U.S. NUCLEAR WASTE
TECHNICAL REVIEW BOARD

Report to
The U.S. Congress
And
The Secretary of Energy

January 1, 2002, to December 31, 2002

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UNITED STATES
NUCLEAR WASTE TECHNICAL REVIEW BOARD
2300 Clarendon Boulevard, Suite 1300
Arlington, VA 22201

April 2003

The Honorable J. Dennis Hastert
Speaker of the House
United States House of Representatives
Washington, D.C. 20515

The Honorable Ted Stevens
President Pro Tempore
United States Senate
Washington, D.C. 20510

The Honorable E. Spencer Abraham
Secretary
U.S. Department of Energy
Washington, D.C. 20585

Dear Speaker Hastert, Senator Stevens, and Secretary Abraham:

The Nuclear Waste Technical Review Board submits this *Report to The U.S. Congress and The Secretary of Energy* in accordance with provisions of the Nuclear Waste Policy Amendments Act of 1987, Public Law 100-203, which requires the Board to report its findings and recommendations to Congress and the Secretary of Energy at least two times each year.

Congress created the Board to evaluate the technical and scientific validity of activities undertaken by the Secretary of Energy related to implementing the Nuclear Waste Policy Act of 1982. In this report, the Board summarizes its major activities from January 1, 2002, through December 31, 2002.

During that period, the Board evaluated the technical basis for the DOE's work related to a site recommendation and provided the Board's views to the administration, Congress, and the public in letters and congressional testimony. Following congressional approval of the Yucca Mountain site, the Board continued its ongoing technical and scientific review of DOE activities. Letters to the DOE related to technical issues identified by the Board as part of its ongoing evaluation are included in an appendix to the report. 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.

The Board believes that information in the Board's report will be useful as important decisions are made on managing the nation's spent nuclear fuel and high-level radioactive waste.

We thank you for this opportunity to present the Board's views.

Sincerely,

Michael L. Corradini
Chairman

NUCLEAR WASTE TECHNICAL REVIEW BOARD 2002

[1] Until June 25, 2002
[2] Since June 26, 2002
[3] Died April 21, 2002

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Executive Summary

In 1987, the U.S. Nuclear Waste Technical Review Board (Board) was created as an independent federal agency by Congress in the Nuclear Waste Policy Amendments Act. The Board was charged with evaluating the technical and scientific validity of the U.S. Department of Energy's (DOE) efforts to develop a system for disposing of high-level radioactive waste and spent nuclear fuel. The Board is required to report its findings and recommendations to Congress and the Secretary of Energy at least twice a year. This document describes activities undertaken by the Board between January 1 and December 31, 2002.*

On January 24, 2002, the Board released a letter report to the Speaker of the House of Representatives, Dennis Hastert; the President Pro Tempore of the Senate, Robert Byrd; and the Secretary of Energy, Spencer Abraham. In the report, the Board made the following key points.

- In evaluating the DOE's technical and scientific work related to individual natural and engineered components of the proposed repository system, the Board finds varying degrees of strength and weakness. Such variability is not surprising, given that the Yucca Mountain project is in many respects a first-of-a-kind, complex undertaking. When the DOE's technical and scientific work is taken as a whole, the Board's view is that the technical basis for the DOE's repository performance estimates is weak to moderate at this time.

- The Board makes no judgment on the question of whether the Yucca Mountain site should be recommended or approved for repository development. Those judgments, which involve a number of public policy considerations as well as an assessment of how much technical certainty is necessary at various decision points, go beyond the Board's congressionally established mandate.

- The DOE uses a complex integrated performance assessment model to project the performance of the repository system. Performance assessment is a useful tool because it assesses how well the repository system as a whole, not just the site or the engineered components, might perform. However, gaps in data and basic understanding cause important uncertainties in the concepts and assumptions on which the DOE's performance estimates are now based. Because of these uncertainties, the Board has limited confidence in current performance estimates generated by the DOE's performance assessment model.

- This is not an assessment of the Board's level of confidence in the Yucca Mountain site. At this point, no individual technical or scientific factor has been identified that would automatically eliminate Yucca Mountain from consideration as the site of a permanent repository.

