

Appendices

Appendix A

U.S. Nuclear Waste Technical Review Board Members

Michael L. Corradini, Ph.D.; Chairman

Dr. Michael L. Corradini was appointed to the Nuclear Waste Technical Review Board as chairman on June 26, 2002, by President George W. Bush. Dr. Corradini resigned from the Board effective January 12, 2004.

Dr. Corradini is chairman of the engineering physics department of the University of Wisconsin-Madison. He brings to the Board expertise in nuclear and industrial safety. His research focuses on multiphase flow and heat/mass transfer, vapor-explosion phenomena, jet-spray breakup, and mixing dynamics, as well as on heat/mass transfer and chemical reactions involved in molten core-concrete interactions.

Dr. Corradini has 25 years of experience in nuclear engineering, including research and teaching. He was elected to membership in the National Academy of Engineering of the National Academy of Sciences in 1998. He is a Fellow of the American Nuclear Society and was a recipient of the 1990 Young Members Engineering Achievement Award. Dr. Corradini is a registered Professional Engineer.

Dr. Corradini has served as a consultant for the U.S. Nuclear Regulatory Commission's Advisory Committee on Reactor Safeguards and for the U.S. Department of Energy National Laboratories (Los Alamos National Laboratory, Oak Ridge National Laboratory, Idaho National Engineering Laboratory, Brookhaven National Laboratory). He also has participated in nationally and internationally sponsored research.

Dr. Corradini earned a bachelor of science degree in mechanical engineering from Marquette University in 1975. He received a master of science degree in nuclear engineering from the Massachusetts Institute of Technology (MIT) in 1976 and a Ph.D. in nuclear engineering from MIT in 1978. For the next three years, he was on the technical staff of Sandia National Laboratories, conducting research on severe reactor accidents. In 1981, Dr. Corradini joined the University of Wisconsin-Madison faculty. He became Associate Dean, Academic Affairs, of the College of Engineering in 1995. In 2001, he became chairman of the Department of Engineering Physics.

Dr. Corradini lives in Madison, Wisconsin.

Mark D. Abkowitz, Ph.D.

Dr. Mark D. Abkowitz was appointed to the Nuclear Waste Technical Review Board on June 26, 2002, by President George W. Bush.

Dr. Abkowitz is a professor of civil and environmental engineering at Vanderbilt University in Nashville, Tennessee, and is director of the Vanderbilt Center for Environmental Management Studies. He brings to the Board expertise in the fields of transportation, risk management and risk assessment, and emergency preparedness.

Dr. Abkowitz has served on several national and international committees, including as chairman of the National Academy of Sciences Transportation Research Board Committee on Hazardous Materials Transport and as a member of the National Research Council Committee on Disposal of Transuranic Waste at the Waste Isolation Pilot Plant. Dr. Abkowitz also serves on the board of Visual Risk Technologies. He is the author of more than 60 journal publications and study reports.

Dr. Abkowitz has been inducted into Chi Epsilon and the National Society of Sigma Xi and is a member of the World Conference on Transportation Research Society. He received the Distinguished Service Award in 1996 from the Transportation Research Board.

Dr. Abkowitz received a bachelor of science degree in civil engineering from the Massachusetts Institute of Technology (MIT) in 1974. In 1976, he received a master of science degree in civil engineering from MIT. He was awarded a Ph.D. in civil engineering-transportation by MIT in 1980. From 1976 to 1980, he worked as a project manager and research investigator for the U.S. Department of Transportation. In 1980, he joined the civil engineering faculty of Rensselaer Polytechnic Institute. During a sabbatical in 1986-87, he served as a senior analyst to the U.S. Congress, Office of Technology Assessment. He joined Vanderbilt in 1987 as Administrative Director, Vanderbilt Engineering Center for Transportation Operations and Research.

Dr. Abkowitz lives in Nashville, Tennessee.

Daniel B. Bullen, Ph.D.

