United States General Accounting Office

GAO

Report to the Congress

September 1988

NUCLEAR WASTE

Fourth Annual Report on DOE's Nuclear Waste Program

043386/136919

GAO/RCED-88-131

GAO

United States
General Accounting Office
Washington, D.C. 20548

Comptroller General
of the United States

B-202377

September 28, 1988

To the President of the Senate and the
Speaker of the House of Representatives

This report presents the results of our fourth annual report on the Department of Energy's efforts to implement the Nuclear Waste Policy Act of 1982 (42 U.S.C. 10101), as amended by Title V of the Budget Reconciliation Act for Fiscal Year 1988 (P.L. 100-203). The act requires us to report to the Congress the results of an annual audit of the Department's Office of Civilian Radioactive Waste Management.

We are sending copies of this report to congressional committees with oversight of the Department's activities, the Secretary of Energy, and other interested parties.

This work was performed under the direction of Keith O. Fultz, Senior Associate Director, Resources, Community, and Economic Development Division. Other major contributors are listed in appendix IV.

Charles A. Bowsher
Comptroller General
of the United States

Executive Summary

Purpose

In 1980, the Department of Energy (DOE) estimated that about 167,000 metric tons of highly radioactive wastes would be produced at commercial nuclear power plants through 2020, with still more waste expected after that date. To find a permanent solution to disposing of these wastes, the Congress enacted the Nuclear Waste Policy Act of 1982. It revised the act in 1987 in response to continuing opposition to DOE's efforts to identify candidate nuclear waste repository sites and to increasing costs of the waste program.

In this fourth annual report, required by the 1982 act, GAO discusses the implications of declining waste quantities and increasing costs for the nuclear waste program, as redirected by the Congress. It also discusses the effects of the 1987 legislation on the advantages that DOE originally perceived in developing a facility for receiving and storing nuclear wastes until they can be disposed of in a repository.

Background

The Budget Reconciliation Act for Fiscal Year 1988, enacted in December 1987, amended the 1982 act in several key ways. It directed DOE to investigate only Yucca Mountain, Nevada, for the first nuclear waste repository, instead of that site and two other candidate sites. However, it retained the 70,000-metric-ton ceiling on the volume of waste that DOE can dispose of in the repository until a second one is developed. According to the legislative history of the 1982 act, the original intent of this provision was to ensure that no state would have to bear the entire waste disposal burden. The act also requires DOE to report to the Congress and the President between 2007 and 2010 on the need for a second repository.

The 1987 act voided DOE's earlier choice of a site for a facility for monitored, retrievable storage of commercial wastes, and linked a facility's development to progress in developing a repository. It also established the Monitored Retrievable Storage Review Commission to study the need for a proposed storage facility and report its findings to the Congress on June 1, 1989.

Results in Brief

Utilities have not ordered new nuclear power plants for 10 years and are not expected to do so unless and until conditions affecting the nuclear power industry improve. Unless new plants are built, the total volume of commercial and government waste that DOE may have to dispose of will exceed the authorized capacity of the first repository by about 50 percent or less. Although this is much less waste than had been

anticipated in the early years of the waste program, the estimated cost of the program has increased by several billion dollars.

DOE is preparing to investigate Yucca Mountain. If the site is eventually selected, DOE will seek Nuclear Regulatory Commission approval to build a repository capable of holding up to 70,000 metric tons of waste. If the waste quantity expected exceeds that amount in about 20 years, then DOE may recommend either development of a second repository or expansion of the Yucca Mountain facility. In view of declining waste estimates and uncertainty about the capacity of Yucca Mountain, there may be advantages to earlier and more complete investigation of the potential capacity of that site.

DOE originally proposed adding a monitored storage facility to the waste disposal system to permit, in part, detailed system planning and implementation up to 8 years before opening a repository. The 1987 act, however, closely ties development of the facility to progress on the repository. Although this approach ensures that a storage facility does not detract from repository development, it also largely eliminates the advantages that were expected from early implementation of the waste system.

GAO's Analysis

Lower Waste Volume and Higher Costs

Waste disposal projections have declined—even with the addition of waste from government defense activities—because utilities have, since 1978, stopped ordering new nuclear power plants. Unless new nuclear plants are built, the total quantity of commercial and defense wastes expected through the estimated 40-year operating lives of existing plants is 105,000 metric tons or less.

Even with declining waste projections, estimates of waste program costs had increased from $23 billion in 1983 to $33 billion or more in 1987.[1] DOE's preliminary estimate of the cost of implementing the revised program is about $31 billion, with a repository at Yucca Mountain and a second one at an unspecified location, and about $23 billion if all wastes are disposed of at Yucca Mountain. (See ch. 2.)

[1] All costs are expressed in constant 1987 dollars.

Capacity of Nevada Site

Studies already conducted from the surface of Yucca Mountain give DOE confidence that the site will hold 70,000 metric tons of waste. There is uncertainty, however, about the capacity of the specific area DOE intends to investigate, and DOE knows still less about the site's potential for expansion. Studies during site investigation are expected to increase DOE's understanding of this potential.

When DOE submits its report on a second repository in about 20 years, it will discuss whether any wastes then projected in excess of 70,000 metric tons should be disposed of by developing a second repository or by expanding the Yucca Mountain facility. Under existing procedures, the latter alternative would require additional detailed site investigation and an amendment to DOE's original authorization to construct and operate the repository. (See ch. 2.)

Monitored Storage Facility

DOE has wanted to build a monitored storage facility for several reasons, principally to begin planning waste shipments to the facility up to 8 years in advance of a repository. Also, a facility could reduce the need for utilities to expand temporary waste storage capabilities at nuclear plant sites.

The 1987 act, however, limits DOE's ability to construct and operate a facility in advance of a repository. For example, DOE cannot select a facility site and make detailed transportation plans to the facility until it completes its investigation of Yucca Mountain in the mid-1990s. In addition, because of a facility's ties to progress on a repository, the facility will not significantly reduce the need for new temporary storage capacity at nuclear plant sites. (See ch. 3.)

Matter for Congressional Consideration

The Congress may wish to explore with DOE the advantages of earlier and more complete information on the potential capacity of Yucca Mountain in view of continuing decline in estimates of waste to be disposed of and uncertainties about the capacity of the primary disposal area at the site.

Recommendation

To provide the Monitored Retrievable Storage Review Commission with the best possible information for its evaluation and report to the Congress, GAO recommends that the Secretary of Energy supplement DOE's original proposal for a facility by identifying, with supporting analyses,

the benefits of the facility under the conditions established in the 1987 act.

Agency Comments

DOE stated that it is evaluating a variety of monitored retrievable storage facility configurations and, as GAO recommended, looks forward to providing the results to the review commission. DOE did not comment on GAO's analysis of the potential advantages of earlier and more complete information on the potential capacity of Yucca Mountain. DOE's comments are contained in appendix III.

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Abbreviations

DOE	Department of Energy
EIA	Energy Information Administration
GAO	General Accounting Office
MRS	monitored retrievable storage
NRC	Nuclear Regulatory Commission
NWPA	Nuclear Waste Policy Act of 1982
OCRWM	Office of Civilian Radioactive Waste Management

Introduction

More than 16,000 metric tons of highly radioactive wastes are temporarily stored in facilities in more than 30 states, and more is generated each year.[1] Coming primarily from 108 operable commercial nuclear power plants at 66 sites and Department of Energy (DOE) national defense activities at 3 sites, this waste will remain dangerous to humans and the environment for tens of thousands of years. Another 12 commercial plants are either under active construction or are awaiting licenses required for commercial operation from the Nuclear Regulatory Commission (NRC). In this report, these 120 plants in various stages of construction or operation are referred to as existing plants.

To dispose of highly radioactive waste permanently and safely, the Congress enacted the Nuclear Waste Policy Act of 1982 (NWPA). The act established a process for DOE to identify a number of candidate nuclear repository sites and recommend that the President select two or more appropriate sites from among those identified. This process included the active participation of potentially affected states and Indian tribes, and licensing and regulation of the repositories by NRC. The act also required generators and owners of commercial waste to finance disposal program costs through fees based on the generation of electricity from nuclear plants. Finally, the President was directed to decide whether defense wastes should be disposed of in the repositories for commercial waste. In April 1985, the President directed the Secretary of Energy to make arrangements to dispose of defense wastes in the commercial repositories.

The NWPA also requires that we conduct an annual audit of DOE's Office of Civilian Radioactive Waste Management (OCRWM) and report the results to the Congress. Our third annual report, issued in April 1987, discussed opposition to the program by states and Indian tribes. Unless DOE could improve the credibility of its program, these parties said, they could be expected to exercise their right under the NWPA to disapprove of the final selection for a repository site. Such a disapproval would eliminate a site from consideration unless the Congress passed a resolution of repository siting approval as provided by the act. The report also addressed slippage in schedules for major program activities leading to operation of the first waste repository.[2] Other major reports in 1987

[1] As used in this report, highly radioactive waste, or "waste," refers to all high-level radioactive waste generated by commercial entities and the government. Most commercial waste is spent (used) nuclear reactor fuel, and most governmental waste comes from defense-related activities and is referred to as defense waste.

[2] Nuclear Waste: Status of DOE's Implementation of the Nuclear Waste Policy Act (GAO/RCED-87-17, Apr. 15, 1987).

addressed problems with DOE's relations with states and tribes; the adequacy of DOE's proposal to develop a Monitored Retrievable Storage (MRS) facility for early acceptance, processing, and temporary storage of commercial waste; increasing program cost estimates, including costs to characterize (investigate) three candidate sites for the first repository; and declining waste quantity projections and their implications for waste program planning.[3]

In some of these earlier reports, we stated that DOE's implementation of the act had been criticized by potentially affected states and Indian tribes, and the waste program had experienced significant delays in meeting the milestones established in the NWPA. In addition, although long-range estimates of the quantity of waste that will require disposal had declined steadily, estimated disposal costs had increased substantially.

We were preparing our fourth annual report, primarily addressing the implications of declining waste quantities and increasing program costs for the waste program when, in December 1987, the Congress redirected the program because of mounting opposition and increasing cost estimates. Specifically, in the Nuclear Waste Policy Amendments Act of 1987—contained in title V of the Budget Reconciliation Act for Fiscal Year 1988 (P.L. 100-203)—the Congress directed DOE to determine if one site—Yucca Mountain, Nevada—is suitable for a waste repository and, if so, to seek NRC's authorization to construct a repository. The amendments also authorized DOE to develop an MRS facility, subject to restrictions imposed by the amendments.

Although the Congress has focused the waste program on the investigation and potential development of a repository at Yucca Mountain, the information that we were developing on projected waste quantities and program cost estimates is relevant to continuing congressional deliberations, oversight, and future decisions on the redirected program. Therefore, we modified the scope of our fourth annual audit. This report assumes that a repository will be developed at Yucca Mountain, unless DOE determines that the site is unsuitable, and that DOE will develop an MRS facility subject to the new restrictions.

[3]Nuclear Waste: Institutional Relations Under the Nuclear Waste Policy Act of 1982 (GAO/RCED-87-14, Feb. 9, 1987), DOE Should Provide More Information on Monitored Retrievable Storage (GAO/RCED-87-92, June 1, 1987), A Look at Current Use of Funds and Cost Estimates for the Future (GAO/RCED-87-121, Aug. 31, 1987), and Information on Cost Growth in Site Characterization Cost Estimates (GAO/RCED-87-200FS, Sept. 10, 1987).

Effect of Amendments on the NWPA

The 1987 amendments designated Yucca Mountain, subject to a determination of its suitability, as the site for the first waste repository, authorized development of an MRS facility, and required additional study of the potential use of storage technologies at nuclear plant sites. In addition, the amendments added several new features to the original act. The following sections discuss those changes and additions to the NWPA.

Repository Location

The NWPA's primary objective is the construction and operation of deep, mined geological repositories for highly radioactive waste. To achieve this objective, the act established certain procedures for identifying and selecting sites for at least two repositories.[4] For each repository, these procedures included (1) recommendation and selection of three candidate sites for characterization,[5] (2) characterization of the sites,[6] and (3) recommendation of the final site to the Congress by the President. For the first repository, if the President's recommendation was permitted to go forward,[7] DOE would seek authorization from NRC to construct a repository at the site.

The 1987 amendments direct DOE to terminate all site-specific activities at the Deaf Smith and Hanford sites and characterize only the Yucca Mountain site as a potential repository. If DOE determines that the site is suitable for a repository, it must recommend its selection to the President. If the site is unsuitable, DOE is not authorized to select another candidate site. Instead, it must terminate all site-specific activities, report to the Congress and the state that the site is unsuitable, and, within 6 months, provide the Congress with recommendations for further action to ensure the safe, permanent disposal of spent nuclear fuel and high-level radioactive waste.

DOE is prohibited from conducting site-specific activities on a second repository unless the Congress specifically authorizes and appropriates

[4]The act required the President to make at least two repository recommendations to the Congress. However, it only authorized construction of the first repository.

[5]On May 28, 1986, the President selected three sites for characterization. They are located in Deaf Smith County, Texas; at Yucca Mountain, Nevada, adjacent to DOE's nuclear weapons testing site; and on DOE's Hanford Reservation in Washington.