- An international consensus is emerging that a fundamental understanding of the potential

* The period of this report overlaps with the period of the report issued by the Board in 2002 (NWTRB 2002c) by one month, January 2002. The overlap is necessary because the key events that took place during that month, the Bush Administration's approval of the Yucca Mountain site for development as a repository and the Board's report on the technical basis for that decision, provide the essential context for what happened during the rest of the year.

behavior of a proposed repository system is of importance comparable to the importance of showing compliance with regulations. The Board agrees that such basic understanding is very important.

- Confidence in waste package and repository performance potentially could increase if the DOE adopts a low-temperature repository design. However, a full and objective comparison of high- and low-temperature repository designs should be completed before the DOE selects a final repository design concept.

- The DOE can increase confidence in its performance estimates by, among other things, developing multiple lines of evidence and strengthening its arguments about defense-in-depth. It also can work to ensure better integration of new data and analyses, monitor repository performance, develop a strategy for modifying or stopping repository construction and waste emplacement if unforeseen circumstances are encountered, and continue external review of its technical and scientific activities.

Three full Board meetings were held in 2002. After each meeting, the Board wrote a letter to the head of the DOE's repository program setting forth its findings and recommendations for improving the program. The recommendations focused on issues relating to repository design, understanding flow in the unsaturated zone, and the analyses used in performance assessments.

Board Activities

The U.S. Nuclear Waste Technical Review Board (Board) was established by Congress in the Nuclear Waste Policy Amendments Act (NWPAA) (U.S. Congress 1987). The NWPAA requires the Board to evaluate the technical and scientific validity of the work undertaken by the U.S. Department of Energy (DOE) to develop a mined geologic repository system for disposing of high-level radioactive waste (HLW) and spent nuclear fuel (SNF) produced by the nation's nuclear defense complex and commercial nuclear power plants. Between January 1, 2002, and December 31, 2002, the period covered by this report, the DOE, the Bush Administration, and Congress reached several important milestones.*

I. Recommendation and Approval of the Yucca Mountain Site

For more than two decades, the DOE has been characterizing Yucca Mountain in Nevada to evaluate the suitability of the site for constructing a mined geologic repository for the permanent disposal of HLW and SNF. The DOE also has been preparing designs of the package that would contain the waste for disposal and of the repository's surface and subsurface complexes.

On January 10, 2002, Secretary of Energy Spencer Abraham notified the Nevada governor and legislature that he intended to recommend to President George W. Bush that Yucca Mountain be approved as the site of a geologic repository for HLW and SNF (Abraham 2002a). The Secretary officially recommended the site to the President (Abraham 2002b, DOE 2002a) on February 14, 2002. At the same time, the DOE published the final environmental impact statement (FEIS) for Yucca Mountain (DOE 2002b), *Science and Engineering Report, Rev. 1* (DOE 2002c), *Site Suitability Evaluation* (2002d), and a document compiling the DOE's responses to public and agency comments on previously released reports (DOE 2002e). On February 15, 2002, the President informed Congress that he had accepted the Secretary's recommendation (Bush 2002).

Under the Nuclear Waste Policy Act (NWPA), the State of Nevada has 60 days to exercise its right to disapprove the selection of the site, which it did on April 8, 2002 (Guinn 2002a, Guinn 2002b). If the State disapproves the selection of the site, Congress has 90 days of continuous session to decide whether to sustain or overturn the State's objection. On May 8, 2002, the House of Representatives voted in favor of a resolution to approve the site, effectively overturning the State's veto; on July 9, 2002, the Senate followed suit. On July 23, 2002, President Bush signed House Joint Resolution 87, formally certifying Yucca Mountain as the presumptive site for the nation's first HLW and SNF repository and authorizing the DOE to file an application with the U.S. Nuclear Regulatory Commission (NRC) for permission to construct the facility.

* The period of this report overlaps with the period of the report issued by the Board in 2002 (NWTRB 2002c) by one month, January 2002. The overlap is necessary because the key events that took place during that month, the Bush Administration's approval of the Yucca Mountain site for development as a repository and the Board's report on the technical basis for that decision, provide the essential context for what happened during the rest of the year.

The State of Nevada's opposition to developing a repository at Yucca Mountain was not limited to the congressional arena. Starting in 2001, it filed lawsuits seeking to invalidate regulations issued by the U.S. Environmental Protection Agency, the NRC, and the DOE. It also objected to the DOE's FEIS, the Secretary's site recommendation, and the President's approval of that recommendation. Finally, the State challenged the constitutionality of the entire site recommendation process. The lawsuits were still pending at the end of 2002.