Dr. Daniel B. Bullen was appointed to the Nuclear Waste Technical Review Board on January 17, 1997, by President William Clinton.

Dr. Bullen is an associate professor of mechanical engineering, Department of Mechanical Engineering, at Iowa State University in Ames, Iowa. He 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 has been teaching since 1989, and he served as Nuclear Engineering Program Coordinator at Iowa State University from 1993 to 1996 and as director of the Iowa State University Nuclear Reactor Laboratory from 1993 to 2001. He has 12 years of industry experience in nuclear engineering and materials science. He has edited and reviewed articles for such professional publications as Nuclear Technology, Journal of the American Ceramic Society, American Nuclear Society Transactions, and Encyclopedia of Chemical Technology. He has written or co-written more than 70 technical publications and reports and has contributed to three books. He is a registered Professional Engineer in mechanical, metallurgical, and nuclear engineering. Dr. Bullen's honors and awards include Tau Beta Pi (National Engineering Honor Society), Phi Kappa Phi, Sigma Xi (Scientific Research Society), Alpha Nu Sigma (Nuclear Engineering Scholastic Honor Society), a Lilly Teaching Fellowship at the Georgia Institute of Technology (1991), and two Outstanding Professor awards. He has appeared in Who's Who in Science and Engineering, Who's Who in America, and Who's Who in the World.

Dr. Bullen is a member of ASM International; American Society of Mechanical Engineers; National Society of Professional Engineers; and Minerals, Metals & Materials Society; and American Nuclear Society (ANS). He is an active member of the Education and Training Division and the Fuel Cycle and Waste Management Division of ANS and has served as Chairman of the Executive Committee of each division.

Dr. Bullen is an international consultant in radioactive waste management. As a consultant to Monitor Scientific, LLC of Denver, Colorado, Dr. Bullen has provided technical expertise to the Japanese and Swedish nuclear waste management programs on issues related to waste package degradation, performance-confirmation monitoring, and long-term performance assessment.

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

Dr. Bullen lives in Ames, Iowa.

Thure E. Cerling, Ph.D.

Dr. Thure E. Cerling was appointed to the Nuclear Waste Technical Review Board on June 26, 2002, by President George W. Bush.

Dr. Cerling is Distinguished Professor of Geology and Geophysics and professor of Biology at the University of Utah. He brings to the Board as expertise in terrestrial geochemistry. His research interests are in the study of geochemistry processes occurring at or near the Earth's surface and in the geological record of ecological change.

Dr. Cerling was elected to membership in the National Academy of Sciences in 2001. He is a fellow of the American Association for the Advancement of Science and of the Geological Society of America. He has been a visiting professor at Scripps Institution of Oceanography, Yale University; the University of Lausanne in Switzerland; and at the California Institute of Technology.

Dr. Cerling has served on numerous boards, panels, and committees, including the National Academy of Sciences–National Research Council Board on Earth Sciences and Resources, Geochemical Society Board of Directors, and the Nuclear Waste Group of the International Union of Geological Sciences. He also served on the Governor's Nuclear Waste Task Force, State of Utah, in 1981–83. In 1998, he received the University of Utah Distinguished Research Award.

In 1972, Dr. Cerling earned a bachelor of science degree in geology and chemistry from Iowa State University. In 1973, he received a master of science degree in geology from Iowa State University. In 1977, he was awarded a Ph.D. in geology by the University of California–Berkeley. From 1977 to 1979, Dr. Cerling worked as a research scientist at Oak Ridge National Laboratory. In 1979, he joined the faculty of the University of Utah.

Dr. Cerling lives in Salt Lake City, Utah.

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

Dr. Norman L. Christensen, Jr. was appointed to the Nuclear Waste Technical Review Board on January 17, 1997, by President William Clinton.

Dr. Christensen is professor of ecology at the Nicholas School of the Environment and Earth Sciences at Duke University in Durham, North Carolina. He 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.

