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 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 (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 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 (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 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. 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 be coming 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 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 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, 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 serves as president of the Geo-Institute of ASCE. 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, 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 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.

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 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 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 post doctoral 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 J. 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 J. 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 18 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.

Appendix B
Meeting List for 1999

January 25
Repository Panel Meeting
Las Vegas, Nevada
Topic:
- License Application Design Selection (LADS)

Transcript available

January 26-27
Board Meeting
Las Vegas, Nevada
Topics:
- Progress in design, science, and regulatory criteria
- Viability assessment of a repository at Yucca Mountain

Transcript available

January 28-29
Board Business Meeting
Las Vegas, Nevada
Minutes available

April 13-15
Board Business Meeting
Washington, D.C.
Minutes available

June 29-30
Summer Board Meeting
Beatty, Nevada
Topic:
- Repository design and the scientific program

Transcripts available

June 29 and July 1
Board Business Meeting
Beatty and Las Vegas, Nevada
Minutes available

September 14-15
Fall Board Meeting
Alexandria, Virginia
Topic:
- Developing a repository safety strategy with special attention to model validation

Transcripts available

September 14-16
Board Business Meeting
Alexandria, Virginia
Minutes available

Appendix C
Panel Organization

1. Panel on Site Characterization

Chairman:	Dr. Debra S. Knopman	Staff:	Leon Reiter*
Members:	Dr. Priscilla P. Nelson		Daniel Fehringer
	Dr. Richard R. Parizek		
	Dr. Donald D. Runnells		
	Dr. Alberto A. Sagüés		

2. Panel on the Repository

Chairman:	Dr. Daniel B. Bullen	Staff:	Carlos A. W. Di Bella*
Members:	Mr. John W. Arendt		Karyn D. Severson
	Dr. Priscilla P. Nelson		
	Dr. Donald D. Runnells		
	Dr. Alberto A. Sagüés		

3. Panel on the Waste Management System

Chairman:	Mr. John W. Arendt	Staff:	Michael G. Carroll*
Members:	Dr. Daniel B. Bullen		Carlos A. W. Di Bella
	Dr. Norman L. Christensen, Jr.		Daniel S. Metlay
	Dr. Paul P. Craig		Karyn D. Severson
	Dr. Debra S. Knopman		

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

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

5. Panel on Performance Assessment

Chairman:	Dr. Daniel B. Bullen	Staff:	Carlos A. W. Di Bella*
Members:	Dr. Paul P. Craig		Daniel S. Metlay
	Dr. Richard R. Parizek		Leon Reiter
	Dr. Alberto A. Sagüés		
	Dr. Jeffrey J. Wong		

*Staff coordinator

Appendix D
U.S. Nuclear Waste Technical Review Board Strategic Plan for FY 1998-2003 (Revised January 11, 2000)

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, 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 will 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 Energy's (DOE) 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 Congress. The Board can make recommendations but cannot compel the DOE to comply.

The attached strategic plan includes the Board's goals and objectives for 1998 through 2003. Those 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." By law, the Board is to continue operating until one year after the date on which the Secretary begins disposal of high-level radioactive waste or spent nuclear fuel in a repository.

Vision

By performing ongoing technical and scientific review and evaluation of the highest quality, the Board makes a unique and essential contribution to enhancing the technical and scientific credibility of the Secretary's efforts to (1) characterize the Yucca Mountain site for its suitability as the location of a permanent repository for the safe disposal of spent nuclear fuel and high-level radioactive waste; (2) license, construct, and operate a repository at the site, if a site recommendation is accepted; and (3) package and transport the waste to the permanent repository.

Values

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

- The Board strives to ensure that its members and staff have no conflicts of interest—real or perceived—in the activities related to the outcome of the Secretary's efforts to characterize the Yucca Mountain site; license, construct, and operate a permanent repository at the site; or package and transport spent fuel and high-level radioactive waste.

- The Board members arrive at their conclusions on the basis of objective analyses of the technical and scientific validity of the Secretary's activities.

- The Board's practices and procedures are open and conducted so that the Board's integrity and objectivity are above reproach.

- The Board's findings and recommendations are technically and scientifically sound and are based on the best available technical analysis and information.

- The Board's findings and recommendations are communicated clearly and in time for them to be most useful to Congress, the Secretary, and the public.

NWTRB General Goals and Objectives

The national goal for radioactive waste management established by Congress in the Nuclear Waste Policy Act of 1982 and the Nuclear Waste Policy Amendments Act of 1987 is the safe disposal of civilian spent nuclear fuel and high-level radioactive waste in a permanent geologic repository at a suitable site or sites. Congress charged the Nuclear Waste Technical Review Board with reviewing the technical and scientific validity of the Secretary of Energy's activities associated with achieving this goal. The Board's general goals have been established in accordance with its congressional mandate.

General Goals

To accomplish its congressional mandate, the Board has established four general goals.