II. The Board's Input Into the Process for Recommending and Approving the Yucca Mountain Site

Aside from the Board's ongoing responsibility to evaluate the scientific and technical validity of the DOE's activities, the NWPAA does not assign the Board any formal responsibility or authority in the site recommendation and approval process. However, its review of the DOE's investigations at Yucca Mountain over the last dozen years placed the Board in a unique position to advise Congress on the technical basis for developing a repository at that site. On December 11, 2001, the Board informed the Secretary that it was preparing a comprehensive report on that subject (Cohon 2001).

In preparing that report, the Board evaluated the full range of scientific and technical activities undertaken by the DOE to determine site suitability. It paid special attention to work that the DOE carried out to address the priorities that the Board announced in January 2001. The priorities 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 should be derived independently of performance assessment and thus not be subject to the limitations of performance assessment.

In addition to these overarching priorities, the Board made recommendations about other investigations and studies that could support, complement, and supplement the four areas. Those investigations and studies included research on the unsaturated and saturated zones.

On January 24, 2002, the Board issued its report to Congress and the Secretary of Energy (NWTRB 2002a). The report's key findings, conclusions, and recommendations were as follows:

- In evaluating the DOE's technical and scientific work related to individual natural and engineered components of the proposed repository system, the Board finds varying degrees of strength and weakness. Such variability is not surprising, given that the Yucca Mountain project is in many respects a first-of-a-kind, complex undertaking. When the DOE's technical and scientific work is taken as a whole, the Board's view is that the technical basis for the DOE's repository performance estimates is weak to moderate at this time.
- The Board makes no judgment on the question of whether the Yucca Mountain site should be recommended or approved for repository development. Those judgments, which involve a number of public policy considerations as well as an assessment of how much technical certainty is necessary at various decision points, go beyond the Board's congressionally established mandate.
- The DOE uses a complex integrated performance assessment model to project the performance of the repository system. Performance assessment is a useful tool because it assesses how well the repository system as a whole, not just the site or the engineered components, might perform. However, gaps in data and basic understanding cause important uncertainties in the concepts and assumptions on

which the DOE's performance estimates are now based. Because of these uncertainties, the Board has limited confidence in current performance estimates generated by the DOE's performance assessment model.

- This is not an assessment of the Board's level of confidence in the Yucca Mountain site. At this point, no individual technical or scientific factor has been identified that would automatically eliminate Yucca Mountain from consideration as the site of a permanent repository.

- An international consensus is emerging that a fundamental understanding of the potential behavior of a proposed repository system is of importance comparable to the importance of showing compliance with regulations. The Board agrees that such basic understanding is very important.

- Confidence in waste package and repository performance potentially could increase if the DOE adopts a low-temperature repository design. However, a full and objective comparison of high- and low-temperature repository designs should be completed before the DOE selects a final repository design concept.

- The DOE can increase confidence in its performance estimates by, among other things, developing multiple lines of evidence and strengthening its arguments about defense-in-depth. It also can work to ensure better integration of new data and analyses, monitor repository performance, develop a strategy for modifying or stopping repository construction and waste emplacement if unforeseen circumstances are encountered, and continue external review of its technical and scientific activities.

On April 18, 2002, Dr. Jared L. Cohon, then the Board's Chairman, testified before the House of Representatives Subcommittee on Energy and Air Quality of the Committee on Energy and Commerce (Cohon 2002b). On May 23, 2002, Dr. Cohon testified before the Senate Committee on Energy and Natural Resources (Cohon 2002d). The committees were considering whether to sustain or overturn the State of Nevada's disapproval of the Yucca Mountain site. In his testimony on both occasions, Dr. Cohon described the process used by the Board to draft its January 24, 2002, report. He also summarized the report's main findings, conclusions, and recommendations. Subsequently, the Board answered written questions posed by members of the two committees (Cohon 2002c, Cohon 2002e). That correspondence is in Appendix F.

III. Board Findings and Recommendations

January 29-30, 2002, Board Meeting in Pahrump, Nevada (NWTRB 2002b)

At this meeting, the Board heard presentations on several recent external reviews of the DOE's estimates of projected repository performance. The Board also was briefed on recent regulatory developments at the NRC. The latest work on modeling fluid flow and transport of radionuclides in the unsaturated and saturated zones was presented. Finally, the DOE described to the Board its efforts to portray and communicate the uncertainties associated with its performance assessment approach, known as Total System Performance Assessment (TSPA).

