Executive Summary

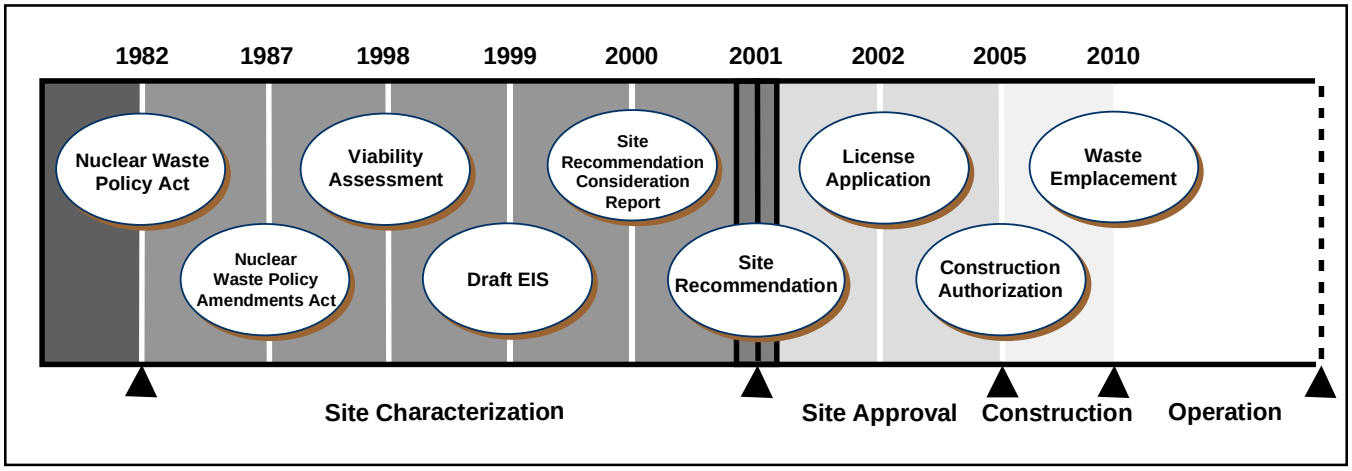
Site Characterization Meets Key Milestone; Waste Acceptance Issues Remain Open

Overview

During Fiscal Year 1999, the Office of Civilian Radioactive Waste Management (OCRWM) continued to make significant progress in its characterization of the Yucca Mountain, Nevada, candidate geologic repository site. Although OCRWM's appropriation for Fiscal Year 1999 was lower than requested, the Program accomplished all three success measures in the Secretary's Fiscal Year 1999 Performance Agreement with the President and completed important work in many other areas. Most of the Program's funding and activity centered on supporting the next major statutory milestone – a Secretarial determination whether to recommend Yucca Mountain for development of a repository for spent nuclear fuel and high-level radioactive waste. Many planning activities related to waste acceptance and transportation and some tasks related to preparing for a license application were deferred.

A key milestone was reached with the publication of the draft environmental impact statement for the potential repository. It is intended as a tool to assist with decision-making and provides public disclosure of information. Completed in July 1999, the draft presents the results of analysis of potential impacts associated with constructing, operating and monitoring, and eventually closing, a repository at Yucca Mountain and of transporting waste to Yucca Mountain from 77 sites across the United States. In general, the proposed action would cause minor, short-term public health impacts due primarily to the transportation of spent nuclear fuel and high-level radioactive waste to Yucca Mountain. We also began a series of 21 public hearings on the draft environmental impact statement. The Nuclear Waste Policy Act requires that a final environmental impact statement accompany a site recommendation.

The peer review panel we had convened in 1997 to provide a formal, independent evaluation and critique