1. Ensure that technical and scientific activities undertaken by the DOE related to determining the suitability of the Yucca Mountain site as the possible location of a permanent repository and predicting the performance of a potential repository establish a sound technical basis for a decision about whether to recommend the site for repository development.

2. Ensure that technical and scientific activities undertaken by the DOE related to designing the repository and waste packages are well integrated and establish a sound technical basis for designing the repository system, including the engineered barrier system (EBS).

3. Ensure that technical and scientific activities undertaken by the DOE related to packaging, handling, and transporting spent nuclear fuel and high-level radioactive waste to a permanent

repository are well integrated and establish a sound technical basis for designing and operating a waste management system.

4. Ensure that technical and scientific performance-confirmation activities undertaken by the DOE during licensing, construction, and operation of the proposed repository establish a sound technical basis for operating a repository, reducing uncertainties related to repository performance, and revising repository and waste package designs.

Strategic Objectives

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

1. Objectives Related to Site Suitability and Predicting Repository Performance

1.1 Evaluate the technical and scientific validity of DOE studies, testing, and analyses supporting a decision about whether to recommend the Yucca Mountain site.

1.2 Evaluate the behavior of the hydrology and other natural processes at the Yucca Mountain site that establish the foundation for predicting repository performance.

1.3 Review the technical and scientific validity of models used to predict repository performance.

1.4 Evaluate the DOE's progress in developing a safety strategy for the Yucca Mountain site.

1.5 Monitor progress in completing development of standards and regulatory guidelines for a potential Yucca Mountain repository.

1.6 Review the *Record of Decision* and maintain awareness of legal challenges to the final environmental impact statement for a potential Yucca Mountain site.

2. Objectives Related to the Engineered Barrier System

2.1 Evaluate repository and waste package designs, including the technical bases for the designs.

2.2 Review the progress or results of materials testing being conducted to address uncertainties about waste package performance.

2.3 Assess the integration of science and engineering in the DOE program, paying particular attention to the effects of site-characterization studies (e.g. modeling, testing, and analyses of thermal and mechanical effects) on repository and waste package designs.

3. Objectives Related to the Waste Management System

3.1 Evaluate the accuracy and reasonableness 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.

3.2 Review the adequacy of plans and requirements for developing the transportation infrastructure necessary 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 effort needed to develop a large-scale transportation capability.

3.3 Review the adequacy of DOE plans for safely handling and packaging spent fuel and high-level radioactive waste for transport to a permanent repository.

3.4 Evaluate the effectiveness of DOE efforts to integrate the various components of the waste management system (packaging, handling, transport, storage, and disposal of the waste).

3.5 Review the DOE's plans for addressing public safety concerns and for enhancing safety capabilities along transportation corridors. This includes activities related to development of plans (e.g., route selection), coordination, accident prevention (e.g., improved inspections and enforcement), and emergency response.

4. Objectives Related to Confirmatory Testing (will apply only if the site is found suitable and a site recommendation is ratified)

4.1 Monitor performance-confirmation activities undertaken by the DOE during licensing, construction, and operation of the repository that are designed to reduce uncertainties related to repository performance.

4.2 Monitor performance-confirmation activities undertaken by the DOE during licensing, construction, and operation of the repository and evaluate the need to revise repository or waste package designs according to the results of such activities.

Achieving the Goals and Objectives

Congress granted significant investigatory powers to the Board 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. By law, no member of the Board is employed by the Department of Energy or its contractors. The Board has adopted strong anti-conflict-of-interest procedures that go even further to ensure that the Board avoids even the appearance of a conflict. Subject 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 Congress to review the scientific and technical adequacy of the DOE's work. Much of the Board's information-gathering is done at open meetings where the DOE, its contractors, and other parties make formal presentations of technical information. 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 to further the Board's review, they have the collateral benefit of promoting communication and integration of technical information within the DOE's program and facilitating the dissemination of information among 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 technically valid 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 next few years, the DOE will decide whether to recommend the Yucca Mountain site. If the decision is positive and the recommendation is approved by the President and Congress, the DOE will apply to the U.S. Nuclear Regulatory Commission (NRC) for a license to construct and operate a repository at the site. If the license is approved, the expectation is that testing will continue to increase confidence in predictions of repository performance. The Board expects to review the analytical processes as well as the basis of technical information used by the DOE in making decisions about site recommendation and possible licensing. The Board also reviews the technical and scientific validity of activities related to confirmatory testing and to transportation and packaging.

The Board reports the results of its reviews at least twice each year to Congress and the Secretary of Energy. Additional communication occurs as needed. Such communications are available to the public either by request or on the Board's Web site at www.nwtrb.gov.

Cross-Cutting Functions

Several entities and agencies share responsibility for the ultimate national goal established by Congress of packaging, transporting, and disposing of spent nuclear fuel and high-level radioactive waste in a geologic repository at a suitable site. Although there may be cross-cutting areas of interest, the Board's role is unique among those involved in managing high-level radioactive waste. For example:

- **Congress and the Administration, including the Secretary of Energy**, make policy decisions on what the national goals will be and how they will be implemented. The Board's role in this process is to ensure that policy-makers are given 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, (2) 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.