In a March 11, 2002, letter to the DOE (Cohon 2002a), the Board made three general recommendations. First, because of existing uncertainties, a sustained commitment to continued scientific and engineering investigations is required to improve the technical basis for evaluating the performance of the proposed repository at Yucca Mountain. In particular, the Board indicated that hydrogeologic processes that affect radionuclide transport below the proposed repository in the unsaturated and saturated zones remain poorly understood. In addition, the DOE's analyses of water accumulation and movement in and around the bulkhead section of the exploratory cross-drift and the DOE's hypothesized drift-shadow concept are not yet technically credible. Moreover, the Board questioned the DOE's conclusion that there is no long-term difference in repository performance predictions that is attributable to the repository's operating temperature. At the very least, the DOE lacks corrosion data for Alloy 22 above 120°C

under repository-relevant conditions. These uncertainties weaken the technical basis of the DOE's performance predictions.

Second, the DOE needs to assimilate its scientific and technical investigations into a realistic TSPA. Making its performance estimates more realistic and characterizing the full range of uncertainty would increase confidence in those estimates and would provide a mechanism for assessing the magnitude of conservatism of the current compliance-oriented TSPA. A realistic analysis also can yield a better understanding of the major subsystems for waste isolation. Third, the DOE's efforts to communicate its scientific and technical conclusions to decision-makers and the general public are inconsistent and lack clarity. It should take additional steps to ensure that this information and—as important—uncertainties associated with this information are conveyed clearly and effectively.

The Board also observed that its previously expressed concerns about the DOE's analysis of the effect on dose of igneous activity have lessened. However, additional work leading to a better understanding of igneous consequences should be undertaken to resolve this issue. Last, the Board stated that it concurred with conclusions conveyed in the January 24, 2002, letter from the DOE (Dyer 2002) that the hypothesis on hydrothermal upwelling had been addressed adequately and may be discounted.

May 7-8, 2002, Board Meeting in Washington, D.C. (NWTRB 2002d)

At this meeting, the Board heard presentations that, to varying degrees, touched on the important task of increasing confidence in the technical basis for the DOE's repository performance estimates. In particular, the DOE described its ongoing work on repository design and waste package corrosion and its plans for long-term research and development and performance confirmation. In addition, individuals representing a wide range of organizations discussed the concepts of a repository safety case and staged repository development.

In a June 20, 2002, letter to the DOE (Cohon 2002f), the Board endorsed the recommendations of the DOE-sponsored Waste Package Materials Performance Peer Review Panel, also known as the Payer Panel. Because of the importance of the Alloy 22 protective passive layer to repository performance, the Board continued to believe that the technical basis for extrapolating corrosion behavior over thousands of years needs to be more firmly established. Although the Board was encouraged by the DOE's announced commitment to preserving the option of a low-temperature repository, it noted that the technical basis for the DOE's selection of a high-temperature repository design for a potential license application remains unclear. The Board concluded that seriously considering designs other than the current high-temperature one may be of considerable value to the program.

The Board reaffirmed its strong support for development of a repository safety case. A document on the safety case should explain how a repository at Yucca Mountain would isolate radioactive waste for thousands of years and should rely not only on numerical analyses, such as TSPA, but also on other lines of evidence and argument that increase confidence in the conclusions of the numerical analyses. The development of a repository safety case would be consistent with the approach taken by many other countries. The Board also noted that the DOE's plans for performance confirmation were still not mature. It recommended that performance confirmation focus on evaluating the validity of estimates of long-term performance and challenging their underlying assumptions.

September 10, 2002, Board Meeting in Las Vegas, Nevada (NWTRB 2002e)

At this meeting, the Board heard presentations from the DOE on two of its key priorities: repository design and corrosion testing. The Board also brought together researchers from the Yucca Mountain Project, the NRC, the Electric Power Research Institute, and the State of Nevada to discuss the similarities and differences in the results of performance assessments conducted by different entities.

In a November 22, 2002, letter to the DOE (Corradini 2002), the Board began with the observation that, although Congress granted the DOE permission to file an application with the NRC to construct a repository at Yucca Mountain, the Board's role remains unchanged: It will continue to carry out a broad scientific and technical review of the DOE's work and will make recommendations on improving the technical defensibility of that work.

