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The Need for and Feasibility of Monitored Retrievable Storage-- A Preliminary Analysis

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Office of Civilian Radioactive Waste Management

PREFACE

The Nuclear Waste Policy Act of 1982 directed the Department of Energy (DOE) to complete a study of the need for, and the feasibility of, monitored retrievable storage (MRS). This study will form part of the basis for the Secretary's recommendation to Congress with regard to an MRS facility. This paper is the DOE's initial analysis of this important topic.

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SUMMARY AND CONCLUSIONS

The Nuclear Waste Policy Act of 1982, Public Law 97-425 (the Act), directed the Secretary of the Department of Energy (DOE) to complete a study of the need for, and the feasibility of, monitored retrievable storage (MRS) and to submit to Congress a proposal for the construction of one or more MRS facilities. The Act specified that the proposal include a program for the siting, development, construction, and operation of an MRS facility; site-specific designs and cost estimates for the construction of the first facility; a plan for funding the construction and operation of such facilities; and a plan for integrating such facilities into the Federal waste-management system.

The primary goal of the Federal waste-management system is to dispose of commercially generated spent fuel and high-level radioactive waste in a manner that protects the health and safety of the public and maintains the quality of the environment. The Act clearly establishes geologic repositories, fully financed by the owners and generators of spent fuel and high-level wastes, as the means for safely isolating this spent fuel and waste for permanent disposal. In addition, the Act establishes 1998 as a goal for beginning to dispose of spent fuel and high-level waste in a repository.

The DOE is fully committed to meeting these responsibilities and furthermore recognizes an obligation to the electric utilities and their rate payers to establish a firm schedule for accepting spent fuel for disposal.

In considering the proper role for monitored retrievable storage, the DOE has evaluated a range of alternative system configurations. Of these, the three options described below have been analyzed in some detail.

Repository Only, Without an MRS Facility. This option is currently authorized by Congress through the Act. Utilities are responsible for onsite storage of spent fuel until the DOE takes title to the fuel at the reactor site before shipment to the repository. The DOE will begin accepting spent fuel not later than January 31, 1998, when the first repository is scheduled to begin operations. However, some additional storage capability would be needed, either at the reactor sites or at the repository, for several years following 1998 because the inventories of spent fuel would continue to grow faster than fuel could be emplaced in the repository.

Repository with an Integral MRS Facility. The construction of an integral MRS facility would require Congressional authorization. As an integral, or essential, part of the waste-management system, the MRS facility could begin to receive and package spent fuel for disposal in 1996. Because this facility would be centrally located for the majority of reactors, it is beneficial to the transportation of the spent fuel: on the average, the distances for shipments from reactors to the MRS facility would be much shorter than the distances between reactors and the first repository, assumed to be located in the Western United States. Most important, cross-country shipments from the MRS facility to the repository could be made with large rail casks and dedicated trains. In this option, the repository would receive in the transport casks from the MRS facility consolidated spent fuel in containers that are uncontaminated and require no further preparation for permanent disposal. Spent fuel that is accepted by the DOE and cannot be immediately emplaced in the repository would be stored temporarily at the MRS facility.

Repository with Backup MRS Facility. The construction of the backup MRS facility would require Congressional authorization. Its primary function would be to provide for the contingency of significant delays in the repository program by receiving and storing spent fuel. It would be deployed only if it became apparent that the repository would be delayed. As a result, the backup MRS facility would not begin receiving fuel until 1998. Once the repository begins operating the backup MRS facility would be phased out of operation by gradually offloading the inventory of spent fuel that it had acquired. This facility would, in effect, duplicate the spent-fuel receiving and consolidation capability of the repository.

Earlier DOE plans (e.g., the April 1984 draft Mission Plan) have described the backup role for MRS. The principal mission of the backup MRS facility would be storage--its need contingent on the timing and success of the repository program. The DOE concluded then that authorization to construct such a backup MRS facility would not be appropriate at this time, because it expects that the schedule for the startup of a geologic repository can be met.

The DOE has come to believe, however, that if Congress authorizes an MRS facility as an integral part of the waste-management system, the facility would significantly improve system operations and the timely deployment of key system functions. The DOE's evaluation of the integral MRS facility has identified important advantages in the development and integration of the waste system, the operation of the system and the provision of a cost-effective contingency capability. These advantages are described below.

Improvements in System Performance

By being centrally located to the existing inventories of spent fuel, an MRS facility would significantly reduce the potential impacts of transportation and would improve the management and control of the transportation function. An integral MRS facility would provide a hub for the logistics of managing spent-fuel transportation, cask-fleet operations, and cask-fleet servicing. By shipping to the repository consolidated fuel, possibly in dedicated trains, the number of cross-country shipments could be significantly reduced. The total cask-miles can be reduced by more than 40 percent, and the number of shipments in progress at any one time can be reduced by 40 to 60 percent, depending on the location of the repository.

Locating the spent-fuel consolidation and packaging functions in an integral MRS facility would simplify the design, construction, and operation of the repository facilities. The repository can receive a controlled stream of uncontaminated, standard packages that are ready for disposal instead of an irregular flow of truck and rail transport casks containing contaminated spent-fuel assemblies that need to be prepared for disposal. The use of an integral MRS facility would reduce the number of shipping casks received by the repository by 80 to 90 percent, thereby simplifying the operation of the receiving and handling facility of the repository. In addition, the heat output of the waste packages can be tailored to emplacement needs. These factors contribute to a more efficient, balanced, and integrated waste-management system.