- **Federal agencies** that have roles in achieving a safe waste management program include the DOE, the NRC, the U.S. Environmental Protection Agency (EPA), the U.S. Department of Transportation (DOT), and the U.S. Geological Survey (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 nuclear 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 regulate the transportation of the waste. The USGS participates in site-characterization activities at the Yucca Mountain site. The Board's role is unique among these federal agencies: provide ongoing, independent review and oversight of the technical and scientific validity of the Secretary of Energy's activities relating to civilian radioactive waste management, including site characterization and packaging and transportation of spent fuel and high-level radioactive waste, and communicate its findings and recommendations to Congress, the Secretary of Energy, and the public. 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 agencies involved in achieving the national goal.

Key External Factors

Some factors that are 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**. The Board is by definition and mandate a review body that can only make recommendations to the DOE. Congress expected that the DOE would accept the Board's recommendations or indicate why the recommendations should not be followed. However, the DOE is not legally obligated to accept any of the Board's recommendations.

  To increase its effectiveness, the Board has developed procedures for increasing the relevance of its findings and recommendations for Congress, the Secretary, DOE program managers, and the public. The Board's recommendations and the DOE's responses are 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**. Nuclear waste legislation has been considered by Congress several times in the last few years, and legislation may be voted on by the current Congress. The effects of such legislation, if enacted, on the program or the Board's activities 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.

Evaluating Board Performance

The Board will conduct an annual review of its actions in achieving its performance goals from the previous year. The Board believes that measuring its effectiveness by directly correlating improvements in the DOE program with Board actions and recommendations would be ideal. However, the Board has no implementing authority, so it cannot compel the DOE to comply with its recommendations. Consequently, a judgment about whether a specific recommendation had a positive outcome for the DOE program is, in most cases, (1) subjective and (2) an imprecise indicator of Board performance because implementation of Board recommendations by the DOE is outside the Board's direct control. Therefore, to measure its performance in a given year, the Board has developed the following performance measures.

In evaluating its performance, the Board will consider (1) whether the reviews, evaluations, and other activities included in its performance goals have been completed; and (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. The results of this evaluation will constitute the Board's assessment of its performance for the year. The Board will regard its performance as minimally effective if the activities, reviews, evaluations, and other activities included in its annual performance goals were completed. The Board will regard its performance as effective if those activities were completed and the results were communicated in a timely way to the Secretary of Energy and Congress

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 program, to establish its annual performance goals and to develop its budget requests for subsequent years. The results of the Board's performance evaluation are included in the Board's annual summary report to Congress and the Secretary.

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 and provided a copy of the plan to the NRC and to representatives of state and local governments. The Board solicited public comment and presented its strategic plan at a session held expressly for this purpose during its meeting in Amargosa Valley, Nevada, on January 20, 1998. In addition, a copy of the plan is available on the Board's Web site.

Appendix E

U.S. Nuclear Waste Technical Review Board FY 1999 Performance Plan And Evaluation (Revised January 19, 2000)

NWTRB General Goals and Strategic Objectives

The national goal for radioactive waste management established by Congress in the Nuclear Waste Policy Act of 1982 and the Nuclear Waste Policy Amendments Act of 1987 is safe disposal of civilian spent nuclear fuel and high-level radioactive waste in a permanent geologic repository at a suitable site or sites. Congress charged the Nuclear Waste Technical Review Board with reviewing the technical and scientific validity of the Secretary of Energy's activities associated with achieving this goal. The Board's general goals have been established in accordance with its congressional mandate.

General Goals

To accomplish its congressional mandate, the Board has established four general goals.

1. Ensure that technical and scientific activities undertaken by the U.S. Department of Energy (DOE) related to determining the suitability of the Yucca Mountain site as the possible location of a permanent repository and predicting the performance of a potential repository establish a sound technical basis for a decision on whether to recommend the site for repository development.

2. Ensure that technical and scientific activities undertaken by the DOE related to designing the repository and waste packages are well integrated and establish a sound technical basis for designing the repository system, including the engineered barrier system (EBS).

3. Ensure that technical and scientific activities undertaken by the DOE related to packaging, handling, and transporting spent nuclear fuel and high-level radioactive waste to a permanent repository are well integrated and establish a sound technical basis for designing and operating a waste management system.

4. Ensure that technical and scientific performance-confirmation activities undertaken by the DOE during licensing, construction, and operation of the proposed repository establish a sound technical basis for operating a repository, reducing uncertainties related to repository performance, and revising repository and waste package designs.

Strategic Objectives

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

1. Objectives Related to Site Suitability and Predicting Repository Performance

1.1 Evaluate the technical and scientific validity of DOE studies, testing, and analyses supporting a decision on whether to recommend the Yucca Mountain site.

1.2 Evaluate hydrologic and other natural processes at the Yucca Mountain site that establish the foundation for predicting repository performance.