[6]Site characterization refers to activities undertaken in either the laboratory or the field to study the geologic condition of a potential repository site. Such testing includes borings, surface excavations, exploratory underground shafts, and testing at repository depth to evaluate the suitability of a site.

[7]The NWPA permits an affected state and Indian tribe to disapprove the President's site recommendation, but it also permits the Congress to override the disapproval.

funds for such activities. It is required to report to the President and the Congress between January 1, 2007, and January 1, 2010, on the need for a second repository. The amendments do not, however, alter the restriction contained in the original act requiring NRC, in licensing the first repository, to prohibit emplacement of more than 70,000 metric tons of waste in the repository until a second one is operational. The temporary capacity limit was, according to the legislative history of the NWPA, intended to ensure that two repositories, regionally dispersed, would be developed so that no state would have to bear the entire burden of waste disposal.

Monitored Retrievable Storage

The NWPA required DOE to study the need for and feasibility of an MRS facility and submit a proposal to the Congress for its construction and operation. This facility was to be capable of providing long-term storage, continuous monitoring, management, and maintenance of the wastes, and ready retrievability for further processing or disposal. On March 31, 1987, DOE submitted its proposal to build and operate an MRS facility at the former Clinch River Breeder Reactor Project site in Oak Ridge, Tennessee.

The amendments authorized DOE to construct and operate an MRS facility but voided DOE's site selection. Instead, DOE is required to conduct a new site selection survey only after the MRS Review Commission, discussed below, has reported to the Congress on the need for an MRS facility. DOE can include its original selection of a preferred site and two alternative sites in the survey, but it cannot give these three sites special weight. Further, site selection and construction phases for a facility are now tied to progress in developing a waste repository, and the amount of waste that DOE can store at a facility is limited.

Finally, a three-member MRS Review Commission was established to evaluate the need for an MRS facility as a part of a national nuclear waste management system that will achieve the purposes of the NWPA, as amended. The commission, whose members are appointed by the Speaker of the House and the President pro tempore of the Senate, is required to report the results of its evaluation, including its recommendations, to the Congress on June 1, 1989.

Demonstration of Nuclear Plant Waste Temporary Storage Technology

The NWPA directed DOE to establish demonstration programs, in cooperation with the private sector, for dry storage of spent fuel at nuclear plant sites and for consolidation of spent nuclear fuel rods in existing reactor storage pools.[8] The dry storage demonstration program was to establish one or more storage technologies that NRC could license for use at the plant sites without the need for additional site-specific approvals.

The amendments also require DOE to evaluate and report to the Congress, by October 1, 1988, on the use of dry cask storage technology for temporary storage of spent fuel at commercial nuclear power plant sites until a repository is operational. The study is to address

- waste storage and transportation costs, health and environmental effects, and any other appropriate factors; and
- the extent to which amounts in the Nuclear Waste Fund can and should be used to construct, operate, maintain, and safeguard spent fuel in dry cask storage at nuclear plant sites.

In conducting the evaluation, DOE is to consult with NRC and solicit the views of states, local governments, and the public.

Nuclear Waste Negotiator

The amendments establish the position of Nuclear Waste Negotiator within the Executive Office of the President. The negotiator's task is to find a state or Indian tribe willing to host a repository or MRS facility and negotiate an agreement specifying the terms and conditions under which the state or tribe would agree to host a waste facility at a technically qualified site. The negotiator would submit any agreement to the Congress for its consideration. No agreement can take effect unless enacted into federal law.

The negotiator is to carry out his or her duties independent of DOE's repository and MRS facility activities. If a negotiated repository or MRS facility agreement is enacted into law, DOE must apply for a license to construct the facility.

The negotiator's activities are to be paid for from the Nuclear Waste Fund.

[8]Spent fuel at nuclear power plants has heretofore been stored underwater in special storage pools constructed as an integral part of the nuclear power plant complex. Dry storage involves storage of spent fuel in devices such as metal casks, without the use of water, on concrete pads at the plant site. Rod consolidation involves rearranging spent fuel assemblies in a more compact configuration for continued storage in pools or with dry storage technology.

Benefit Agreements

The Secretary of Energy may enter into an agreement with Nevada and a potential host state for an MRS facility for the annual payment of benefits out of the Nuclear Waste Fund. Eligibility to receive these benefit payments is contingent upon the state agreeing to waive its right to veto the President's selection of a repository or MRS facility site, as well as rights to impact assistance authorized by NWPA. Only one repository and MRS facility agreement may be in effect at any one time. Benefits may be paid as shown in table 1.1, and one-third of the benefits must be transferred to affected local governments.

Table 1.1: Annual Benefits Payable to Host State

(Dollars in millions)

	Benefit amount	
Pay schedule	**MRS**	**Repository**
Annual payments prior to receipt of first spent fuel	$5	$10
Upon first receipt of spent fuel	10	20
Annual payments after receipt of first spent fuel until closure of the facility	10	20

Objectives, Scope, and Methodology

Our primary objective was to assess the implications of declining waste projections and increasing cost estimates for the nuclear waste program, as redirected by the December 1987 amendments. We also assessed the effects of the amendments on the advantages that DOE perceives in adding its proposed MRS facility to the nuclear waste disposal system. The scope of our review encompassed both commercial and defense waste projections, waste disposal costs, the potential waste disposal capacity of the Yucca Mountain site, DOE's proposal to develop an MRS facility, and the outlook for development and demonstration of waste storage technologies that may increase storage capabilities at nuclear power plant sites.

As described in more detail below, we relied on earlier reports of our evaluations of various waste issues in developing most of the analyses presented in this report. We also supplemented and updated information contained in these earlier reports through additional audit work performed at DOE and NRC, and we reviewed the recent amendments to the NWPA.

Waste Volume

In our August 1987 report on funds and cost estimates, we noted that for waste program planning, DOE relies primarily on nuclear electrical generating capacity and waste volume projections that show significant

future growth in nuclear power between the years 2001 and 2020.[9] We recommended that DOE base its waste program planning, including cost and revenue analyses, on lower projections derived from existing nuclear power plants.

The nuclear electricity generating capacity and commercial waste projections that we discussed in our earlier report were taken from DOE's April 1986 report on the cost of the total waste system and Energy Information Administration (EIA) reports published in 1985.[10] For this report, therefore, we updated these projections on the basis of DOE's most recent report on the total cost of the waste system,[11] and EIA reports issued in July and August 1987.[12] These projections are used by DOE in planning the nuclear waste disposal program. We did not verify the accuracy of the data obtained from the EIA reports.

For estimates of defense waste volume, we used DOE reports addressing defense waste management plans. These reports included DOE's June 1987 report on the total cost of the waste system, its December 1986 study on methods for allocating repository costs, its December 1987 environmental statement on waste management at the Hanford Reservation, and its defense waste reports pertaining to its Idaho National Engineering Laboratory and Savannah River Reservation. In addition, we reviewed other publications relating to defense waste estimates and discussed defense waste volumes with officials from DOE's Office of Defense Programs.

Waste Disposal Costs

For our analysis of waste disposal costs, we obtained and reviewed each of DOE's annual reports on the total cost of the waste program for 1983 through 1987. We did not independently verify the accuracy and reasonableness of these cost estimates. However, in our August 1987 report on the use of waste program funds and future cost estimates, we selectively reviewed the basis for DOE's repository cost estimates and found that the uncertainty in the estimates may not be unreasonable in view of the

[9]GAO/RCED-87-121.

[10]EIA is the independent statistical and analytical agency within DOE.

[11]Analysis of the Total System Life Cycle Cost for the Civilian Radioactive Waste Management Program (DOE/RW-0047, June 1987).

[12]Commercial Nuclear Power: Prospects for the United States and the World (DOE/EIA-0438(86), July 1987), and World Nuclear Fuel Cycle Requirements 1986 (DOE/EIA-0436(86), Aug. 1987).

uncertainty inherent in long-range cost estimates at this early stage of the waste program.

We also obtained and reviewed information from DOE supporting its method for allocating defense waste costs and estimating the commercial and defense waste shares of total program costs projected under various assumptions about the volume of commercial waste and the cost of repositories. We expect to report the results of our ongoing evaluation of the reasonableness of DOE's cost allocation method later in 1988.

Yucca Mountain Waste Disposal Capacity

To address the capacity of the Yucca Mountain site and DOE's plans to characterize and develop it, we reviewed the agency's May 1986 environmental assessment for the site, its January 1988 "consultation draft" site characterization plan, and reports prepared by DOE contractors that address this issue. We also discussed the capacity issue with OCRWM officials to obtain clarifications on how DOE plans to address the issue during site characterization.

MRS Facility

We evaluated the effects that the NWPA amendments will have on the benefits of an MRS facility, as set forth by DOE in its March 1987 proposal and a November 1987 document supplementing the proposal. In addition, we assessed utilities' capabilities for storing their wastes until DOE removes them from nuclear power plant sites by reviewing (1) DOE reports on commercial waste inventories at individual nuclear power plants, (2) the NRC's basis for concluding that utilities should be able to store their waste at plant sites for at least 30 years, and (3) EIA information on the extent to which utilities have investigated the potential for dry storage. We also discussed commercial waste dry storage issues with officials of the NRC's Division of Waste Management, Office of Nuclear Materials Safety and Safeguards.

Our purposes were to determine the potential effects of the amendments on the benefits of the previously proposed facility and on the potential for storage technologies at nuclear power plants to alleviate any storage burden in advance of the facility or a repository.

We performed our audit work between March 1987 and February 1988 in accordance with generally accepted government auditing standards.

Lower Waste Quantities and Higher Costs May Have Implications for Investigation Approach at Yucca Mountain

The 1987 NWPA amendments focused the search for a repository site on Yucca Mountain. This action, together with the continuing decline in the amount of waste that will require disposal and the increasing cost of developing one or more repositories, raise issues regarding the need for an early understanding of the capability of the Yucca Mountain site to hold wastes up to and beyond the 70,000-metric-ton ceiling contained in the NWPA, as amended. Unless new nuclear plants beyond those already under construction are built, the total quantity of highly radioactive wastes produced from existing nuclear plants and government defense activities is likely to be between 96,000 and 105,000 metric tons.[1] Preliminary DOE cost estimates of the program, as redirected by the 1987 amendments, indicate that disposal of this waste at Yucca Mountain and a second repository will cost about $31 billion,[2] or about $8 billion more than DOE's initial estimate, made in 1983, of the cost of implementing the original waste program. DOE estimates that disposing of all wastes at Yucca Mountain would cost about $23 billion.

DOE has identified a specific area within Yucca Mountain that it intends to characterize. Unless unforeseen geologic conditions are encountered, DOE believes the area will be suitable for disposal of 70,000 metric tons of waste and may even offer "substantial" potential for future expansion. If DOE determines that the site is suitable for a repository, it expects to obtain authorization from NRC to construct a repository capable of holding up to 70,000 metric tons of waste. This is an appropriate approach in view of the limitation on waste emplacement contained in the NWPA, as amended. In its report on the need for a second repository—to be submitted in about 20 years—DOE expects to discuss the potential for expanding the repository as an alternative to developing a second one. Expanding the disposal capacity at that time could require additional characterization work to establish the suitability of the area to be used for expansion, another licensing proceeding to obtain NRC's approval for the expansion, and construction of the additional repository capacity concurrent with waste disposal operations at the original repository facility.

In view of declining waste estimates and uncertainty about the capacity of the currently defined primary disposal area at Yucca Mountain, the Congress may wish to explore with DOE the advantages of earlier and

[1]As used in this report, a metric ton of spent fuel, or an equivalent metric ton of waste from atomic energy defense activities, is a metric ton of uranium or "heavy metal." One metric ton is 2,200 pounds.

[2]Unless otherwise indicated, all costs discussed in this report are expressed in constant 1987 dollars.

more complete site characterization information on the potential repository area.

Waste Quantity Projections Continue to Decline

For waste program planning, DOE has been using EIA forecasts of commercial waste generated through 2020. In 1980, EIA projected that about 167,000 metric tons of spent fuel would be generated through 2020. Its estimates since then have declined. For example, DOE used an EIA projection of 134,000 metric tons of commercial waste through 2020 in its April 1984 draft mission plan,[3] and it used a later estimate of 106,000 metric tons for its June 1987 report on waste program costs.

EIA derived these commercial waste projections from long-range forecasts of economic growth, energy demand (including electricity), and the projected nuclear power share of electrical generating capacity. These projections assume that utilities would continue to rely on both coal and nuclear fuels to reduce reliance on oil and gas and meet projected growth in electricity demand. After EIA estimated the long-range electrical generating capacity of nuclear power plants, it projected the amount of electricity and the volume of waste that would be produced by that capacity. The waste volume estimate that DOE used in June 1987, for example, is based on EIA's projection that nuclear power capacity will grow from about 94 gigawatts of electricity at the end of 1987 to almost 220 gigawatts of electricity through 2020, or from about 120 to 220 operating nuclear power plants.[4]

Realistic Commercial Waste Projections Are Lower

In our August 1987 report on DOE's waste volume projections, (GAO/RCED-87-121), we concluded that by using certain forecasts of nuclear power generating capacity and waste volume that are based on long-range forecasts of the economy's performance, DOE is likely to overstate waste disposal needs. The realities of the nuclear power industry do not match DOE's optimistic projections. That is, no nuclear plants have been ordered by utilities since 1978; all plants ordered between 1974 and 1978 were subsequently canceled; and the condition of the nuclear industry does not point to further expansion unless and until favorable changes occur in the environment for the industry.

