

# **APPENDIX A**

## **U.S. NUCLEAR WASTE TECHNICAL REVIEW BOARD MEMBERS**



## Rodney C. Ewing, Ph.D.

### *Chairman*

Dr. Rodney C. Ewing was appointed to the U.S. Nuclear Waste Technical Review Board by President Barack Obama on July 28, 2011, and designated by the President to serve as Chairman of the Board on September 25, 2012. Dr. Ewing was reappointed as Chairman and member of the Board by the President on July 1, 2014.

Dr. Ewing is the Frank Stanton Professor in Nuclear Security in the Center for International Security and Cooperation and a Professor of Geological and Environmental Sciences in the School of Earth Sciences at Stanford University. He is also the Edward H. Kraus Distinguished University Professor Emeritus at the University of Michigan and Regents' Professor Emeritus at the University of New Mexico.

Dr. Ewing is a fellow of the Geological Society of America, the Mineralogical Society of America, the American Geophysical Union, the Geochemical Society, the American Ceramic Society, the American Association for the Advancement of Science, and the Materials Research Society. He has been a guest scientist at numerous institutions, including the Centre D'Études Nucléaires de Fontenay-Aux-Roses, Commissariat A L'Énergie Atomique et aux Énergies Alternatives, Paris, France; Hahn-Meitner Institut in Berlin, Germany; and the University of Tokyo in Japan.

Among Dr. Ewing's numerous awards and honors are Royal Society of Canada, Foreign Fellow; Honorary Doctor of Université Pierre et Marie Curie; Dana Medal of the Mineralogical Society of America; Lomonosov Great Gold Medal of the Russian Academy of Sciences; and Association of Earth Science Editors Award for Outstanding Editorial or Publishing Contributions.

Dr. Ewing has written extensively on issues related to nuclear waste management and is co-editor of *Radioactive Waste Forms for the Future* (1988) and *Uncertainty Underground - Yucca Mountain and the Nation's High-Level Nuclear Waste* (2006). He has published over 600 scientific papers in journals and proceedings volumes.

Dr. Ewing received a Ph.D. from Stanford University in 1974 and an M.S. from Stanford in 1972. He received a B.S. in geology from Texas Christian University.

Dr. Ewing lives in Menlo Park, California.

## Jean Bahr, Ph.D.

**Dr. Jean M. Bahr** was appointed to the U.S. Nuclear Waste Technical Review Board by President Barack Obama on September 25, 2012.

Dr. Bahr is a professor in the Department of Geoscience at the University of Wisconsin-Madison, where she has been on the faculty since 1987. She also is a member of the UW-Madison Geological Engineering Program Faculty and is a faculty affiliate of the Nelson Institute for Environmental Studies. She served as chair of Geoscience (formerly Geology and Geophysics) from 2005 to 2008 and of the Nelson Institute's Water Resources Management Graduate Program from 1995 to 1999. Dr. Bahr's research explores physical, geochemical, and biogeochemical controls on the movement of water and associated solutes in subsurface geologic systems.

Dr. Bahr has served on many advisory committees through the National Research Council of the National Academies and was a member of the Board on Radioactive Waste Management from 1992 to 1997. She chaired the Committee on Restoration of the Greater Everglades Ecosystem, and from 2004 to 2006 she was a member of the Committee on Research Priorities in Earth Science and Public Health. In addition to her service for the National Academies, Dr. Bahr has been a member of proposal review panels for the National Science Foundation, the U.S. Environmental Protection Agency, the U.S. Department of Energy, and the international Ocean Drilling Program. She served terms on the editorial boards of the journals *Water Resources Research*, *Ground Water*, and *Hydrogeology*.

Dr. Bahr was elected to Sigma Xi in 1984, named a fellow of the Geological Society of America (GSA) in 1996, and received the GSA Hydrogeology Division's Distinguished Service Award in 2006. She was the 2003 GSA Birdsall-Dreiss Distinguished Lecturer and was elected President of GSA for 2009-2010. She was named a lifetime National Associate of the National Academies in 2002 and is the 2012 recipient of the Association for Women Geoscientists' Outstanding Educator Award.

Dr. Bahr received a B.A. in geology and geophysics from Yale University in 1976, and an M.S. and a Ph.D. in 1985 and 1987, respectively, in applied earth sciences (hydrogeology) from Stanford University.

Dr. Bahr resides in Madison, Wisconsin.

## **Steven M. Becker, Ph.D.**

Dr. Steven M. Becker was appointed to the U.S. Nuclear Waste Technical Review Board by President Barack Obama on September 25, 2012.

Dr. Becker is professor of community and environmental health in the College of Health Sciences at Old Dominion University in Norfolk, Virginia. He is a leading expert in emergency planning, public health preparedness, and crisis and emergency risk communication for chemical, biological, radiological, and nuclear issues. Dr. Becker also has extensive on-the-ground experience at the sites of major events and emergencies around the world. In 2011, he was a member of a three-person assistance team invited to Japan in response to the earthquake-tsunami and accident at the Fukushima Daiichi nuclear plant.

Before becoming a professor at Old Dominion University, Dr. Becker was a professor of environmental health sciences at the University of Alabama at Birmingham School of Public Health. For the last 11 years, he also has been an invited faculty member for the Harvard School of Public Health training course on radiological emergency planning.

In 2005, Dr. Becker was elected by his scientific peers to serve on the National Council on Radiation Protection and Measurements. His work on emergency preparedness and risk communication has been recognized with awards from such scientific organizations as the Health Physics Society and the Oak Ridge Associated Universities.

Dr. Becker holds a B.A. from George Washington University, an M.A. from Columbia University, and a Ph.D. from Bryn Mawr College. He also was a Kreitman Scholar and postdoctoral fellow at Ben-Gurion University of the Negev in Israel and a Visiting Fellow at the Japan Emergency Medicine Foundation and National Hospital Tokyo Disaster Medical Center.

## **Susan L. Brantley, Ph.D.**

Dr. Susan L. Brantley was appointed to the U.S. Nuclear Waste Technical Review Board on September 25, 2012, by President Barack Obama.

Dr. Brantley is Distinguished Professor of Geosciences in the College of Earth and Mineral Sciences at Pennsylvania State University, where she also is Director of the Earth and Environmental Systems Institute. She has been a member of the faculty at the University since 1986. As a geochemist, Dr. Brantley has concentrated on the chemistry of natural waters, both at the surface of the earth and deeper in the crust. Much of her research focuses on understanding what controls the chemistry of natural water and how water interacts with the rocks through which it flows. Dr. Brantley and her research group investigate chemical, biological, and physical processes associated with the circulation of aqueous fluids in shallow hydrogeologic settings through field and laboratory work and theoretical modeling of observations. Of particular interest are questions concerning the measurement and prediction of the rates of natural processes, including chemical weathering with and without microorganisms. Her recent work has focused on the effect of microbial life on mineral reactivity and measuring and modeling how rock turns into regolith. Dr. Brantley has published more than 160 refereed journal articles and 15 book chapters.

Professor Brantley is a fellow of the American Geophysical Union, a fellow of the GSA, a fellow of the Geochemical Society, a fellow of the European Association of Geochemistry, and a fellow of the International Association for GeoChemistry. She was president of the Geochemical Society from 2006 to 2008. She has served on several National Research Council committees, and she has been a member of the U.S. Department of Energy Council on Earth Sciences since 2009.

In 2011, Professor Brantley received the Arthur L. Day Medal from GSA, as well as an honorary doctorate from the Paul Sabatier University (Toulouse III) in France. In 2012, she received the Presidential Award from the Soil Science Society of America, and she also was elected to membership in the U.S. National Academy of Sciences.

Dr. Brantley received an A.B. in chemistry in 1980 and an M.A. and a Ph.D. in geological and geophysical sciences in 1983 and 1987, respectively, from Princeton University.

Dr. Brantley lives in State College, Pennsylvania.

## Sue B. Clark, Ph.D.<sup>1</sup>

Dr. Sue B. Clark was appointed to the U.S. Nuclear Waste Technical Review Board by President Barack Obama on July 28, 2011. Dr. Clark was reappointed to the Board by the President on July 1, 2014.

Dr. Clark is Regents Professor of Chemistry at Washington State University in Pullman, Washington, where she has taught and conducted research in actinide environmental chemistry and radioanalytical chemistry since 1996. From 1992 to 1996, she was a research ecologist at the University of Georgia's Savannah River Ecology Laboratory. From 1991 to 1996, she was an adjunct assistant professor in the Environmental Systems Engineering Department at Clemson University, and from 1989 to 1992, she was a senior scientist in the Interim Waste Technology Division at the Westinghouse Savannah River Laboratory.

Dr. Clark has served on numerous national advisory committees. From 2009 to 2011, she was a member of the Board of Directors of the U.S. Council for Chemical Research. From 2005 to 2009, she served on the Nuclear and Radiation Studies Board of the National Research Council. From 2004 to 2005, she served on the Board on Radioactive Waste Management of the National Research Council and various study committees for that Board. From 2003 to 2011, she was a member of the Basic Energy Sciences Advisory Committee of the Office of Science, U.S. Department of Energy.

Dr. Clark's awards and achievements include being a fellow of the American Chemical Society, selected in 2010. In 2008, she was Fink Distinguished Lecturer, Georgia Institute of Technology, Department of Chemistry. From 2002 to 2008, she was Westinghouse Distinguished Professor of Materials Science and Engineering at Washington State University.

Professor Clark has published over 100 peer-reviewed papers in environmental chemistry of plutonium and other actinides, chemistry of high-level radioactive waste systems, and actinide radioanalytical chemistry. She is currently serving as an Editor for the journal *Radiochimica Acta*. Dr. Clark earned a Ph.D. and an M.S. in inorganic/radiochemistry from The Florida State University. She earned a B.S. in chemistry from Lander College in Greenwood, South Carolina.

Dr. Clark lives in Pullman, Washington.

<sup>1</sup> Dr. Clark resigned from the Board effective October 31, 2014.