Major Program phases

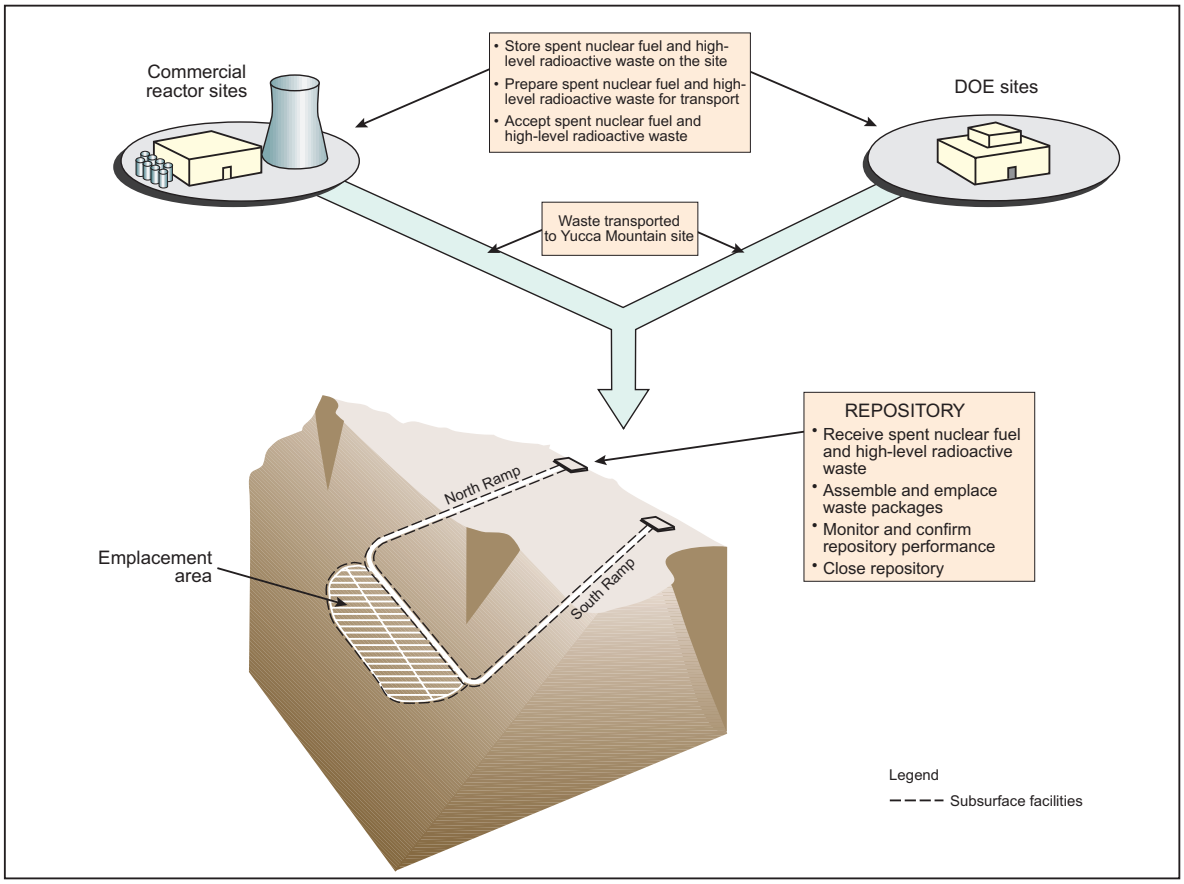
of our total system performance assessment methodology delivered its final report in February 1999. The panel, which included experts in all fields related to repository performance, evaluated all aspects of our analytical approach, reviewed supporting documentation, attended technical meetings, and examined documentation for the total system performance assessment as it was being prepared. The panel's findings and recommendations were factored into our work plans for Fiscal Years 1999 and 2000.

In April 1999, we completed enhanced repository and waste package designs for use in the total system performance assessment to support a site recommendation and potential repository license application. Based on a study we began in July 1998 to reduce uncertainties about repository system performance, the enhanced design will be the basis for the total system performance assessment prepared in support of a determination whether to recommend the site. The enhanced design reduces thermal loading, which will make water movement near the waste packages easier to predict and model. The new design also uses a more corrosion-resistant waste package design and a drip shield to protect waste packages from water and possible rock falls.

Yucca Mountain Site Characterization Project

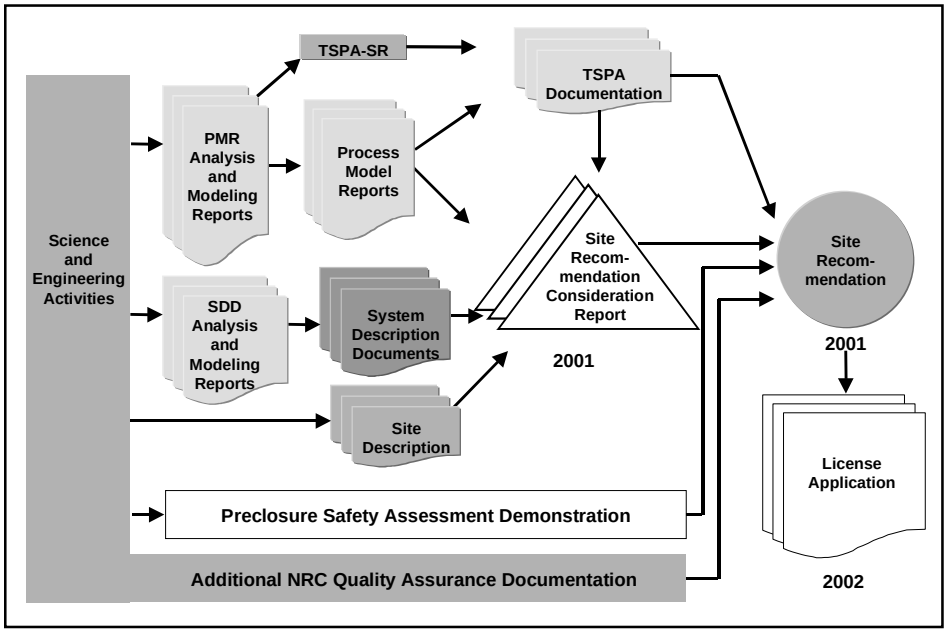
Preparing for the determination on site recommendation

Fiscal Year 1999 work focused on preparing for a Secretarial determination on site recommendation. Section 114 of the Nuclear Waste Policy Act requires that, before making this determination, the Secretary hold public hearings near the site. If a recommendation



Waste management system concept

is made by the Secretary, that recommendation must be accompanied by a comprehensive statement of the basis for the recommendation, and it must be provided to the public at the same time it is submitted to the President. We expect to release a Site Recommendation Consideration Report that will inform the public of the information and data underlying a possible site recommendation. It will include a description of the repository system and a preliminary evaluation of site suitability consistent with DOE's repository siting guidelines. It will inform local residents and solicit the comments of the Governor and legislature of the potential host State.