[3]The NWPA required DOE to prepare a mission plan that would provide an informational basis sufficient to permit informed program decisions to be made. Among other things, the plan was to include an estimate of the total repository capacity required to safely accommodate the disposal of all highly radioactive wastes expected to be generated through the end of 2020.

[4]A gigawatt of electricity is 1,000 megawatts, or approximately the generating capacity of a modern nuclear power plant.

We pointed out that, although construction and operation of new nuclear plants cannot be ruled out, the weight of evidence does not point to such an occurrence in the foreseeable future. For example, in commenting on its projections showing growth in nuclear power, EIA states that before the projected growth in nuclear generating capacity can occur, changes must occur in existing economic and regulatory conditions; new technology must be developed; the public must show greater acceptance of nuclear power; and a satisfactory solution to the nuclear waste problem must be found. We recommended in our report that DOE base its planning on waste estimates derived from the 120 existing nuclear plants until the condition of the nuclear power industry clearly suggests additional growth.

At that time DOE did not agree with our recommendation. It said that its higher estimates represented prudent planning for the maximum amount of waste that could be reasonably projected, and that it could understate repository requirements if it followed our recommendation. Subsequently, however, DOE has changed its position. According to DOE's June 1988 draft amendment to its mission plan for the nuclear waste program, it now intends to base waste program plans on the projected waste quantity produced by the existing nuclear plants over their estimated operating lives.

EIA also projects the volume of waste that existing nuclear power plants will generate. For this analysis, stated simply, EIA assumes that utilities will operate each of the approximately 120 existing nuclear power plants for 40 years but will not invest in new plants. DOE uses these EIA projections to test the sensitivity of its waste program plans to smaller volumes of waste.

Finally, EIA projects waste volume using two different assumptions about fuel management. According to EIA, at historical rates of fuel consumption, existing nuclear plants will generate about 86,000 metric tons of waste through 2020. Some utilities, however, have begun to use nuclear fuel in these plants for longer periods before replacing it with fresh fuel. This technique, known as extended burnup, lengthens the time between refueling outages and, in comparison with historical fuel management practices, reduces nuclear fuel requirements. EIA sees a definite trend toward extended burnup; however, the agency is uncertain how vigorously the industry will pursue this fuel management option. Therefore, it projects waste volume on the basis of both historical burnup levels and a 30-percent increase in burnup by 1998. At the

extended burnup rate, EIA estimates that about 78,000 metric tons of waste will be generated through 2020.

For the extended burnup case, EIA also projects the total quantity of waste that would be generated assuming a 40-year operating life for each of the 120 existing plants. In this case, EIA's projection period extends beyond 2020 to the retirement of the last plant by 2040. If utilities make extensive use of extended burnup fuel management practices, the agency expects the waste volume produced through the end of the commercial nuclear power program to be about 87,000 metric tons. Widespread decisions by utilities not to adopt extended burnup fuel management strategies would result in a larger volume of commercial waste. EIA did not project the effects of such a case through the end of the operating lives of all existing nuclear plants. However, we estimate that a maximum of about 96,000 metric tons of waste would be generated at the historical burnup rate. This estimate is based on EIA's projections through 2020 that assume both historical and extended burnup rates, and its projection through the end of the nuclear power program, assuming the extended fuel burnup rate.

The smaller waste quantity that would result from utilities' widespread adoption of extended burnup fuel management would not necessarily reduce the repository area required for disposal of the waste. The amount of waste that can be disposed of in a given area depends, among other things, on the heat produced by the waste. Because extended burnup involves using the fuel in nuclear plants for longer periods of time, the resulting waste would be relatively hotter and more radioactive than waste produced from fuel consumed at lower (historical) burnup rates. DOE estimates, for example, that waste generated at the historical burnup rate would produce 14 percent less heat than waste generated with extended fuel burnup. Therefore, for our review, we use the waste quantity projection at the historical burnup rate to estimate the maximum quantity of waste from existing commercial nuclear power plants.

In addition to the 87,000 to 96,000 metric tons of waste projected from commercial nuclear power plants, DOE estimates that it will dispose of about 640 metric tons of waste from a commercial reprocessing plant at West Valley, New York, that has been permanently shut down for more

than 15 years.[5] Also, as discussed below, DOE expects to eventually dispose of 8,000 metric tons of waste that it expects to produce through 2020 in its atomic energy defense activities. Therefore, the most realistic current estimates of the total quantity of waste that DOE may be required to dispose of under the nuclear waste program is about 96,000 to 105,000 metric tons.

DOE's Defense Waste Estimates

DOE estimates that the equivalent of 8,000 metric tons of defense wastes will have been generated by 2020 and will require disposal in a geologic repository.[6] This estimate is based on the amount of waste expected if all existing defense facilities that produce highly radioactive waste run at full capacity until the year 2000, and if a new defense production reactor is brought on line and operates through 2020 to replace retired facilities. At present, however, the three nuclear materials production reactors at Savannah River are running at less than full capacity, and the production reactor at Hanford is shut down. In February 1988, DOE announced that it does not plan to restart the latter facility in the absence of a compelling need to produce additional nuclear materials to meet various defense requirements.

To the extent that these conditions continue, DOE's projection may be overstated. On the other hand, it is possible that defense wastes not included in DOE's projection may eventually be designated for disposal in a repository. As discussed in more detail in appendix I, whether this occurs will depend on future decisions related to wastes at DOE's Hanford and Idaho facilities. A December 1986 DOE study indicates that the maximum quantity of highly radioactive defense waste that might be produced through 2020 is about 9,000 equivalent metric tons.[7] DOE has not projected defense waste quantities beyond 2020 as EIA has for commercial wastes.

DOE is currently conducting studies to provide an improved basis for future forecasts. In the interim, it believes that its estimate of 8,000

[5]Almost all of the commercial waste that will be disposed of under the act is in the form of spent fuel. There is, however, a limited quantity of waste located at West Valley that resulted from a commercial reprocessing plant shutdown in 1972.

[6]Waste resulting from nuclear defense materials production is generated and stored at DOE's Savannah River Plant (South Carolina), Idaho National Engineering Laboratory, and Hanford Reservation.

[7]Perspective on Methods to Calculate a Fee for Disposal of Defense High-Level Waste in Combined (Civilian/Defense) Repositories (DOE/RL-86-10, Dec. 1986).

equivalent metric tons through 2020 is the most accurate estimate available. In the absence of defense waste forecasts for a period comparable with commercial waste, and in view of the uncertainties related to (1) the capacity at which existing defense facilities will be operated and (2) future defense waste management decisions, we accepted DOE's projection for the purposes of our review. We recognize that later projections could be either higher or lower; however, in view of the small number of equivalent metric tons of defense waste in comparison with commercial wastes, revised defense waste projections should not significantly increase overall estimates of highly radioactive wastes.

Waste Program Costs Have Increased

Although waste quantity projections have declined even with the addition of defense waste, program cost estimates have increased. After adjustment to account for the effects of inflation, DOE's estimates of the total cost of the program had increased from about $23 billion in 1983 to between $33 billion and $39 billion (depending on variations in program cost assumptions) in DOE's last cost estimate, published in June 1987, prior to the NWPA amendments. This cost growth is illustrated in table 2.1. We discussed these increasing program cost estimates and general reasons for them in our August 1987 report on DOE's use of waste program funds and future cost estimates (GAO/RCED-87-121) and our September 1987 report on growth in cost estimates for site characterization (GAO/RCED-87-200FS).

Table 2.1: Growth in Waste Program Cost Estimates

(Dollars in billions)

Major cost category	1983 estimate	1985 estimate	1987 estimate
Development and evaluation[a]	$5.5	$8.5	$15.0–15.1
Transportation	4.6	3.6–5.5	2.1–2.3
Repository construction and operation	12.5–13.1	13.6–18.4	12.9–19.2
MRS facility	[b]	[b]	2.8
Total	**$22.7–23.3[c]**	**$25.7–32.3[c]**	**$32.9–39.2[c]**

[a]Includes all site selection costs, such as the costs of selecting and characterizing candidate sites for two repositories; repository, transportation, and MRS system design costs; and regulatory, institutional, and government administration costs.

[b]No estimate was prepared in 1983 and 1985 because DOE had not yet decided on whether an MRS facility was needed.

[c]Figures may not add due to rounding.

Shortly after the NWPA amendments were enacted, DOE analyzed the potential cost of the revised waste program. In this analysis, DOE

assumed that the total quantity of commercial waste would be about 87,000 metric tons. This is the EIA projection of commercial waste generated throughout the operating lives of existing nuclear plants, assuming that utilities adopt extended burnup fuel management practices. To this amount, DOE added its estimate of 8,000 equivalent metric tons of defense wastes and the small quantity of waste from the West Valley reprocessing plant. DOE assumed that all of these wastes would be disposed of in two repositories—one located at Yucca Mountain and another developed at an unspecified, low-cost site. DOE also analyzed costs using the assumption that all wastes would be disposed of at Yucca Mountain.

Table 2.2 presents the results of DOE's preliminary analyses. It shows that disposing of the projected quantity of wastes in two repositories would cost about $8.3 billion, or 36 percent, more than disposing of all wastes in a repository at Yucca Mountain. In making these preliminary cost estimates, DOE noted that final estimates could be as much as 10 percent higher or lower, and that all of the figures shown in the cost categories—particularly development and evaluation and transportation costs—are likely to change by the time it completes its next comprehensive cost estimate.

Table 2.2: DOE's Preliminary Waste Disposal Cost Estimates

(Dollars in billions)

Cost category	2 repositories	1 repository
Development and evaluation	$11.7	$8.4
Transportation	2.0	2.1
Repository 1	5.5	7.3
Repository 2	6.5	0
MRS facility	2.5	3.1
Subtotal	**$28.2**	**$20.9**
Benefit payments	3.0	2.0
Total	**$31.1[a]**	**$22.8[a]**

[a]Figures do not add due to rounding.

Although the 1987 amendments to the NWPA eliminated characterization of two candidate repository sites and prohibited site-specific activities related to a second repository, the estimated cost of the revised program is still over $31 billion when two repositories are assumed. This is about $2 billion less than the lowest DOE estimate of the cost of the program prior to the amendments. The estimate is not lower principally because of the addition of the MRS facility and the benefit payments. Also, the

$31 billion cost estimate for two repositories is about $8 billion more than DOE's first estimate, prepared in 1983, of the total cost of the original nuclear waste disposal program.

DOE also allocated the preliminary cost estimates shown in table 2.2 between commercial waste generators and the government using the cost allocation method that it adopted in August 1987. According to DOE, the government's defense waste disposal costs would be about $6.3 billion with two repositories and about $4.2 billion with all wastes disposed of at Yucca Mountain—a decrease of about $2.1 billion. The commercial cost share would be about $24.8 billion and $18.6 billion, respectively, or a decrease of $6.2 billion, with all wastes disposed of in a repository at Yucca Mountain.

DOE Will Determine If Yucca Mountain Is Suitable for a 70,000-Metric-Ton Repository

DOE will focus its detailed investigation of Yucca Mountain primarily on one of the six underground rock formations that comprise the site. Because there is uncertainty over whether the formation is capable of holding 70,000 metric tons of waste, DOE also plans to investigate small portions of two adjacent rock formations. DOE is confident that geologic conditions in the area to be characterized will permit construction of a repository of that size and, perhaps, permit "substantial" expansion. Because the NWPA, as amended, requires NRC to prohibit DOE from emplacing more than 70,000 metric tons of waste in the first repository until a second one is operational, DOE does not intend to determine if the site can accommodate all projected wastes. Instead, DOE expects to increase its understanding of, and confidence in, the potential total capacity of the site using information acquired through surface-based studies planned during site characterization.

If DOE eventually develops a repository at Yucca Mountain, it plans to discuss, in its future report on the need for a second repository, whether any wastes projected in excess of 70,000 metric tons should be disposed of by expanding the Yucca Mountain repository or by developing a second repository. A decision at that time to expand the repository would, if the present NWPA licensing provisions were retained, require DOE to (1) conduct additional site characterization work to establish the suitability of the expansion area, (2) prepare and submit an application to NRC requesting a license amendment authorizing the expansion, and (3) construct the expanded area concurrent with waste disposal operations in the original repository area.

Description of the Site and Proposed Repository Development

In its May 1986 environmental assessment describing the Yucca Mountain site, DOE said the potential host rock is comprised of a primary area and five secondary areas. Figure 2.1 highlights the primary (1) and secondary (2-6) areas. The repository would be constructed in the primary area about 1,000 feet beneath the surface of the eastern side of Yucca Mountain (see figure 2.2).