## **Efi Foufoula-Georgiou, Ph.D.**

Dr. Efi Foufoula-Georgiou was appointed to the U.S. Nuclear Waste Technical Review Board by President Barack Obama on September 25, 2012.

Dr. Foufoula-Georgiou is a University of Minnesota McKnight Distinguished Professor in the Department of Civil Engineering and the Joseph T. and Rose S. Ling Chair in Environmental Engineering. She is Director of the National Science Foundation (NSF) Science and Technology Center "National Center for Earth-Surface Dynamics," and has served as Director of St. Anthony Falls Laboratory at the University of Minnesota. Her area of research is hydrology and geomorphology, with special interest in scaling theories, multiscale dynamics, and space-time modeling of precipitation and landforms.

Dr. Foufoula-Georgiou has served on many national and international advisory boards, including the Water Science and Technology Board of the National Academies, the Advisory Council of the Geosciences Directorate of NSF, and the Earth Sciences Subcommittee of the Science Advisory Council of NASA. She has also been a member of several National Research Council committees, the most recent one producing the report "Challenges and Opportunities in the Hydrologic Sciences." She has served as chair of the Board of Directors of the Consortium of Universities for the Advancement of Hydrologic Sciences and as an elected Trustee of the University Corporation for Atmospheric Research. Dr. Foufoula-Georgiou has published over 130 journal refereed papers and has been the recipient of the John Dalton Medal of the European Geophysical Society and the American Geophysical Union's (AGU) Hydrologic Sciences Award. She is a fellow of AGU and the American Meteorological Society and is an elected member of the European Academy of Sciences. In 2012, she was elected president of the Hydrology Section of AGU.

Dr. Foufoula-Georgiou received a diploma in civil engineering (1979) from the National Technical University of Athens, Greece, and an M.S. and a Ph.D. (1985) in environmental engineering from the University of Florida.

Dr. Foufoula-Georgiou resides in Saint Paul, Minnesota.

## Gerald S. Frankel, Sc.D.

Dr. Gerald S. Frankel was appointed to the U.S. Nuclear Waste Technical Review Board by President Barack Obama on September 25, 2012.

Dr. Frankel is the DNV Chair, Professor of Materials Science and Engineering, and Director of the Fontana Corrosion Center at The Ohio State University (OSU). Before joining OSU, he was a postdoctoral researcher at the Swiss Federal Technical Institute in Zurich and a research staff member at the IBM Watson Research Center in Yorktown Heights, New York. His primary research interests are in the passivation and localized corrosion of metals and alloys, corrosion inhibition, and protective coatings.

Dr. Frankel is a member of the editorial board of *The Journal of the Electrochemical Society*; *Corrosion*; *Materials and Corrosion*; and *Corrosion Reviews*. He also is past chairman of the Corrosion Division of The Electrochemical Society and past chairman of the Research Committee of NACE. Dr. Frankel is a fellow of NACE International, The Electrochemical Society, and ASM International. He received the UR Evans Award from the Institute of Corrosion in 2011, the OSU Distinguished Scholar Award in 2010, the 2010 ECS Corrosion Division H.H. Uhlig Award, the Alexander von Humboldt Foundation Research Award for Senior US Scientists in 2004, the 2007 TP Hoar Prize from the UK Institute of Corrosion, the 2000 Uhlig Award from NACE, and the Harrison Faculty Award from the OSU College of Engineering in 2000. He was on sabbatical at the Max Planck Institute for Iron Research in Dusseldorf in 2005, a visiting professor at the University of Paris in 2008, and a visiting professor at Monash University in Melbourne in 2012. In 2009, he was named adjunct professor, Pohang Institute of Science and Technology, Graduate Institute of Ferrous Technology, Pohang, Korea.

Dr. Frankel earned a Sc.B. degree in materials science and engineering from Brown University in 1978 and a Sc.D. degree in materials science and engineering from The Massachusetts Institute of Technology in 1985.

Dr. Frankel resides in Bexley, Ohio.

## **Linda K. Nozick, Ph.D.**

Dr. Linda Nozick was appointed to the U.S. Nuclear Waste Technical Review Board by President Barack Obama on July 28, 2011. Dr. Nozick was reappointed to the Board by the President on July 1, 2014.

Dr. Nozick is a professor of civil and environmental engineering at Cornell University. She also is Director of the College Program in Systems Engineering, a program that she co-founded. She has been on the Cornell faculty since 1992 and has been a Full Professor since 2003. From 1998 to 1999, Dr. Nozick was Visiting Associate Professor in the Operations Research Department at the U.S. Naval Postgraduate School in Monterey, California. In 1998, she was Visiting Professor in the Operations Research Department at General Motors Research & Development in Warren, Michigan. She has played a leading role in developing optimization models for planning and policy to support the National Security Enterprise and Homeland Security.

Dr. Nozick has served on two National Academy committees to advise the U.S. Department of Energy on renewal of their infrastructure. She has authored more than 60 peer-reviewed publications, many focused on transportation, moving hazardous materials, and modeling critical infrastructure systems. She has been an associate editor for Naval Research Logistics and a member of the editorial board of Transportation Research Part A.

She has received numerous awards, including a CAREER award from the National Science Foundation and a Presidential Early Career Award for Scientists and Engineers from President Bill Clinton for "the development of innovative solutions to problems associated with the transportation of hazardous waste." Dr. Nozick also received several recognition awards from Sandia National Laboratories and the National Nuclear Security Administration for the development of modeling tools for nuclear stockpile analysis, transportation of hazardous/sensitive materials, enterprise planning, and budget analysis.

Dr. Nozick received a Ph.D. and an M.S.E. in systems engineering from The University of Pennsylvania and a B.S. in systems analysis and engineering from The George Washington University.

Dr. Nozick lives in Ithaca, New York.

## **Kenneth Lee Peddicord, Ph.D., P.E.**

Dr. Kenneth L. Peddicord was appointed to the U.S. Nuclear Waste Technical Review Board by President Barack Obama on September 25, 2012. Dr. Peddicord was reappointed to the Board by the President on July 1, 2014.

Dr. Peddicord is Director of the Nuclear Power Institute (NPI) and a professor of nuclear engineering at Texas A&M University, where he has been a member of the faculty since 1983. From 1972 to 1975, he was employed as a research nuclear engineer at the Eidgenössisches Institut für Reaktorforschung (the Swiss Federal Institute for Reactor Research), now the Paul Scherrer Institut, in Würenlingen, Switzerland. From 1975 to 1981, he was an assistant professor and an associate professor of nuclear engineering at Oregon State University. From 1981 to 1982, he was a Visiting Scientist at the EURATOM Joint Research Centre in Ispra, Italy.

At Texas A&M University, Dr. Peddicord has served as Head of the Department of Nuclear Engineering, Associate Dean and Interim Dean of the College of Engineering, Associate Vice Chancellor and Vice Chancellor of The Texas A&M University System for Research and Federal Relations. Since 2007, he has been the Director of NPI, a joint institute of the Texas Engineering Experiment Station and Texas A&M University. NPI is a partnership involving universities, community colleges, industry, high schools and junior highs, teachers, students, elected and civic leaders, and government agencies. The focus is to inform, attract, and prepare students for the nuclear industry.

Dr. Peddicord has published more than 200 articles, papers, and reports. His technical interests include nuclear engineering education, human resources and nuclear workforce development, and advanced nuclear fuels. He is a licensed Professional Engineer in the State of Texas.

Dr. Peddicord received a B.S. degree in mechanical engineering from the University of Notre Dame in 1965 and an M.S. in 1967 and a Ph.D. in 1972 in nuclear engineering from the University of Illinois at Urbana-Champaign.

Dr. Peddicord resides in College Station, Texas.

## **Paul J. Turinsky, Ph.D.**

Dr. Paul J. Turinsky was appointed to the U.S. Nuclear Waste Technical Review Board by President Barack Obama on September 25, 2012. Dr. Turinsky was reappointed to the Board by the President on July 1, 2014.

Dr. Turinsky is a professor of nuclear engineering at North Carolina State University in Raleigh, North Carolina. He also is the Chief Scientist for the Department of Energy's (DOE) Innovation Hub for Modeling and Simulation of Nuclear Reactors.

Dr. Turinsky's areas of expertise are computational reactor physics in support of mathematical optimization of fuel management and nuclear fuel-cycle multiobjective decisions; uncertainty quantification and data assimilation in support of optimum experimental design applied to nuclear power plant safety and fuel-cycle assessments; and adaptive model refinement applied to nuclear power plant transient simulation.

Dr. Turinsky's writings and publications include contributions to three books and numerous peer-reviewed technical publications. He is the recipient of the American Society for Engineering Education Glenn Murphy Award, Edison Electric Institute Power Engineering Educator Award, the US DOE E.O. Lawrence Award in Atomic Energy, and American Nuclear Society (ANS) Eugene P. Wigner Reactor Physics Award and Arthur Holly Compton Award.

Dr. Turinsky has been on the faculty of Rensselaer Polytechnic Institute and has held engineering and management positions at Westinghouse Electric Corporation. He also has served on the Commissariat à l'énergie Atomique Scientific Committee of the Nuclear Energy Division, Duke Power Company Nuclear Safety Review Board, DOE Fuel Cycle R&D External Review Committee, and Board of Managers of Battelle Energy Alliance.

Dr. Turinsky is a fellow of the ANS and a member of the Society for Industrial and Applied Mathematics, the American Society for Engineering Education, and the American Association for the Advancement of Science.

Dr. Turinsky received a B.S. (1966) in chemical engineering from the University of Rhode Island, an M.S.E. (1967) and a Ph.D. (1970) in nuclear engineering from the University of Michigan, and an M.B.A. (1979) from the University of Pittsburgh.

Dr. Turinsky resides in Raleigh, North Carolina.

## **Mary Lou Zoback, Ph.D.**

Dr. Mary Lou Zoback was appointed to the U.S. Nuclear Waste Technical Review Board by President Barack Obama on September 25, 2012.