Dr. Christensen has been teaching for more than 29 years and has more than 90 scientific articles and books to his credit. 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 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 made a Fellow of the American Association for the Advancement of Science in 1993 and is 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*. He is currently Vice-president of the Ecological Society of America and Chairman of the National Commission on Science for Sustainable Forestry.

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.

Dr. Christensen earned a bachelor’s degree in biology from Fresno State College in 1968. He earned a master of science 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 was dean of the Nicholas School of the Environment from 1991 to 2001.

Dr. Christensen lives in Chapel Hill, North Carolina.

Paul P. Craig, Ph.D.

Dr. Paul P. Craig was appointed to the Nuclear Waste Technical Review Board on January 30, 1997, by President William Clinton.

Dr. 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 brings to the Board special expertise and research interest in energy and environmental policy.

Dr. Craig has more than 21 years of teaching experience and more than 100 refereed publications to his credit. He is Chairman of the Sierra Club's National Global Warming and Energy Committee. He was a Lawrence Berkeley National Laboratory Participating Guest Scientist from 1976 to 1997 and again starting in 2002. He is a Fellow of the American Physical Society. Dr. Craig's 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 earned a bachelor of science degree in mathematics and physics from Haverford College in 1954. 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 member of the National Academy of Sciences–National Research Council Board on Radioactive Waste Management.

Dr. Craig lives in Martinez, California.

David J. Duquette, Ph.D.

Dr. David J. Duquette was appointed to the Nuclear Waste Technical Review Board on June 26, 2002, by President George W. Bush.

Dr. Duquette is Department Head and a professor of materials science and engineering at Rensselaer Polytechnic Institute (RPI) in Troy, New York. He brings to the Board expertise in the physical, chemical, and mechanical properties of metals and alloys, with special emphasis on environmental interactions. His current research interests include the physical, chemical, and mechanical properties of metals and alloys, with specific reference to studies of cyclic deformation behavior as affected by environment and temperatures, basic corrosion studies, and stress-corrosion cracking.

Dr. Duquette is author or co-author of more than 200 scientific publications, primarily in environmental degradation of materials and electrochemical processing of semiconductor interconnects. Among the awards that he has received are the Willis Rodney Whitney Award from the National Association of Corrosion Engineers in 1990 and the Humboldt Prize from the Alexander von Humboldt Foundation in 1983. He has been elected an Honorary Member of Alpha Sigma Mu, the national metallurgical honorary society, and has received an Outstanding Paper Award from Acta Metallurgica. He is a Fellow of the National Association of Corrosion Engineers and of the American Society for Metals and is also a member of the Minerals, Metals & Materials Society and of the Electrochemical Society.

Dr. Duquette spent more than five years as a member of a scientific review group that advised the Canadian government on disposal of high-level nuclear waste. He also has been a member of a panel that advised the United States government on container design and materials selection for disposing of nuclear waste.

Dr. Duquette received a bachelor of science degree from the U.S. Coast Guard Academy in 1961. From 1961 to 1965, he served as a commissioned officer in the U.S. Coast Guard. From 1965 to 1968, he was a research assistant in the Department of Metallurgy and Materials Science at the Massachusetts Institute of Technology (MIT). In 1968, he was awarded a Ph.D. in materials science by MIT. From 1968 to 1970, he worked as a senior research associate in the Advanced Materials Research and Development Laboratory of Pratt and Whitney Aircraft. Dr. Duquette joined the RPI faculty in 1970.

Dr. Duquette lives in Loudonville, New York.

Debra S. Knopman, Ph.D.

On January 17 1997, President William Clinton appointed Debra Knopman to serve on the Nuclear Waste Technical Review Board. Dr. Knopman resigned from the Board on January 17, 2003.

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

Dr. Knopman resides in Washington, D.C.

Ronald M. Latanision, Ph.D.

Dr. Ronald M. Latanision was appointed to the Nuclear Waste Technical Review Board on June 26, 2002, by President George W. Bush.