Carrying out this role, the Board encouraged the DOE to support work for determining whether the proposed repository's natural system makes a greater contribution to isolating and containing waste than current performance assessments suggest. If a *strong technical case* can be made for such an increased contribution, it would provide additional defense-in-depth, thereby increasing confidence in the repository's long-term performance.

The Board noted that the DOE has not yet provided a persuasive explanation for either the conflicting data collected with respect to the presence of bomb-pulse chlorine-36 at the proposed repository horizon or the moisture observed in the bulkhead section of the exploratory cross-drift. The Board urged the DOE to continue its efforts in these two areas, saying that their resolution was essential for developing an understanding of key processes affecting repository performance.

The Board continued its technical evaluation of the DOE's repository design decisions. It requested that the DOE provide detailed information on the technical bases for the apparent selection of a high-temperature design in preparing its application for a construction authorization to the NRC. The Board indicated that this decision appeared to be premised on two conclusions: (1) the projected performance of the high-temperature design is comparable to a low-temperature design and, in any case, is well below the regulatory limit; and (2) the overall uncertainty in projected performance of the two designs is roughly equivalent.

The Board pointed out that both conclusions were called into question by information presented at the meeting. Regarding the first conclusion, the presence of nitrate leads to less of a corrosion safety margin at temperatures above 140°C. Moreover, short-term weight-loss measurements, when extrapolated to higher temperatures, show a significant increase in the rate of corrosion. Thus, it was unclear why the DOE concluded that the two designs provide comparable levels of performance.

Regarding the second conclusion, the Board stated that performance assessment is not capable of showing uncertainty unless the models used appropriately incorporate uncertainty. Yet, some parts of some key performance assessment models for the engineered subsystem are based not on data but on a number of assumptions. To use these assumptions about high-temperature uncertainties as input to performance assessment models and then say the performance assessment reveals that uncertainties are equivalent for the two temperature regimes constitutes circular and therefore faulty reasoning. The DOE's analysis is complicated further by the fact that investigations, such as the drift-scale test, have not been completed. Thus, conclusions about the overall level of uncertainty associated with low- and high-temperature repositories may be premature.

The Board complimented the DOE for carrying out a "one-on" barrier analysis. It indicated that, on balance, such analyses could provide important insights into the roles of different natural and engineered barriers. The Board urged the DOE to continue supporting this kind of work.

The Board was very interested in the discussion of the similarities and differences in the results of performance assessments conducted by different entities. For example, many of the differences can be traced to the assumptions used and the influence of new data. However, confidence in the projections will depend in part on understanding and explaining clearly why variations arise. In particular, the stability of these projections is an important element in building confidence.

IV. Other Board Undertakings

Saturated Zone Field Trip

On September 12, 2002, the Board sponsored a Yucca Mountain regional hydrogeology field trip. In addition to Board members and staff, representatives of the DOE, Nye County, the United States Geological Survey, the National Park Service, and the United States Fish and Wildlife Service participated. Transport of radionuclides dissolved in groundwater is the main exposure pathway for humans in the DOE's nominal-case performance assessment. The purpose of the trip was for the Board to discuss the status of research and issues relating to the saturated-zone groundwater in and around Yucca Mountain. The entire flow field was considered in the discussion, from the recharge area on the north to the ultimate discharge area in Death Valley, California.

The participants on the field trip observed several key elements in the DOE's analysis of the saturated zone, including mineral deposits related to paleohydrology, naturally occurring springs discharging groundwater, the hydrogeology associated with the volcanic and alluvial rocks down the flow path from Yucca Mountain, structural geologic controls on water occurrence and movement in the region, and the Death Valley Regional Flow System groundwater model. Biotic communities sensitive to variability in modern flow and withdrawals also were discussed, along with biosphere pathways featured in the DOE's performance computations.

International Travel

In 2002, the Board continued to expand its understanding of the scientific and technical components of the DOE's work at Yucca Mountain through participation in a selected number of international activities.

In March 2002, at the invitation of the Swedish Nuclear Waste Management Council (KASAM), a small delegation of the Board participated for the fourth time in KASAM's review of the Swedish Nuclear Waste Management Company (SKB) research and development program. (In accordance with Swedish law, KASAM reviews the SKB program every three years.) In addition to assisting KASAM in its review, Board representatives learned about the SKB's efforts to design, manufacture, and predict the performance of its proposed engineered-barrier components. The Board was interested in obtaining information on the SKB's continued effort to achieve commercial production rates in manufacturing its waste canister as well as results from its research on microbial processes and how the results are being incorporated in the SKB's performance assessment models. The Board was briefed on the SKB's work to produce a simplified TSPA.