Dr. Zoback is a seismologist and a consulting professor in the Geophysics Department at Stanford University. From 2006 to 2011, she was Vice President for Earthquake Risk Applications with Risk Management Solutions, a private catastrophe-modeling firm serving the insurance industry. In that role, she utilized the company's commercial risk models to explore the societal role of earthquake insurance and to quantify the costs and benefits of risk reduction. She previously was a senior research scientist at the U.S. Geological Survey in Menlo Park, California, where she served, among other positions, as Chief Scientist of the Western Earthquake Hazards team. Her research interests include the relationship between active faulting, deformation and state of stress in the earth's crust, quantifying earthquake likelihood, and characterizing natural-hazard risk.

Dr. Zoback has served on numerous national committees and panels on topics ranging from increasing the nation's resilience to disasters, defining the next generation of Earth observations from space, storage of high-level radioactive waste, facilitating interdisciplinary research, and science education. From 1997 to 2000, she was a member of the National Research Council's Board on Radioactive Waste Management.

In 2007, she received from the Geological Society of America (GSA) both the Day Medal "for outstanding distinction in contributing to geologic knowledge through the application of physics and chemistry to the solution of geologic problems" and their Public Service Award. In 2002, she was awarded the Department of Interior Meritorious Service Award, and in 1987, she received the James B. Macelwane Award of the American Geophysical Union (AGU) for "significant contributions to the geophysical sciences by a young scientist of outstanding ability."

In 1995, Dr. Zoback was elected a member of the U.S. National Academy of Sciences (NAS). She is a member of the AGU and the Seismological Society of America and is a past president of GSA. Dr. Zoback also is past chair of the Advisory Committee for San Francisco's Community Action Plan for Seismic Safety (CAPSS) program. She is a member of the NAS Disaster Roundtable and the Advisory Committee for the National Earthquake Hazard Reduction Program.

Dr. Zoback received a Ph.D. in 1978, an M.S. in 1975, and a B.S. in 1974, all in geophysics and all from Stanford University.

Dr. Zoback resides in Stanford, California.

**FORMER MEMBERS**  
OF THE  
**U.S. NUCLEAR WASTE TECHNICAL REVIEW BOARD**  
*Who Served During the Period Covered by This Report*<sup>2</sup>

B. John Garrick, Ph.D., P.E., Chairman

Mark D. Abkowitz, Ph.D.

William Howard Arnold, Ph.D., P.E.

Thure E. Cerling, Ph.D.

David J. Duquette, Ph.D.

George M. Hornberger, Ph.D.

Andrew C. Kadak, Ph.D.

Ronald M. Latanision, Ph.D.

Ali Mosleh, Ph.D.

William M. Murphy, Ph.D.

Henry Petroski, Ph.D, P.E.

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<sup>2</sup> Full biographies of former Board members who served during the period covered by this report can be found in the Board's Report to the U.S. Congress and the Secretary of Energy, issued in September 2008. The report is available on the Board's website at [www.nwtrb.gov](http://www.nwtrb.gov)





## **APPENDIX B**

# **U.S. NUCLEAR WASTE TECHNICAL REVIEW BOARD STRATEGIC PLAN – FISCAL YEARS 2011-2016<sup>1</sup>**

<sup>1</sup>The Board's Strategic Plan was revised in March 2014. It is available on the Board's website: [www.nwtrb.gov](http://www.nwtrb.gov)





# **U.S. NUCLEAR WASTE TECHNICAL REVIEW BOARD STRATEGIC PLAN**

**FISCAL YEARS 2011-2016**

**REVISED SEPTEMBER 13, 2010**



# U.S. Nuclear Waste Technical Review Board Strategic Plan

FY 2011-2016

## Mission

The U.S. Nuclear Waste Technical Review Board was established in the 1987 amendments to the Nuclear Waste Policy Act (NWPA) to "...evaluate the technical and scientific validity of activities [for managing and disposing of spent nuclear fuel and high-level radioactive waste] undertaken by the Secretary [of Energy], including

- (1) site characterization activities; and
- (2) activities relating to the packaging or transportation of high-level radioactive waste or spent nuclear fuel."

As set forth in the legislative history, the purpose of the Board is to provide independent expert advice to Congress and the Secretary on technical issues and to review the technical validity of the U.S. Department of Energy's (DOE) implementation of the NWPA (P.L. 97-145, as amended). In accordance with this mandate, the Board conducts an objective, ongoing, and integrated technical peer review of DOE activities related to the management, transportation, packaging, storage, and disposal of commercial spent nuclear fuel and of DOE-owned spent nuclear fuel and high-level radioactive waste. The Board reports its findings, conclusions, and recommendations to Congress and the Secretary at least twice yearly.

## Vision

By performing ongoing and independent technical and scientific peer review of the highest quality, the Board makes a unique and essential contribution to increasing confidence in the technical validity of DOE activities related to the management and disposition of spent nuclear fuel and high-level radioactive waste. The Board provides technical and scientific information to decision-makers in Congress, the Administration, DOE, and the public on the full range of technical issues related to the management and disposition of such waste.

## Values

The Board conducts its technical and scientific peer review according to the following values:

- Board members have no real or perceived conflicts of interest related to the Board's mission.
- Board findings and recommendations are based on objective and unbiased evaluations of the technical and scientific validity of the Secretary's activities.
- The Board's deliberations are transparent and conducted in such a way that its integrity and objectivity are above reproach.

- The Board's findings, conclusions, and recommendations are technically and scientifically sound and are based on the best available technical analysis and information.
- The Board's findings, conclusions, and recommendations are communicated clearly and in time for them to be most useful to Congress, the Secretary, and the public.
- The Board encourages public comment and discussion of DOE activities and Board findings, conclusions, and recommendations.

## Members

The Board is composed of 11 members who are appointed by the President from a list of nominees submitted by the National Academy of Sciences (NAS). Nominees to the Board must be eminent in a field of science or engineering and are selected solely on the basis of established records of distinguished service. The Board is nonpartisan and apolitical. By law, no nominee to the Board may be an employee of DOE, a National Laboratory under contract to DOE, or an entity performing high-level radioactive waste or spent nuclear fuel activities under contract to DOE.

## Powers

The law grants significant investigatory powers to the Board. 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. At the request of the Board and subject to existing law, DOE is required to provide all records, files, papers, data, and information necessary for the Board to conduct its technical review, including drafts of work products and documentation of work in progress. According to the legislative history, Congress provided such access with the expectation that the Board will review and comment on DOE decisions, plans, and actions as they occur, not after the fact.

## Continuing Role

For 20 years, DOE focused on developing a deep geologic repository for the permanent disposal of spent nuclear fuel and high-level radioactive waste at Yucca Mountain in Nevada. In January 2010, Secretary of Energy Steven Chu appointed a Blue Ribbon Commission on America's Nuclear Future (BRC) that was established to consider alternatives for managing the back end of the nuclear fuel cycle. At approximately the same time, DOE petitioned the Nuclear Regulatory Commission (NRC) for permission to withdraw the license application (LA) for constructing a repository for disposal of spent nuclear fuel and high-level radioactive waste at Yucca Mountain.

Even as new options for managing nuclear waste are evaluated, DOE continues to have responsibility under the NWPAA for the management and disposition of DOE-owned spent nuclear fuel and high-level radioactive waste and for the disposition of spent nuclear fuel from commercial reactors. Similarly, the Board's statutory responsibility for conducting ongoing technical peer review of DOE's nuclear waste management and disposition activities and for advising Congress and the Secretary on the technical and scientific validity of those activities remains unchanged.

## Strategic Goals

Given the Board's ongoing peer review role, the Board's overarching strategic goals are the following:

- The Board will perform ongoing and objective technical and scientific peer review of DOE activities related to the management, packaging, transportation, storage, and disposition of spent nuclear fuel and high-level radioactive waste.
- The Board will make findings and recommendations that are based on its ongoing peer review related to the technical and scientific validity of DOE activities.
- The Board will report its findings and recommendations to Congress and the Secretary and will provide technical and scientific information to policy-makers to help inform decision-making and increase confidence in the validity of the technical and scientific process.

## Performance Goals for FY 2011-2016

To accomplish its strategic goals, the Board has established three performance goals for fiscal years (FY) 2011-2016. The performance goals refocus the work of the Board to reflect plans, discussed in DOE's FY 2011 budget justification document, for transitioning activities related to DOE obligations under the NWPAs from the Office of Civilian Radioactive Waste Management (DOE-RW) to the Office of Nuclear Energy (DOE-NE). The performance goals also reflect the Board's continuing evaluation of activities undertaken by the Office of Environmental Management (DOE-EM) related to DOE-owned spent nuclear fuel and high-level radioactive wastes that require treatment, storage, and eventual disposal. The Board has the necessary authority, under current law, to achieve its performance goals.

During FY 2011-2016, the Board will do the following:

- Compile objective technical information required to perform its technical review of DOE nuclear waste management activities and to advise Congress and the Secretary on the technical implications of alternatives for nuclear waste management.
- Continually update and report on Board experience with the U.S. nuclear waste program and programs in other countries.
- Review and report on the technical and scientific validity of DOE activities related to implementation of the NWPAs, including the activities transitioning from the DOE-RW to DOE-NE and DOE-EM.

## Achieving the Performance Goals

**Priority Goals.** For each performance goal, shorter-term "priority goals" have been established and are expected to be completed by the end of FY 2012. The priority goals are discussed in more detail in the Board's performance budget for FY 2012. The Board will evaluate its performance in achieving the priority goals in its performance budget and will update them as appropriate.

**Board Panels.** The Board maintains the option of organizing panels and working groups that correspond with its performance and priority goals to help facilitate and focus its technical review.