Dr. Latanision is professor emeritus of materials science and engineering and nuclear engineering at the Massachusetts Institute of Technology (MIT) and a principal and Director, Mechanics and Materials in Exponent Corporation. He brings to the Board expertise in materials processing and in corrosion of metals and other materials in aqueous (ambient as well as high-temperature and high-pressure) environments.

Dr. Latanision is the author or co-author of more than 200 scientific publications. Among the awards that Dr. Latanision has received are the David Ford McFarland Award for Achievement in Metallurgy from The Pennsylvania State University Chapter of the American Society for Metals, in 1986, and the Willis Rodney Whitney Award from the National Association of Corrosion Engineers in 1994. He was elected Distinguished Alumnus of The Ohio State University College of Engineering in 1991, and Honorary Alumnus of MIT in 1992.

Dr. Latanision is a Fellow of the American Society of Metals International and the National Association of Corrosion Engineers. He is founder and co-chairman of the New England Science Teachers and is a member of the National Academy of Engineering and the American Academy of Arts and Sciences. He has been a consultant to industry and government and has been active in organizing international conferences.

In 1964, Dr. Latanision received a bachelor of science degree in metallurgy from The Pennsylvania State University. In 1968, he was awarded a Ph.D. in metallurgical engineering by The Ohio State University. In 1968 and 1969, he was a Postdoctoral Fellow at the National Bureau of Standards. From 1969 to 1974, he worked for Martin Marietta Laboratories, first as a research scientist and then as acting head of materials science. He joined MIT in 1975 as director of the H. H. Uhlig Corrosion Laboratory. During a sabbatical in 1982–83, he served as a science advisor to the U.S. House of Representatives Committee on Science and Technology. He also served as a member of the National Materials Advisory Board of the National Research Council.

Dr. Latanision lives in Winchester, Massachusetts.

Priscilla P. Nelson, Ph.D.

Dr. Priscilla P. Nelson was appointed to the Nuclear Waste Technical Review Board on January 17, 1997, by President William Clinton.

Dr. Nelson is Director, Division of Civil and Mechanical Systems, for the Directorate for Engineering at the National Science Foundation. Dr. Nelson brings to the Board special expertise in rock engineering and underground construction.

In 1970, Dr. Nelson earned a bachelor of science degree in geological sciences from the University of Rochester. She earned master of science 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 has more than 13 years of teaching experience and more than 100 technical and scientific publications to her credit. She has served as a member of the U.S. National Committee for Rock Mechanics, the U.S. National Committee for Tunneling Technology, and the Board on Radioactive Waste Management, all activities of the National Research Council. She is a member of the American Rock Mechanics Association (ARMA), the American Society of Civil Engineers (ASCE), the International Tunnelling Association, the American Underground Construction Association, the Association of Engineering Geologists, the American Society for Engineering Education, and other professional organizations. She is past president of the Geo-Institute of ASCE and of ARMA. Her honors and awards include Exxon Teaching Fellowships at The University of Texas at Austin (1985–1987), the Case Studies Award from the U.S. National Committee for Rock Mechanics (1988), the Haliburton Education Foundation Award of Excellence (1991), the Basic Research Award from the U.S. National Committee for Rock Mechanics (1993), and election to The Moles, an association of the heavy construction industry (1995). At the National Science Foundation, she has received the Director's Award for Integrative Collaboration three times, and she received the Director's Award for Meritorious Service in 1997. In 1999, she was appointed to the Senior Executive Service. Also in 1999, she received the Director's Award for Superior Accomplishment from the NSF.

Dr. Nelson lives in Arlington, Virginia.

Richard R. Parizek, Ph.D.

Dr. Richard R. Parizek was appointed to the Nuclear Waste Technical Review Board on February 11, 1997, by President William Clinton.

