

Appendices

Appendix A

U.S. 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 the awards that Dr. Cohon has received is 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 (National Engineering Honor Society) and of Sigma Xi (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 the 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 11, 1999, President Bill Clinton reappointed John Arendt to serve on the Nuclear Waste Technical Review Board. Mr. Arendt was first appointed to the Board in 1995.

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 at 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 associate professor of mechanical engineering, Department of Mechanical Engineering, at Iowa State University in Ames, Iowa. He has been teaching since 1989, and he served as Nuclear Engineering Program Coordinator at Iowa State University from 1993 to 1996 and as director of the Iowa State University Nuclear Reactor Laboratory from 1993 to 2001. He has 12 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 65 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 (Scientific Research Society), Alpha Nu Sigma (Nuclear Engineering Scholastic Honor Society), a Lilly Teaching Fellowship at the Georgia Institute of Technology (1991), and two Outstanding Professor awards. He has appeared in Who's Who in Science and Engineering, Who's Who in America, and Who's Who in the World.

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; ASM International; the American Society of Mechanical Engineers; the National Society of Professional Engineers; and the Minerals, Metals & Materials Society.

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.

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 (Scientific Research Society), 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 a senior engineer at RAND Corporation in Arlington, Virginia. 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. 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 earned a master of science degree in civil engineering from the Massachusetts Institute of Technology in 1978 and 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, U.S. Department of the Interior. She served as director of the Progressive Policy Institute's Center for Innovation and the Environment from 1995 to 2000.

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 Director, Division of Civil and Mechanical Systems, 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 (ARMA), the American Society of Civil Engineers (ASCE), the International Tunnelling Association, the American Underground Construction Association, the Association of Engineering Geologists, the British Tunnelling Society, and other professional organizations. She is past president of the Geo-Institute of ASCE and of ARMA. Her honors and awards include Exxon Teaching Fellowships 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 of the heavy construction industry (1995). At the National Science Foundation, she has received the Director's Award for Integrative Collaboration three times, and she received the Director's Award for Meritorious Service in 1997. In 1999, she was appointed to the Senior Executive Service. Also in 1999, she received the Director's Award for Superior Accomplishment from the NSF.

Dr. Nelson brings to the Board special expertise in rock engineering and underground construction. 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. She has served as a consultant for major underground construction projects, including for the Superconducting Super Collider project from 1985 through 1992.

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 (Scientific Research Society).

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 a research assistant with the Illinois State Geological Survey in 1956 and began teaching in 1961 as an 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 a technical consultant to 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 election to the presidency of the Association of Exploration Geochemists. 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 Association of Exploration Geochemists, 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 in 1975 and was elected chairman of the Department of Geological Sciences in 1990. He continued in that position until 1993, when he became president of Shepherd Miller, Inc. He now serves as a technical consultant to Shepherd Miller, Inc., specializing in water-rock interaction and water contamination.

Dr. Runnells resides in Fort Collins, Colorado.

Alberto A. Sagüés, Ph.D.

On June 11, 1999, President Bill Clinton reappointed Alberto Sagüés to serve on the Nuclear Waste Technical Review Board. Dr. Sagüés was first appointed to the Board in 1997.

Dr. Alberto A. Sagüés is Distinguished University Professor 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 more than 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, Central America, 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 electrochemical measurements. 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 of 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 in 1991 and Distinguished University Professor, Department of Civil and Environmental Engineering, in 1999.

Dr. Sagüés resides in Lutz, Florida.

Jeffrey Wong, Ph.D.

On June 11, 1999, President Bill Clinton reappointed Jeffrey Wong to serve on the Nuclear Waste Technical Review Board. Dr. Wong was first appointed to the Board in 1995.

Dr. Jeffrey Wong is Deputy Director for Science, Pollution Prevention and Technology; Department of Toxic Substances Control; California Environmental Protection Agency. Dr. Wong has nearly 20 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. Before assuming his current position, he was chief of the Human and Ecological Risk Division of the Department of Toxic Substances Control, California Environmental Protection Agency.

Dr. Wong resides in Sacramento, California.