**Information Gathering.** Much of the Board's peer review and information gathering takes place at open public meetings where technical information is presented according to an agenda prepared by the Board. At the meetings, Board members and staff question presenters, and time is provided for comments from interested members of the public. The Board typically holds two or three public meetings each year. Board panels and smaller groups of Board members and staff meet, as needed, to investigate specific technical topics. The Board's public meetings are announced in the *Federal Register* four to six weeks before the meetings are held.

The Board also gathers information from site visits, visits to National Laboratories and facilities, and meetings with individuals working on specific projects and programs. Board members and staff attend national and international symposia and conferences related to the science and technology of nuclear waste management and disposition. From time to time, Board members and staff visit other countries to meet with organizations involved in the management of spent nuclear fuel and high-level radioactive waste to review best practices, perform benchmarking, and assess potential analogs.

**Technical Analysis.** Technical information is analyzed by Board members with assistance from a full-time senior professional staff. When necessary, the Board is authorized to hire expert consultants to perform in-depth reviews of specific technical and scientific topics. On the basis of the analyses, the Board reports its findings and recommendations to Congress and the Secretary of Energy. Board reports, testimony, correspondence and meeting agendas, transcripts, presentations, and public comments are posted on the Board's Web site at [www.nwtrb.gov](http://www.nwtrb.gov).

## Crosscutting Functions

Many agencies, organizations, and entities are involved in some aspect of managing spent nuclear fuel and high-level radioactive waste, including, but not limited to, Congress, DOE, the BRC, the NRC, the Environmental Protection Agency (EPA), the Department of Transportation, the NAS, the Government Accountability Office, the State of Nevada and affected units of local governments in Nevada and California, the National Association of Utility Commissioners, the National Governors' Association and regional governors' groups, the National Conference of State Legislatures, the Nuclear Energy Institute, the Electric Power Research Institute, and environmental organizations, such as the Natural Resources Defense Council.

The Board's technical evaluation is at once different from and complementary to the activities of most of these groups in that the Board is (1) unconstrained by any stake, beyond technical and scientific credibility, in the outcome of the activities it reviews, (2) limited by its statutory mandate to reviewing the technical and scientific validity of DOE activities (not the policy implications or regulatory compliance), and (3) a permanent independent federal agency whose members are appointed by the President.

## Key External Factors

As discussed below, some factors that are outside the Board's control can alter nuclear waste policy and could require the Board to revise its strategic goals to enable it to fulfill its mandated responsibilities.

- *The Board has no authority to implement its recommendations.* The Board is, by statute, a technical and scientific peer-review body that makes findings and recommendations. According to the legislative history, Congress expected that DOE would accept Board recommendations or indicate why the recommendations could not or should not be implemented. However, the statute does not obligate DOE to comply with Board recommendations. If DOE does not accept a Board recommendation, the Board can advise Congress, reiterate its recommendation to DOE, or both.
- *Funding levels may not be consistent or adequate.* Funding constraints can affect the Board's ability to conduct its comprehensive review of DOE activities and provide technical and scientific findings and recommendations to Congress and the Secretary. Funding levels and allocation decisions also affect the kinds and extent of activities undertaken by DOE that are subject to the Board's ongoing technical and scientific review.
- *Administrative, judicial, or legislative actions may alter nuclear waste policy.* As discussed in an earlier section, in the last year, DOE has petitioned NRC to withdraw the LA for constructing a repository at Yucca Mountain in Nevada, and a decision by NRC is expected soon. Court challenges to DOE's decision to withdraw the LA already have been filed, and more can be expected once NRC makes a final decision on DOE's petition. Many DOE activities related to its obligations under the NWPA are transitioning from DOE-RW to DOE-NE, while others remain with DOE-EM. The BRC was established to consider alternatives for managing the back-end of the nuclear fuel cycle, and, if implemented, the BRC recommendations may be expected to change further national policy on nuclear waste management.

The Board's ongoing technical peer review is especially important in enhancing confidence in the technical and scientific process during periods of uncertainty. The Board will continue to 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

To measure its performance in a given year, for each priority goal, the Board considers the following criteria:

1. Did the Board undertake the activities needed to complete the priority goal effectively and efficiently?
2. Did the Board complete its review of DOE's work on schedule and at reasonable cost?
3. Were the findings and recommendations associated with the priority goal communicated in a timely, understandable, and appropriate way to Congress, the Secretary of Energy, and the public?

Progress in meeting the priority goals will be evaluated quarterly, and adjustments will be made, as necessary. At the end of the fiscal year, the Board's success in meeting each of the performance criteria will be measured on a numerical scale of 1 to 5, with 1 being minimally successful and 5 being fully successful. Each priority goal will be given an overall performance measure based on the sum for the three criteria. The Board will use the evaluation of its performance as input in developing its annual performance goals and performance budget for subsequent years. The results of the Board's annual performance evaluations are included in its summary reports.

## **Transparency**

In developing its Strategic Plan for FY 2011-2016, the Board consulted with the Office of Management and Budget and will solicit comment from Congress, the Department of Energy, and members of the public. Copies of the strategic plan will be provided to NRC, NAS, and other interested parties and will be posted on the Board's Web site for a 90-day comment period. After incorporating comments, the final plan will be posted on the Board's Web site.



# **APPENDIX C**

## **NUCLEAR WASTE TECHNICAL REVIEW BOARD PUBLICATIONS**



***Nuclear Waste Assessment System for Technical Evaluation (NUWASTE): Status and Initial Results.***

June 2011.

The report describes work being performed by the Board to evaluate the effects on the management of spent nuclear fuel and high-level radioactive waste of various fuel-cycle options being considered by the U.S. Department of Energy (DOE). Of particular interest to the Board are the types and quantities of the radioactive waste streams that would be generated. The Board has developed a computer-based systems analysis tool (NUWASTE) to support its technical evaluation of DOE activities in this area. Included in the report are initial findings from NUWASTE analyses.

***Technical Advancements and Issues Associated with the Permanent Disposal of High-Activity Wastes: Lessons Learned from Yucca Mountain and Other Programs.***

June 2011.

The purpose of this report is to extract knowledge while it is still available from experiences to date of the Yucca Mountain deep geologic repository program and other management programs for high-activity waste. In this report, the Board examines from a technical perspective the history of the Yucca Mountain program and some other nuclear waste programs and discusses technical information and insights that may be useful for future U.S. high-activity waste management and disposal efforts.

***Experience Gained from Programs to Manage High-Level Radioactive Waste and Spent Nuclear Fuel in the United States and Other Countries.***

April 2011.

This report explores the efforts of 13 nations to find a permanent solution for isolating high-level radioactive waste and spent nuclear fuel generated within their borders. It builds on information in the Board's 2009 *Survey of National Programs for Managing High-Level Radioactive Waste and Spent Nuclear Fuel*. Unlike the earlier document, however, this report describes the programs and their histories and discusses inferences that can be drawn from their experiences.

***Evaluation of the Technical Basis for Extended Dry Storage and Transportation of Used Nuclear Fuel - Executive Summary.***

December 2010.

This report was prepared to inform DOE and Congress about the current state of the technical basis for extended dry storage of used nuclear fuel and its transportation following storage.

***Evaluation of the Technical Basis for Extended Dry Storage and Transportation of Used Nuclear Fuel.***

December 2010.

This report reviews available public literature on storage and handling of used nuclear fuel related to the safety of extended-term dry storage and subsequent transportation of U.S. commercial used nuclear fuel after long storage periods.

***Survey of National Programs for Managing High-Level Radioactive Waste and Spent Nuclear Fuel.***

October 2009.

The report describes 30 technical and institutional attributes of nuclear waste programs in 13 countries. It does not make judgments; rather the report provides factual information for Congress and the Secretary that can be used for evaluating waste management options.

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

October 27, 2009.

This letter report updates Congress and the Secretary of Energy on the U.S. Nuclear Waste Technical Review Board's mission, continuing role, and refocused goals as the U.S. approach to managing spent nuclear fuel and high-level radioactive waste (HLW) is evolving.

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

September 2008.

Between March 1, 2006, and December 31, 2007, the period covered by this report, the Board focused its evaluation on five critical technical issues dealing with preclosure operations of the waste management system and on six critical technical issues dealing with post-closure performance of the proposed Yucca Mountain repository. The Board also explored in depth the crosscutting issue of thermal management. The Board's views on these issues are summarized below and are explained in greater detail in the body of this report.

***Technical Evaluation of U.S. Department of Energy Yucca Mountain Infiltration Estimates: A Report to Congress and the Secretary of Energy.***

December 2007.

In this report, the U.S. Nuclear Waste Technical Review Board presents its evaluation of revised DOE estimates of water infiltration at Yucca Mountain. The infiltration estimates were revised because violations of quality assurance procedures were alleged to have been committed by U.S. Geological Survey employees involved in gathering and analyzing infiltration data at Yucca Mountain in the 1990s.

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

January 2007.

This report contains summaries of Board findings and recommendations contained in the following: letters to the Director of the Office of Civilian Radioactive Waste Management (OCRWM) following Board meetings held in February, May, and September 2006, a letter and enclosures sent to the Director of OCRWM following a Board workshop on deliquescence-induced localized corrosion in September 2006, and testimony presented in May 2006 by the Board's Chairman before the Senate Energy and Natural Resources Committee.

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

June 2006.

In this report, the Board summarizes its major activities from January 1, 2005, through February 28, 2006. During that period, the Board focused its attention on the Project's efforts to develop post-closure performance estimates for the repository it proposes to construct at Yucca Mountain in Nevada. Correspondence and related materials are included in the appendices to the report along with the Board's strategic plan for fiscal years 2004-2009, its performance plans for fiscal years 2005-2006, and its performance evaluation for 2005.

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

December 2005.

In this letter report to Congress and the Secretary of Energy, the Board presents its views on the status of some important issues related to the technical basis for DOE activities related to the waste management system, the engineered system, the natural system, the repository system, and the assessment of the performance of the systems. The Board also outlines issues that it expects may continue to be of interest in the future.

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

May 2005.