Dr. 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. 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 has more than 42 years of teaching experience and numerous journal publications to his credit. His awards include a cooperative fellowship from the National Science Foundation (1960), Kurl Mason Award, Pennsylvania Department of Environmental Resources, 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), the medal for distinguished service to environmental science and engineering of the Institute of Meteorology and Water Management, Warsaw, Poland (1991), M. King Hubbard Award, National Ground Water Association (1998), Award for Distinguished Service in Hydrogeology, Geological Society of America (1999), and C.V. Theis Award, American Institute of Hydrology (2001). 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 is a member of the American Association for the Advancement of Science, the American Institute of Hydrology, the Geological Society of America, the National Groundwater Association, the International Association of Scientific Hydrology, and Sigma Xi.

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

Dr. Parizek lives in State College, Pennsylvania.

Appendix B

2003 Meeting List

- January 28** **Winter Board Meeting**
Las Vegas, Nevada
Topics:
• Yucca Mountain science programs
• Materials testing
• Barrier analyses
Transcript available
- January 29–30** **Board Business Meeting**
Las Vegas, Nevada
Minutes available
- February 24** **Joint Panel on the Repository and Panel on Site Characterization Meeting**
Las Vegas, Nevada
Topic:
• Seismic issues
Transcript available
- February 25** **Panel on the Waste Management System Meeting**
Las Vegas, Nevada
Topics:
• Waste receipt
• Transportation
• Repository operation
Transcript available
- May 13–14** **Spring Board Meeting**
Washington, D.C.
Topic:
• Thermal aspects of Yucca Mountain repository design
Transcript available
- May 14–15** **Board Business Meeting**
Washington, D.C.
Minutes available
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September 16–17

Fall Board Meeting

Amargosa Valley, Nevada

Topics:

- Program update and project review
- Flow and transport in the unsaturated and saturated zones
- Updates on igneous issues
- Updates on DOE's transportation activities

Transcript available

September 17–18

Board Business Meeting

Las Vegas, Nevada

Minutes available

Appendix C

Panel Organization

Panel on the Natural System

Chair:	Richard R. Parizek	Staff:	David M. Diodato*
Members:	Thure E. Cerling		John H. Pye
	Norman L. Christensen, Jr.		Leon Reiter
	Paul P. Craig		
	Priscilla P. Nelson		

Panel on the Engineered System

Chair:	Ronald M. Latanision	Staff:	Carlos A. W. Di Bella*
Members:	Daniel B. Bullen		John H. Pye
	Paul P. Craig		Karyn D. Severson
	David J. Duquette		
	Priscilla P. Nelson		

Panel on Repository System Performance and Integration

Chair:	Daniel B. Bullen	Staff:	Leon Reiter*
Members:	Mark D. Abkowitz		David M. Diodato
	Thure E. Cerling		Daniel S. Metlay
	Ronald M. Latanision		John H. Pye
	Priscilla P. Nelson		
	Richard R. Parizek		

Panel on the Waste Management System

Chair:	Norman L. Christensen, Jr.	Staff:	Daniel J. Fehringer*
Members:	Mark D. Abkowitz		Carlos A. W. Di Bella
	Daniel B. Bullen		Joyce M. Dory
	Paul P. Craig		Daniel S. Metlay
	David J. Duquette		Karyn D. Severson

* Staff coordinator

Appendix D

U.S. Nuclear Waste Technical Review Board Publications

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

***Report to Congress and the Secretary of Energy.
December 19, 2003.***

This letter and attachments constitute the Board's second report to Congress and the Secretary of Energy for calendar year 2003. This report is composed of letters on localized corrosion sent to the director of the Office of Civilian Radioactive Waste Management (OCRWM) on October 21, 2003, and November 25, 2003. It also contains the Board Technical Report on Localized Corrosion.

***Board Technical Report on Localized Corrosion.
November 25, 2003.***

Technical report supporting Board conclusions on October 21, 2003, letter to the DOE related to the potential for localized corrosion of waste packages during the thermal pulse.