The integral MRS facility would increase the flexibility of the waste-management system by providing a buffer between waste acceptance and waste emplacement. With the MRS facility acting as a buffer, the key functions of waste acceptance and emplacement would be independent of one another. Waste-acceptance activities would not be affected by temporary slowdowns or other operational problems that could be experienced at the repository. Consequently, a firm schedule for spent-fuel acceptance could be established to accommodate the DOE's contractual commitments to the utilities paying fees into the Nuclear Waste Fund. In addition, the MRS facility would improve system flexibility by having the capability to serve the second repository as well. With the working inventory of spent fuel controlled at a centrally located MRS facility rather than at the repository, there would be opportunities for improving the orderly progression of spent fuel toward its permanent disposal in geologic repositories.

Improvements in System Development, Deployment, and Integration

By performing the pre-waste-emplacement functions (waste acceptance, transportation, operational storage, and packaging) at an MRS facility, the development and integration of all system functions would proceed with greater certainty and focus, ensuring that the resources of the Nuclear Waste Fund are effectively used to achieve a fully functioning and integrated disposal system by 1998. The development and deployment of the essential pre-waste-emplacement functions would be separated from the licensing and construction of the geologic repository. Separating these functions from the repository would provide a clear and well-defined interface with the waste generators (utilities). In addition, the development of the repository could concentrate on demonstrating the safety of long-term isolation. Waste acceptance, transportation, and packaging issues would be separated from geologic issues related to the long-term performance. This separation would allow early definition of system requirements--including waste-acceptance schedules, transportation routes, and cask-fleet requirements--thus providing utilities with a firm planning base and providing private industry with the certainty it will need to develop a fully functional transportation system. The MRS facility would also be a focal point for system-integration activities. It would provide opportunities for the early testing of key system functions and allow the experience gained to improve system operations.

Monitored retrievable storage has been found to be a feasible option for the safe, reliable storage of spent fuel and high-level waste. The functions performed at the integral MRS facility, the packaging and storage of spent fuel, have been safely performed at various licensed facilities for the past 20 years. Because of this experience, the identification of suitable sites and the design, licensing, and construction of such a facility would be relatively straightforward. The construction and operation of an integral MRS facility would be a positive step toward the implementation of the waste-management system.

Cost-Effective Ability to Accommodate Repository Delays

The MRS facility allows the Federal waste management system to receive spent fuel without interruption even if the repository is delayed or its emplacement operations are reduced. The MRS facility would safely store spent fuel until the repository was capable of receiving and emplacing it.

Because the MRS facility would provide essential packaging and waste-acceptance functions, storage capability would be available at a very low incremental cost, less than $20 per kilogram. The cost to utilities of providing dry storage once their storage pools are full is estimated to range from $50 per kilogram to $125 per kilogram. For each year that the repository is delayed beyond 1998 (or that emplacement capability is reduced an equivalent amount) utilities would have to store 1500 to 1900 metric tons of uranium in excess of the quantity that can be handled in fully reracked pools. The contingency capability provided by the MRS facility would prevent these unnecessary expenditures by utilities and their rate payers.

An integral MRS facility would provide an early focus for developing and integrating the essential operational functions of waste acceptance, transportation, and packaging for disposal. By separating these short-lived operational functions from the repository-development process, which must concentrate on demonstrating that the spent fuel can be safely isolated for thousands of years, they can be developed more quickly and with greater certainty. An integral MRS facility would therefore allow early productivity for the resources of the Nuclear Waste Fund and would provide utilities with the assurance they need to plan for orderly power-plant operations. In addition, an integral MRS facility would add operational flexibility to the total system, improve the management and control of the transportation system, and reduce the potential impacts from transportation because fewer cross-country shipments to a repository would be required (perhaps as few as two or three dedicated trains per month). These significant benefits would be achieved at a very slight increase, about 2 percent in the costs of the Federal waste-management system. By precluding the need for substantial expenditures by the utilities to provide at-reactor storage after 1998, an integral MRS facility could reduce the total costs in the long run.

Chapter 1

INTRODUCTION

The Nuclear Waste Policy Act (the Act) of 1982 affirmed the responsibility of the Federal Government to dispose of the spent fuel and high-level radioactive waste resulting from civilian nuclear activities* and assigned to the Department of Energy (DOE) the responsibility for providing the disposal facilities. The disposal facility authorized by Congress is a deep underground repository where radioactive material can be permanently isolated without significant risk to present or future generations. The Act establishes 1998 as a goal for the DOE to begin accepting the waste for disposal. The Act further indicates that monitored retrievable storage (MRS) is a safe, reliable option for the long-term storage of high-level radioactive waste or spent nuclear fuel.

The Act does not clearly define the role of MRS facilities nor authorize their construction. Rather, it directs the Secretary of Energy to complete a detailed study of the need for, and the feasibility of, such facilities and to submit to Congress a proposal for the construction of one or more MRS facilities (Section 141(b)(1)). Among other things, this proposal is to include a plan for integrating MRS facilities with the other storage and disposal facilities authorized by the Act (Section 141(b)(2)(D)).