In this report, the Board summarizes its major activities from January 1, 2004, through December 31, 2004. During that period, the Board focused on the Department of Energy's efforts to develop a system for accepting, transporting, and handling high-level radioactive waste and spent nuclear fuel before disposal in the repository proposed for Yucca Mountain. Correspondence and related materials are included in the appendices to the report along with the Board's strategic plan for fiscal years 2004-2009, its performance plans for 2005, and its performance evaluation for 2004.

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

December 2004.

This letter and enclosure comprise the Board's second report to Congress and the Secretary of Energy for calendar year 2004. The letter briefly summarizes areas where the Board believes the DOE has made progress, areas requiring attention, and the Board's priorities for the coming year. The enclosure contains a more detailed discussion of these topics.

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

May 2004.

In this report, the Board summarizes its major activities from January 1, 2003, through December 31, 2003. During that period, the Board continued its evaluation and held meetings on a range of technical and scientific issues, including seismicity, DOE plans for transporting spent nuclear fuel and high-level radioactive waste, the design and operation of facilities at the proposed repository site, performance-confirmation activities, and the potential for localized corrosion. Correspondence and related materials are included in the appendices to the report along with the Board's strategic plan for fiscal years 2004-2009, its performance plans for 2004 and 2005, and its performance evaluation for 2003.

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

December 19, 2003.

This letter and attachments constitutes the Board's second report to Congress and the Secretary of Energy for calendar year 2003. This letter 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.

***Board Technical Report on Localized Corrosion.***

November 25, 2003.

Technical report supporting Board conclusions in 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 strategic plan for fiscal years 2003-2008, its performance plans for FY 2003 and FY 2004, and its performance evaluation for FY 2002.

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

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.

***Letter report 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.

***Proceedings from an International Workshop on Long-Term Extrapolation of Passive Behavior, July 19-20, 2001, Arlington, Virginia.***

December 2001.

The Board conducted a workshop on issues related to predicting corrosion behavior for periods of unprecedented duration. The workshop was held on July 19 and 20, 2001, in Arlington, Virginia. The workshop consisted of a panel of 3 Board members and 14 internationally recognized corrosion scientists, 8 of whom were from outside the United States. Following the workshop, most panelists submitted brief papers giving their views on issues related to predicting very long term corrosion. This publication is a compilation of those submissions.

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

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 the 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 longterm 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.

***Board Completes Review of Material on Hydrothermal Activity.***

July 24, 1998.

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

***1997 Findings and Recommendations.***

April 1998.

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

***Report by Letter to the Secretary of Energy and the Congress.***

December 23, 1997.

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

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

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 Nuclear Regulatory Commission.

Appendices include information on Board members, the organization of the Board's panels, meetings held in 1996 and scheduled for 1997, the DOE's responses to previous Board recommendations, a list of Board publications, references for the report, and a glossary of technical terms.

***Nuclear Waste Management in the United States - The Board's Perspective.***

June 1996.

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

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

April 1996.

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

***Disposal and Storage of Spent Nuclear Fuel - Finding the Right Balance.***

March 1996.

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

***Report by Letter to the Secretary of Energy and the Congress.***

December 13, 1995.

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

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

March 1995.

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

issues. The Board also details its observations from its visit to Japan and the Japanese nuclear waste disposal program. Findings and recommendations in the report centered around structural geology and geoengineering, hydrogeology and geochemistry, the engineered barrier system, and risk and performance analysis.

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

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

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

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

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

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

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

March 1993.

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

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

December 1992.

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

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

June 1992.

The Board's fifth report focuses on the cross-cutting issue of thermal loading. It explores thermal-loading strategies (U.S. and others) and the technical issues and uncertainties related to thermal loading. It also details the Board's position on the implications of thermal loading for the U.S. radioactive waste management system.

Also included are updates on Board and panel activities during the reporting period. The report offers fifteen recommendations to the DOE on the following subjects: ESF and repository design enhancements, repository sealing, seismic vulnerabilities (vibratory ground motion and fault displacement), the DOE approach to the engineered barrier system, and transportation and systems program status.

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

December 1991.

The fourth report provides update on the Board's activities and explores in depth the following areas: exploratory studies facility (ESF) construction; test prioritization; rock mechanics; tectonic features and processes; volcanism; hydrogeology and geochemistry in the unsaturated zone; the engineered barrier system; regulations promulgated by the Environmental Protection Agency, the Nuclear Regulatory Commission (NRC), and the DOE; the DOE performance assessment program; and quality assurance in the Yucca Mountain project. Ten recommendations are made across these diverse subject areas. Chapter 3 offers insights from the Board's visit with officials from the Canadian nuclear power and spent fuel disposal programs. Background on the Canadian program is in Appendix D.

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

May 1991.

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

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

November 1990.

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

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

March 1990.

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





**APPENDIX D**  
**U.S. NUCLEAR WASTE TECHNICAL REVIEW BOARD**  
**TESTIMONY**



- **Statement of Dr. B. John Garrick, Chairman, U.S. Nuclear Waste Technical Review Board**  
July 15, 2008  
Presented to the Subcommittee on Energy and Air Quality Committee on Energy and Commerce; United States House of Representatives
- **Summary of Statement of Dr. B. John Garrick, Chairman, U.S. Nuclear Waste Technical Review Board**  
July 15-16, 2008  
Presented to the Subcommittee on Energy and Air Quality
- **Summary and Statement of Dr. Daniel S. Metlay, Senior Professional Staff; U.S. Nuclear Waste Technical Review Board**  
June 7, 2012  
Presented to the Subcommittee on Clean Air and Nuclear Safety Committee on Environment and Public Works; United States Senate

**Statement of Dr. B. John Garrick, Chairman  
U.S. Nuclear Waste Technical Review Board  
Before the  
Subcommittee on Energy and Air Quality  
Committee on Energy and Commerce  
United States House of Representatives  
July 15, 2008**

Mr. Chairman and members of the Subcommittee, good morning. My name is John Garrick. I am Chairman of the U.S. Nuclear Waste Technical Review Board. The 11 part-time members of the Board are appointed by the President and most of us have other occupations. In my case, I am a consultant specializing in the application of the risk sciences to complex technological systems in the space, defense, chemical, marine, and nuclear fields. I am pleased to represent the Board at this hearing on “progress toward opening a storage facility for high-level civilian nuclear waste at Yucca Mountain in Nye County, Nevada.”

As has been discussed, Mr. Chairman, after many years of characterizing Yucca Mountain for its suitability as the proposed site for a deep geologic repository for the permanent disposal of spent nuclear fuel and high-level radioactive waste, the Department of Energy (DOE) recently submitted a license application to the Nuclear Regulatory Commission (NRC). This action represents the achievement of a major program milestone. The questions asked by the Subcommittee in its invitation letter about what happens next are very timely. The questions are paraphrased in my written statement, and I will do my best to present the Board’s answers to the questions as directly and succinctly as possible.

***What is the timing of decisions on the license application?***

NRC will address the adequacy of DOE's license application in relation to NRC regulations and will determine whether the proposed repository complies with whatever repository radiation standard is ultimately promulgated by the Environmental Protection Agency. The NRC is therefore in a better position to respond to questions about the timeline for decisions on a license application.

***What is the Board's role going forward?***

The Board's congressional mandate, set forth in the 1987 amendments to the Nuclear Waste Policy Act (NWPA), is to perform an unbiased ongoing peer review of the technical and scientific validity of DOE activities related to implementing the NWPA. Because the Board is completely independent, it does not have a direct stake in the development of a Yucca Mountain repository and will not be a party to the licensing proceeding. That is as it should be.

In carrying out its technical peer review, the Board takes an integrated view of the many diverse components of the DOE program and focuses on fundamental understanding as opposed to regulatory compliance. Using the extensive scientific and engineering expertise of its members, the Board evaluates the technical basis of DOE's approach to the entire waste management system, from waste acceptance (i.e., handling of waste at generation sites) through transportation and isolation of spent nuclear fuel and high-level radioactive waste at Yucca Mountain. The Board provides an integrated technical assessment of whether the waste management system will work, based on answers to the following questions:

- Will DOE (or any managing entity) be able to effectively implement the design and fabrication of waste packages; accept spent nuclear fuel at reactor sites or high-level

radioactive waste at federal facilities; transport the waste to the repository; perform necessary surface operations at the repository site, including storage; and emplace waste packages and other engineered barriers underground?

- How strong is the technical basis supporting DOE's assessment that the repository system, including the natural and engineered barriers, will perform as planned?

The Board attempts to make its body of technical work available to the public. For example, most of the Board's public meetings are held in Nevada. The Board reports its findings and recommendations regularly to Congress and the Secretary of Energy. Finally, Board documents, including letters, reports, congressional testimony, and meeting transcripts, are posted on the Board's Web site at [www.nwtrb.gov](http://www.nwtrb.gov). Anyone can use this information, including parties involved in NRC's licensing proceedings.

Going forward, based on its ongoing technical review the Board will continue to make recommendations to DOE on designing and implementing a safe and effective waste management system, including a permanent repository. We hope that Congress will find the Board's technical findings and recommendations useful as context for policy decisions about radioactive waste management.

***What are the outstanding technical issues that could potentially cause delay or increase the costs associated with developing a repository?***

Mr. Chairman, as part of its ongoing evaluation, the Board has identified several priority technical issues that if addressed could increase operational effectiveness or feasibility, enhance the technical basis for repository performance estimates, or improve fundamental understanding. Before I present examples of the technical issues, Mr. Chairman, I want to make clear that the Board's identification of these issues should not be construed as comment on the sufficiency of DOE's license application; NRC will make that determination. Furthermore, the Board's

systematic review of DOE activities did not uncover any issue that it believes would have prevented DOE from submitting its license application for regulatory review.

I will begin by commenting on issues related to the first component of the waste management system: preclosure operations.

#### *Preclosure Operational Issues*

Several operational and design issues identified by the Board could significantly affect funding requirements and schedules.