In June 2002, members of the Board who had never visited the Swedish program visited the SKB's waste management facilities, followed up on some of the issues addressed during the March visit, and met with representatives of the affected municipalities who are involved in scientific and technical review and with representatives of KASAM and Sweden's safety authorities.

The Board's final international activity for 2002 took place in October, when two representatives of the Board attended a Nuclear Energy Agency workshop on the integration of the engineered barrier system (EBS) in Oxford, England. Approximately 15 countries were represented at the workshop, which was the first of a series of four to be held over the next three years. The purpose of the workshops is to assess the various EBS concepts under study and to discuss the integration of design, testing, modeling, and performance assessment for the EBS.

V. The Board in Transition

The year 2002 was a major transition time for the Board. On April 21, 2002, John Arendt died. He joined the Board in June 1995, an appointee of then-President Bill Clinton. John's dedication and commitment to the Board was exemplary. Both his humor and his no-nonsense approach to reviewing the DOE's repository program will be sorely missed.

On June 26, 2002, President Bush appointed five new members to the Board. Michael Corradini,

professor of engineering physics at the University of Wisconsin, was named chairman. In addition, the President selected Mark Abkowitz, professor of civil and environmental engineering at Vanderbilt University in Tennessee; Thure Cerling, professor of geology and geophysics at the University of Utah; David Duquette, professor of materials science and engineering at Rensselaer Polytechnic Institute in New York; and Ronald Latanision, professor of materials science and engineering and nuclear engineering at the Massachusetts Institute of Technology.

Leaving the Board were Jared L. Cohon, former chairman, after seven years of service; Donald Runnells, after four years of service; Alberto Sagüés, after five years of service; and Jeffrey Wong, after seven years of service. Those former Board members each made important contributions to fulfilling the Board's task of evaluating the scientific and technical validity of the DOE's repository development program.

VI. Evaluation of the Board's Performance During 2002

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

1. Were the reviews, evaluations, and other activities undertaken under the auspices of the goal completed?
2. Were the results of the reviews, evaluations, and other activities communicated in a timely, understandable, and appropriate way to Congress and the Secretary of Energy?

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

The Board will use its evaluation of its own performance from the current year, together with its assessment of current or potential key issues of concern related to the DOE program, to establish its annual performance objectives and develop its budget request for subsequent years. The results of the Board's performance evaluation are included in the Board's annual summary report to Congress and the Secretary.

On the basis of the following evaluation and consistent with the performance measures described in the previous section, the Board's performance for 2002 was found to be effective. However, the Secretary's activities related to the waste management program were very limited in 2002. Therefore, most of the Board's 2002 goals in that area have been deferred until 2003. Additional details about the Board's evaluation are in Appendix H.

Abbreviations and Acronyms

Board	Nuclear Waste Technical Review Board
DOE	Department of Energy
EBS	engineered barrier system
ECRB	enhanced characterization of the repository block
FEIS	final environmental impact statement
HLW	high-level radioactive waste
KASAM	Swedish Nuclear Waste Management Council
NRC	U.S. Nuclear Regulatory Commission
NWPA	*Nuclear Waste Policy Act of 1982*
NWPAA	*Nuclear Waste Policy Amendments Act of 1987*
NWTRB	Nuclear Waste Technical Review Board
OCRWM	Office of Civilian Radioactive Waste Management
SKB	Swedish Nuclear Waste Management Company
SNF	spent nuclear fuel
TSPA	total system performance assessment

Glossary

The following list was compiled to help the reader understand some of the terms used in this report.

barrier Something that prevents or retards the passage of radionuclides toward the environment.

biosphere The part of the earth that supports self-sustaining and self-regulating ecological systems.

chlorine-36 (^{36}Cl) A long-lived radioactive isotope of chlorine produced by irradiation of natural chlorine, argon, or other materials by cosmic rays or neutrons. Atmospheric testing of nuclear weapons in the 1950's temporarily increased concentrations of chlorine-36. The resulting "bomb pulse" levels of chlorine-36 can sometimes serve as a tracer to determine how precipitation from the 1950's has moved through soil and rocks, such as those present at Yucca Mountain.

container A receptacle used to hold radioactive waste (usually spent fuel).