Appendix B

Meeting List for 2000

January 25 –26

Winter Board Meeting

Las Vegas, Nevada

Topics:

- Addressing uncertainty; Repository safety strategy;
- Scientific program update

January 27

Board Business Meeting

Las Vegas, Nevada

April 30

Board Business Meeting

Pahrump, Nevada

May 1

Spring Board Meeting

Pahrump, Nevada

Topic:

- Repository design and geochemistry

May 2-3

Board Business Meeting

Las Vegas, Nevada

July 10

Meeting of the Panel on the Waste Management System

Idaho Falls, Idaho

Topic:

- Spent fuel transportation

August 1-2

Summer Board Meeting

Carson City, Nevada

Topic:

- Scientific and technical issues and Total system performance assessment

August 3

Board Business Meeting

Carson City, Nevada

December 4-6

Board Business Meeting

Durham, North Carolina

Appendix C

Panel Organization

Calendar Year 2000

1. Panel on Site Characterization

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

Staff: Leon Reiter¹
 David M. Diodato
 Daniel J. Fehringer

2. Panel on the Repository

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

Staff: Carlos A. W. Di Bella¹
 Karyn D. Severson

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. Carroll²
 Carlos A. W. Di Bella¹
 Daniel S. Metlay
 Karyn D. Severson

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

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

Staff: Daniel J. Fehringer¹
 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 Wong

Staff: Leon Reiter¹
 Carlos A. W. Di Bella
 Daniel S. Metlay

¹Staff coordinator

²Staff coordinator until May 2000

Appendix D

U.S. Nuclear Waste Technical Review Board Publications

The following publications are available by mail from the Nuclear Waste Technical Review Board or electronically from the Board's web site at www.nwtrb.gov.

Report by letter to the Secretary of Energy and Congress. December 2000

This report, in the form of a letter, presents a brief update of the Board's views on the status of the DOE program.

Report to the U.S. Congress and the Secretary of Energy. April 2000.

In this report, the Board summarizes its major activities in calendar year 1999. Among the activities discussed in the report is the Board's 1999 review of the DOE's viability assessment (VA) of the Yucca Mountain site. The Board's evaluation of the VA concludes that Yucca Mountain continues to warrant study as the candidate site for a permanent geologic repository and that work should proceed to support a decision on whether to recommend the site for repository development. The Board suggests that the 2001 date for a decision is very ambitious, and focused study should continue on natural and engineered barriers. The Board states that a credible technical basis does not currently exist for the above-boiling repository design included in the VA. The Board recommends evaluation of alternative repository designs, including lower-temperature designs, as a potential way to help reduce the significance of uncertainties related to predictions of repository performance.

Report to the U.S. Congress and The Secretary of Energy. April 1999.

In this report, the Board summarizes its major activities during calendar year 1998. The report discusses the research needs identified in the DOE's recently issued *Viability Assessment* of the Yucca Mountain site, including plans to gather information on the amount of water that will eventually seep into repository drifts, whether formations under the repository will retard the migration of radionuclides, the flow-and-transport properties of the groundwater that lies approximately 200 meters beneath the repository horizon, and long-term corrosion rates of materials that may be used for the waste packages. The report describes other activities undertaken by the Board in 1998, including a review of the hypothesis that there were hydrothermal upwellings at Yucca Mountain, a workshop held to increase understanding of the range of expert opinion on waste package materials, and a review of the DOE's draft environmental impact statement for the Yucca Mountain site.

Report to the U.S. Congress and the Secretary of Energy: Moving Beyond the Viability Assessment. April 1999.

In its report, the Board offers its views on the DOE's December 1998 *Viability Assessment* of the Yucca Mountain site in Nevada. The Yucca Mountain site is

being characterized to determine its suitability as the location of a permanent repository for disposing of spent nuclear fuel and high-level radioactive waste. The Board discusses the need to address key uncertainties that remain about the site, including the performance of the engineered and natural barriers. The Board addresses the DOE's plans for reducing those uncertainties and suggests that consideration be given to alternative repository designs, including ventilated low-temperature designs that have the potential to reduce uncertainties and simplify the analytical bases for determining site suitability and for licensing. The Board also comments on the DOE's total system performance assessment, the analytical tool that pulls together information on the performance of the repository system.

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 under way and planned by the 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.

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.

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.

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).

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 planning, 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 NRC. 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.

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 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: 1995 Findings and Recommendations. April 1996.

This report summarizes Board activities during 1995. Chapter 1 provides an overview of the DOE's 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.

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 DOE'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 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.

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 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.

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 DOE's fiscal year 1995 budget and new funding mechanisms sought by the Secretary of Energy. The 8-page report (ninth in the NWTRB series) restates a recommendation made in the Board's Special Report, that an independent review of the OCRWM'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.

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 ESF 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.

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 (OCRWM) organization and management. These recommendations should be implemented without slowing the progress of site-characterization activities at Yucca Mountain.

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 dan-

gers 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.

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.

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.

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.

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.

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.