Documentation required for site recommendation and license application

Our Fiscal Year 1999 work to develop the Site Recommendation Consideration Report built on the *Viability Assessment of a Repository at Yucca Mountain* that the Secretary released in December 1998. To reflect information presented in the viability assessment, we refined the repository safety strategy that guides our site characterization studies. We placed additional emphasis on:

- **Strengthening total system performance assessment** – updating and documenting the models that will provide the technical basis for site recommendation.
- **Reducing scientific uncertainties** – determining the range and variability of potential impacts of water movement on the engineered barrier system and of heat from radioactive decay on the natural barrier system.
- **Improving engineering designs** – adopting a repository design concept with a lower repository temperature, drip shields to help keep water from waste packages and use of more corrosion-resistant materials in the waste packages. The enhanced design concept preserves flexibility that will permit future design enhancements and would allow future generations to determine when to close the repository.
- **Releasing the draft environmental impact statement** – publishing for public comment and holding hearings so that a final environmental impact statement can be prepared to accompany a site recommendation.
- **Proposing revised DOE repository siting guidelines (10 CFR 963)** – promulgating revised site- specific guidelines that focus on how the total system of natural and engineered barriers would perform.

Strengthening total system performance assessment

In a major Fiscal Year 1999 initiative, we began developing two sets of reports describing in detail the bases of the performance assessment models that will support evaluation of site performance. These numerical models integrate data from site investigations and laboratory studies, expert judgment,

and information about engineered barriers designed to isolate waste. A total system model simulates how a repository at the site might perform under a range of conditions over thousands of years. The result is an estimate of the annual radiation dose a person might receive from radioactive waste emplaced within Yucca Mountain. If the repository is to be licensed, that dose cannot exceed the regulatory standards that are now being finalized.

The reports we are developing, which reflect the insights of peer reviewers, present technical information in a way that ensures that all data and references used in these assessments are accounted for, are transparent, and can be traced to their sources.

During the fiscal year, we continued to refine the performance assessment models used in the viability assessment to reflect new information from site investigations and laboratory studies, advances in modeling physical processes at the site, and the enhanced repository design. The scientific and engineering work reflected in these refinements is described below. Model refinement will be completed in Fiscal Year 2000, and an iteration of total system performance assessment will be conducted for the Site Recommendation Consideration Report.

Reducing scientific uncertainties

Our scientific data collection and experimentation continued to focus on reducing uncertainty about the range of variability in the natural environment. As we reduce uncertainty, our models become more realistic.

Most scientific studies are carried out at facilities on the site, augmented by off-site laboratory and field studies. The centerpiece is the underground Exploratory Studies Facility, the main loop of which is nearly 8 kilometers (5 miles) long. Transecting it is the cross-drift, a tunnel 2.8 kilometers (1.67 miles) long that provides direct access to the central and western portions of the proposed repository block. Alcoves and niches within these facilities are instrumented for testing. Other facilities include more than 350 boreholes drilled from within underground facilities; more than 450 boreholes drilled from the surface; the Busted Butte Test Facility, which gives us access to rock similar to that beneath the potential repository horizon; over 200 pits and trenches; monitoring wells; and Global Positioning System stations. These locations yielded data on geologic, geochemical, geomechanical, and hydrologic features and processes, and the coupled mechanical, hyrologic and chemical effects of heat on rock.

We are most interested in two areas: movement of water and the effect of heat on the host rock. These areas, which have been studied since the

Cross drift

Gathering data on rock characteristics in the cross drift

beginning of site investigations at Yucca Mountain, were identified once again in the viability assessment and raised as concerns by the Nuclear Waste Technical Review Board.

Water could seep from the surface of the site into the repository and onto waste packages, corroding them. This could result in the release of radionuclides that could eventually be transported through the unsaturated zone above the water table to the saturated zone and ultimately to the accessible environment. We are studying water movement through three zones: through unsaturated rocks from the surface to the repository, and then from the repository to the water table, and finally within saturated rocks below the water table.

Water seeping from the surface down approximately 300 meters (1,000 feet) to the repository is expected to be the primary source of waste package corrosion. We are continuing to investigate under what conditions, in what quantities, and at what rates water could seep onto waste packages. Studies of seepage and water flow helped us learn how water infiltrates the rock of the unsaturated zone. To further such studies, we began to construct facilities within the cross-drift, directly within repository host rock. Seepage tests were also performed within the main tunnel of the cross-drift. We will use the resulting data to verify and increase confidence in models of water flow from the surface to the repository. Results so far indicate that water does not flow uniformly through the rock and that, under current climatic conditions, very little water flows through the repository horizon.