During site characterization, DOE plans to construct an exploratory shaft facility in the primary area. The facility will be comprised of a principal shaft, including testing areas in tunnels and rooms at three elevations adjacent to the shaft, and a secondary shaft for ventilation, materials handling, and emergency exit. In addition to the tests to be conducted in the exploratory shaft facility, DOE plans to conduct extensive studies from the surface.

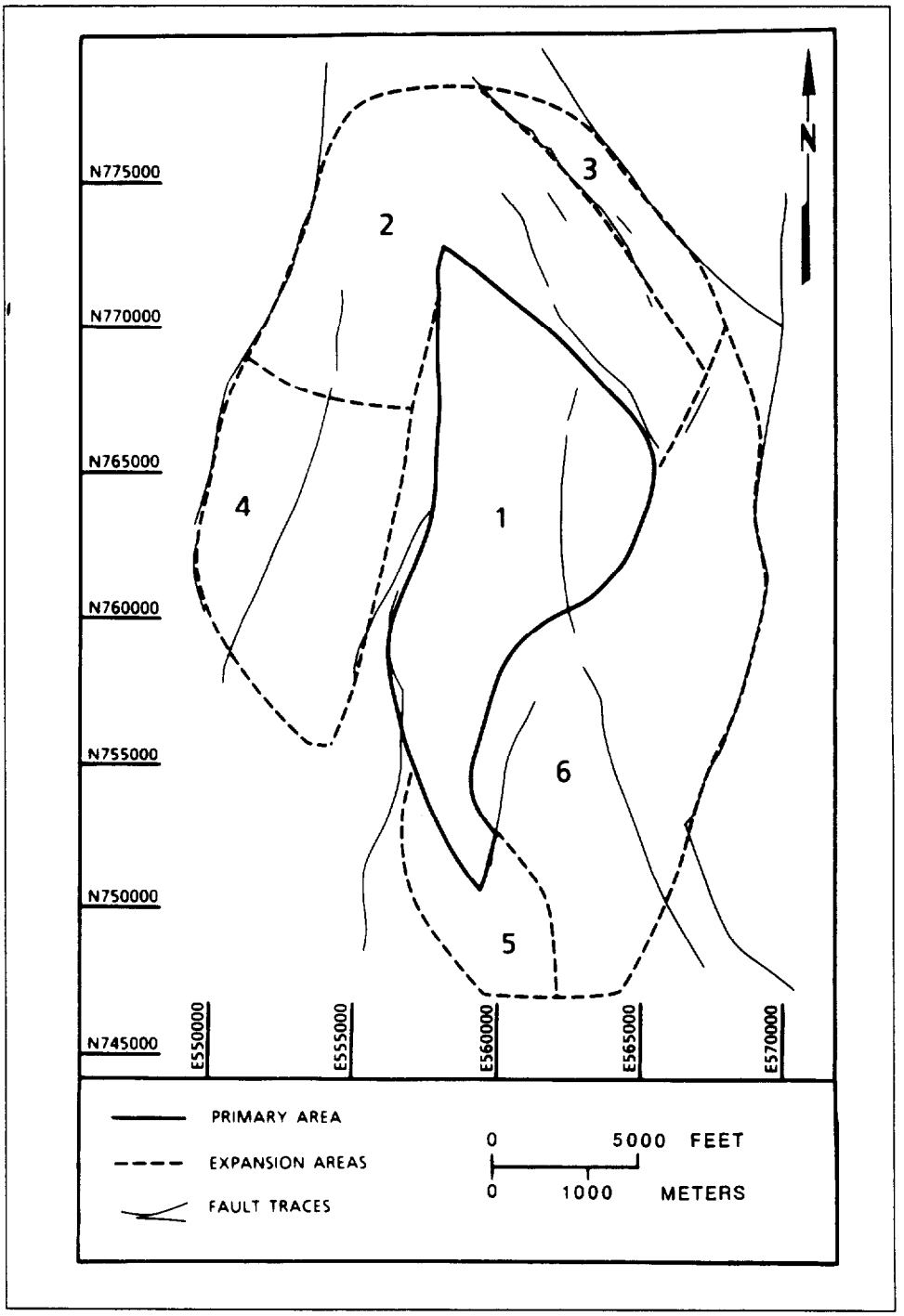
DOE expects to begin detailed site characterization in mid-1989 and finish in the mid-1990s. This work is expected to cost about $1.8 billion (year-of-expenditure dollars). At the completion of site characterization, DOE will determine if the area under investigation is suitable for a repository. If the determination is positive, DOE will recommend that the President formally recommend the selection of Yucca Mountain as the site of the first repository. In this case, and in the absence of a successful veto of the President's recommendation by the state of Nevada, DOE will prepare and submit to NRC an application for authorization to construct a repository capable of holding up to 70,000 metric tons of highly radioactive waste.

The application will consist of general information, a report analyzing the safety of the proposed repository, and an environmental impact statement. The safety analysis report is to include, among other things, a description and assessment of the site at which the proposed surface and subsurface repository operations areas are to be located. Appropriate attention is to be given to site features that might affect design and performance of the repository operations area.

Following a licensing proceeding that is expected to be unprecedented in its scope and depth and to last about 3 to 4 years, NRC will issue or deny the requested construction authorization. If it issues the authorization, DOE would then begin constructing the repository.

As illustrated in figure 2.3, the repository would consist of horizontal main tunnels and 18 perpendicular tunnels that would be used for waste disposal. Each of the main tunnels would be dedicated to either waste

Figure 2.1: Schematic Map of Potential Repository Site at Yucca Mountain

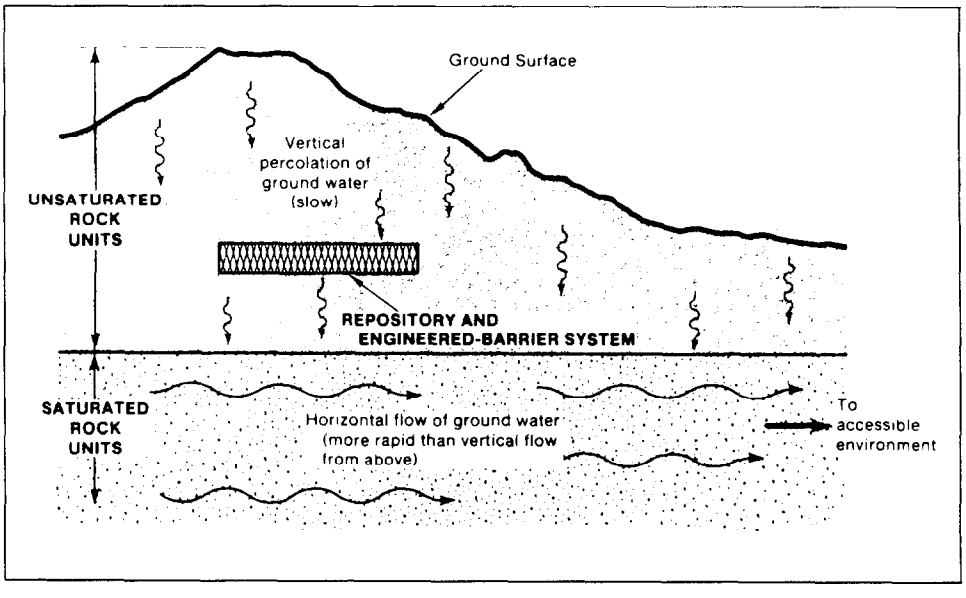


Source: DOE.

handling, removal of mined rock (called "tuff") and bulk materials, or ventilation and electrical services. The entire repository area would be enclosed by a tunnel. Waste would be transported from surface facilities to the main and final waste disposal tunnels through an inclined ramp (waste ramp) in vehicles developed for that purpose. Mined rock would be removed from the repository area to the surface through another inclined ramp (tuff ramp) constructed roughly perpendicular to the waste emplacement tunnel.

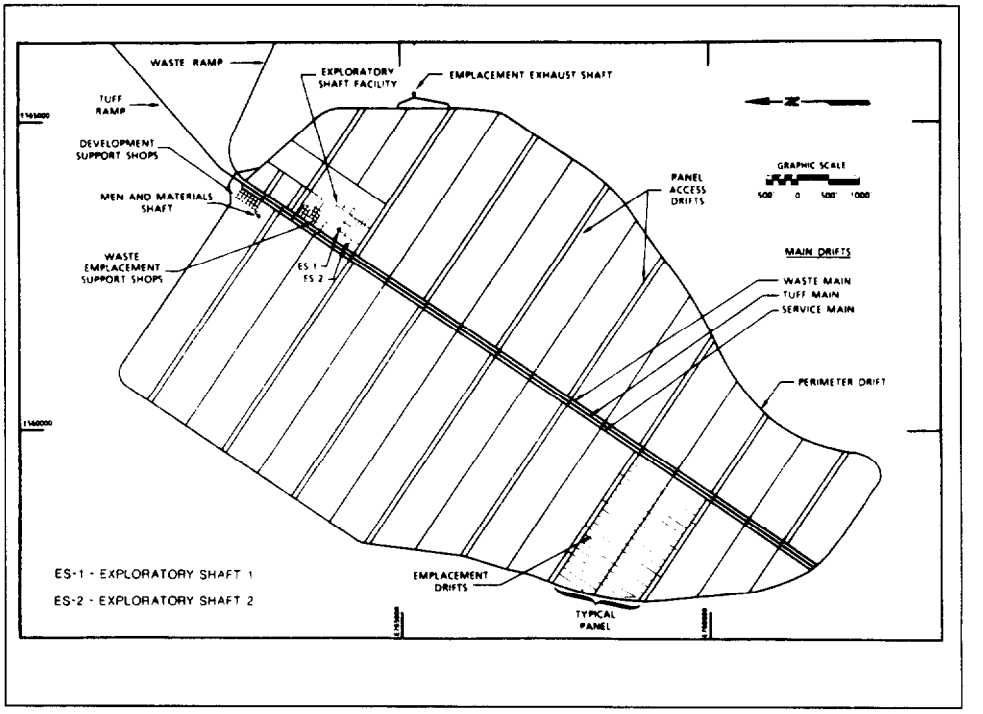
The repository would be constructed in stages, or modules. After completing two modules, DOE would begin waste disposal operations in one module while continuing to construct new ones. One empty module would always be used as a buffer between construction and waste disposal operations. In this manner, DOE expects to be ready to begin disposal operations in 2003. Repository construction is expected to be completed by about 2007.

Figure 2.2: Schematic Cross Section Through Yucca Mountain



Source: DOE.

Figure 2.3: Conceptual Drawing of Repository at Yucca Mountain



Source: DOE.

Uncertainty Over Capacity of the Primary Area

According to DOE's guidelines for identifying potential repository sites, one favorable condition is a host rock that is sufficiently thick, long, and wide enough to allow flexibility in selecting the specific repository depth, configuration, and location within the host rock formation. Flexibility is important to permit designing and constructing the repository around any areas of geologic anomalies that might be found during site characterization.

DOE addressed this condition in its environmental assessment of the site. It noted that surface and subsurface geologic exploration has generally concentrated on the primary area (shown as area 1 in figure 2.1). Available data, according to the assessment, indicate that rock with acceptable characteristics is present in the primary area, and could be present in area 2 as well as outside these two areas. The area designated as area 2 was thought to have the best potential, in addition to the primary area, for having rock with acceptable characteristics. Data for this area, however, were limited to that obtained from surface mapping and

extrapolation of drill hole data obtained mainly around the primary area.

Although DOE did not rule out the potential use of the other four secondary areas, it identified potential problems with all of them and, for area 4, indicated that little is known about it. One potential problem affecting the secondary areas, according to the environmental assessment, is that portions of most of them may not comply with the condition contained in DOE's siting guidelines that a site will be disqualified if waste cannot be disposed of at a depth of at least 200 meters (656 feet) below the overlying ground surface.

In the environmental assessment, DOE stated that a three-dimensional computer graphics model of Yucca Mountain indicates that the primary area contains about 2,200 acres, of which about 1,850 acres are potentially usable. About 1,520 acres would be needed for a repository capable of holding 70,000 metric tons.[8] This suggested, according to the assessment, that additional acreage outside the primary area may be needed for significant lateral flexibility in repository design.

On the basis of the available evidence, DOE concluded that the primary area, which had been the focus of exploration, provides insufficient flexibility in its length and width to meet the favorable condition criterion. Although the surrounding areas appeared to have some rock that may be suitable, DOE concluded that additional geologic characterization would be necessary to claim that one or more of them provide significant flexibility.

We discussed this issue with officials in the OCRWM Office of Facilities Siting and Development. The officials expressed confidence that the Yucca Mountain site will hold 70,000 metric tons of waste. They pointed to a March 30, 1987, memorandum from Sandia Laboratories, a DOE national laboratory and contractor on the Yucca Mountain repository project, as the principal support for this view. The memorandum summarized the current understanding of the relationship between the site's capacity to the size of the repository, considering the repository design, the site geology, the range of acceptable environmental conditions, and the nature of the highly radioactive wastes.

[8]DOE states in its January 1988 "consultation draft" site characterization plan that its current plans call for using 1,380 acres.