First, DOE has designed its waste management system around a canister system that can be used for transportation, aging, and disposal (TAD) of spent nuclear fuel. The Board believes that the TAD concept may have merit. However, a smaller TAD that could be transported by truck does not currently exist. DOE representatives confirmed at a Board meeting held in January that developing a waste management system using TADs makes the Nevada rail line necessary. DOE also has acknowledged in correspondence to the Board that constructing a Nevada rail line may present significant institutional challenges. The Board therefore has recommended that DOE initiate contingency planning to identify alternatives that can be implemented if significant delays are encountered during construction of the rail line to Yucca Mountain.

Second, DOE has established requirements for a TAD-based repository design assuming that 90 percent of commercial spent nuclear fuel will arrive at the repository in TAD canisters. However, utilities may need incentives to use TADs, and some nuclear power plants appear to lack the necessary infrastructure for handling the large TAD canisters. If TAD utilization falls below the planned 90 percent, the lower utilization rate could adversely affect surface facility throughput. It also may require constructing additional waste handling facilities or increasing the amount of spent nuclear fuel that must be placed in storage at the repository site, thus reducing the rate of waste emplacement into the repository. The Board recommends that DOE consider

operational and design contingencies that could be implemented if TAD utilization rates are significantly lower than the 90 percent utilization currently assumed, including an analysis of the effects of direct disposal of dual-purpose canisters.

Third, repository performance estimates included in DOE's total system performance assessment (TSPA) depend on functioning drip shields to prevent water and rocks from falling on waste packages. However, DOE assumptions about drift degradation and repository tunnel tolerances may make installation of the drip shields, as currently designed, problematic.

#### *Issues Affecting Repository Performance Estimates*

Examples of technical issues that could affect calculated repository performance estimates are the potential for the occurrence of deliquescence-induced localized corrosion of the waste packages during the thermal pulse, questions about the rates of general corrosion of waste packages, and the magnitude and variability of water recharge that occurs as a result of climate change. The Board also will continue to follow DOE's ongoing scientific investigations of seismicity and volcanism at Yucca Mountain. It is very likely that many of these issues will be addressed during licensing. In any case, the Board believes that addressing these issues is feasible and could reduce uncertainty and strengthen the technical basis for DOE's repository performance estimates.

Mr. Chairman, we can report that DOE has made very significant progress over the last several years in enhancing the technical basis for the assumptions and analyses supporting its repository performance estimates in the TSPA used in the license application. As can be expected, however, for time periods of up to one million years, some uncertainty related to estimates of repository performance are inevitable.

Deciding on the best way to address such uncertainties can be challenging. DOE has addressed uncertainties by making conservative assumptions and using probabilistic representations of performance indicators. In its letters and reports, the Board has suggested design changes, contingency planning, and additional research as ways of addressing uncertainties. Different approaches require different time and resource commitments. The Board will continue to evaluate the possible use of all of these methods to achieve defensible technical assessments.

***Does the Board have any recommendations related to nuclear legislation or policy?***

Mr. Chairman, the Board historically has not recommended changes in legislation or policy because it views its role as providing needed technical context and information for decision-makers. The Board is very comfortable with its statutory mandate and takes its mission very seriously. The Board looks forward to continuing its independent technical peer review, as described earlier in my statement.

On behalf of the Board members, I thank the Subcommittee for inviting us to participate in this hearing. We hope that the information we have furnished today will be useful.

I will be pleased to respond to your questions.

**Summary of Statement of Dr. B. John Garrick, Chairman  
U.S. Nuclear Waste Technical Review Board Before  
the Subcommittee on Energy and Air Quality July  
15-16, 2008**

- The Board's role was established in the Nuclear Waste Policy Amendments Act of 1987. The Board is expected to perform ongoing peer review of the technical and scientific validity of DOE activities related to implementing the Nuclear Waste Policy Act. The Board reports its findings and recommendations at least twice a year to Congress and the Secretary of Energy.
- The Department of Energy's (DOE) submittal of a Yucca Mountain license application to the Nuclear Regulatory Commission (NRC) represents the achievement of a major program milestone.
- Because the Board is completely independent, it does not have a direct stake in the development of a Yucca Mountain repository and will not be a party to the licensing proceeding. That is as it should be.
- Focusing on fundamental understanding as opposed to regulatory compliance, the Board evaluates the technical basis of DOE's approach to the entire waste management system, from waste acceptance through transportation and isolation of spent nuclear fuel and high-level radioactive waste as proposed at Yucca Mountain.
- The Board makes its technical evaluation available by posting Board documents, including letters, reports, congressional testimony, and meeting transcripts, on its Web site at [www.nwtrb.gov](http://www.nwtrb.gov). Anyone can use this information, including parties involved in NRC's licensing proceedings.
- The Board has identified several technical issues that if addressed could increase operational effectiveness or feasibility, enhance the technical basis for repository performance estimates, or improve fundamental understanding. The Board did not uncover any issue that it believes would have prevented DOE from submitting its license application for regulatory review.
- Operational issues identified by the Board include developing contingencies in case of (1) delay in the development of a Nevada rail spur, (2) lower rate of TAD utilization, and (3) potential problems related to drip shield installation.
- Technical issues that might affect calculated repository performance estimates are deliquescence-induced localized corrosion of the waste packages during the thermal pulse, general corrosion of waste packages, and water recharge that results from climate change. DOE also is investigating seismicity and volcanism at Yucca Mountain.
- DOE has made very significant progress over the last several years, but given the million-year timeframe, some uncertainty in repository performance estimates is inevitable. Uncertainty can be addressed in several ways, and different approaches require different time and resource commitments.
- The Board is very comfortable with its statutory mandate and looks forward to continuing its independent technical peer review.

**Summary**  
**Statement of Dr. Daniel S. Metlay,**  
**Senior Professional Staff**  
**U.S. Nuclear Waste Technical Review Board**  
**Before the**  
**Subcommittee on Clean Air and Nuclear Safety**  
**Committee on Environment and Public Works**  
**United States Senate**  
**June 7, 2012**

- *The U.S. Nuclear Waste Technical Review Board* was created in the 1987 amendments to the Nuclear Waste Policy Act to provide an ongoing and independent technical and scientific evaluation of activities undertaken by the Secretary of Energy related to implementing the Nuclear Waste Policy Act.
- *Site-selection strategies* for a deep-mined geologic repository involve two “filters,” one consisting of technical requirements and the other consisting of nontechnical considerations. The two filters can be applied in any order, although the suite of sites eventually selected may be different.
- *The Nuclear Waste Policy Act, passed in 1982*, provided for two repositories, one that presumably would be in the western U.S. and another presumably one in the east. Three western sites were to be characterized simultaneously to assess their suitability as the location of the first repository. After the second repository program was suspended in 1986, Congress amended the Nuclear Waste Policy Act in 1987. Among other things, the amendments act identified one of the western sites, Yucca Mountain in Nevada, as the sole site to be characterized for the first repository. The Department of Energy (DOE) recommended the Yucca Mountain site to President George W. Bush in 2002, and Congress overturned a veto by the State of Nevada of the site recommendations later that year. In 2008, DOE submitted a license application for the Yucca Mountain repository to the U.S. Nuclear Regulatory Commission. DOE requested withdrawal of the license application in 2010. A final decision on whether the licensing process will proceed is pending in the courts.
- *A deep-mined geologic repository is the preferred option of all countries* for disposing of high-activity radioactive waste. In the last 40 years, the U.S. and other nations have initiated roughly two-dozen efforts to identify potential repository sites. Only three of those efforts have led to the selection of a site and are still on track. In no case has a construction license for a high-activity waste repository been issued by the responsible regulatory authority.
- *The experiences in selected countries can be summarized briefly:*
  - In France, two communities volunteered to be considered for an underground research laboratory (URL), but the granite underlying one of them proved to be technically unsuitable. Today a URL has been constructed in clay near the village of Bure. A site adjacent to the laboratory has been chosen for a repository for high-activity waste.
  - Sweden’s consent-based siting process resulted in a competition between two municipalities, Osthrammar and Oskarshamn, to host a repository for high-activity waste. Osthrammar ultimately was selected.

- The United Kingdom initiated a new approach to repository siting, inviting communities to express interest in hosting such a facility. Several borough and county councils near the Sellafield reprocessing site in West Cumbria are considering whether to participate. A decision is expected in the fall.
  - In Canada, after a deliberate effort by the siting implementer to understand the views of Canadians, including Canada's aboriginal people, more than a dozen communities have expressed interest in learning more about the implications of hosting a repository.
  - Japan called for volunteers to host a repository more than a decade ago. The one mayor that accepted the offer was recalled, and no other communities have come forward since. The damage to the facilities at the Fukushima-Daiichi site caused by last year's tsunami may have reduced the prospects for finding a volunteer host still further.
  - In Switzerland, after identifying regions of Opalinus clay as potentially suitable for repository siting, discussions are underway with communities to determine their willingness to host a disposal facility. The Swiss government will ultimately make the siting decision, but the decision could be overturned by national referendum.
  - The German State of Lower Saxony invited the German Federal Government to develop a repository at a salt site near the community of Gorleben decades ago, but the expression of interest created considerable controversy nationally. After 35 years, the site is still under consideration, but selection of the site remains problematic.
- *What characterizes national repository programs most is their variety.* In some cases, efforts to identify candidate sites have focused from the beginning on specific host-rock formations. In other cases, countries have used generic qualifying and disqualifying conditions. Some countries evaluate sites one by one, while others adopt a "parallel" approach, characterizing and comparing at least two sites simultaneously.
  - *Communities already hosting nuclear facilities* may be especially receptive to consideration as a candidate repository site. The prospect of receiving a generous benefits package is instrumental in gaining community acceptance, in some cases.
  - *Lessons that can be taken from the U.S. and other countries:* (1) Potential host communities must at least acquiesce to site investigations. (2) Implementers must engage potential host communities by establishing a strong, long-term local presence. (3) Potential host communities must have a realistic, practical way to withdraw from the siting process.
  - *The experience of the U.S. Nuclear Waste Negotiator may be especially relevant* because it reflects a consent-based siting effort undertaken in the U.S. The Negotiator was given authority to search for a voluntary host for a storage facility or a permanent repository site and could negotiate a benefits package with any acceptable incentives. Approval by act of law would have been required to complete the process. At least one Native American Tribe sought to negotiate an agreement, but funding was eventually eliminated for the Negotiator's Office by Congress.
  - *Public trust in the institutions involved in a consent-based site-selection process* is an essential element underlying the potential for success of all the efforts discussed in this testimony. It is vitally important that entities and localities that might consider hosting a storage or disposal facility for high-activity waste have confidence in the credibility of the process and the trustworthiness of the implementer of the program.