1.3 Review the technical and scientific validity of models used to predict repository performance.

1.4 Evaluate the DOE's progress in developing a safety strategy for the Yucca Mountain site.

1.5 Monitor progress in completing development of standards and regulatory guidelines for a potential Yucca Mountain repository.

1.6 Review the *Record of Decision* and maintain awareness of legal challenges to the final environmental impact statement (EIS) for a potential Yucca Mountain site.

2. Objectives Related to the Engineered Barrier System

2.1 Evaluate repository and waste package designs, including the technical bases for the designs.

2.2 Review the progress or results of materials testing being conducted to address uncertainties about waste package performance.

2.3 Assess the integration of science and engineering in the DOE program, paying particular attention to the effects of site-characterization studies (e.g. modeling, testing, and analyses of thermal and mechanical effects) on repository and waste package designs.

3. Objectives Related to the Waste Management System

3.1 Evaluate the accuracy and reasonableness 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.

3.2 Review the adequacy of plans and requirements for developing the transportation infrastructure necessary 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 effort needed to develop a large-scale transportation capability.

3.3 Review the adequacy of the DOE's plans for safely handling and packaging spent fuel and high-level radioactive waste for transport to a permanent repository.

3.4 Evaluate the effectiveness of DOE efforts to integrate the various components of the waste management system (packaging, handling, transport, storage, and disposal of the waste).

3.5 Review the DOE's plans for addressing public safety concerns and for enhancing safety capabilities along transportation corridors. This includes activities related to development of plans (e.g., route selection), coordination, accident prevention (e.g., improved inspections and enforcement), and emergency response.

4. Objectives Related to Confirmatory Testing (will apply only if the site is found suitable and a site recommendation is ratified)

4.1 Monitor performance-confirmation activities undertaken by the DOE during licensing, construction, and operation of the repository that are designed to reduce uncertainties related to repository performance.

4.2 Monitor performance-confirmation activities undertaken by the DOE during licensing, construction, and operation of the repository, and evaluate the need to revise repository or waste package designs on the basis of the results of such activities.

Performance Goals for 1999

The Board developed its fiscal year 1999 performance goals on the basis of its general goals and strategic objectives. One major emphasis was the review of the DOE's congressionally mandated report, *Viability Assessment of a Repository at Yucca Mountain* (*VA*).

Performance Goals Related to Site Suitability and Predicting Repository Performance

1.1.1 Determine what the DOE's viability assessment can and cannot tell us about additional 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.

1.2.1 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, paying particular attention to estimates of infiltration rates and identification of fast pathways for water flow.

1.3.1 Monitor the results of ongoing thermal tests and evaluate the DOE's plans for using the test results to support models of the thermally disturbed region near the proposed repository.

1.4.1 Determine the strengths and weaknesses of the *VA*'s total system performance assessment (TSPA-VA) and how they could influence the conclusions to be drawn.

1.4.2 Evaluate the DOE's use of risk assessment and quantification of uncertainty, and determine whether it is being used appropriately.

1.4.3 Determine how the design of the waste package (for disposal) at the time of the *VA* is likely to influence decisions about the suitability of the site.

1.5.1 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 (NRC). Advise the DOE and Congress of the technical implications (e.g., cost, ability to demonstrate compliance with the standards and regulations).

1.6.1 Review the technical basis for the EIS 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.

Performance Goal Related to the Engineered Barrier System (EBS)

2.3.1 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 EBS.

Performance Goal Related to the Waste Management System

3.1.1 Evaluate the DOE's plans for enhancing safety capabilities along the transportation corridors by reviewing the DOE's planning and coordination activities (e.g., route selection), accident prevention activities (e.g., improved inspections and enforcement), and emergency response activities.

Performance Measurement

The Board believes that measuring its effectiveness by directly correlating improvements in the DOE program to the Board's recommendations and actions would be ideal. However, the Board has no implementing authority, so it cannot compel the DOE to comply with its recommendations. Consequently, the judgment of whether a specific recommendation had a positive outcome for the DOE program is, in most cases, (1) subjective and (2) an imprecise indicator of Board performance because implementation of Board recommendations by the DOE is outside the Board's direct control. Furthermore, even if the Board's recommendation is implemented by the DOE, a correlating change in the DOE program may not be evident for several years.

Therefore, to measure its performance in a given year, the Board has developed the following

performance measures. For each annual performance goal, the Board considers the following:

1. Whether the reviews, evaluations, and other activities undertaken according to the goal were completed.

2. Whether the results of the reviews, evaluations, and other activities were communicated in a timely, understandable, and appropriate way to Congress and the Secretary of Energy.

If both measures are met, the Board's performance in meeting the annual goal will be judged effective. If only one measure is met, the performance of the Board in achieving that goal will be judged minimally effective. Failing to meet both performance measures without sufficient and compelling explanation will result in a judgment that the Board has been ineffective in achieving the performance goal. To supplement its own evaluation, the Board will seek comments from Congress, the DOE, 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 waste management program, to establish its annual performance goals and to develop its budget requests for subsequent years. The results of the Board's performance evaluation are included in the Board's annual summary report to Congress and the Secretary.