Sandia noted that insufficient data were available during preparation of the environmental assessment to claim the favorable condition of flexibility in the length and width of the host rock. It added, however, that if future analysis and site characterization recommendations contained in the memorandum are followed, data should be available to claim favorable site flexibility. Specifically, Sandia recommended that the plan for characterizing the primary area include verifying the qualification of the area by confirmatory drilling, sinking an exploratory shaft, and mining and investigating the potential for unsuitable ground that may have to be bypassed. In addition, Sandia recommended that DOE qualify a minimum of 300 extra acres in two secondary areas to establish additional flexibility by exploring

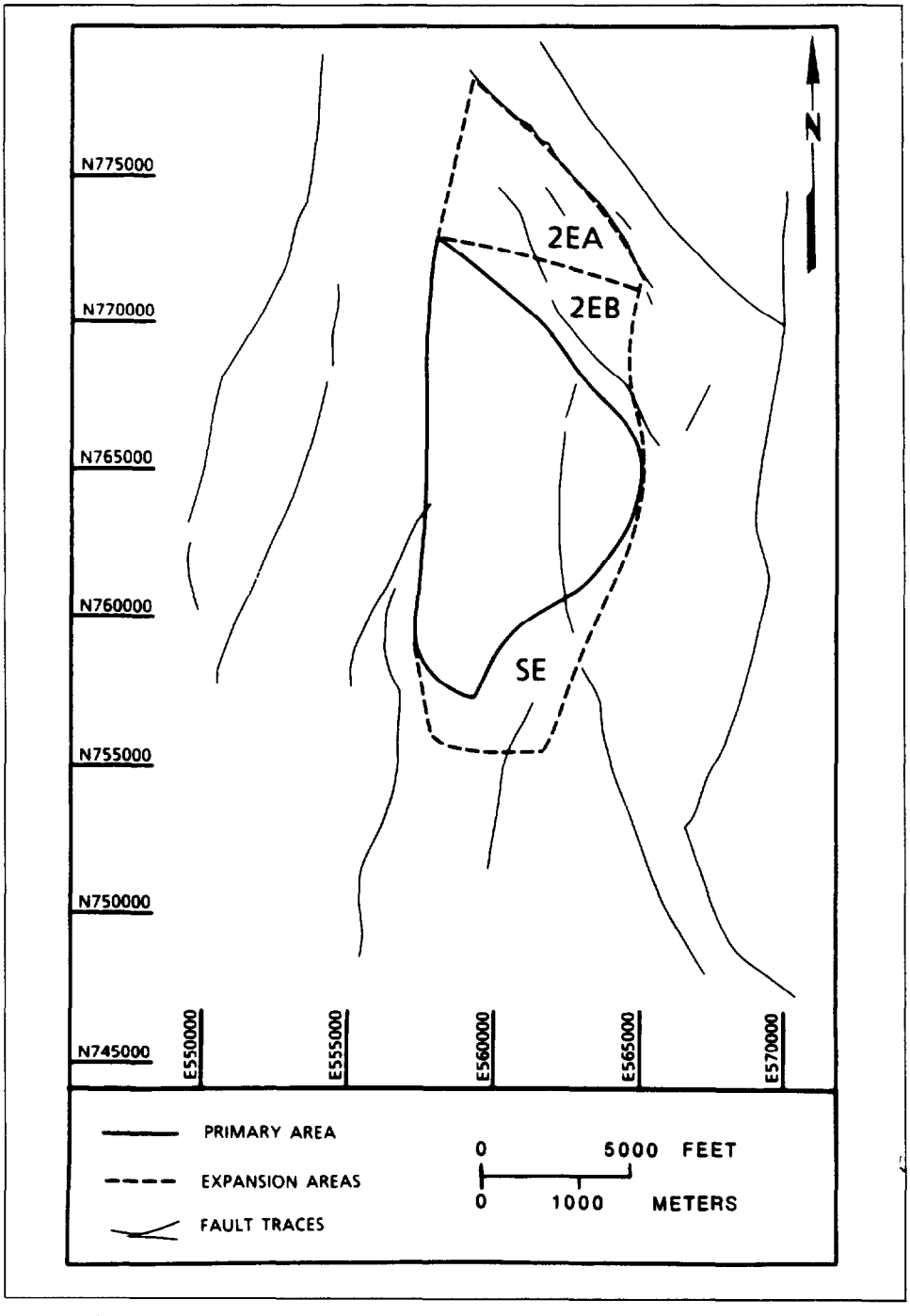
- the surrounding secondary area (area 2 in figure 2.1) north of the primary area by means of surface drilling and
- the secondary area southeast of the primary area (area 6 in figure 2.1), by means of both lateral tunnels at repository depth and surface drilling, to reduce uncertainty in the southeastern boundary of the primary area and to determine how much additional area can be qualified for the repository.

DOE's Approach to Addressing the Capacity of Yucca Mountain

As illustrated in figure 2.4, DOE intends to firmly establish the capacity of most of the primary area—dropping out the narrow, southern leg (see figure 2.1)—and small portions of adjacent areas 2 and 6. If DOE determines that this area of interest is suitable for a repository, it intends to seek authorization from NRC to construct and then operate a repository capable of holding 70,000 metric tons of waste. DOE does not plan to determine during site characterization if the site can hold all projected wastes. Officials in OCRWM's Office of Facilities Siting and Development pointed out to us that confirming site capacity is expensive. It requires information that must be obtained beneath the surface, through construction of the exploratory shaft facility and horizontal tunnels and tests performed in these areas.

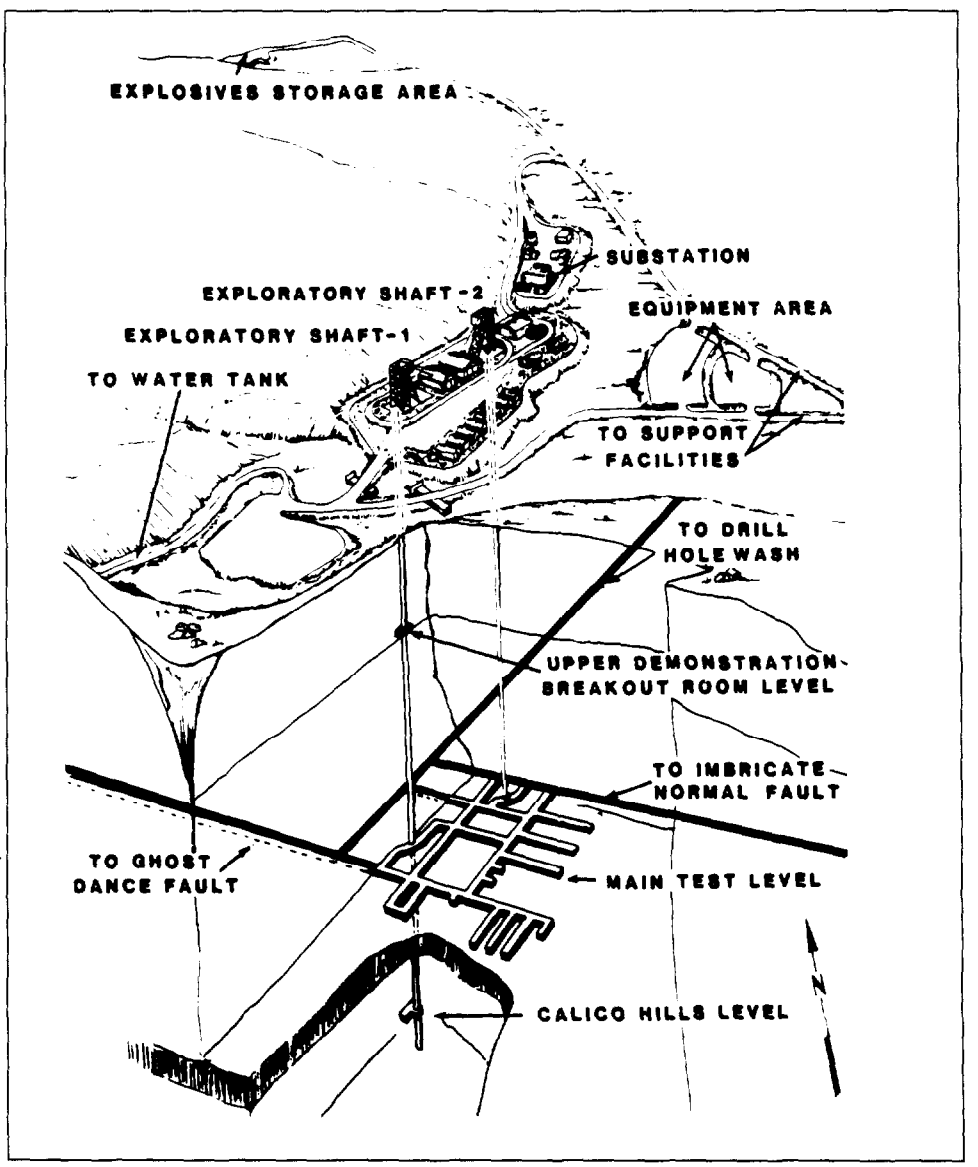
DOE plans to begin constructing the principal exploratory shaft at Yucca Mountain in June 1989. Following completion of two exploratory shafts, DOE plans to mine a series of interconnected tunnels to use as the main test area in the rock formation. In addition, DOE will mine three long exploratory tunnels to provide access to specific features in the proposed repository area. The main test and exploratory tunnels are illustrated in figure 2.5. One of the tunnels, to be constructed in a

Figure 2.4: Area That DOE Plans to Characterize



Source: DOE.

Figure 2.5: Illustration of Exploratory Shaft Facility and Tunnels



Source: DOE.

Conclusions

DOE now plans, as we previously recommended, to base waste planning on EIA projections of waste produced from existing nuclear plants. In addition, DOE intends to extend the period on which the projections are based from 2020 to the end of the operating life of each plant. We agree with this approach. On this basis, estimates of the total commercial and

defense waste quantity that will require disposal range from about 96,000 to 105,000 metric tons.

Although total waste volume projections have declined even with the addition of defense wastes, program cost estimates increased from about $23 billion in 1983 to between $33 billion and $39 billion in 1987. DOE's recent preliminary estimates of the total cost of the revised waste program now indicate that disposing of all wastes at Yucca Mountain and a second repository would cost about $31 billion, but disposing of all projected wastes at Yucca Mountain would reduce the total program cost to about $23 billion, or about $8 billion less.

DOE has identified a specific area within Yucca Mountain that it intends to characterize by means of the exploratory shaft facility and tunnels. Unless unforeseen geologic conditions are encountered, DOE believes the area will be suitable for disposal of 70,000 metric tons of waste and may, if geologic anomalies such as faulting are not encountered, even offer "substantial" potential for future expansion. If DOE determines that the site is suitable for a repository, it expects to obtain authorization from NRC to construct a repository capable of holding up to 70,000 metric tons of waste. This approach is appropriate in view of the capacity limitation on the first repository, and is consistent with congressional direction embodied in the 1987 amendments to the NWPA.

In about 20 years, when DOE submits its report on the need for a second repository, it expects to discuss the potential for expanding the repository at Yucca Mountain (assuming that a facility is developed there) as an alternative to developing a second one. DOE's current plans and schedules indicate that in 20 years it would be finishing construction of the planned repository and conducting waste disposal operations at the site. Expanding the disposal capacity at that time could require additional characterization work to establish the suitability of the area to be used for expansion, another licensing proceeding to obtain NRC's approval for the expansion, and construction of the additional repository capacity concurrent with ongoing waste disposal operations.

In view of the continuing decline in estimates of waste to be generated for disposal, there may be advantages to earlier and more complete site characterization information on the secondary rock formations at Yucca Mountain.

DOE Comments

In a July 28, 1988, letter, DOE provided comments on a draft of our report; however, DOE did not comment on the matters discussed in this chapter. By separate letter, DOE provided technical and editorial comments, some of which pertained to the matters discussed in this chapter. We have revised our report, as appropriate, to address the latter comments.

Matter for Congressional Consideration

The Congress may wish to explore with DOE the advantages of earlier and more complete site characterization information on the secondary rock formations at Yucca Mountain in view of the continuing decline in the estimates of waste to be disposed of and uncertainty about the capacity of the currently defined primary disposal area at that site.

DOE Would Not Obtain Benefits It Envisioned From MRS Facility With Current Statutory Restrictions

The MRS facility that DOE proposed in March 1987 would be used to collect, process, and temporarily store wastes from eastern nuclear plants before shipping them to a repository in the West, such as Yucca Mountain. DOE anticipated constructing and operating the MRS facility about 5 years before the repository was to be used. This would, in its view, permit early planning and implementation of the waste system and acceptance of waste for disposal in 1998. DOE also perceived other benefits, such as improved waste transportation, that did not depend upon early operation of the MRS facility. To dispel doubts about its resolve to develop both a repository and an MRS facility, DOE proposed to link authority to operate the facility to authorization to construct a repository.