In carrying out these requirements, the DOE has considered alternative roles and schedules for MRS facilities and has assessed their value to the Federal waste management system. Specifically, the DOE has evaluated (1) a backup MRS facility to be constructed only if there is a significant delay in the repository program and (2) an integral MRS facility that would receive, prepare, and package spent fuel for disposal. Both options have been compared with the currently authorized system, which does not include an MRS facility. The DOE is considering proposing the construction of an MRS facility as an integral part of the total waste-management system.

This paper presents a preliminary analysis of (1) the need for, and the advantages of, an integral MRS facility considered in the context of existing authorized facilities and (2) the feasibility of deploying this facility in the system. The analysis addresses the following questions:

- What are the requirements of the waste-management system? (Chapter 2)

- What are the elements of the currently authorized waste-management system that form the basis for assessing the value of additional elements? What alternative system configurations can meet the system's requirements? (Chapter 3)

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*For simplicity and brevity, the term "waste" is frequently used in this paper to mean both high-level waste and spent nuclear fuel.

- What are the potential advantages and disadvantages of each of the alternative system configurations? (Chapter 4)

- What does an integral MRS facility look like and what will it do? (Appendix A)

- How would an integral MRS facility be implemented? (Appendix B)

By answering these questions, the analysis concludes that an integral MRS facility enhances the ability of the waste-management system to perform in a manner that is safe, efficient, reliable, timely, and cost effective.

This analysis is based solely on spent nuclear fuel, the principal waste type to be accepted by the system. High-level radioactive waste, either from commercial or defense sources, was not specifically considered. However, the routing of such wastes through an MRS facility could improve the transportation of these wastes, depending on the location of the wastes and the repository.

Chapter 2

THE OBJECTIVES AND REQUIREMENTS OF THE WASTE-MANAGEMENT SYSTEM

This chapter describes the objectives and requirements of the waste-management system. Alternative roles for monitored retrievable storage are reviewed in the context of what the system must accomplish and what features would make the system successful.

2.1 OBJECTIVES OF THE SYSTEM

The overall goal of the system, as embodied in the Act, is to manage and dispose of commercially generated spent fuel and high-level radioactive waste in a manner that is safe and environmentally acceptable.

The Act clearly establishes geologic repositories, fully financed by the owners and generators of spent fuel and nuclear wastes, as the means for safely isolating this spent fuel and wastes for permanent disposal. In addition, the Act establishes 1998 as a goal for beginning to dispose of spent fuel and wastes in a repository.

The need for utilities to add storage facilities after 1998 and to maintain orderly power-plant operations thereafter are important considerations in establishing a Federal acceptance rate. Early definition of and progress toward meeting the acceptance schedule will allow utilities to confidently plan for their interim onsite storage needs. (The Act reaffirmed the responsibility of the utilities to provide for such storage needs prior to Federal acceptance for disposal.)

This paper defines the waste-management system to include all steps from waste generation through disposal in a geologic repository. Thus, the analysis considers the activities that are conducted by the utilities and other waste generators before the transfer of the waste to the Federal Government. The activities of the utilities will influence what equipment the DOE will need to transport the waste from the site at which it is generated or stored and what waste-handling or preparation operations may be necessary at Federal facilities. Therefore, the waste-management system is defined to include the waste generators, and the waste-management system is divided into two portions, with the waste generators being responsible for one portion and the Federal Government being responsible for the other portion.

The storage of spent fuel at the reactor site and its loading into transportation casks for shipment to a Federal facility are and will remain the responsibilities of the utilities. The transportation casks, licensed by the Nuclear Regulatory Commission, will be provided by the DOE. The DOE will then accept title to the spent fuel at the reactor site and transport it to either the MRS facility or the repository. These activities constitute the principal interface between the Federal portion of the system and the waste generators.

2.2 THE FUNCTIONAL REQUIREMENTS OF THE SYSTEM

To meet the program objectives, the waste-management system must be able to perform the following functions:

- Accept spent nuclear fuel and high-level waste.
- Transport the waste from reactors sites or other locations to disposal sites, including intermediate facilities designed for waste storage and preparation, as required.
- Prepare the waste for permanent disposal by consolidating the spent-fuel rods into closely spaced arrays and packaging the spent-fuel into disposal containers.
- Manage the waste as needed before disposal.
- Provide permanent disposal in geologic repositories for all waste accepted into the system.

For the program to be successful in meeting its objectives and performing the required functions, the system must possess several characteristics. First and foremost, the system must be designed, developed and operated in a manner that is safe and environmentally acceptable. Second, the system should be implemented on a schedule that meets the requirements of the Act--in particular, the waste-acceptance date of January 31, 1998, while not compromising on safety. Third, the system should be efficient. Fourth, the system must be sufficiently flexible to deal with contingencies and unexpected problems that might occur. Fifth, the system must be built and operated at a reasonable cost and within the revenues supplied by the waste generators. Sixth, the system should be implemented in a deliberate and careful fashion that provides for confidence in both the safety and the pace of the program.

The next section discusses two alternative roles for an integral MRS facility in the system and explains how its inclusion can enhance the likelihood of success for the program.