Eventually, waste packages will corrode, and water beneath the repository will carry

Conducting a seepage test in Alcove 1

radionuclides. We are studying the mechanisms and pathways by which, and rates at which, water could travel from waste packages down 300 meters (1,000 feet) to the water table. We are studying both water movement and the interactions of radionuclides with the host rock. At the Busted Butte facility, scientists studied how water travels through rock identical to that beneath the potential repository horizon. Sorption measurements at Busted Butte using surrogate radionuclides confirmed that transport data from laboratory tests are applicable to site-scale modeling.

Once radionuclide-bearing water reaches the water table, it can flow horizontally and could eventually reach the accessible environment. To understand how groundwater flows in the fractured aquifer below the repository and what the radionuclide sorption properties of the aquifer are, we monitored boreholes and conducted tracer testing at the C-Well complex. Wells drilled by Nye County, Nevada, also yielded valuable data on the saturated zone. Laboratory tests helped us better understand the radionuclide-sorption properties of the alluvium and volcanic aquifers. We used the data to develop estimates of groundwater travel time and to better understand how sorption of radionuclides could reduce radionuclide concentrations.

To more closely calibrate a regional hydrologic model to observations of actual conditions at the Yucca Mountain site, we continued our 5-year collaboration with the U.S. Geological Survey; the U.S. Fish and Wildlife Service; the U.S. Park Service; representatives from Nye County, Nevada, and Inyo County, California; and the Nevada State Engineer's Office. Fiscal Year 1999 tasks included field work to gather new data and refinement of the regional hydrologic model. We also incorporated new data into our three-dimensional geologic model of the site.

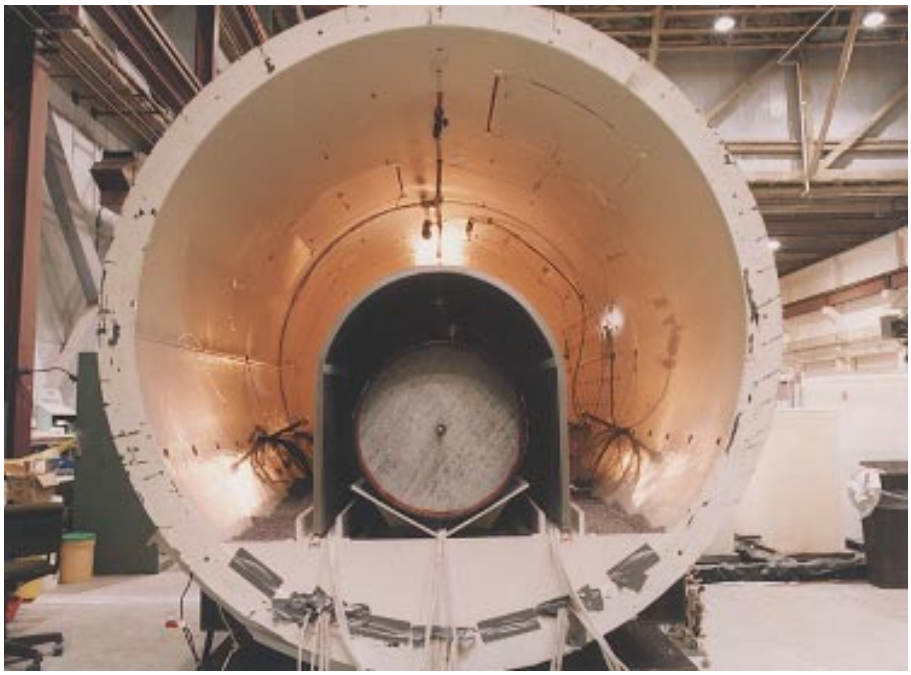
Nye County drilling program

Heat generated by radioactive decay of the waste could alter the surrounding rock and affect the rate at which waste packages degrade and radionuclides are released. Three field heater tests and additional laboratory tests continued to generate valuable data. Results thus far include identification of conduction as the dominant heat transfer mechanism and the preliminary indication that rock pore water mobilized by the heat tends to drain by gravity to below the heated region, rather than staying perched above it.

Improving engineering design

A major Fiscal Year 1999 accomplishment was the adoption of repository design enhancements for the total system performance assessment that will support the Secretarial determination on site recommendation. Some of the new features had been recommended by the Nuclear Waste Technical Review Board. A key aspect is a lower repository temperature, achieved through a set of thermal management techniques, because the heat from radioactive decay may cause water to boil and condense, introducing uncertainties. The enhanced design also includes the use of drip shields to help keep water from waste packages and waste package materials with improved corrosion-resistance. The enhanced design concept preserves flexibility that will permit future design enhancements and would allow future generations to determine when to close the repository.

Another important task that will support the Site Recommendation



Preparation for a pilot-scale drip shield test

Consideration Report was continued development of system description documents for major repository subsystems related to safety, such as the materials handling system. These documents specify requirements for a repository subsystem and describe the resulting design.

Releasing the draft environmental impact statement

In July 1999, we completed the *Draft Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (EIS). It provides the background, data, and analyses that can help government officials and the public understand the potential environmental impacts of actions that the Department may propose: constructing, operating and monitoring, and eventually closing, a repository at Yucca Mountain. It also examines the impacts of transporting waste from around the country to the repository.