The recent NWPA amendments authorize DOE to construct and operate an MRS facility but provide that facility construction may not begin until NRC authorizes DOE to construct a repository. As a result, the benefits that DOE saw in the early development and operation of its previously proposed facility would be greatly reduced. For example, although DOE originally expected that a facility could eliminate the need for 10,000 metric tons of new waste storage capacity at nuclear plant sites, it may no longer be able to achieve this benefit. Also, the amendments introduce enough delay and uncertainty about the availability of a facility that utilities have more incentive to expand on-site storage.

The amendments do not appear to materially affect some facility benefits, such as reducing the distances that waste has to be transported, that do not depend on its early development. Other benefits, however, appear questionable in view of the added cost of an MRS facility and the restrictions on its early development.

DOE recognizes the schedule constraints imposed by the 1987 amendments. It is now conducting studies to optimize the performance and effectiveness of the total waste system. One possibility under review, for example, is to accelerate the start of waste acceptance at an MRS facility by developing it in stages.

DOE's Proposed MRS Facility

In the NWPA, the Congress found that long-term storage of highly radioactive wastes in monitored retrievable storage facilities is an option that provides safe and reliable waste management, and that the executive

branch and the Congress should fully consider a proposal for constructing one or more such facilities. The act required DOE to develop and submit to the Congress a proposal for an MRS facility to safely store wastes as long as may be necessary.

On March 31, 1987, DOE proposed building and operating an MRS facility in Oak Ridge, Tennessee. Although the facility could be used for long-term storage, its principal purpose was to receive wastes from eastern nuclear power plants, prepare them for disposal, and, if necessary, store them prior to their shipment to a western repository for disposal.

DOE proposed to obtain a construction permit from NRC and build the facility over about an 11-year period, from mid-1987 through the end of 1997, and to begin accepting waste at it in January 1998. This schedule would have permitted DOE to use the MRS facility to meet its contractual obligation to begin accepting wastes from utilities by January 31, 1998.[1] On this schedule, DOE expected to operate the MRS facility for 5 years before opening the first repository in 2003.

This schedule was contingent upon DOE's obtaining authorization from NRC to construct the first repository by January 1998. DOE had proposed this contingency as one way to dispel doubts about the national resolve to develop a repository. DOE noted that the history of the waste management program suggested that the credibility of any interim storage measures, such as an MRS facility, will be suspect unless there is confidence that a permanent repository will be available within a reasonable period of time.

Although DOE estimated that an MRS facility would add about $1.5 billion (1986 dollars) to the total cost of the waste program, it stated that the added costs are small in comparison with the benefits. DOE also stated that the additional cost would be partially offset by savings in new storage capacity for spent fuel that would otherwise be required at some nuclear power plants.

Some of the stated benefits were directly related to the planned development of an MRS facility years ahead of the first repository, but others were not. Those benefits that depended on the early operation of an MRS facility were

[1]Section 302 of the NWPA required DOE to include a clause in its contracts that required it to accept wastes from utilities no later than January 31, 1998.

- planning and implementing waste acceptance, transportation, consolidation,[2] and packaging functions some 5 to 8 years before the repository opened;
- reducing the need for new storage capacity at nuclear plant sites by accepting waste from utilities 5 years sooner than otherwise possible; and
- gaining experience, through negotiations and interactions with the state of Tennessee, that would be useful in dealing with other potential waste facility hosts.

DOE also stated that adding an MRS facility to the waste disposal system would offer advantages related to the geographical separation of temporary storage and permanent disposal facilities. The achievement of these benefits would not depend upon the early operation of an MRS facility. These perceived benefits were

- transportation improvements related to reducing the number of shipments of waste to a repository and minimizing the distances of waste shipments by truck from nuclear plants to an MRS facility;
- improvements in waste system reliability and flexibility gained from separating the functions of accepting waste (at an MRS facility) and disposing of it in a repository, and the addition of significant operational storage capacity to the system; and
- simplifying repository operations by performing waste preparation functions at an MRS facility and using it to control the rate at which waste would be transferred to the repository.

In our June 1987 report on DOE's proposal, we pointed out that the MRS concept outlined in the NWPA emphasizes long-term storage, but the principal role of the MRS facility in DOE's proposal would be waste preparation.[3] We also concluded that the proposal does not demonstrate how the (then) authorized waste system, without an MRS facility, could best be improved, so that the authorized system could be compared with a waste system that includes the proposed MRS facility. We recommended that DOE identify the best configuration of the waste system without an MRS facility and present the Congress with the benefits and costs of this

[2]Waste consolidation involves extracting spent fuel rods from their assemblies and consolidating them into a more compact configuration to provide greater efficiency in handling, storage, transportation, and disposal.

[3](GAO/RCED-87-92).

system. In response to our report, DOE issued a supplement to its proposal in November 1987 that, with one exception, addressed our recommendations. The exception was that DOE did not collect nuclear plant-specific information to use in the recommended analysis.

Amendments Affect DOE's Proposed MRS Facility Schedule

The NWPA amendments contain a number of provisions that will delay the operation of an MRS facility beyond the 1998 time that DOE had planned. The amendments also tie the development and operation of a facility to progress in developing a repository. Thus, the amendments assure that an MRS facility does not become a substitute for a permanent repository; however, delays in the repository program would also delay the availability of an MRS facility.[4]

In the absence of a negotiated agreement, approved by the Congress, that is less restrictive than the 1987 amendments, the provisions in the amendments will delay the construction and operation of an MRS facility beyond the schedule established in DOE's proposal for the following reasons:

- DOE's proposal to develop an MRS facility site in Oak Ridge, Tennessee, is annulled and revoked;
- DOE may not begin a new survey and evaluation of potential MRS facility sites until the MRS Review Commission submits its report to the Congress on June 1, 1989, and DOE may not select a facility site until after it recommends a repository site to the President (expected in the mid-1990s); and
- MRS facility construction may not begin until NRC has issued DOE a construction authorization for a repository, and neither construction of an MRS facility nor acceptance of waste at it is permissible during any time that the repository authorization is revoked by NRC or repository construction ceases.

In view of these amendments, DOE, according to its fiscal year 1989 budget submission, plans to update its analysis of the need for an MRS facility and the facility's role in the nuclear waste disposal system. DOE has requested $15 million in fiscal year 1989 for this and other MRS-

[4]As discussed in ch. 1, the Nuclear Waste Negotiator is empowered to find a state or Indian tribe willing to host a repository or MRS facility, and to negotiate the terms and conditions under which the state or tribe would host either facility. Any such agreement would be effective only if enacted into federal law. Through this mechanism, therefore, it is possible that an MRS facility could be authorized and developed earlier than would be permitted under the MRS-related provisions in the 1987 NWPA amendments.

related activities, and indicated that additional amounts of $44 million and $53 million for continued development of a facility may be requested in fiscal years 1990 and 1991, respectively. In this regard, in May 1988 DOE prepared a plan identifying the near-term technical studies necessary to prepare a report documenting its technical position on an MRS facility and to be responsive to the new MRS Commission.

In June 1988 DOE issued a draft amendment to its mission plan that conforms the nuclear waste program to the 1987 amendments. DOE recognized the conditions placed on development of an MRS facility. It noted that it may be possible to accelerate the start of waste acceptance at an MRS facility by developing it in phases. The waste preparation functions to be performed at a facility will, according to DOE, be reevaluated in the context of optimizing the performance of the total waste management system.

Early MRS Development and Operation Benefits Are Largely Not Achievable

Because the NWPA amendments preclude development and operation of an MRS facility much in advance of a repository, the advantages associated with early operation of the facility proposed by DOE—improved waste system development, accelerated waste acceptance, and institutional benefits for the waste system—are reduced or eliminated. In addition, the usefulness of the facility for backup waste storage, a secondary benefit in the event that construction of a repository ceases, is uncertain.

Improvements in System Development

In its proposal, DOE stated that developing and operating an MRS facility 5 years earlier than the repository would enable key waste system functions to be developed without delay. DOE reasoned that early facility development would allow the key systems, such as waste transportation, acceptance of waste, consolidation, and packaging, to be developed without the threat of being significantly affected by the uncertainties associated with repository development and construction. The effects of the amendments on the construction and operation of a facility will not permit DOE to achieve these benefits.

In its MRS proposal, DOE cited transportation planning as an important systems development benefit that would be derived from early MRS facility development and operation. DOE stated that its MRS facility plans would accelerate transportation system development because it would be able to determine specific routing, logistics, and equipment requirements for shipments from the nuclear plants several years earlier and

would have more time available to work with states, Indian tribes, and the public on route-specific planning. DOE indicated that, because the MRS facility location would be known far in advance of the repository site, it could define shipping routes and requirements from nuclear plants to the facility up to 8 years earlier than it could plan transportation routes to a repository site.

Because of the conditions on development of an MRS facility imposed by the amendments, however, an MRS facility will not accelerate development of the waste transportation system. In fact, the situation regarding transportation planning is now reversed—the tentative location of the repository is known, but the site of an MRS facility cannot be determined for several more years. As a result, the inclusion of an MRS facility in DOE's waste program plans could adversely affect early planning for a waste system. Without a facility, DOE could begin planning for waste transportation shipments from nuclear plants to Yucca Mountain. With the proposed MRS facility, however, DOE must postpone detailed transportation route planning, including working with states, tribes, and the public, for the entire system until it can select the MRS facility site.

Accelerated Waste Acceptance

As noted earlier, DOE saw three principal benefits in the early acceptance of waste at an MRS facility: (1) meeting its contractual obligation to begin accepting waste by January 1998; (2) significantly reducing the need for temporary capacity for waste storage at plant sites, and associated costs; and (3) enabling utilities to develop firm plans for future waste storage needs because of the activation of the MRS facility. However, the NWPA amendments largely eliminate these benefits.

An MRS Facility Will Not Be Available to Accept Waste by 1998

As noted earlier, the amendments preclude DOE from beginning construction of the facility at a DOE-selected site until NRC authorizes it to construct a repository. According to DOE's draft mission plan amendment, it expects to obtain an authorization for repository construction in 1998 and to begin operating a repository at limited capacity in 2003, with full-scale operations planned to begin in 2008. DOE would also begin construction of an MRS facility in 1998 and begin accepting waste at the facility in 2003. As noted earlier, however, DOE believes that it may be possible to accelerate the start of waste acceptance if an MRS facility is developed in phases.

Benefit of Reducing New Nuclear Plant Storage Requirements Is Largely Eliminated

DOE estimated that an MRS facility could eliminate the need for additional storage capability at more than 15 nuclear plant sites and could offset more than 10,000 metric tons of storage at plant sites, with a potential savings to utilities of $1 billion. The NWPA amendments, however, will essentially eliminate this benefit.

According to EIA, by the end of 1990 utilities will have accumulated about 21,000 metric tons of spent fuel at existing nuclear power plants. It also projects that utilities will discharge an average of about 2,200 metric tons of waste each year in the 1990s, and an average of about 2,300 and 2,000 metric tons each year in the first 2 decades, respectively, of the next century. These projections assume that utilities will continue to follow historical fuel management practices. With extended fuel burnup, EIA does not expect the discharge rate to exceed, on the average, 2,000 metric tons per year during these 30 years.

DOE estimates that a number of utilities will soon fill their existing spent fuel storage pools. When this occurs, utilities will have to use alternative means, such as dry storage, to accommodate their additional spent fuel. For example, in September 1987 DOE projected that the quantity of commercial waste generated in excess of existing storage pool capacity could total 5,100 to 6,800 metric tons by the end of the century. The higher figure excludes shipments between plants to maximize use of spent fuel storage pool capacity, and the lower figure considers such shipments. DOE offered several reasons, however, why the actual quantity could be less. Its forecast did not include the potential waste reductions that are associated with extended burnup; and future increases in the fuel burnup rate consistent with the trend in that direction, according to DOE, could reduce the upper end of the projection by a "considerable margin." As discussed in chapter 2, for waste program planning purposes DOE assumes that utilities will achieve a 30-percent increase in fuel burnup by 1998.

In February 1987 DOE also estimated the amount of waste that will be generated through 2010 and 2020 from existing nuclear plants and contrasted these estimates with current storage pool capacities. On the basis of this information, the projected volume of waste in excess of existing pool storage capacity is about 10,700 and 24,600 metric tons, through 2010 and 2020, respectively.

According to DOE, once its full-scale operation is achieved in 2008, the first repository could accept 3,000 metric tons of commercial waste each year, either directly from nuclear plants, or from both nuclear plants

and an MRS facility. Beginning in that year, DOE had planned to ship 2,650 metric tons of commercial waste from the eastern MRS facility, and 350 metric tons directly from western nuclear plants, to the repository each year until it reached a capacity of 70,000 metric tons (including 4,640 metric tons of defense and West Valley plant waste). Table 3.1 shows the quantities, by year, from 1998 through 2008, of commercial waste that DOE had planned to accept at the MRS facility and the repository.

Table 3.1: DOE's Original Schedule for Commercial Waste Acceptance

(In metric tons)

	MRS facility			Repository		
Year	Waste received	Waste shipped	Waste in storage	Waste from MRS facility	Waste from nuclear plants	Total
1998	1,200	0	1,200	0	0	**0**
1999	1,200	0	2,400	0	0	**0**
2000	1,200	0	3,600	0	0	**0**
2001	1,200	0	4,800	0	0	**0**
2002	1,200	0	6,000	0	0	**0**
2003	2,000	400	7,600	400	0	**400**
2004	2,650	400	9,850	400	0	**800**
2005	2,650	400	12,100	400	0	**1,200**
2006	2,650	900	13,850	900	0	**2,100**
2007	2,650	1,800	14,700	1,800	0	**3,900**
2008	2,650	2,650	14,700	2,650	350	**6,900**

Source: DOE.