2.3 THE ROLE OF AN MRS FACILITY IN THE SYSTEM

The DOE's initial plans for monitored retrievable storage, as reflected in the April 1984 draft Mission Plan,* consisted of an MRS facility to provide backup storage capability should there be significant delays in the availability of a geologic repository. In this case, the DOE planned to build and operate an MRS facility to store the spent fuel until the repository was

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*U.S. Department of Energy, Mission Plan for the Civilian Radioactive Waste Management Program, DOE/RW-0005, draft, April 1984.

Chapter 3

ALTERNATIVE SYSTEM OPTIONS

This chapter describes three options that have been examined in an effort to define the most appropriate configuration for a waste-management system that can meet the objectives and requirements identified in Chapter 2. These three alternative options are (1) repository only, without an MRS facility; (2) repository with an integral MRS facility; and (3) repository with a backup MRS facility.

Each option is shown in Figure 3-1 and described briefly in Sections 3.1, 3.2, and 3.3 in terms of how and when each provides the essential functions of waste acceptance, transportation, packaging, storage, and disposal. Variations on these system options were considered but not carried through the analysis. Two of these variations, which are discussed in more detail in Section 3.4, include expanded lag storage at the repository and multiple eastern MRS facilities. The spent-fuel logistics are also described (Section 3.5) to illustrate how the system would operate for each system option and to provide a consistent basis for comparing the relative merits of the options.

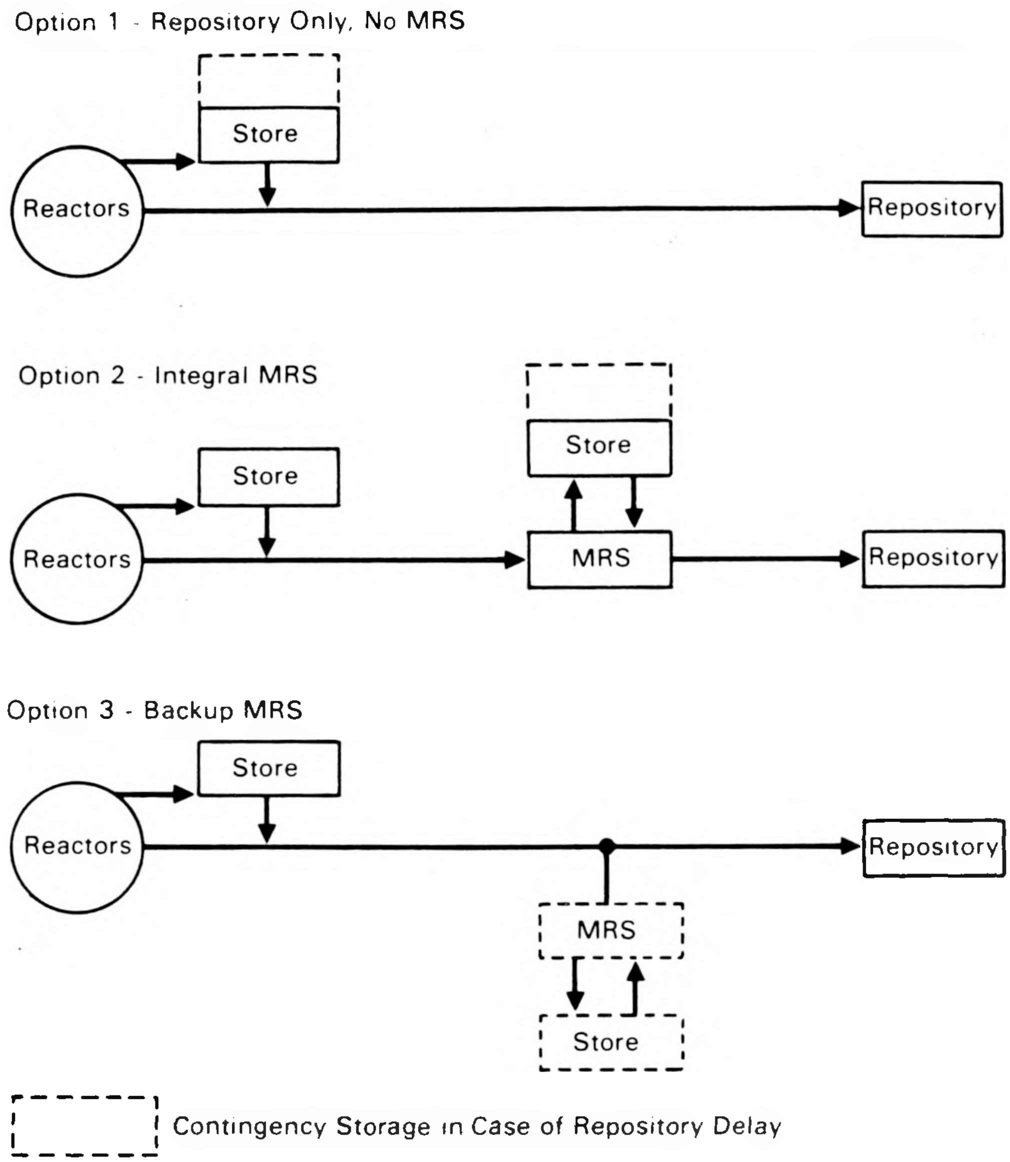
For each of the three options there are opportunities for improving system performance given the conditions that exist when the facilities are deployed. For example, if the backup MRS facility was constructed and operated, it may continue to receive and package fuel from reactors even after the repository attains full-scale operation. Similarly, if there was no MRS facility in the system and the development of the repository proceeded on schedule, the repository might start receiving spent fuel from utilities even before emplacement operations begin. The extent of such early receipt would depend on the availability of storage space at the site of the repository and the lack of storage space at the reactors.