Proposed Action Alternative (Preferred)	Non-Action Alternative
• DOE proposes to construct, operate and monitor, and eventually close a repository at Yucca Mountain for the geologic disposal of SNF and HLW	• DOE will decommission and reclaim the Yucca Mountain site and continue to store SNF and HLW at existing commercial and DOE sites

Alternatives examined in the draft EIS

To provide a basis for comparison with the proposed action, the draft EIS presents a No Action Alternative that analyzes the consequences of continued storage of spent nuclear fuel and high-level radioactive waste at current sites. The draft EIS states that the Department's preferred alternative is to proceed with repository development, because analyses did not identify any potential environmental impacts that would be a basis for not proceeding with the proposed action.

A series of 21 public hearings on the draft EIS was under way as the fiscal year closed. We also held periodic meetings to brief stakeholders on EIS-related issues. Comments and responses will be published in a comment response document that will be part of the final EIS, scheduled for release in Fiscal Year 2001.

Proposing revised DOE repository siting guidelines (10 CFR 963)

In Fiscal Year 1999, the regulatory framework for evaluating the suitability of the Yucca Mountain site moved closer to final form. On November 30, 1999, the Department published a proposed revision to its repository siting guidelines. The proposed revised guidelines reflect a shift away from a generic approach that could apply to any site and that focused on individual technical criteria to a site-specific approach that relies on an overall systems evaluation of the expected performance of a repository at Yucca

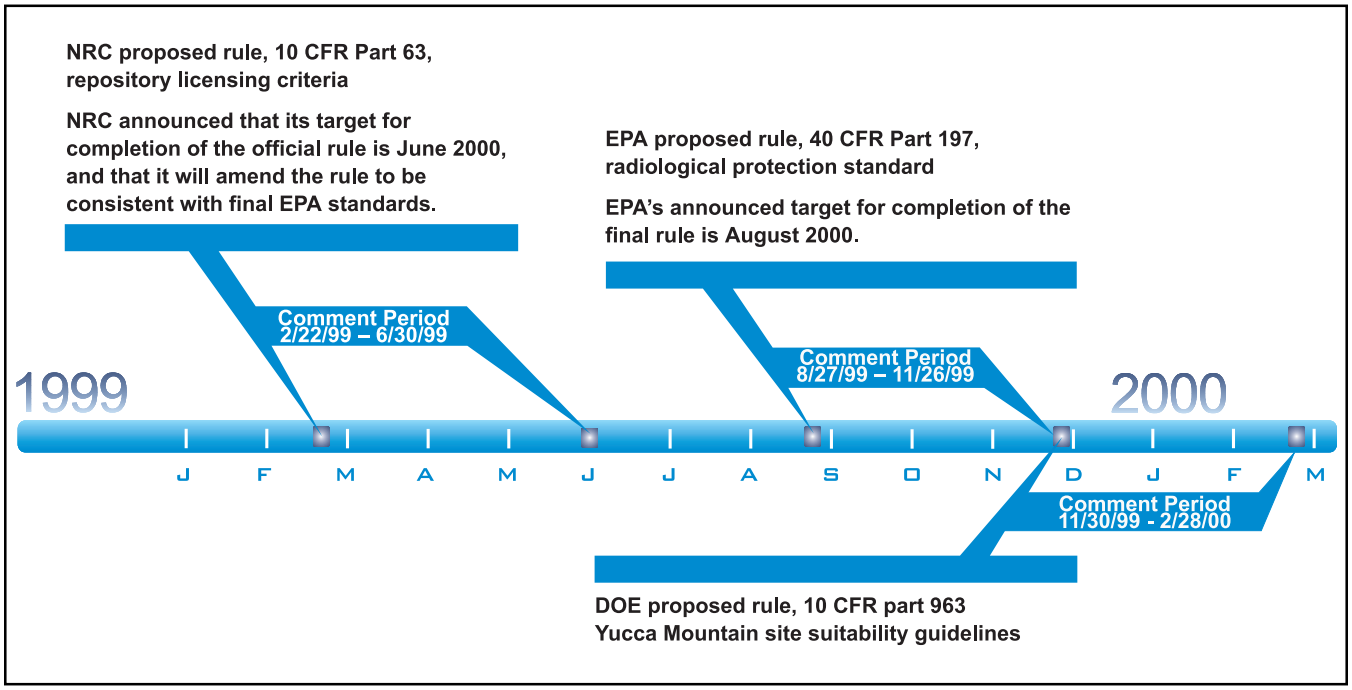
Mountain. This same approach had been taken by NRC in the proposed repository licensing regulations it published on February 22, 1999. The Department's proposed siting guidelines will result in an assessment of the site's ability to meet NRC's licensing regulations. On August 27, 1999, the Environmental Protection Agency (EPA) published proposed radiation protection standards for a repository at Yucca Mountain. NRC's regulations must implement EPA's standards. NRC has announced that it will, if necessary, revise its regulations once EPA's standards are finalized.