As table 3.1 shows, by the end of 2007 DOE had anticipated having 3,900 metric tons of commercial waste at a repository and an additional 14,700 metric tons in storage at an MRS facility. Thereafter, DOE planned to accept a total of 3,000 metric tons of waste at the two facilities each year.

In its amendment to its draft mission plan, DOE has revised its waste acceptance plans in view of the 1987 amendments to the NWPA. DOE now plans to begin accepting waste at both the repository and an MRS facility in 2003. Table 3.2 illustrates DOE's current waste acceptance plans through 2008. As the table shows, when the repository begins to operate at full capacity in 2008, DOE would have 5,200 metric tons of waste in storage at an MRS facility. This is 9,500 metric tons less than originally planned. Thus, DOE's current plans for operation of an MRS facility

appear to largely eliminate the original benefit stated in its proposal to prevent the development of 10,000 metric tons of additional storage capacity at nuclear plants at a potential cost of $1 billion.

Table 3.2: Commercial Waste Acceptance Schedule Under NWPA Amendments

(In metric tons)

	MRS facility			Repository		
Year	Waste received	Waste shipped	Waste in storage	Waste from MRS facility	Waste from nuclear plants	Total
2003[a]	1,200	400	800	400	0	**400**
2004	1,200	400	1,600	400	0	**800**
2005	2,000	400	3,200	400	0	**1,200**
2006	2,000	900	4,300	900	0	**2,100**
2007	2,700	1,800	5,200	1,800	0	**3,900**
2008	2,700	2,700	5,200	2,700	300	**6,900**

[a]DOE states that it may be possible to start limited waste acceptance at an MRS facility before 2003, but this cannot be determined until additional engineering and siting information is available.

Source: DOE.

Under DOE's current preliminary plans, the waste quantity in storage at an MRS facility would never exceed 5,200 metric tons. DOE would, from 2008 on, receive only as much waste at a facility as it could process and ship to a repository. This feature emphasizes that the primary purpose of a facility lies in its waste preparation function, such as loading fuel into canisters.

MRS Facility Does Not Provide Utilities With a Firm Basis for Storage Planning

The longer time that the 1987 amendments require for DOE to develop an MRS facility and the potential for further delays because of its link to repository progress introduce uncertainty over when a facility would be available to begin accepting waste from utilities. Until utilities can use either of these facilities, they will have to find alternative storage.

Because an MRS facility now depends on progress in siting, licensing, and constructing a repository, it no longer provides utilities with a firm basis for waste storage planning. On the contrary, an MRS facility's ties to the repository program introduce new uncertainty about its future availability, as well as delaying completion by up to 5 years. For this reason, on-site storage in dry casks now appears to offer utilities a more predictable storage option than an MRS facility. As discussed in detail in appendix II, dry storage demonstration programs required by the NWPA and designed to assist utilities in enhancing waste storage capacity at

nuclear reactors are underway at Carolina Power and Light's H. B. Robinson plant (South Carolina) and Virginia Power's Surry plant. Further, NRC has not identified any technical or institutional impediments to the use of dry storage technology at nuclear plants and is preparing a rule to facilitate approval of its use at nuclear plant sites.

Institutional Benefits for Waste System Would Not Occur

The additional time required to develop an MRS facility under the 1987 amendments would not permit DOE to realize benefits that it had previously identified for the early implementation of key waste system functions—enhanced confidence in the schedule for operation of the total system and momentum for implementing the system. Further, it would not allow DOE to use an MRS facility, as originally envisioned—for an early demonstration that its waste facilities are safe and that DOE is a responsible corporate citizen and neighbor.

According to DOE's MRS proposal, the development of an MRS facility would also provide institutional benefits through the experience gained from interactions with the state of Tennessee. As noted earlier, however, DOE's interactions with a prospective host state for an MRS facility would start much later than originally anticipated. While MRS siting activities have been delayed, however, DOE is already working with Nevada on the Yucca Mountain repository site. Therefore, because interactions with a host state for an MRS facility will now occur after DOE has been working with the repository host, an MRS facility will not provide DOE with the benefit of experience in institutional relations that can then be applied with the host state for the repository.

Repository Backup

DOE does not suggest that an MRS facility should be built as a backup to a repository, but it has stated that the facility could serve this function if the repository was delayed. In such a situation, DOE indicated that the MRS facility could begin accepting and storing spent fuel from nuclear plants until the repository could begin operating.

However, because of the 1987 amendments, any delay in the development of a repository will also delay an MRS facility. Thus, any backup storage would be severely restricted, if not eliminated.

DOE Has Not Demonstrated the Value of Other Benefits

In addition to an MRS facility's time-related benefits, DOE identified other advantages associated with it that would not be affected by changes in timing. These advantages included (1) improvements in the performance of the transportation system, (2) improvements in the reliability and flexibility of the waste management system, and (3) certain benefits for the repository, such as simplification of repository facilities. However, DOE has not clearly demonstrated the value of these benefits to the waste management system, or that an MRS facility is needed to achieve them, in view of the changed conditions under which a facility could now be developed.

Transportation Improvements

In its MRS facility proposal, DOE stated that because spent fuel would be shipped from the facility to a repository in relatively large quantities on dedicated trains, an MRS facility would significantly reduce the number of miles that spent fuel must travel in less efficient truck- and rail-mounted casks. This benefit assumes that the facility would be located in the East (such as in DOE's proposed Oak Ridge, Tennessee, location), central to the majority of nuclear power plants. If an MRS facility was located somewhere other than the East, its transportation benefits would be reduced.

Table 3.3 shows DOE's estimates, contained in the environmental assessment report that accompanied its MRS proposal, of the distances that wastes would have to be shipped in waste systems with and without an MRS facility. These estimates assume an MRS facility located in Tennessee and a repository located at Yucca Mountain.

Table 3.3: Waste Transportation Distances

(In millions of miles)	
Waste system with MRS facility	
Rail (to MRS)	4.6
Rail (repository)	1.3
Total	**5.9**
Truck	11.9
Total	**17.8**
Waste system without MRS Facility	
Rail	16.2
Truck	42.5
Total	**58.7**

By decreasing the number of miles waste would have to travel in the system, an MRS facility would reduce the risks of shipping accidents. We applied accident rates recently developed for NRC by DOE's Lawrence Livermore National Laboratory to the estimated total transportation distances shown in table 3.3 to estimate the number of accidents that would be expected to occur.[5] Table 3.4 presents the results.

Table 3.4: Projected Transportation Accidents

Waste System	Projected Accidents		
	Rail	Truck	Total
System with MRS facility			
To MRS facility	55	76	131
To repository	16	[a]	16
Total	**71**	**76**	**147**
System without MRS facility	194	272	466

[a]With the repository, truck transportation will not be used.

Because the projected number of shipping accidents would be lower in a system with an MRS facility, the risks of accidental radiological releases would also be lower. Although a lower number of spent fuel shipments is generally perceived as safer from the perspective of radiological releases, the effect may not be significant. According to the Livermore study, risks of radiological releases from spent fuel shipment accidents are extremely low. Livermore estimated, for example, that the risk to the general public from spent fuel shipments is less than one latent cancer fatality in the general population every 2,300 years. This estimate assumes that DOE ships 3,000 metric tons of spent fuel each year.

System Reliability and Flexibility

DOE has stated that an MRS facility would improve the reliability and flexibility of the waste management system by separating the acceptance of waste from nuclear plants from emplacement in a repository and by adding significant operational storage capacity to the system. For example, a facility would allow receipt of waste from plants to be independent of waste receipt and emplacement at a repository. According to DOE, this decoupling of waste receipt from repository operations is important because the optimal rates for unloading the individual nuclear plant storage pools will differ from waste receipt and emplacement rates compatible with efficient repository operation. Further,

[5]Livermore calculated an accident frequency rate for trucks of about 6.4 per million vehicle miles, and for trains, 12 per million rail miles.

delays in waste emplacement at a repository would not prevent continued removal of waste from nuclear plants.

While the benefit of greater flexibility in management and coordination of spent fuel acceptance and emplacement rates may be important to the waste management system, DOE has not demonstrated the need for the amount of storage that an MRS facility would provide—15,000 metric tons—for this purpose. It is not clear that this much storage capability would be needed, particularly since this storage would not now be available until about the time that nuclear plants will begin shutting down, which will reduce the total amount of waste that will be generated.

It is also not clear that an MRS facility is needed to provide storage to maximize the efficiency of repository waste emplacement operations. An alternative would be to expand, if necessary, the planned temporary storage capacity at the repository. Current DOE plans provide for temporarily storing up to about 750 metric tons of commercial waste at the repository site. Although this capacity may not provide the management flexibility that DOE envisions, the size of the Yucca Mountain site (approximately 85 square miles) would permit expansion of the repository's storage capability to meet this need without an MRS facility, and at less cost.

Simplified Repository Operations

According to DOE, an MRS facility would simplify facilities and operations at the repository because many of the major waste preparation functions would be performed at an MRS facility. DOE does not, however, demonstrate how this would benefit the entire waste management system. DOE appears to assume that the fewer activities performed at the repository site the better. However, consolidating all waste preparation, storage, and emplacement activities at a single site would reduce the total number of facilities required in the waste system and may improve waste system management and facilitate coordination of these activities. Excluding transportation considerations, DOE has not clearly demonstrated significant advantages to performing waste preparation operations at an MRS facility rather than at the repository site.

Conclusions

DOE's MRS proposal and November 1987 supplement state that an MRS facility would enhance the operation of the waste management system. To support this position, DOE identified a number of benefits that would result from developing and operating an MRS facility by January 1998. These benefits essentially fall into two categories: (1) benefits derived

from developing and operating the facility several years ahead of a repository and (2) benefits for the waste system operations by including an MRS facility centrally located to the relatively large number of nuclear power plants in the eastern part of the country.

In December 1987, the Congress authorized DOE to develop and operate an MRS facility but also placed a number of restrictions on it. Because these restrictions tie selection of an MRS facility site and facility construction to progress on a waste repository, DOE can no longer achieve all of the time-dependent benefits of the proposed facility. Other perceived benefits of the facility are also not readily apparent in view of the changed conditions under which the facility is to be developed.

Because these benefits are either not achievable or readily apparent, it is questionable whether the remaining advantages that DOE perceived in adding the proposed MRS facility to the waste system are worth its additional $1.5 billion cost to the waste program, particularly since the facility will no longer be available in time to eliminate the need for utilities to spend about $1 billion for additional on-site storage capacity.

Therefore, to evaluate the time-related effects of the NWPA amendments and questions about the significance of the perceived benefits of the proposed MRS facility that are not directly time-related, the MRS Review Commission needs the benefit of DOE's ongoing reassessment of the role of an MRS facility in the nuclear waste disposal system. Also, we are providing the Commission with this report for its consideration in its review of the need for an MRS facility.

Recommendation to the Secretary of Energy

To provide the MRS Review Commission with the best possible information for its evaluation and report to the Congress on June 1, 1989, we recommend that the Secretary of Energy supplement DOE's original MRS facility proposal by identifying, with supporting analyses, the benefits of adding a facility to the nuclear waste system under the conditions established in the Nuclear Waste Policy Amendments Act of 1987.

DOE Comments and Our Evaluation

In commenting on a draft of our report, DOE stated that it concurs with our recommendation and readily agrees that substantial new analyses of the benefits of various MRS facility configurations are needed. DOE noted it is in the process of performing such analyses, and it looks forward to providing, as we are recommending, information to the MRS Review Commission.

DOE also stated, however, that we incorrectly assumed that it would proceed with the configuration and design identified in its March 1987 MRS proposal. DOE said that it is in the process of evaluating a variety of possible MRS configurations. Although we analyzed the effects of the 1987 amendments on the MRS facility that DOE had proposed, we also recognized that DOE is studying ways to optimize the performance and effectiveness of the total waste system—including reevaluating the waste preparation functions that might be performed at an MRS facility.

Uncertainties in Defense Waste Estimates

Highly radioactive defense waste is generated and stored at DOE's Savannah River Plant (South Carolina), Idaho National Engineering Laboratory, and Hanford Reservation. Most of this waste is presently stored in underground tanks as liquid, sludge, slurry, saltcake, or granules. Almost all of DOE's strategies for disposal of defense waste anticipate that it will be solidified into either a glass or ceramic form and sealed in metal canisters before being shipped to a repository for disposal.