The DOE recognizes that improvements could be made in each of the options, but, for the present analysis, the fundamental differences between the options are emphasized. Continued analysis by the DOE will better define each option, with particular emphasis on option 1, the repository-only system. For this option, improvements are being considered in the techniques of at-reactor storage; methods for fuel consolidation and packaging at the reactor site; trends toward extended burnup levels of fuel; and improvements in the at-reactor transportation system, such as the ability to handle larger casks or to haul rail casks to the nearest railspur by truck. Each of these improvements, however, would also enhance the performance of a system that includes an MRS facility. The results of these further analyses will feed into the final report of the need and feasibility study that the DOE will submit with its MRS proposal to Congress in January 1986.

3.1 OPTION 1--REPOSITORY ONLY, WITHOUT AN MRS FACILITY

This option is currently authorized by Congress through the Nuclear Waste Policy Act (the Act). Utilities are responsible for the onsite storage of

Figure 3-1



Option 1 - Repository Only, No MRS
Store
Reactors
Repository
Option 2 - Integral MRS
Store
Store
Reactors
MRS
Repository
Option 3 - Backup MRS
Store
Reactors
Repository
MRS
Store
Contingency Storage in Case of Repository Delay

spent fuel until the DOE takes title to the fuel at the reactor site before shipment to the repository. The DOE will begin accepting spent fuel not later than January 31, 1998, when the first repository is scheduled to begin operations. However, some additional storage capability would be needed, either at the reactor sites or at the repository, for several years following 1998 because the inventories of spent fuel would continue to grow faster than fuel could be emplaced in the repository.

Waste Acceptance. The DOE would accept spent nuclear fuel for direct shipment to a repository. The waste-acceptance rate would be tied to the rate of waste-emplacement at the repository except to the extent that some surge storage at the repository (approximately 750 MTU) might be provided. If there are delays in the startup of the repository, spent fuel would continue to be stored at reactor sites. The Federal Government could provide for at-reactor storage if the repository is delayed and contract holders elect this option.

Packaging. All preparation and packaging for disposal would be done at the repository, although some utilities may consolidate their spent fuel before acceptance by the DOE to alleviate space shortages in their spent-fuel pools. The consolidated fuel may require repackaging at the repository into a standard container. No packaging would occur until the complete repository is licensed and constructed.

Transportation. The transportation system would move spent fuel from more than 80 reactor sites, mostly in the eastern part of the country, to the first repository. The site of the first repository is most likely to be in the west, because, as reported in the draft environmental assessments prepared for the nine sites identified as potentially acceptable for the repository,* the DOE has found that the three sites preferred for further study are a site in basalt in the State of Washington, a site in bedded salt in northwestern Texas, and a site in volcanic tuff in southern Nevada. The entire transportation system would be constrained by the cask-handling capabilities of individual reactors; that is, cross-country truck and rail shipments would be required from most reactors.

Storage. No significant amounts of storage would be provided in the Federal portion of the system with this option. A modest working storage capability would be provided at the repository to ensure efficient operation.

3.2 OPTION 2--INTEGRAL MRS FACILITY

The construction of an integral MRS facility would require Congressional authorization. As an integral, or essential, part of the waste-management system, the MRS facility could begin to receive and package spent fuel for disposal in 1996. Because this facility would be centrally located for the majority of reactors, it would be beneficial to the transportation of the

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*See, for example, U.S. Department of Energy, Draft Environmental Assessment--Yucca Mountain Site, Nevada Research and Development Area, Nevada, DOE/RW-0012, December 1984.

spent fuel: on the average, the distances for shipments from reactors to the MRS facility would be much smaller than the distances between reactors and thefirst repository, assumed to be located in the Western United States. Most important, cross-country shipments from the MRS facility to the repository could be made with large rail casks and dedicated trains. In this option, the repository would receive from the MRS facility consolidated spent fuel in containers that would be uncontaminated with radioactive material and would require no further preparation for permanent disposal. Spent fuel that is accepted by the DOE and cannot be immediately emplaced in the repository would be stored temporarily at the MRS facility. Appendix A describes the MRS facility and the methods used for spent-fuel storage at such a facility.

Waste Acceptance. The integral MRS facility would enhance the DOE's waste-acceptance capability, especially in the early years of system operation. Since an MRS facility could begin operations in 1996, DOE could start to accept fuel at or near the rate of spent-fuel generation by 1998.

Packaging. The integral MRS facility would consolidate spent fuel and package it for disposal in the repository. Although current evaluations indicate benefits from this integral MRS configuration, a number of decisions remain regarding the exact configuration of a system with such a facility. These decisions include the location of the overpacking function,* the handling of spent fuel from western reactors,** and the configuration of the system to serve the second repository*** if a second repository is authorized by Congress.