Performance Evaluation for Fiscal Year 1999

According to the performance measures described above and on the basis of the following evaluation, the Board's performance for fiscal year 1999 was found effective.

Performance Evaluation of Goals Related to Site Suitability and Predicting Repository Performance

1.1.1 Determine what the DOE's viability assessment can and can not tell us about additional 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.

- Evaluation of 1.1.1: The Board completed the initial part of its assessment and communicated its views and findings to Congress and the Secretary of Energy in its report *Moving Beyond the Viability Assessment*, issued in April 1999. Specific recommendations were communicated to the DOE in letters to the acting director of the Office of Civilian Radioactive Waste Management (OCRWM) dated July 9, 1999, and August 3, 1999.

1.2.1 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, paying particular attention to estimates of infiltration rates and identification of fast pathways for water flow.

- Evaluation of 1.2.1: The Board continued its evaluation of key technical issues and commented on needed additional studies in its April 1999 report *Moving Beyond the Viability Assessment* and in letters to the acting director of the OCRWM dated July 9, 1999, August 3, 1999, and November 10, 1999.

1.3.1 Monitor the results of ongoing thermal tests, and evaluate the DOE's plans for using the test results to support models of the thermally disturbed region near the proposed repository.

- Evaluation of 1.3.1: The Board continued to monitor the results of thermal tests undertaken at the site and commented on (1) the status of the tests, (2) when results might be expected, and (3) the implications of the results of such tests for repository design and potential repository performance in a July 9, 1999, letter to the acting director of the OCRWM.

1.4.1 Determine the strengths and weaknesses of TSPA-VA and how they could influence the conclusions to be drawn from the viability assessment.

- Evaluation of 1.4.1: The Board reviewed the TSPA-VA and commented on its strengths and weaknesses in its report *Moving Beyond the Viability Assessment* in April 1999.

1.4.2 Evaluate the DOE's use of risk assessment and quantification of uncertainty, and determine whether it is being used appropriately.

- Evaluation of 1.4.2: The Board conducted its evaluation and commented to the DOE in a letter to the acting director of the OCRWM on November 10, 1999.

1.4.3 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.

- Evaluation of 1.4.3: The Board extensively examined the evaluation conducted by the OCRWM related to repository design and commented to the DOE on its views and recommendations in letters to the acting director of the OCRWM dated July 9, 1999, May 7, 1999, and March 3, 1999.

1.5.1 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 NRC. Advise the DOE and Congress of the technical implications (e.g., cost, ability to demonstrate compliance with the standards and regulations).

- Evaluation of 1.5.1: The Board's purview includes reviewing the technical and scientific validity of activities undertaken by the Secretary of Energy. Therefore, the Board determined that the appropriate Board involvement relating to the radiation protection standard is to monitor progress in developing the standard but not to comment on the substance of the standard.

1.6.1 Review the technical basis for the EIS 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.

- Evaluation of 1.6.1: The Board reviewed the DOE's draft EIS (DEIS) and has provided ongoing feedback to the DOE. The Board will provide its written comments on the DEIS during the first months of 2000. The Board's performance related to meeting this objective is determined to have been effective because its review and comments are on schedule.

Performance Evaluation of Goals Related to Engineered Barrier System

2.3.1 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 EBS.

- Evaluation of 2.3.1: The Board commented on the integration of science and engineering and the need to consider alternative repository and waste package designs in its November 1998 *Report to Congress and the Secretary of Energy* and in its March 3, 1999, and July 9, 1999, letters to the acting director of the OCRWM.

Performance Evaluation of Goals Related to Waste Management System

3.1.1 Evaluate the DOE's plans for enhancing safety capabilities along the transportation corridors by reviewing the DOE's planning and coordination activities (e.g., route selection), accident prevention activities (e.g., improved inspections and enforcement), and emergency response activities.

- Evaluation of 3.1.1: The DOE deferred most activities related to transportation of spent nuclear fuel and high-level radioactive waste. Therefore, the Board monitored the efforts of

the railroad industry to create a performance specification for the transportation of spent fuel and high-level radioactive waste. The Board also monitored industry capability to manufacture shipping and storage casks for a potential major shipping campaign.

Board Operations

The Board consists of 11 members appointed by the President on the basis of distinguished service. The Board members serve on a part-time basis and are eminent in a field of science or engineering, including environmental sciences. 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 the professional staff, a small administrative staff supports Board activities. The full Board meets three or four times each year, and Board panels meet as needed. 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. On the basis of the information gathered throughout the year, the Board issues its findings in letters and reports.