**Statement of Dr. Daniel S. Metlay  
Senior Professional Staff  
U.S. Nuclear Waste Technical Review Board**

**Before the**

**Subcommittee on Clean Air and Nuclear Safety  
Committee on Environment and Public Works**

**United States Senate**

**June 7, 2012**

Mr. Chairman and members of the Subcommittee, good morning. My name is Daniel Metlay. I am a senior professional staff member at the U.S. Nuclear Waste Technical Review Board. The Board was created in the 1987 amendments to the Nuclear Waste Policy Act to provide an ongoing and independent technical and scientific evaluation of activities undertaken by the Secretary of Energy related to implementing the Nuclear Waste Policy Act. The Board's 11 members are technical and scientific experts who are nominated by the National Academy of Sciences and appointed by the President. A small professional staff supports the work of the part-time Board members. I am a member of that staff. I hold a Ph.D. in public policy, and I have a scientific undergraduate degree. Over several decades, I have held various positions in academia and in government related to nuclear waste management and disposal. A short biography is attached to this statement. My responsibilities on the Board staff include nuclear waste transportation, institutional issues, and, most particularly, the ongoing work in other countries for managing their high-level radioactive waste and spent nuclear fuel.

Today, I have been asked by the Subcommittee to provide a historical perspective on efforts in this country and in other countries for establishing a consent-based process for siting nuclear waste storage and disposal facilities. Developing such a consent-based approach to siting was a major recommendation of the Blue Ribbon Commission on America's Nuclear Future (BRC).

Before I begin, I want to make clear that I can only convey Board comments that are part of publicly available Board documents; I cannot speculate about Board opinions, findings, or recommendations. What I will try to do is provide relevant general information that is based on my own experience and expertise and on information that is included in two Board publications: *Survey of National Programs for Managing High-Level Radioactive Waste and Spent Nuclear Fuel*, issued in October 2009; and *Experience Gained From Programs to Manage High-Level Radioactive Waste and Spent Nuclear Fuel in the United States and Other Countries*, issued in April 2011. I also have attached to this statement a letter that the Board wrote to the Secretary of Energy on the BRC recommendations. These and all other Board documents, including Board presentations and correspondence to the BRC, are available on the Board's Web site at [www.nwtrb.gov](http://www.nwtrb.gov). I hope that the Committee will find these perspectives useful as context for considering BRC recommendations on establishing a consent-based process for siting a nuclear waste storage or disposal facility in the United States.

I will begin today by talking generally about the requirements for developing a siting process. I then will provide a brief history of efforts in this country to site and develop storage and disposal facilities for high-level radioactive waste and spent nuclear fuel. I next will discuss factors affecting consent-driven site-selection activities in other countries. I will end with some tentative conclusions that might be drawn from these efforts and with a short discussion of some factors that may limit the lessons that can be applied to this country from international experience.

### **Designing a Siting Process**

Site-selection strategies for a deep-mined geologic repository necessarily involve passing candidates through what is, in effect, two different "filters." On the one hand, detailed and

quantitative technical requirements have to be met. They include such issues as suitability criteria related to geologic stability, hydrologic conditions, geochemical conditions, disruptive processes, coupled processes, and operational practicality. On the other hand, sites could be disqualified because of nontechnical considerations, such as the “lack of social acceptance, high population density, or difficulty of access.” These two filters, the “technical” and the “non-technical,” can be applied in any order, although the suite of sites eventually selected might be different.

In constructing the filters, formal processes need to be crafted that can be used to establish technical criteria, prescribe how the criteria will be updated, specify how a “safety case” will be constructed, lay out compliance methodologies, and provide resources for public involvement and support of local and state oversight activities. Describing every aspect of these filters and how they have been applied would require a very long discussion. I will limit my testimony to the experiences in the United States and internationally that are relevant to the BRC’s recommendation for a consent-based site-selection process.

### **History of the U.S. Program**

Members of the Subcommittee are familiar with how the waste management program in the United States has evolved to its present state. I will mention just a few salient episodes.

Early efforts to develop a permanent repository for high-activity radioactive waste focused on finding a site in salt, a host-rock recommended in a 1957 National Academy of Sciences report. In 1970, on the basis of some preliminary investigations undertaken by Oak Ridge National Laboratory, the Atomic Energy Commission (AEC) announced plans for siting a repository for high-activity waste at an abandoned salt mine near Lyons, Kansas. The AEC’s announcement took state and local officials by surprise. The State Geologist, strongly supported

by the Kansas congressional delegation, opposed this siting effort. In the end, unresolved technical issues forced the AEC to abandon its plans in 1974. Subsequently, two other salt formations were considered as potential locations for a repository. Community leaders in Carlsbad, New Mexico, launched an initiative to persuade the AEC to look at potential repository sites in the Permian Basin; at the same time, the federal government sought permission from governors to investigate possible locations for a repository in the Salina Basin around the Great Lakes. The latter efforts provided futile, but, as the Subcommittee knows well, a sustained campaign by congressional, legislative, and community leaders around Carlsbad resulted in the construction of the Waste Isolation Pilot Plant (WIPP) repository, which began receiving transuranic-contaminated waste in 1999.

Problems encountered in trying to site a repository for high-activity radioactive waste led policy-makers in the late 1970s and early 1980s to try developing principles that would form the basis of a national policy for managing and disposing of spent nuclear fuel and high-level radioactive waste. President Jimmy Carter created the Interagency Review Group on Nuclear Waste Management (IRG) in 1978. Represented on the IRG were more than 20 federal agencies that had a “stake” in the long-term management of high-activity waste. Of particular importance was the IRG’s recommendation that a policy of “consultation and concurrence” be adopted. Such a policy would walk a fine line between, on the one hand, outright federal preemption of any state role in siting a repository, and, on the other, an absolute state veto, exercised at one specific moment in time. Instead, the IRG argued for an adaptive process with full involvement by affected states. “Under this approach, a state effectively has the continuing ability to participate in activities at all points throughout the course of [site investigations] and, if it deems appropriate, to prevent the continuance of Federal activities.”

Although other elements of the IRG recommendations found their way into the Nuclear Waste Policy Act (NWPA), which passed in 1982 after almost 4 years of debate, Congress transformed the notion of “consultation and concurrence” into “consultation and cooperation.” The NWPA also provided that the President’s decision to develop a repository could be vetoed by the governor of the *situs* state. That veto, however, could be overridden by a majority vote in both Houses of Congress.

To increase geographic equity, the Act also authorized the development of two repositories, presumably one in the eastern United States and one in the west, which would be selected after a technically based evaluation process. Three western sites eventually were chosen that would be characterized simultaneously for their suitability as the location of the first repository. As opposition grew in the eastern United States to a second repository, Secretary of Energy John Harrington suspended the second repository program in 1986.

In 1987, Congress tried to address the resistance that had developed over time to some of the policies and practices established in the NWPA. Congress amended the NWPA in December of that year and identified Yucca Mountain in Nevada as the sole site to be characterized for a first repository. The Office of the Nuclear Waste Negotiator also was created in the Amendments Act. The Negotiator was authorized by the legislation to “find a State or Indian tribe willing to host a repository or monitored retrievable storage facility at a technically qualified site on reasonable terms and...to negotiate with any State or Indian tribe which expresses an interest in hosting a repository or monitored retrievable storage facility.” After several years of effort, the first Negotiator, David Leroy, and then his successor, Richard Stallings, were unable to reach an agreement with a willing host, although one Native American

tribe, the Mescaleros of New Mexico, expressed some interest. Congress defunded the Office of the Nuclear Waste Negotiator in 1995.

For more than 20 years after passage of the Amendments Act, the Yucca Mountain site was technically evaluated by the U.S. Department of Energy (DOE), even as the State of Nevada voiced its strong and unwavering opposition to locating a repository at the site. In early 2002, DOE recommended to President George W. Bush that the site be developed as a repository. Congress overturned a veto of the President's suitability decision by the state of Nevada later in 2002. In 2008, DOE submitted a license application for a Yucca Mountain repository to the U.S. Nuclear Regulatory Commission. DOE requested that the license be withdrawn in 2010. A final decision on whether the licensing process will proceed is pending in the courts.

Now I will move on to a discussion of factors that have shaped the site-selection approaches of other countries.

### **International Experience in Site Selection**

Almost universally, policy-makers have determined that disposal of high-activity waste in a deep-mined geologic repository is the preferred option for protecting human health and the environment for many millennia. In the last 40 years, the United States and other nations have initiated roughly two-dozen efforts to identify or create processes for identifying potential repository sites. Only three of those efforts have identified a potentially suitable site *and* are still on track. In no case has a license been issued by the cognizant regulatory authority to construct a deep-mined geologic repository for high-activity radioactive waste. The experience in selected countries can be summarized briefly.

#### *France*

When the call went out for volunteer communities to host underground research laboratories both in clay and in granite, potential host localities knew from the start that if the laboratory site or a site nearby were found to be technically sound, then a full-scale repository might be constructed there. Two communities stepped forward. However, the granite formation underlying one of them proved technically unsuitable for repository development. After several years of informal consultations and negotiations by the French Government, no other community was willing to volunteer to host an underground laboratory in granite. Today, the village of Bure, the community that agreed to host an underground laboratory in clay, strongly supports activities conducted by the implementer, the National Radioactive Waste Management Agency (ANDRA), related to constructing a repository. Noteworthy, however, is that when ANDRA called for volunteers to host a separate repository for long-lived, intermediate-level waste, several communities in the same province as Bure declined.