Transportation. By centrally locating the MRS facility with respect to the majority of existing reactors, transportation requirements can be significantly reduced. The distances for truck and rail shipments from most of the approximately 80 reactor sites will be much shorter, requiring a smaller fleet and less material in transit at any given time. From the MRS facility, the spent fuel, consolidated into standard noncontaminated containers, could be shipped to the repository in large rail casks and dedicated trains. The number of cross-country shipments to the repository would be reduced to as few as 2 to 3 dedicated train shipments per month. With fewer shipments, the management and control of these shipments would be easier.

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*Overpacking of waste packages could be done either at the MRS facility or the repository. Systems analyses will determine where overpacking should occur by evaluating the tradeoffs between added storage and transportation cost if overpacking occurs at the MRS facility and some additional facility cost if the repository installs the overpacks.

**Fuel from western reactors, which represents less than 10 percent of the fuel inventory, could be shipped to the MRS, facility, directly to the repository, or to an alternative facility in the west, where it could be packaged for disposal.

***An integral MRS facility can provide additional advantages by packaging spent fuel for both the first and the second repositories. Should this be a feasible and desirable option, additional cost savings could be realized because the MRS facility would provide packaging for two repositories instead of one. Handling-facility requirements and costs would be reduced at both repositories.

Storage. An integral MRS facility can meet a range of system storage needs. It can provide storage for (1) fuel that does not yet meet the heat-output criterion of the repository; (2) fuel that exceeds the quantities that can be efficiently received by the repository, and (3) fuel that must be stored for any other reason. Such storage capability at the MRS facility also would allow shipments to the repository to be closely coordinated with the waste-emplacement capability of the repository.

3.3 OPTION 3--BACKUP MRS FACILITY

The construction of the backup MRS facility would require Congressional authorization. Its primary function would be to provide for the contingency of significant delays in the repository program by receiving and storing spent fuel. It would be deployed only if it became apparent that the repository would be delayed. As a result, the backup MRS facility would not begi· receiving fuel until 1998. Once the repository begins operating, th backup MRS facility would be phased out of operation by gradually offloading the inventory of spent fuel that it had acquired. This facility would, in effect, duplicate the spent-fuel receiving and consolidation capability of the repository.

Waste Acceptance. If there were significant delays in the repository, the MRS facility would start receiving spent fuel in 1998 so as to fulfill the DOE's waste-acceptance commitments. Once the repository begins operation, the spent fuel would be shipped from reactors directly to the repository.

Packaging. The backup MRS facility would consolidate the spent fuel and store it in canisters that could be loaded into disposal containers either before shipment to the repository or at the repository itself. This option would duplicate the cask receiving and handling function (since both the MRS facility and the repository would have the capability to service all reactors) and the consolidation and packaging function.

Transportation. The transportation system would be much like that of option 1 (the system without an MRS facility) because most fuel would go directly from reactors to the repository. The fuel stored at the MRS facility would be consolidated and could be shipped to the repository in large rail casks and dedicated trains.

Storage. A backup MRS facility would provide storage needed to avoid additional at-reactor storage if the startup of the repository is delayed. In addition, the MRS facility could provide buffer storage for the system to be used in the event of operational problems at the repository.

3.4 OTHER SYSTEM OPTIONS

Two additional system options were considered in evaluating the need for MRS facilities in the waste-management system. These options and the reasons for not carrying them fully through the analysis at present are described below.

3.4.1 Expanded Lag Storage at the First Repository

An alternative to the integral MRS facility that would separate waste acceptance from emplacement in a repository would be the provision of expanded lag storage at the surface facilities of the repository. This option is currently authorized by Congress. The licensing and construction of the surface facilities would proceed independently of the underground repository. This would enable the system to receive, prepare, and store spent fuel on a schedule that is not constrained by the licensing and the development of the repository.

This option has the potential for eliminating the duplication of the receiving and packaging functions. However, obtaining authorization to proceed with surface-facility construction without having obtained a license to construct the underground repository could be quite difficult. If the site of the repository is found unsuitable, spent fuel would be stored at the site until another repository could receive it. The original repository would become, in effect, an MRS facility, but it would not be centrally located and would have significantly increased transportation impacts.

3.4.2 Multiple MRS Facilities

Another deployment variation for MRS is to operate two or more facilities in the eastern half of the country. This system would provide multiple destinations for transportation from reactors. For two eastern MRS facilities, the facility and operating costs would be higher than those of a system with a single MRS facility of equivalent total capacity; this increase would result from a loss of the economies of scale and the fixed costs of operation. The transportation requirements would be reduced, however. Two MRS facilities whose combined capacity equals that of a single larger MRS facility would cost at least 20 to 30 percent more than a single facility because of the loss of the economies of scale and the duplication of support facilities.

A single, centrally located MRS facility would provide a net reduction of about 40 percent in transportation requirements (a reduction of about 25 million cask-miles*) compared with a system without an MRS facility. If fuel from western reactors were to be shipped directly to the repository or a western MRS facility, there would be a further reduction of 8 million cask-miles. This reduction may be worthwhile if the western fuel can be handled at the repository without costly facility additions.

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*A cask-mile refers to the movement of a single cask (either by truck or rail) a distance of 1 mile. The alternative measure is the shipment-mile, which is the distance traveled by each shipment; that is, five rail casks transported 1 mile on a single train would correspond to 1 shipment-mile. Cask-miles and shipment-miles are used throughout this paper as measures of transportation-system requirements. The basis for these calculations is explained more fully in Section 4.3.1.