Appendix F
U.S. Nuclear Waste Technical Review Board FY 2000 Performance Plan (Revised January 4, 2000)

NWTRB General Goals and Strategic Objectives

The national goal for radioactive waste management established by Congress in the Nuclear Waste Policy Act of 1982 and the Nuclear Waste Policy Amendments Act of 1987 is the safe disposal of civilian spent nuclear fuel and high-level radioactive waste in a permanent geologic repository at a suitable site or sites. Congress charged the Nuclear Waste Technical Review Board with reviewing the technical and scientific validity of the Secretary of Energy's activities associated with achieving this goal. The Board's general goals have been established in accordance with its congressional mandate.

General Goals

To accomplish its congressional mandate, the Board has established four general goals.

1. Ensure that technical and scientific activities undertaken by the U.S. Department of Energy (DOE) related to determining the suitability of the Yucca Mountain site as the possible location of a permanent repository and predicting the performance of a potential repository establish a sound technical basis for a decision on whether to recommend the site for repository development.

2. Ensure that technical and scientific activities undertaken by the DOE related to designing the repository and waste packages are well integrated and establish a sound technical basis for designing the repository system, including the engineered barrier system (EBS).

3. Ensure that technical and scientific activities undertaken by the DOE related to packaging, handling, and transporting spent nuclear fuel and high-level radioactive waste to a permanent repository are well integrated and establish a sound technical basis for designing and operating a waste management system.

4. Ensure that technical and scientific performance-confirmation activities undertaken by the DOE during licensing, construction, and operation of the proposed repository establish a sound technical basis for operating a repository, reducing uncertainties related to repository performance, and revising repository and waste package designs.

Strategic Objectives

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

1. Objectives Related to Site Suitability and Predicting Repository Performance

1.1 Evaluate the technical and scientific validity of DOE studies, testing, and analyses supporting a decision on whether to recommend the Yucca Mountain site.

1.2 Evaluate hydrologic and other natural processes at the Yucca Mountain site that establish the foundation for predicting repository performance.

1.3 Review the technical and scientific validity of models used to predict repository performance.

1.4 Evaluate the DOE's progress in developing a safety strategy for the Yucca Mountain site.

1.5 Monitor progress in completing development of standards and regulatory guidelines for a potential Yucca Mountain repository.

1.6 Review the *Record of Decision* and maintain awareness of legal challenges to the final environmental impact statement (EIS) for a potential Yucca Mountain site.

2. Objectives Related to the Engineered Barrier System

2.1 Evaluate repository and waste package designs, including the technical bases for the designs.

2.2 Review the progress or results of materials testing being conducted to address uncertainties about waste package performance.

2.3 Assess the integration of science and engineering in the DOE program, paying particular attention to the effects of site-characterization studies (e.g. modeling, testing, and analyses of thermal and mechanical effects) on repository and waste package designs.

3. Objectives Related to the Waste Management System

3.1 Evaluate the accuracy and reasonableness 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.

3.2 Review the adequacy of plans and requirements for developing the transportation infrastructure necessary 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 effort needed to develop a large-scale transportation capability.

3.3 Review the adequacy of the DOE's plans for safely handling and packaging spent fuel and high-level radioactive waste for transport to a permanent repository.

3.4 Evaluate the effectiveness of DOE efforts to integrate the various components of the waste management system (packaging, handling, transport, storage, and disposal of the waste).

3.5 Review the DOE's plans for addressing public safety concerns and for enhancing safety capabilities along transportation corridors. This includes activities related to development of plans (e.g., route selection), coordination, accident prevention (e.g., improved inspections and enforcement), and emergency response.

4. Objectives Related to Confirmatory Testing (will apply only if the site is found suitable and a site recommendation is ratified)

4.1 Monitor performance-confirmation activities undertaken by the DOE during licensing, construction, and operation of the repository that are designed to reduce uncertainties related to repository performance.

4.2 Monitor performance-confirmation activities undertaken by the DOE during licensing, construction, and operation of the repository, and evaluate the need to revise repository or waste package designs on the basis of the results of such activities.

Performance Goals for FY 2000

The Board's performance goals for FY 2000 have been developed to further the achievement of the Board's general goals and strategic objectives. Because some of the general goals and strategic objectives relate to work and activities that will be undertaken in the future, they may not have corresponding annual performance goals in any given year. For example, the following performance goals for FY 2000 relate primarily to DOE activities

supporting a DOE decision on whether to recommend the Yucca Mountain site to the President, the design of a potential repository and waste package, and transportation planning.

Performance Goals Related to Site Suitability and Predicting Repository Performance

1.1.1 Identify and evaluate uncertainties that need to be addressed for making a technically supportable site-suitability decision in preparation for a possible site recommendation.

1.1.2 On the basis of an evaluation of the natural processes at work at the Yucca Mountain site, recommend additional needed information, paying particular attention to estimates of the rate and distribution of water seepage into the proposed repository.

1.2.1 Evaluate geologic, hydrologic, and geochemical information obtained from the enhanced characterization of the repository block (ECRB) at Yucca Mountain.

1.2.2 Monitor the results of ongoing thermal tests, and evaluate the DOE's plans for using the test results to support models of the thermally disturbed region near the repository.