Waste Acceptance, Storage, and Transportation Project

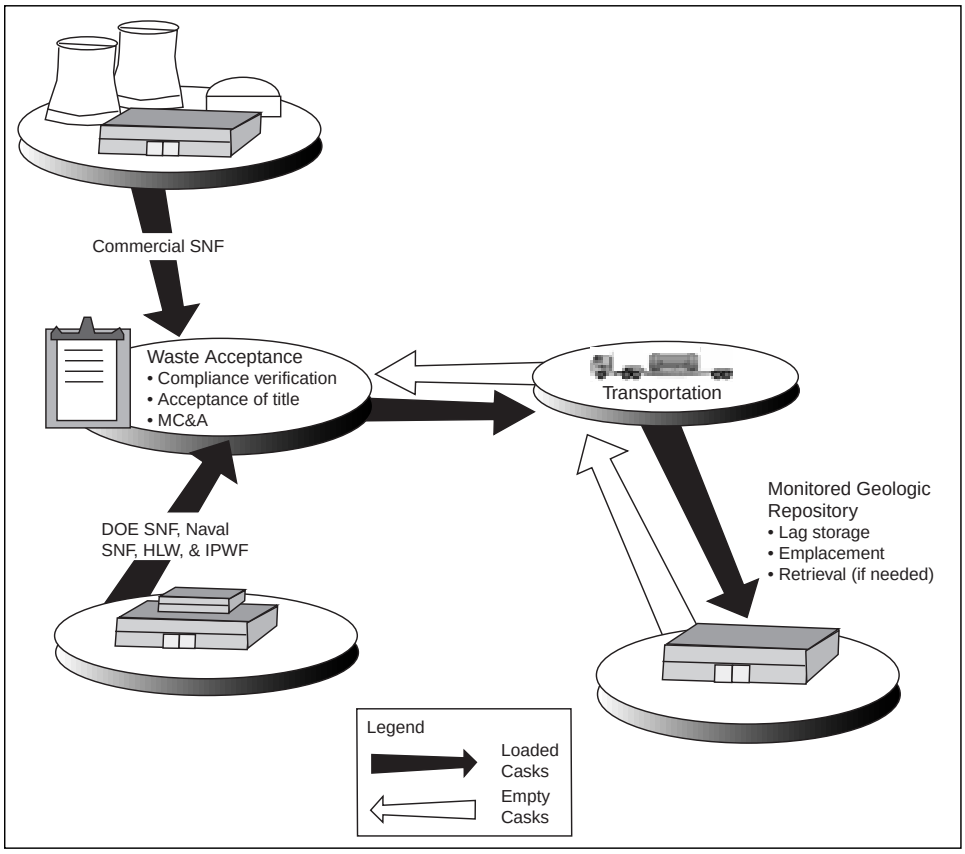
With funding for this Project at less than 1 percent of our Fiscal Year 1999 budget, work remained curtailed. We continued to manage the contracts we executed with utilities under the Nuclear Waste Policy Act and to gather the data about their spent fuel inventories that are required for waste acceptance.

Under these contracts, DOE was to start accepting spent nuclear fuel from utilities in 1998. With no Federal facility available to receive the material, utilities continued to pursue litigation to seek relief from hardships they allege as a consequence of the Department's inability to accept waste. In an effort to resolve this dispute, in March 1999 testimony before Congress, the Secretary proposed that the Department take title to utilities' spent nuclear fuel and manage it at their sites. Analysis of this option is still under way.

Some utilities are running out of "wet storage," in engineered pools of water where spent nuclear fuel assemblies are stored pending disposal. In October 1999, a successful demonstration of a prototype for a dry transfer system for spent nuclear fuel, which Congress had directed DOE to develop cooperatively with the nuclear utility industry, was concluded. The NRC issued its draft assessment of our Topical Safety Analysis Report in February 2000. A final report will be prepared after comments are received and reviewed.



Timeline for regulatory activities



Movement of waste to the repository

Throughout the fiscal year, OCRWM and DOE offices that manage nuclear materials slated for disposal in a repository continued to implement the terms of their memoranda of agreement and to otherwise coordinate planning for waste acceptance.

Program Management Center

Quality assurance

Headquartered in Las Vegas, OCRWM's Office of Quality Assurance (QA) used audits, surveillance, inspections, and participation in reviews of technical documents to examine the full range of quality-affecting activities performed by OCRWM, its contractors, and the organizations within DOE's Office of Environmental Management that interface with OCRWM.

QA personnel worked closely with technical personnel conducting scientific studies, design work, and performance assessment to identify the activities with greatest impact on levels of confidence related to evaluations of site suitability and possible licensing. They examined whether that work was performed under appropriate QA requirements, whether requirements were fully understood, whether they were properly implemented, and whether compliance was adequately documented. For performance assessment, QA reviews focused on model validation, qualification of existing data, and software control. Deficiencies were evaluated and, if warranted, root causes were investigated. For each deficiency, a corrective action plan was developed, reviewed, and implemented. The result will be work products that can withstand scrutiny and be used to support a possible site recommendation.

Program management and integration

Revision 2 of the *Civilian Radioactive Waste Management Program Plan*, issued in July 1998, describes Program objectives and outlines work scope, key milestones, and budgetary resources required to complete them. The fact that Congress appropriated significantly less funding than required to carry out planned work as scheduled resulted in a reprioritization of our efforts and a reassessment of near-term milestones. In Fiscal Year 1999, we began to update plans and schedules to reflect lower appropriations and build upon recent events, including DOE's issuance of the viability assessment, the draft EIS, and proposed revisions to DOE's repository siting guidelines; EPA's issuance of proposed site-specific radiation standards; and NRC's release of proposed new licensing regulations.