A second eastern MRS facility, however, would reduce transportation requirements by only 6 percent (about 4 million cask-miles) at best. Such a reduction does not justify the added expense of a second eastern MRS facility. The proportionally larger transportation reduction from the separate handling of western fuel will be considered in the overall system configuration, but this decision does not affect the desirability of an integral MRS facility centrally located with respect to the existing inventories of spent fuel.

3.5 WASTE-ACCEPTANCE SCHEDULES

This section describes the waste-acceptance schedules used to characterize spent-fuel logistics for the three system options. For this analysis, only the logistical relationships between the reactors, the first repository, and the alternative MRS facilities (integral or backup) are considered. This is a simplification of the actual waste management system, which may include a second repository if authorized by Congress. The second repository was not considered in this analysis, because the key waste-acceptance attributes of the alternative MRS facilities are characterized by their interactions with the first repository. In addition, in order to evaluate the transportation impacts of including an integral MRS facility in the waste-management system, it is necessary to assume locations for the major facilities in the system. The potential sites for the first repository are known, but potentially acceptable sites for the second repository have not been identified. This simplification of the waste-management system is for analysis purposes only. The DOE's Mission Plan and system cost evaluations will cover the entire system.

The analysis reported here is limited to the first 70,000 MTU of spent fuel generated under the "middle case" forecast of future nuclear capacity by the DOE's Energy Information Administration (EIA).* This EIA forecast is the planning basis for the waste-management program and was used for the draft Mission Plan and the financial analysis of the Nuclear Waste Fund.** Future forecasts to be used in Waste Management System planning will take into account extended burnup trends in addition to uncertainties in Nuclear Power growth projections. For this analysis, the first 70,000 MTU of fuel is assumed to be emplaced in the first repository. In the actual waste-management system, which is likely to include a second repository, some of the first 70,000 MTU of fuel is likely to go to the second repository, and some fuel generated later will go to the first repository. However, this would have little effect on the logistics calculations reported in Chapter 4.

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*M. Gielecki et al., 1984. Commercial Nuclear Power 1984: Prospects for the Unites States and the World, DOE/EIA-0438, U.S. Department of Energy, Washington, D.C., 1984.

**U.S. Department of Energy, Nuclear Waste Fund Fee Adequacy: An Assessment, DOE/RW-0020, Washington, D.C., 1985.

Table 3-1 shows the assumed waste-acceptance schedules for the integral MRS facility and an on-time repository. The repository is assumed to begin receiving spent fuel at an annual rate of 400 MTU, reaching its full-operation rate of 3000 MTU per year by 2003. These rates are consistent with the April 1984 draft Mission Plan.* By contrast, the waste-management system that includes an integral MRS facility could begin receiving fuel and performing the waste-preparation functions in 1996 (400 MTU/per year), achieving a rate of 3000 MTU per year by 1998. The current design receipt rate of the MRS facility is 3600 MTU per year, with a nominal receipt rate of 3000 MTU per year for steady-state operations. The introduction of an integral MRS facility into the waste-management system would allow the system to achieve the full operational rate of 3000 MTU per year by 1998.

For a 5-year delay in repository startup, the repository receipt schedule is assumed to slip by 5 years, but there is no change in the repository ramp-up rate. The integral MRS facility is assumed to operate as before, receiving 400 MTU in 1996 and 3000 MTU by 1998. For option 3, however, the backup MRS facility is assumed to preserve the total-system receipt rate defined by an on-time repository; that is, the receipt rate of the backup MRS facility is exactly the same as the rate scheduled for the first repository. As noted earlier, however, the backup MRS facility would enable the system to accept even greater quantities if desired.

*The DOE's draft Mission Plan (DOE/RW-0005) is being revised concurrently with this analysis. The revised Mission Plan will show a slightly lower initial receipt rate for the repository. For purposes of the present analysis, however, the assumed rate provides a reasonable basis for comparing system options. Any reductions in the initial repository receipt rate would lead to slightly larger inventories of spent fuel at reactors than those reported in Chapter 4.

Table 3-1

Waste-Acceptance Schedules[A]
(Metric tons of uranium)

Year	On-Time Repository: Repository Only: On-time Repository	On-Time Repository: Repository Only: Total System	On-Time Repository: Integral MRS Facility: Integral MRS	On-Time Repository: Integral MRS Facility: On-time Repository	On-Time Repository: Integral MRS Facility: Total System	5-Year Delay in Repository: Integral MRS Facility: Integral MRS	5-Year Delay in Repository: Integral MRS Facility: Delayed Repository	5-Year Delay in Repository: Integral MRS Facility: Total System	5-Year Delay in Repository: Backup MRS: Backup MRS	5-Year Delay in Repository: Backup MRS: Delayed Repository	5-Year Delay in Repository: Backup MRS: Total System
1995	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	400	0	400	400	0	400	0	0	0
1997	0	0	1800	0	1800	1800	0	1800	0	0	0
1998	400	400	3000	400	3000	3000	0	3000	400	0	400
1999	400	400	3000	400	3000	3000	0	3000	400	0	400
2000	400	400	3000	400	3000	3000	0	3000	400	0	400
2001	900	900	3000	900	3000	3000	0	3000	900	0	900
2002	1800	1800	3000	1800	3000	3000	0	3000	1800	0	1800
2003	3000	3000	3000	3000	3000	3000	400	3000	2600	400	3000
2004	3000	3000	3000	3000	3000	3000	400	3000	2600	400	3000
2005	3000	3000	3000	3000	3000	3000	400	3000	2600	400	3000
2006	3000	3000	3000	3000	3000	3000	900	3000	2100	900	3000
2007	3000	3000	3000	3000	3000	3000	1800	3000	1200	1800	3000
2008	3000	3000	3000	3000	3000	3000	3000	3000	0	3000	3000
2009	3000	3000	3000	3000	3000	3000	3000	3000	0	3000	3000
2010[B]	3000	3000	3000	3000	3000	3000	3000	3000	0	3000	3000