defense high-level nuclear waste High-level waste generated in the course of national defense activities, as opposed to spent nuclear fuel, which is generated during the production of nuclear energy from commercial reactors.

exploratory cross-drift A small tunnel across the proposed repository for enabling scientists to examine the geologic and hydrologic conditions.

engineered barrier system The constructed components of a disposal system designed to retard or prevent the releases of radionuclides from the underground facility. They can include the waste forms, fillers, waste containers, shielding material placed over and around such containers, and backfill materials.

environmental impact statement (EIS) A detailed written statement for supporting a decision to proceed with major federal actions affecting the quality of the human environment. Required by the National Environmental Policy Act (NEPA), the EIS describes the environmental impact of the proposed action; any adverse environmental effects that cannot be avoided if the proposal is implemented; alternatives to the proposed action (although the Nuclear Waste Policy Act, as amended, precludes consideration of certain alternatives); the relationship between local short-term uses of the human environment and the maintenance and enhancement of long-term productivity; and any irreversible and irretrievable commitments of resources that would be involved in the proposed action if it is implemented. Preparation of an EIS requires a public process that includes public meetings, reviews, and comments, as well as agency responses to the public comments.

geologic repository A facility for disposing of radioactive waste in excavated geologic media, including surface and subsurface areas of operation and the adjacent part of the natural setting.

groundwater Subsurface water as distinct from surface water.

high-level radioactive waste Highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and any other highly radioactive material that the Nuclear Regulatory Commission, consistent with existing law, determines requires permanent isolation by disposal in a geologic repository.

high-temperature operating mode Allowing the temperature of the waste package surface to exceed the boiling point of water for a significant period of time.

igneous Formed by volcanic activity.

license application A document submitted to the Nuclear Regulatory Commission seeking permission to construct a repository, to receive and emplace radioactive waste in a repository, or to close a repository. It contains general information and a safety analysis.

low-temperature operating mode Keeping the temperature of the waste package surface significantly below the boiling point of water.

multiple lines of evidence Varied methodological approaches used to infer the behavior of the repository system (or its major components) for extended time periods. Examples include analogues, simplified calculations, and arguments based on defense in depth.

Nuclear Waste Policy Act (42 USC 10101 et seq.) The federal statute enacted in 1982 that established the Office of Civilian Radioactive Waste Management and defined its mission to develop a federal system for the management and geologic disposal of commercial spent nuclear fuel and other high-level radioactive wastes. The Act also specified other federal responsibilities for nuclear waste management, established the Nuclear Waste Fund to cover the cost of geologic disposal, authorized interim storage until a repository is available, and defined interactions between federal agencies and the states, local governments, and Indian tribes.

Nuclear Waste Policy Amendments Act of 1987 (42 USC 10101 et seq.) The legislation that amended the Nuclear Waste Policy Act to limit repository site-characterization activities to Yucca Mountain, Nevada; established the Office of the Nuclear Waste Negotiator to seek a state or Indian tribe willing to host a repository or monitored retrievable storage facility; and created the Nuclear Waste Technical Review Board.

peer review A documented critical review performed by those who are independent from individuals who performed the work but who have technical expertise equivalent to those who performed the original work.

performance assessment (PA) A complex computer-based analysis that predicts the behavior of an entire repository system under a given set of conditions.

postclosure The period of time after the closure of the geologic repository.

preclosure The period of time before the closure of the geologic repository.

radionuclide transport The movement of radionuclides, generally in liquid or gas forms, through a rock formation.

saturated zone The part of the Earth's crust in which all empty spaces are filled with water.

site characterization The process of collecting information necessary to evaluate the suitability of a region or site for geologic disposal.

site recommendation The President's recommendation to Congress that a site be developed as a repository. The site recommendation process is set forth in the Nuclear Waste Policy Act.

spent nuclear fuel Fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing.

thermal loading strategies Placing waste in a repository so that the heat produced by it will cause specific effects on repository performance.

total system performance assessment (TSPA) Analyses undertaken by the U.S. Department of Energy to assess the ability of the potential repository at Yucca Mountain to provide long-term waste isolation and containment.

unsaturated zone A rock in which some of the empty spaces are filled with water.

waste isolation and containment Separation of the waste from the environment so that any radioactive material reentering the environment will be kept within prescribed limits.

waste package The waste form, any fillers, and any containers, shielding, packing, and other absorbent materials immediately surrounding an individual waste container.

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