***Report to the Secretary of Energy and the
Congress. April 2003.***

This report summarizes the Board's major activities between January 1, 2002, and December 31, 2002. During this period, the Board focused on evaluating the technical basis of the DOE's work related to analyzing a planned repository site at Yucca Mountain in Nevada. Included in an appendix to the report are letters to the DOE related to technical issues identified by the Board as part of its ongoing review in 2002. Also included in the appendices are the Board's strate-

gic plan for fiscal years 2003–2008, its performance plans for FY 2003 and FY 2004, and its performance evaluation for FY 2002.

***Report to Congress and the Secretary of Energy.
April 2002.***

This report summarizes the Board's major activities between February 1, 2001, and January 31, 2002. During this period, the Board focused on evaluating the technical basis of the DOE's work related to a site recommendation, including the DOE's characterization of the Yucca Mountain site, the DOE's design of the repository and waste package, and the DOE's estimates of how a repository system developed at the site might perform. The report includes a description of activities undertaken by the Board in developing its assessment of the technical basis for the DOE's current performance estimates.

***Report by letter to Congress and the Secretary
of Energy. January 24, 2002.***

Letter report summarizing the Board's evaluation of the DOE's technical and scientific investigation of the Yucca Mountain site.

***Report to Congress and the Secretary of Energy.
April 2001.***

In this report, the Board summarizes its major activities in calendar year 2000. During 2000, the Board identified four priority areas for evaluating the potential repository at Yucca Mountain. The areas are the following:

- meaningful quantification of conservatisms and uncertainties in the DOE's performance assessments

- progress in understanding the underlying fundamental processes involved in predicting the rate of waste package corrosion
- an evaluation and a comparison of the base-case repository design with a low-temperature design
- development of multiple lines of evidence to support the safety case of the proposed repository, the lines of evidence being derived independently of performance assessment and thus not being subject to the limitations of performance assessment.

The report summarizes the Board's views on each priority area. A more detailed discussion of the priorities can be found in letters to the DOE included among the appendices to the report.

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

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

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

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

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

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

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

In its report, the Board offers its views on the DOE's December 1998 *Viability Assessment* of the Yucca Mountain site in Nevada. The Yucca Mountain site is being characterized to determine its suitability as the location of a permanent repository for disposing of spent nuclear fuel and high-level radioactive waste. The Board discusses the need to address key uncertainties that remain about the site, including the performance of the engineered and natural barriers. The Board addresses the DOE's plans for reducing those uncertainties and suggests that consideration be given to alternative repository designs, including ventilated low-temperature designs that have the potential to reduce uncertainties and simplify the analytical bases for determining site suitability and for licensing. The Board also comments on the DOE's total system performance assessment, the analytical tool that pulls together information on the performance of the repository system.

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

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

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

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

1997 Findings and Recommendations. April 1998.

This report details the Board's activities in 1997 and covers, among other things, the DOE's viability assessment, due later this year; underground exploration of the candidate repository site at Yucca Mountain, Nevada; thermal testing under way at the site; what happens when radioactive waste reaches the water table beneath Yucca Mountain; transportation of spent fuel; and the use of expert judgment. The Board makes four recommendations in the report concerning (1) the need for the DOE to begin now to develop alternative design concepts for a repository, (2) the need for the DOE to include estimates of the likely variation in doses for

alternative candidate critical groups in its interim performance measure for Yucca Mountain, (3) the need for the DOE to evaluate whether site-specific biosphere data is needed for license application, and (4) the need for the DOE to make full and effective use of formally elicited expert judgment.