1.3.1 Monitor the results of flow-and-transport studies being conducted to obtain information on the potential performance of the saturated zone as a natural barrier in the repository system.

1.3.2 Determine the strengths and weaknesses of the total system performance assessment (TSPA).

1.3.3 Evaluate the DOE's use of risk assessment and quantification of uncertainty, and determine whether they are being used appropriately.

Strategy for Achieving Performance Goals Related to Site Suitability and Predicting Repository Performance

The strategy for achieving performance goals for fiscal year 2000 is similar to that used and proven successful in previous years. The Board will accomplish its goals by doing the following:

- Reviewing critical documents provided by the DOE and its contractors, including contractor reports, process model reports, the TSPA for site recommendation, and the site recommendation.

- Meeting with contractor principal investigators on technical issues, including those related to climate change, unsaturated and saturated zone flow and transport, seepage, and the biosphere.

- Holding public meetings with the DOE and contractor personnel at least three times a year involving the full Board and several meetings involving individual Board Panels.

- Visiting and observing ongoing laboratory investigations, including the facilities at Lawrence Livermore National Laboratory, Lawrence Berkeley National Laboratory, Sandia National Laboratory, and the engineered barrier test facility. Observing field investigations including the niche, alcove, and sealed cross-drift studies and the Busted Butte studies.

- Meeting with other entities carrying out research on, or providing input to, scientific and technical issues related to waste disposal, including the U.S. Nuclear Regulatory Commission and its contractors, the Southwest Research Institute, the Nye County Early Warning Drilling Program, the University of Nevada at Las Vegas project on fluid inclusions, the U.S. Environmental Protection Agency, and the State of Nevada Nuclear Waste Projects Office.

Performance Goals Related to the Engineered Barrier System

2.1.1 Monitor and evaluate the DOE's progress in analyzing alternatives to the reference design for the waste package and the repository.

2.2.1 Evaluate the results of corrosion studies on materials being proposed for the EBS.

2.3.1 Assess the effects of site-characterization studies on the EBS design.

Strategy for Achieving Annual Goals Related to the Engineered Barrier System

The Board will accomplish its goals by doing the following:

- Evaluating the technical bases for EBS design by reviewing technical documents and databases, particularly the technical bases for making and inspecting final closure welds of the waste package and the methods for making drip shield sections. Meetings will be held as necessary with project personnel to obtain clarification and confirmation.

- Evaluating the technical bases for repository design by reviewing documents and databases, paying particular attention to design features developed to promote drainage, control ventilation, and protect workers in the exhaust end of the ventilation system.

- Evaluating repository and waste package designs to identify which parts (if any) of the designs do not have a satisfactory technical basis.

- Evaluating the DOE's technical bases for alternative design features.

- After identifying the corrosion mechanisms most important to performance of the overall repository system, reviewing the common database (literature, laboratory, and field data), and judging the adequacy of the database for a site recommendation decision.

Performance Goals Related to the Waste Management System

3.1.1 Determine the adequacy of the DOE's treatment of transportation in the draft environmental impact statement (DEIS).

3.5.1 Monitor progress by the railroad industry in implementing new technologies (e.g., electronic braking, wheel-bearing monitoring).

Strategy for Achieving Objectives Related to the Waste Management System

The Board will accomplish its goals by doing the following:

- Attending DOE-sponsored public hearings to determine what, in the public's view, are the critical issues not currently addressed or adequately addressed in the DEIS. The Board also will contract with an independent contractor to conduct an analysis of the treatment of transportation in the DEIS. If the Board determines that there are weaknesses in the DEIS, it will provide feedback to the DOE.

- Meeting with the American Association of Railroads (AAR) to review draft performance specification and evaluating the potential effect of the performance specification on the safety of the DOE's proposed shipping campaign. The Board will conduct a panel meeting with the AAR, the DOE, the U.S. Department of Transportation, and others to further evaluate the benefits of the AAR's performance specification. The Board will travel to the AAR's Technology Center in Pueblo, Colorado, to see demonstrations of the latest technologies related to train safety.

Measuring Board Performance

The Board believes that measuring its effectiveness by directly correlating improvements in the DOE program with Board actions and recommendations would be ideal. However, the Board has no implementing authority, so it cannot compel the DOE to comply with its recommendations. Consequently, a judgment about whether a specific recommendation had a positive outcome for the DOE program is, in most cases, (1) subjective and (2) an imprecise indicator of Board performance because implementation of Board recommendations by the DOE is outside the Board's direct control. Therefore, to measure its performance in a given year, the Board has developed the following performance measures.

For each annual performance goal, the Board considers the following:

1. Whether the reviews, evaluations, and other activities undertaken under the auspices of the goal were completed.

2. Whether the results of the reviews, evaluations, and other activities were communicated in a timely, understandable, and appropriate way to Congress and the Secretary of Energy.

If both measures are met, the Board's performance in meeting the annual goal will be judged effective. If only one measure is met, the performance of the Board in achieving that goal will be judged minimally effective. Failing to meet both performance measures without sufficient and compelling explanation will result in a judgment that the Board has been ineffective in achieving that performance goal.