Consistent with Department-wide efforts to improve project management, we strengthened the planning and control that will ensure that the components of a waste management system are integrated, safe, reliable, and cost-effective. During Fiscal Year 1999, we analyzed alternative approaches to managing the construction phase of repository development, so that spending could remain relatively level through 2020. We also updated the *Design Basis Waste Stream Report*, which provides the reference inventory of spent nuclear fuel and high-level radioactive waste intended for disposal in the repository. The information will support the Site Recommendation Consideration Report and a potential license application.

Maintaining the integrity of the information generated by years of site investigations, engineering, and performance assessment and making it readily accessible remained a top priority. In Fiscal Year 1999, we consolidated information management functions under an Office of Information Management within the Yucca Mountain Site Characterization Office.

Y2K compliance proceeded smoothly. We met all DOE Y2K milestones for mission-critical and non-mission-critical systems ahead of the Secretary's stretch goals. The mission-critical systems were subsequently independently verified and validated, and we completed and tested our Y2K Business Continuity Plan. The transition to 2000 was problem-free.

A principal driver behind our application of information technology is the need to access information during a potential licensing proceeding. On December 30, 1998, NRC finalized its revision of requirements for an Internet-based Licensing Support Network that would provide an electronic means of supporting document discovery motions and permit electronic docketing of the license application itself. The rule changes the requirement for a large centralized database but retains the requirement to provide scanned images with associated bibliographic indexes and the capability to perform full text searches of each document related to licensing. We have continued to reprocess legacy records and process current records into the format required. At the end of Fiscal Year 1999, our system held a total of 917,200 legacy and current records.

To provide our managers and potential vendors with a useful roadmap for future acquisitions, in Fiscal Year 1999, we published an *OCRWM Program Business Plan* documenting our overall business and contracting strategy for managing acquisitions. For the short term, it focuses on the recompetition of a contract for management and operating services. If repository development is approved, the plan will guide acquisition of contractors to construct and operate the repository. The concepts and strategies presented are predicated on our receiving adequate funding and necessary approvals, as well as on other external factors. The plan has been designated a model for other DOE programs to follow in developing site management plans required by the Department.

External interactions

In Fiscal Year 1999, OCRWM's Acting Director and staff at headquarters and at the Yucca Mountain Site Characterization Office met with representatives of over 25 Federal agencies, environmental groups, technical and professional organizations, policy groups, and international organizations.

International efforts gained greater visibility when, in 1998, Secretary Richardson announced at the first International Atomic Energy Agency (IAEA) General Conference that the Department would convene an international conference to highlight global progress on management of nuclear materials and radioactive waste in geologic repositories. OCRWM was assigned lead responsibility, and we worked with other offices within the Department to coordinate planning in cooperation with the IAEA and the Organization for Economic Cooperation and Development/Nuclear Energy Agency (OECD/NEA). Hosted by the City of Denver, Colorado, the conference was held October 31 - November 2, 1999. Participants were invited to tour the Yucca Mountain site and the Waste Isolation Pilot Plant (WIPP) the next day. We coordinated the timing of the conference with the National Academy of Sciences' technical workshop on geologic disposal in Irvine, California, on November 4-5, 1999.

We met several times with officials of the Russian Federation's Ministry for Atomic Energy (Minatom) in

an effort to formalize an agreement for cooperative activities on geologic disposal of radioactive materials. In June 1999, senior Minatom officials met with us at DOE headquarters and the Yucca Mountain Site Characterization Office and visited the Yucca Mountain site. We established a joint working group on spent nuclear fuel to assess broader issues associated with the shipment, storage, direct disposal, and management of radioactive waste and spent nuclear materials.

OCRWM also continued its membership in the OECD/NEA, the IAEA, and the newly formed International Association for the Environmentally Safe Disposal of Radioactive Materials.

Conclusion

As the year closed, we were engaged in tasks that will culminate in a determination by the Secretary whether to recommend Yucca Mountain for development as a repository. Scheduled for Fiscal Year 2001, the determination will mark the end of the site characterization phase of our work, an 18-year, approximately $4 billion effort that has produced a comprehensive understanding of the Yucca Mountain site and of what is required to design a repository that would perform safely in that setting.

How geologic disposal would work at Yucca Mountain

If Yucca Mountain is approved for development as a repository, waste materials, all in solid form, would be placed into robust containers called waste packages. These containers would be emplaced in tunnels, termed *drifts*, excavated deep within the mountain, at a depth of approximately 300 meters (1,000 feet) below the surface and approximately 300 meters (1,000 feet) above the water table.

A combination of natural and engineered barriers would contain the waste for thousands of years, thereby minimizing the amount of radioactive material that would eventually be released and transported to the human environment. The natural barriers include the semiarid environment at Yucca Mountain, which is favorable for long-term waste isolation. The engineered barriers would include robust, long-lived waste packages and other design features of a repository, described in Chapter 1.