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

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

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

This report summarizes Board activities during 1996. Chapter 1 provides an overview of the Department of Energy's high-level nuclear waste management program from the Board's perspective, including the viability assessment, program status, and progress in exploration and testing. The chapter ends with conclusions and recommendations. Chapter 2 examines the three technical issues—hydrology, radionuclide transport, and performance assessment—and provides conclusions and recommendations. Chapter 3 deals with design, including the concept for underground operations, repository layout and design alternatives, construction planning, thermal loading, and engineered barriers. The Board also makes conclusions and recommendations. Chapter 4 provides an overview of recent Board activities, including the international exchange of information, the Board's visit to the River Mountains tunnel, and a presentation to the NRC. Appendices include information on Board members, the organization of the Board's panels, meetings held in 1996 and scheduled for 1997, the DOE's responses to previous Board recommendations, a list of Board publications, references for the report, and a glossary of technical terms.

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

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

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

This report summarizes Board activities during 1995. Chapter 1 provides an overview of the DOE's high-level waste management program, including highlights, current status, legislative issues, milestones, and recommendations. Chapter 2 reports on Board Panel activities and Chapter 3 provides information on new Board members, meetings attended, interactions with Congress and congressional staff, Board presentations to other organizations, interactions with foreign programs, and a review of the Board's report on interim storage of spent nuclear fuel. Appendices include Board testimony and statements before Congress, Board correspondence of note, and the Department of Energy's responses to recommendations in previous Board reports.

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

This special report caps more than two years of study and analysis by the Board into the issues surrounding the need for interim storage of com-

mercial spent nuclear fuel and the advisability and timing of the development of a federal centralized storage facility. The Board concludes in the report that the DOE's efforts should remain focused on permanent geologic disposal and the site investigations at Yucca Mountain, Nevada; that planning for a federal centralized spent fuel storage facility and the required transportation infrastructure be begun now, but actual construction delayed until after a site-suitability decision is made about the Yucca Mountain site; that storage should be developed incrementally; that limited, emergency backup storage capacity be authorized at an existing nuclear facility; and that, if the Yucca Mountain site proves unacceptable for repository development, other potential sites for both centralized storage and disposal be considered.

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

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

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

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

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

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

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

This report is issued in letter format due to impending legislative hearings on the DOE's fiscal year 1995 budget and new funding mechanisms sought by the Secretary of Energy. The 8-page report restates a recommendation made in the Board's Special Report, that an independent review of the OCRWM's management and organizational structure be initiated as soon as possible. Also, it adds two additional recommendations: ensure sufficient and reliable funding for site characterization and performance assessment, whether the program budget remains level or is increased, and build on the Secretary of Energy's new public involvement initiative by expanding current efforts to integrate the views of the various stakeholders during the decision-making process—not afterward.

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

This report focuses on the exploratory studies facility (ESF) at Yucca Mountain, Nevada: the conceptual design, planned exploration and testing, and excavation plans and schedules. In addition to a number of detailed recommendations, the Board makes three general recommendations. First, the DOE should develop a comprehensive

strategy that integrates exploration and testing priorities with the design and excavation approach for the exploratory facility. Second, underground thermal testing should be resumed as soon as possible. Third, the DOE should establish a geoengineering board with expertise in the engineering, construction, and management of large underground projects.

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

The Board's 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 OCRWM organization and management. These recommendations should be implemented without slowing the progress of site-characterization activities at Yucca Mountain.

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

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

tory construction schedules, and alternative approaches to licensing. Appendix F provides background on the Finnish and Swiss programs.

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

The Board's 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 15 recommendations to the DOE on the following subjects: ESF and repository design enhancements, repository sealing, seismic vulnerabilities (vibratory ground motion and fault displacement), the DOE approach to the engineered barrier system, and transportation and systems program status.

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

The Board's report provides update on the Board's activities and explores in depth the following areas: 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 EPA, the NRC, and the DOE; the DOE performance assessment program; and quality assurance in the Yucca Mountain project. Ten recommendations are made across these diverse subject areas. Chapter 3 offers insights from the Board's visit with officials from the Canadian nuclear power and spent fuel disposal programs. Background on the Canadian program is in Appendix D.

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

The Board's report briefly describes recent Board activities and congressional testimony.

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

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

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

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

The Board's report sets the stage for the Board's evaluation of the 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.