In its June 1987 report on the total cost of the waste system, DOE estimated that 16,000 canisters of defense waste would be disposed of in the 2 planned commercial repositories. Because DOE can dispose of only 70,000 metric tons of waste in the first repository until a second one is operational, DOE also estimated the equivalent number of metric tons, on the basis of types and quantities of radioactive materials, that the defense waste canisters would represent. DOE stated that two defense waste canisters are likely to be the equivalent of 1 metric ton of commercial spent fuel, for a total of 8,000 equivalent metric tons. The specific sources and quantities of waste are shown in table I.1, and were derived from a study by DOE's Richland Operations Office.[1]

Table I.1: DOE Estimates of Defense Waste Requiring Disposal in Commercial Repositories

	Amount	
Location	**Canisters**	**Equivalent metric tons**
Savannah River Plant	7,000	3,500
Idaho National Engineering Laboratory	6,000	3,000
Hanford Reservation	1,500	750
Unspecified future site[a]	1,500	750
	16,000	8,000

[a]For planning purposes, DOE has assumed that a new defense nuclear materials production reactor will be constructed and begin operating after 2000 at a site that has not yet been selected.

For Savannah River and Hanford, these estimates are based on defense waste quantities produced to date and projected levels of production through 2000. The estimate for Idaho is based on continued operations through 2020, and for the undesignated future site, the estimate assumes waste production from 2001 through 2020. All estimates assume operation of the facilities at full capacity for the designated time frame. At present, however, the production reactor at Hanford is shut down, and DOE has recently announced that it does not plan to restart it.

[1]Perspective on Methods to Calculate a Fee for Disposal of Defense High-Level Waste in Combined (Equivalent Defense) Repositories (DOE/RL-86-10, Dec. 1986).

In addition, the three production reactors at Savannah River are operating at about 50 percent of full capacity because of safety-related concerns.

In addition to the uncertainty associated with future levels of waste, there are uncertainties in DOE's waste management plans at Idaho and Hanford that could increase the number of waste canisters and equivalent metric tons of commercial spent fuel to be disposed of in one or more commercial repositories. Also, DOE recently decided that an additional 500 canisters of Hanford wastes, for a total of at least 2,000 waste canisters, will be disposed of in a repository.

At Idaho, DOE estimates that it will produce enough waste through 2020 to fill 22,000 waste canisters for deposit in a repository if it does not reduce the volume of waste. It expects, however, that it will be able to take advantage of volume reduction technology currently under development to reduce the waste volume so that it will fill only 6,000 canisters. DOE plans to evaluate and test alternative volume reduction processes, select an approach in 1992, and begin full-scale waste processing in 2011. Because DOE calculates equivalent metric tons of defense waste on the basis of the inventory of radioactive materials, the equivalent metric tons of Idaho wastes would not change if DOE decides not to reduce the volume even though the number of waste canisters would increase from 6,000 to 22,000. According to DOE, consideration of the eventual number of Idaho waste canisters can be deferred for repository planning purposes because no canisters of waste will be produced for more than 20 years.

At the Hanford Reservation, the 1,500 canisters of defense waste that DOE projected would be generated by the year 2000 represents wastes that are, or are expected to be, stored in up to 28 double-shell storage tanks. At Hanford, all high-level wastes generated since 1972, and all future high-level wastes, have been or will be temporarily stored in these tanks.

From the early 1940s until 1972, high-level wastes at Hanford were stored in 149 single-shell tanks. During that period, however, about 450,000 gallons of waste leaked from 20 of these tanks into the surrounding soil. As a result, the Atomic Energy Commission—a predecessor to DOE—attempted to transfer wastes from these tanks to the newer, double-shell tanks, but encountered serious problems in doing so. Although the liquid waste could be pumped from the single-shell tanks,

the nitric acid process required to dissolve sludge and salt cake in the tanks corroded the tank walls.

DOE discussed the ultimate disposal of high-level and other radioactive wastes at Hanford in a December 1987 environmental impact statement. It intends to extract and process the wastes stored in double-shell tanks—the estimated 1,500 canisters shown in table I.1—and dispose of them in a commercial repository. In addition, when the Atomic Energy Commission attempted to transfer high-level wastes from single-shell to double-shell tanks, it also extracted and encapsulated two high-heat-generating waste fission products—strontium-90 and cesium-137. DOE presently stores these capsules in water basins on the Reservation. DOE also intends to dispose of these wastes—estimated to represent about 500 waste canisters—in a repository.

The high-level wastes still stored in the 149 older, single-shell waste storage tanks, are not readily retrievable. Therefore, DOE prefers to defer a decision on their ultimate disposal pending additional development and evaluation. According to DOE, extraction, processing, and disposal of these wastes may be too costly and potentially hazardous to justify. DOE estimates that these wastes, if extracted, processed, and placed in waste canisters, would fill about 21,500 canisters. Because the inventory of radioactive materials in this waste is relatively small in comparison with the total waste volume, however, DOE estimates that the 21,500 canisters would only be equivalent to about 1,000 metric tons of spent fuel.

Table I.2 summarizes the maximum quantities—expressed in both numbers of waste canisters and equivalent metric tons—of high-level defense waste projected to be generated through 2020 that could require disposal in a repository. The quantities shown include the wastes from the Hanford single-shell tanks.

Table I.2: Maximum Potential Quantity of Defense Waste Through 2020

	Amount	
Location	**Canisters**	**Equivalent metric tons**
Savannah River Plant	7,000	3,500
Idaho National Engineering Laboratory	22,000	3,000
Hanford Reservation	23,500	1,750
Unspecified future site	1,500	750
Total	**54,000**	**9,000**

Commercial Waste Storage at Nuclear Power Plants

On the basis of its studies, NRC concluded that there are no impediments to the use of dry storage technology at nuclear plant sites and that utilities can safely store their wastes at plant sites for 30 years after their plants are retired. In addition, demonstration programs for two dry storage technologies are underway at two nuclear plant sites; NRC is preparing a new rule to facilitate regulatory approval of dry storage; and it has issued one company a license to manufacture casks for dry storage of commercial waste. A recent EIA survey of utilities, however, indicates that few utilities have studied the dry storage option.

NRC Did Not Identify Impediments to Extended Dry Storage

In August 1984 NRC completed a 5-year rulemaking, generally referred to as the waste confidence rulemaking, to assess the degree of assurance with which radioactive waste can be safely disposed of in geologic repositories. One part of the rulemaking addressed whether commercial waste in the form of spent fuel could be safely stored at nuclear power plant sites until off-site disposal or storage is available. NRC found reasonable assurance that these wastes can be safely stored without significant environmental effects in the plants' storage pools or at on-site independent storage installations such as dry storage for at least 30 years after nuclear plants are retired.

In making its finding, NRC concluded that dry storage is simpler technology than conventional pool storage. That is, dry storage does not require active systems such as cooling systems; does not involve the potentially corrosive effects of water; and, the modular nature of dry storage enhances the ability to perform maintenance. Therefore, NRC concluded that safe dry storage should be achievable without undue difficulty.

Moreover, NRC found that no additional land would need to be devoted to the extended storage of commercial waste beyond the operating periods of nuclear power plants. It based this finding on the fact that nuclear plants have adequate space for either additional storage pools or dry storage installations.

Approved and Pending Dry Storage Applications

Two dry storage projects, at Carolina Power and Light's H. B. Robinson plant (South Carolina) and Virginia Power's Surry plant, are being conducted under the DOE cooperative demonstration program called for by NWPA. These demonstrations are designed to assist utilities in enhancing waste storage capacity at nuclear plant sites. They are intended to encourage and expedite utilities' efficient use of existing storage facilities and to provide technologies for adding new storage capacity. An

independent waste storage installation has been constructed at the Surry plant. NRC issued a license for the system in July 1986. Carolina Power and Light obtained a license in August 1986 for dry storage, in modular concrete silos, at its Robinson plant. Wastes are now in storage at both facilities.

NRC expected an application for a license amendment from Virginia Power later in 1987 to consolidate some spent fuel and store it in a dry storage cask at Surry. NRC is also expecting an application for modular dry storage from Duke Power for its Oconee site. This utility had earlier identified potential impediments to using dry storage at this three-reactor nuclear power plant in South Carolina.

NRC Certification of Dry Storage Casks for General Use

NRC is preparing a rule that will allow the general (non-site-specific) approval of the use of dry storage casks at nuclear power plant sites. This rule is being prepared in accordance with Section 133 of the NWPA, which states that NRC shall, by rule, establish procedures for the licensing of any dry storage or rod consolidation technology approved by NRC for use at the site of any civilian nuclear power plant.

According to the section leader of NRC's irradiated fuels division, the planned new rule would amend NRC's existing regulations to provide for the approval and certification of specific dry storage casks by NRC for use at all nuclear power plants. This dry cask certification would represent a general license for any utility with an operating plant to store commercial waste on site in the form of spent fuel in NRC-certified dry storage casks after first notifying NRC. Therefore, according to this official, a utility would not have to apply for site-specific approval to use an approved cask. This NRC official expects this new rule to make the dry storage option available to a broad range of nuclear plants.

The NRC official told us that, after the final rule is issued, dry cask manufacturers will be able to submit cask designs to NRC for approval or certification. NRC staff will review the manufacturer's technical analyses, perform a safety analysis of each cask design, and state whether it is acceptable. By 1990, according to the NRC official, a number of dry storage casks should be available to utilities and approved under the certification process. The NRC official expects issuance of a site-specific license for dry storage to take from 12 to 15 months. Once the certification process is established, however, a utility could use dry storage after notifying NRC and procuring the cask. In October 1987 NRC issued a dry storage

cask manufacturing certificate to one company. However, this NRC official told us that, in the absence of the final certification rule, a utility desiring to purchase and use this cask for dry storage would still have to get a specific licensing approval from NRC.

NRC regulations will still allow site-by-site approvals for dry storage technologies other than those approved under the certification process, according to the NRC official. Any utility that for some reason cannot use the particular cask or casks certified under NRC's generic rule at its nuclear plant site will be able to apply for a site-specific license amendment for another cask or some other form of dry storage, such as vault storage or the concrete silos in use at the Robinson plant. For example, if a nuclear plant's storage pool crane has a low lifting capacity and, therefore, cannot utilize a particular NRC-approved dry storage cask, the utility can apply for site-specific approval of vault-type dry storage designs.

The section leader of NRC's irradiated fuels division told us that NRC has not received any strong indication from utilities that they are interested in dry storage. He added, however, that in the early 1990s there are likely to be many candidates for dry storage. Also, some of the current prospective candidates may be waiting until the certification process is established, while others may be waiting to see what design is most economical for them on a site-by-site basis.

Current NRC Staff Views

The NRC section leader told us that NRC has not identified technical factors that would prevent any utilities from using some form of dry storage at any nuclear power plant to accommodate all of their waste. Further, NRC examined the question of institutional impediments to using on-site dry storage and concluded that there are no impediments to its use. He also stated that NRC has encountered no public opposition to licensing dry storage technology. In fact, this official stated that dry storage appears to be the politically or socially preferred alternative to expanding storage pools, shipping wastes between sites, or federal interim storage because it is rather innocuous compared with these other options. Dry storage (1) is modular, so only two or three casks a year would be placed on site; (2) involves passive storage and requires no maintenance, so no workers are needed to run it; (3) is sealed, so the risk of exposure to radiation is lessened; and (4) involves no water, and therefore, reaching a self-sustaining chain reaction, or criticality, is a "remote" possibility. On the latter point, this official stated that even if

water were to somehow enter the cask, the wastes would not achieve criticality.

Few Utilities Have Apparently Fully Assessed Dry Storage

In 1986 EIA canvassed utilities' knowledge of the potential for dry storage at their nuclear power plants. Utilities operating 29 of 119 plants indicated that they had studied dry storage. For the 29 plants, utilities said that their studies identified impediments to dry storage use at 8 plants, and no impediments at 12 plants. For the remaining nine plants, utilities either stated that they did not know of any impediments or did not respond to EIA's questions.

Comments From the Department of Energy

Department of Energy
Washington, DC 20585

JUL 28 1988

Mr. Keith O. Fultz
Senior Associate Director
Resources, Community, and
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U.S. General Accounting Office
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Dear Mr. Fultz:

The Department of Energy (DOE) appreciates the opportunity to review and comment on the General Accounting Office (GAO) draft report entitled "Nuclear Waste: Fourth Annual Report on DOE's Nuclear Waste Program."

The Department concurs with the recommendation to supply the MRS Review Commission with additional supporting analyses of the benefits of adding such a facility to the nuclear waste management system. However, GAO's discussion in Chapter 3 of how the DOE would proceed, following the December 1987 Amendments Act, is not the approach the Department has contemplated. In fact, the Department's approach appears to closely parallel the recommendation of the GAO.

Specifically, GAO has incorrectly assumed that DOE would proceed with the facility configuration and design as identified in the March 1987 Monitored Retrievable Storage (MRS) submission to Congress. As a result of the December 1987 Amendments Act, the Department is in the process of evaluating a variety of possible MRS configurations.

The DOE appreciates the difficulty of developing valid assumptions and readily agrees with GAO on the need for substantial new analyses of the benefits of various MRS configurations to the waste management system. Additionally, the Department looks forward to providing information to the MRS Review Commission.

The Department hopes that these comments will be helpful to GAO in its preparation of the final report. Additional technical and editorial comments are being provided directly to Mr. Dwayne Weigel.

Sincerely,

Lawrence F. Davenport
Assistant Secretary
Management and Administration

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