Scientists believe that water is the primary means by which radionuclides could be transported and that four key attributes of a repository in this geologic setting would protect public health and the environment for thousands of years:

- Limited water would contact waste packages.
- Waste packages would last a long time.
- Once waste packages were breached, radionuclides would be released slowly.
- The concentration of radionuclides would diminish as they are transported toward the human environment.

Accordingly, the barriers would serve these principal functions:

- They would keep water away from the waste as long as possible.
- They would limit the amount of water that finally contacts the waste.
- They would slow the release of radionuclides from the waste.
- They would reduce the concentrations of radionuclides in groundwater.

The natural and engineered barriers would work as a system that would exploit a design strategy termed defense-in-depth. This means that some barriers would continue to function even if others failed because no two barriers would be likely to fail for the same reason or at the same time.

The Environmental Protection Agency (EPA) published its proposed site-specific radiation standards for Yucca Mountain, 40 CFR 197, in the *Federal Register* on August 27, 1999. The standards would establish limits for the radiation doses to which a repository system at Yucca Mountain could expose future residents near the site. If the Yucca Mountain site is approved for development as a repository, the Department would have to demonstrate in a licensing proceeding before the Nuclear Regulatory Commission that radiation releases from a repository system at Yucca Mountain would not exceed EPA dose limits.

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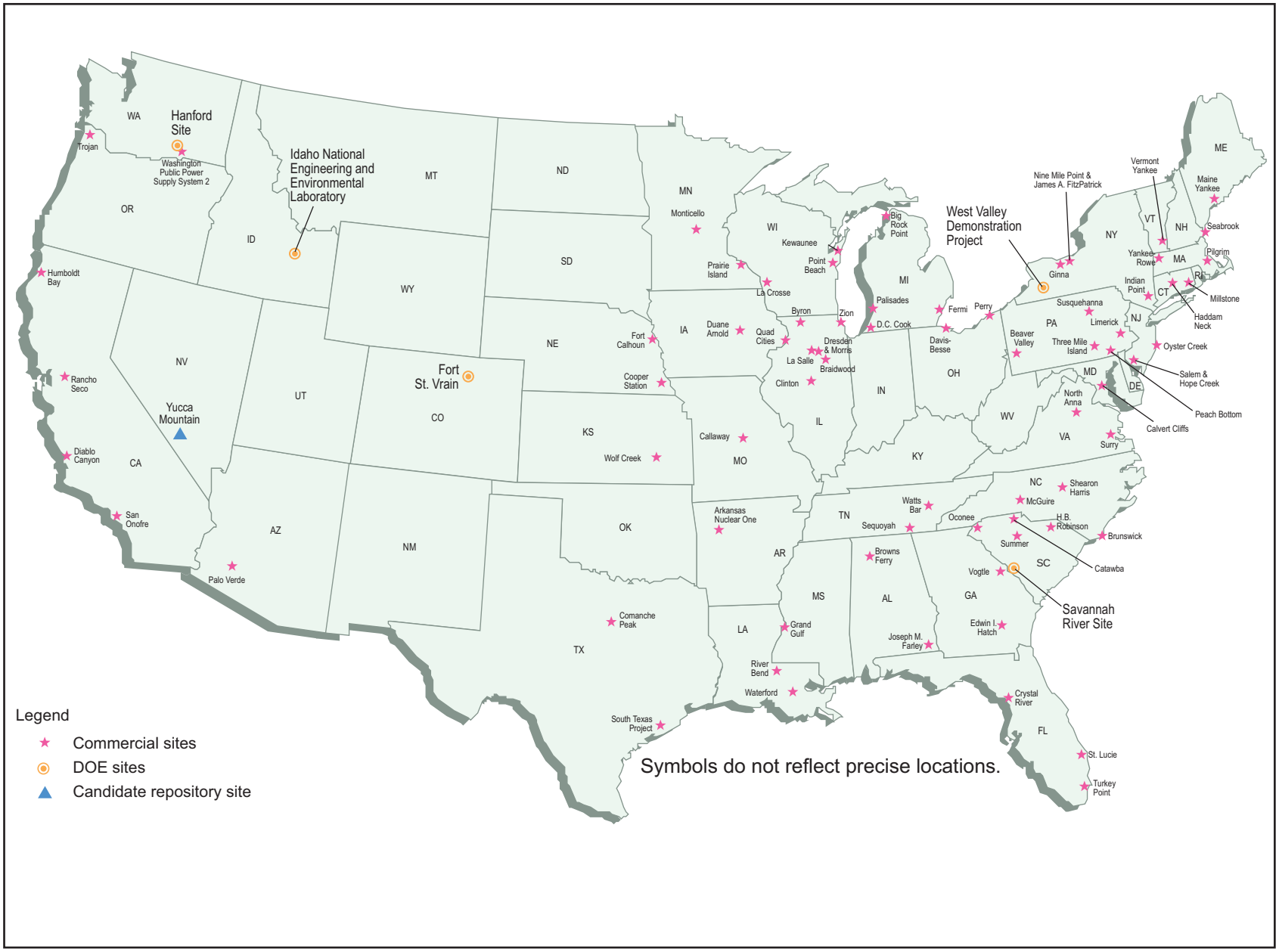

Location of commercial and DOE sites and Yucca Mountain