The Board will use its evaluation of its own performance from the current year to establish its annual performance objectives and develop its budget requests for subsequent years. The results of the Board's performance evaluation are included in the Board's annual summary report to Congress and the Secretary.

Board Operations

The Board is composed of 11 members appointed by the President who serve on a part-time basis; are eminent in a relevant 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 small professional staff of 10 full-time employees to support the Board's comprehensive review of the DOE program. In addition to the members and professional staff, a small administrative staff supports Board activities.

The full Board meets three or four times each year. The Board has organized itself into panels that meet as needed. The Board also gathers information from field trips to the Yucca Mountain site, visits to contractor laboratories and facilities, and informal meetings with individuals working on the project. On the basis of the information gathered throughout the year, the Board issues its findings in letters and reports.

Resource Allocation for Fiscal Year 2000

The Board's budget request for fiscal year 2000 was $3,150,000. Of that total, $2,150,000 was allocated to activities related to site characterization. The allocation included the salaries and benefits of the Board's members and professional staff. It also included the cost of conducting meetings, field trips, and other fact-finding activities and the production of reports related to the activities. Transportation and packaging activities, which include activities similar to those used to evaluate site-characterization efforts, were allocated $550,000. The balance of $450,000 was allocated to the management and administrative support of the Board's activities in fiscal year 2000.

The Board's appropriation for fiscal year 2000 was $2,600,000. The Board has had to adapt the performance plan to reflect the appropriation level. The revised allocations are as follows: $1,350,000 for activities related to site characterization; $500,000 for transportation and packaging activities, which include activities similar to those used to evaluate site-characterization efforts; $200,000 for communications (Congress, public, etc.); and $550,000 for management support and for administrative and information technology support of the Board's activities in fiscal year 2000.

Appendix G
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**.

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 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 (OCRWM) 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 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.

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.

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 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 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.

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: 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 Yucca 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.

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 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.

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 suitably 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. 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.

Appendix H
Communications Between the Board and the OCRWM

In addition to published reports, the Board periodically writes letters to the Director of the U.S. Department of Energy's (DOE) Office of Civilian Radioactive Waste Management (OCRWM). The letters typically provide the OCRWM with the Board's views on specific technical areas earlier than do Board reports. The letters are posted on the Board's Web site after they have been sent to the OCRWM. For archival purposes, the four letters written during calendar year 1999 are reproduced here

The OCRWM typically responds to the Board's reports and letters, indicating its plans to respond to the Board's recommendations. Included here are the OCRWM's responses received by the Board during calendar year 1999. Inclusion of these responses does not imply the Board's concurrence.

- Letter from Lake H. Barrett, Acting Director, OCRWM, to Chairman Jared L. Cohon; April 29, 1999. Subject: The DOE's response to the Board's *Report to the U.S. Congress and the Secretary of Energy, November 1998.*

- Letter from Lake H. Barrett, Acting Director, OCRWM, to Chairman Jared L. Cohon; September 20, 1999. Subject: The DOE's response to the Board's *Report to The U.S. Congress and The Secretary of Energy, Moving Beyond Yucca Mountain Viability Assessment.* April 1999

- Letter from Lake H. Barrett, Acting Director, OCRWM, to Chairman Jared L. Cohon; September 20, 1999. Subject: The DOE's response to the Board's *Report to the U.S. Congress and the Secretary of Energy, April 1999, summarizing the Board's 1998 activities.*

- Letter from Chairman Jared L. Cohon to Lake H. Barrett, Acting Director, OCRWM; March 3, 1999. Subject: Comments on repository design, site investigations, and Nye county drilling program.

- Letter from Lake H. Barrett, Acting Director, OCRWM, to Chairman Jared L. Cohon; June 15, 1999. Subject: The DOE's response to March 3, 1999, Board letter.

- Letter from Chairman Jared L. Cohon to Lake H. Barrett, Acting Director, OCRWM; July 9, 1999. Subject: Comments on the DOE's process for selecting a repository design and on the recommended repository design.

- Letter from Lake H. Barrett, Acting Director, OCRWM, to Chairman Jared L. Cohon; September 10, 1999. Subject: The DOE's response to July 9, 1999, Board letter.

- Letter from Chairman Jared L. Cohon to Lake H. Barrett, Acting Director, OCRWM; August 3, 1999. Subject: Comments on the DOE's scientific program for Yucca Mountain, including testing and analysis undertaken to address uncertainties related to the natural and engineered systems.

- Letter from Lake H. Barrett, Acting Director, OCRWM, to Chairman Jared L. Cohon; November 23, 1999. Subject: The DOE's response to August 3, 1999, Board letter.

- Letter from Chairman Jared L. Cohon to Lake H. Barrett, Acting Director, OCRWM; November 10, 1999. Subject: Reactions to information presented by the DOE at the Board's September meeting, including repository safety strategy, model validation, treatment of uncertainty, and modeling results and technical investigations.