### *Sweden*

Perhaps the most encouraging example of the efficacy of a consent-based siting process is the approach used in Sweden. In the 1970s, the implementer there, Swedish Nuclear Fuel and Waste Management Company (SKB), developed a disposal concept, which evolved incrementally into the current concept, KBS-3. The disposal concept received strong technical support from the international scientific community. It could be employed throughout most of Sweden, which lies largely on the granitic Baltic Shield. In the late 1980s, SKB unilaterally sought to characterize sites in several areas. That effort was met by strong opposition and blockaded entry roads. Reassessing the situation, SKB approached four northern municipalities, asking for their consent to initiate site investigations. Two municipalities declined early on;

referenda were held in two others, and, by varying margins, those municipalities also declined to participate further. Without hesitation, SKB stopped its work in all four places.

Subsequently, SKB invited approximately a dozen communities to join in a process to explore whether they would be interested in hosting a repository for high-activity waste. At the end of a very extensive engagement process, two municipalities, Osthhammar and Oskarshamn, signaled that they were prepared to host such a facility. SKB ultimately selected Osthhammar.

### *United Kingdom*

In 2006, the government of the United Kingdom approved a new approach—Managing Radioactive Waste Safely—for developing a repository. Key to that new approach was an invitation for willing and informed communities to express an interest in hosting such a facility. The response from communities in the United Kingdom, however, has been quite subdued to date. Several borough and county councils near the Sellafield reprocessing plant in West Cumbria have begun investigating whether they should participate in the new initiative. Studies by the British Geological Survey suggested that at least some of the “rock” in the area might be suitable for constructing a repository. A decision by the West Cumbria partnership on whether to participate is expected in the fall. Ironically, the same councils that denied local planning permission for constructing an underground research laboratory 20 years ago are the ones now considering participation in the repository program. One important factor that may have caused this shift in attitude has been the concerted efforts by the U.K. implementer, the Nuclear Decommissioning Authority, to establish trustworthy relations with the localities.

## *Canada*

Perhaps the most promising national initiative that relies on a consent-based siting process has unfolded in Canada. Adopting a very deliberate and careful approach to understanding the views of Canadians, especially those belonging to that country's aboriginal people, the implementer, the Nuclear Waste Management Organization (NWMO), put forward a plan for adaptive management of Canada's high-activity waste. NWMO is working with more than a dozen communities that have expressed interest in learning more about the implications of hosting a deep-mined repository.

## *Japan*

In sharp contrast to the Canadian experience, more than a decade ago, Japan's implementer, Nuclear Waste Management Organization (NUMO), called for volunteers to participate in a stepwise siting process. Although the mayor of one southern Japanese town accepted NUMO's offer, opposition quickly developed at both the local and prefectural levels. The mayor was recalled; no other community has come forward since. After the damage caused to the Fukushima-Daiichi reactors and spent-fuel storage pools by last year's earthquake and tsunami, the prospects for volunteers now appear to be even slimmer.

## *Switzerland*

In Switzerland, the steps of the typical siting process have been reversed. Under the country's Sectoral Plan, the implementer, National Cooperative for the Disposal of Radioactive Waste, first identified potential regions where Opalinus clay might be suitable for locating a repository. Altogether, five regions were identified in the first phase of the plan. Now, in the plan's second phase, discussions are under way with communities in the regions to determine if

any of them are prepared to host a facility for disposing of high-activity waste. Ultimately, the Swiss Federal Government will decide where a repository will be sited, but that decision could be overturned by a national referendum.

### *Germany*

In many respects, the siting efforts in Germany parallel those in the United States. When, in the 1970s, the State of Lower Saxony invited the German Federal Government to develop a repository in salt near the community of Gorleben, that expression of interest aroused considerable controversy nationally. Although the site is still under consideration 35 years later, its selection remains problematic.

### **What Can We Learn from U.S. and International Experiences?**

In discussions of the international efforts for implementing a consent-based approach, it is important to remember, as noted above, that there are several aspects to the process that can have significant consequences for the outcome. First are technical factors, including choices about what reactor technology to adopt and about what nuclear fuel cycle to pursue. Others are social and political in nature, including how concerns about intergenerational equity should be addressed and what pace should be followed in implementing a long-term management option. Importantly, the interdependencies, both subtle and overt, among the technical, social, and political forces are inescapable.

Because of those interdependencies, what characterizes national programs most notably is their variety. In some cases, efforts to identify candidate sites have focused from the beginning on specific host-rock formations. The choice of those formations has been dictated by constraints imposed by a country's geology or land-use patterns, by a view that particular host-

rock formations possess distinctive advantages in terms of isolating and containing high-activity radioactive waste, or by a combination of these rationales. In other cases, efforts to identify candidate sites cast the net more broadly by enumerating generic qualifying and disqualifying conditions. Qualifying conditions must be satisfied for a candidate site to be considered acceptable; disqualifying conditions eliminate a candidate site from further consideration.

An additional source of variation among national programs can be traced to policies that govern the sequence for accepting or rejecting a candidate site. A country can adopt a “serial” policy whereby sites would be evaluated formally one by one until a suitable site is found. Alternatively, a “parallel” approach can be adopted in which at least two candidate sites would be characterized simultaneously and compared.

Just as the construction of the technical filter introduces considerable variation in strategies for selecting candidate sites for a deep geologic repository, so does the construction of the nontechnical filter. Arguably this filter’s most important property relates to the power that a state or community can exercise. Since the early 1990s, nations outside the United States increasingly have constructed their nontechnical filters in ways that empower local jurisdictions. Especially when issues of federalism come to the fore, how power is distributed between the central government and state governments can be very consequential, as the cases of Japan, Germany, and the United States illustrate. So does the situation in Switzerland. There, a change in the law governing the management of high-activity waste eliminated the possibility of a cantonal referendum after one canton (roughly equivalent to a U.S. state) disapproved of the siting of an intermediate-level waste repository.

Experiences in the United States and other nations also suggest that communities already hosting nuclear facilities or communities where benefits might make a significant economic or

social difference may be especially receptive to being considered a candidate repository site. For example, in Sweden and Finland, candidate sites were identified in communities with nuclear reactors, and in the United Kingdom, borough and county councils in West Cumbria near the Sellafield nuclear facilities have expressed interest in becoming considered a repository site. For many, but not all, municipalities and states, the prospect of receiving generous benefit packages is instrumental in gaining community acceptance for a repository.

Lessons from all of these siting experiences have not been lost on the directors of national waste-management programs. Siting efforts now under way in Canada and the United Kingdom reflect these lessons, and the recommendations by the BRC in the United States are in line with this “new” understanding:

- *Potential host communities must at least acquiesce to site investigations.* Carlsbad, New Mexico, the town closest to WIPP, assertively lobbied for the facility. The Meuse and Haute Marne districts surrounding Bure in France welcomed the construction of a URL, knowing that if the argillite clay there was suitable, a full-scale repository might be constructed nearby. In Finland and in Sweden, the town of Eurajoki and the municipality of Osthrammar, respectively, responded positively to invitations from the two national implementers, Posiva and SKB, respectively.
- *Implementers must work intensively to engage potential host communities by establishing a strong, long-term local presence.* DOE required that officials involved with the WIPP project and researchers from National Laboratories live in Carlsbad, New Mexico, even requiring those not already living there to relocate. In France, a Local Information and Oversight Committee has been established so that representatives of communities in the Meuse and Haute-Marne districts near Bure can continuously interact with ANDRA. In

Sweden and Finland, the potential repository host communities had already become familiar with the implementers because they (or their consortium members) had operated nuclear reactors at those sites for a long time. In each case, however, interactions were intensified when the municipalities began to be considered potential locations for deep-mined geologic repositories.

- *Potential host communities must have a realistic, practical way to withdraw from the siting process.* The state of New Mexico was a full partner in negotiating the terms of the Land Withdrawal Act that permitted WIPP to operate. In France, the districts near Bure willingly accepted the prospects of hosting a deep-mined geologic repository when they volunteered to host the research laboratory. Yet, despite considerable effort by the French Government, no community located above a granite formation was willing to step forward, and none were forced to. In Finland, Eurajoki's consent was required before Parliament could pass the "decision-in-principle" to site the proposed geologic repository. In Sweden, Osthrammar must agree to the granting of a license by the government. If the municipality decides for some unexpected reason to exercise its veto power, the veto could, in theory, be overridden by the government. As a pragmatic matter, however, national culture and historical precedents would make such an override highly unlikely.

In the United States, the experience of the Nuclear Waste Negotiator may be especially relevant because that effort was truly consent-based. The Negotiator was given authority to search for a voluntary host for a storage facility or a permanent repository site and could negotiate a package with any acceptable incentives. Approval by act of law would be required to complete the process. Some local communities expressed interest, but the states in which they were located prevented them from pursuing an agreement with the negotiator. Some Native

American Tribes sought agreements, but funding was eventually eliminated for the Office of the Negotiator by Congress. It is not clear what factors would lead to a different outcome if that effort were reinitiated today.

Finally, public trust in the institutions involved in a consent-based site-selection process is an essential element underlying the potential for success of all the efforts I have discussed today. Vitally important is that entities and localities that might consider hosting a storage or disposal facility for high-activity waste have confidence in the credibility of the process and the trustworthiness of the implementer of the program.

### **Summary**

In closing, I would observe that few public policy issues rival the management of high-activity radioactive waste in terms of the demands placed on scientific research and engineering practice and the controversy that is engendered. After decades of dedicated work in more than a dozen nations, evidence is beginning to increase confidence that “solutions” can be found to this pressing environmental problem. More important, lessons are being learned about how to design social processes that lead to technically and politically defensible outcomes. Given this progress, and because the stakes are so high, it would be unfortunate if temporization displaced action.



