, if the Yucca Mountain site proves unacceptable for repository development, other potential sites for both centralized storage and disposal be considered.

***Report to the U.S. Congress and the Secretary of Energy: 1995 Findings and Recommendations. April 1996.***

This report summarizes Board activities during 1995. Chapter 1 provides an overview of the Department of Energy high-level waste management program, including highlights, current status, legislative issues, milestones, and recommendations. Chapter 2 reports on Board Panel activities and

Chapter 3 provides information on new Board members, meetings attended, interactions with Congress and congressional staff, Board presentations to other organizations, interactions with foreign programs, and a review of the Board's report on interim storage of spent nuclear fuel. Appendices include Board testimony and statements before Congress, Board correspondence of note, and the Department of Energy's responses to recommendations in previous Board reports.

***Nuclear Waste Management in the United States – The Board's Perspective. June 1996.***

This publication was developed from remarks made by Dr. John Cantlon, Chairman of the Nuclear Waste Technical Review Board, at Topseal '96, an international conference on nuclear waste management and disposal. The meeting was sponsored by the Swedish Nuclear Fuel and Waste Management Company (SKB) and the European Nuclear Society. The publication highlights the Board's views on the status of the U.S. program for management and disposal of commercial spent nuclear fuel and provides a brief overview of the program's organization. It summarizes the DOE's efforts to characterize the Yucca Mountain site and to develop a waste isolation strategy for the site. The publication also outlines legislative and regulatory changes under consideration at that time and the Board's views on the technical implications of those possible changes.

***Report to the U.S. Congress and the Secretary of Energy: January to December 1996. March 1997.***

This report summarizes Board activities during 1996. Chapter 1 provides an overview of the Department of Energy's high-level nuclear waste management program from the Board's perspective, including the viability assessment, program status, and progress in exploration and testing. The chapter ends with conclusions and recommendations. Chapter 2 examines the three technical issues—hydrology, radionuclide transport, and performance assessment—and provides conclusions and recommendations. Chapter 3 deals with design, including the concept for underground operations, repository layout and design alternatives, construction plan-

ning, thermal loading, and engineered barriers. The Board also makes conclusions and recommendations. Chapter 4 provides an overview of recent Board activities, including the international exchange of information, the Board's visit to the River Mountains tunnel, and a presentation to the Nuclear Regulatory Commission. Appendices include information on Board members, the organization of the Board's panels, meetings held in 1996 and scheduled for 1997, the DOE's responses to previous Board recommendations, a list of Board publications, references for the report, and a glossary of technical terms.

***Report by letter to the Secretary of Energy and the Congress, December 23, 1997.***

This report, in the form of a letter, addresses several key issues, including the DOE's viability assessment of the Yucca Mountain site, design of the potential repository and waste package, the total system performance assessment, and the enhanced characterization of the repository block (east-west crossing).

***1997 Findings and Recommendations. April 1998***

This report details the Board's activities in 1997 and covers, among other things, the DOE's viability assessment, due later this year; underground exploration of the candidate repository site at Yucca Mountain, Nevada; thermal testing underway at the site; what happens when radioactive waste reaches the water table beneath Yucca Mountain; transportation of spent fuel; and the use of expert judgment. The Board makes four recommendations in the report concerning (1) the need for the DOE to begin now to develop alternative design concepts for a repository, (2) the need for the DOE to include estimates of the likely variation in doses for alternative candidate critical groups in its interim performance measure for Yucca Mountain, (3) the need for the DOE to evaluate whether site-specific biosphere data is needed for license application, and (4) the need for the DOE to make full and effective use of formally elicited expert judgment.

***Review of Material on Hydrothermal Activity.  
July 24, 1998***

This series of documents concerns the Board's review of material related to Mr. Jerry Szymanski's hypothesis of ongoing, intermittent hydrothermal activity at Yucca Mountain and large earthquake-induced changes in the water table there. The series includes a cover letter, the Board's review, and the reports of the four consultants the Board contracted with to assist in the review.

***Report to the U.S. Congress and The Secretary of Energy. November 1998***

In its report, the Board offers its views on the direction of future scientific and technical research underway and planned by the Department of Energy (DOE) as part of its program for characterizing a site at Yucca Mountain, Nevada, as a potential repository for spent fuel and high-level radioactive waste. The Board discusses some of the remaining key scientific and technical uncertainties related to performance of a potential repository. The Board's report addresses some of these uncertainties by examining information about the proposed repository system presented to it in meetings and other technical exchanges. The Board considers and comments on some of the important connections between the site's natural properties and the current designs for the waste package and other engineered features of the repository.