[A]Acceptance rates based on the April 1984 draft Mission Plan. The actual values will depend on the standard contract (10 CFR Part 961) with the utilities.

[B]The annual acceptance rate of 3000 MTU will continue until the repository receives 70,000 MTU.

ready to receive it. As soon as the repository became available, the utilities would ship their fuel to the repository for packaging and disposal. When the repository had sufficiently reduced the backlog at the reactors, the MRS facility would ship its waste, packaged in disposal containers, to the repository for any necessary additional preparation and disposal.

The DOE currently is evaluating an integrated waste-management system that consists of both storage and disposal components. An MRS facility is the part of the integrated system that would perform most, if not all, of the waste-preparation functions before emplacement in a repository. The MRS facility would be centrally located with respect to existing reactors in order to reduce the total transportation-system requirements.

The role of the MRS facility in this integrated waste-management system is not the same as the MRS facility studied in the past or described in the draft Mission Plan. Its primary function is waste preparation for emplacement in a repository. Its role in providing backup storage is secondary. Such a facility could, however, provide backup storage if the startup of the repository is delayed. In addition, the schedule for accepting waste from the utilities is separated from the capability to emplace the waste in a repository. Furthermore, an MRS facility could commence operations in 1996--a year or more in advance of the waste-acceptance date specified in the DOE's contracts with the utilities. By 1998, the system could be accepting waste at a rate close to the rate of spent-fuel generation, thus curbing the growing inventory of spent fuel at reactors while making major progress in the implementation of permanent disposal.

Chapter 4

COMPARISON OF SYSTEM OPTIONS

This chapter compares the three options for the waste-management system that were described in Chapter 3: a system without an MRS facility and with utility backup storage; a system with an integral MRS facility; and a system with a backup MRS facility constructed if there is a significant delay in the startup of the first repository.

4.1 OVERVIEW OF SYSTEM COMPARISONS

The three options for the waste-management system are compared in terms of the following:

1. Ability to perform the required system functions on time and efficiently (includes such factors as operating flexibility, management of the transportation function, and the timely development and deployment of key functions).

2. Ability to perform the required functions without significant impact on the public from transportation, on utilities' storage requirements, or on system cost.

3. Ability to provide a cost-effective contingency storage capability to protect the overall system against delays in the startup of the first repository.

The key comparison discussed in this chapter is between option 2--an integral MRS--and a system without an MRS, either option 1 or option 3. This comparison assumes that the first repository is on schedule and addresses the system operational effects and impacts of having an integral MRS facility. Other comparisons are made between the three system options in the final section--system contingencies. Each option is evaluated in terms of its ability to provide contingency storage to protect against delays in the repository program.

This analysis does not compare differences in option 1 due to different suppliers of at-reactor backup storage--utilities or the Federal Government. Although there are some differences between these two approaches, especially in the types of investments required by the utilities, the resulting impact on system operation and its net impacts on transportation, storage requirements, and costs are essentially the same. Further analyses by the DOE will explicitly compare these two approaches, but such analyses are not germane to the present comparisons. As noted earlier, these further analyses will include a wide set of variations, especially for the repository-only option.

The key differences between the system options are summarized in Table 4-1. As noted earlier, options 1 and 3 differ only in how they provide for backup storage. The costs reported in the table are based on very preliminary estimates of the impact of adding an integral MRS facility and removing the

Table 4-1

Summary of Comparisons of Options for the Waste-Management System Options

System Option	System Operations	System Impacts	System Contingency
Option 1: repository only, at-reactor storage backup	• Performance of pre-waste-emplacement functions begin only when repository issues are resolved • Gradual buildup to full operations by 2003 • Acceptance rate dependent on repository operations	• Transportation: more cask-miles; entire transportation system dependent on reactor handling limitations; more cross-country shipments • Utilities: 7300 MTU of dry storage required at 54 reactors • System cost: less expensive with on-time repository	• Contingency storage at reactors in case of repository slippage at $50 to $125 per kilogram
Option 2: repository and integral MRS facility	• Pre-waste-emplacement activities (waste acceptance, transportations and packaging) fully developed and operational by 1998 • Staging area for managing and optimizing transportation system • Potential for emplacement by 1998 enhanced • Acceptance rate independent of repository operations	• Transportation: reduced cask-miles; reduced shipments in progress; fewer cross-country shipments • Utilities: about 3300 MTU of dry storage required at 33 reactors in 1996; no further increases experienced • System cost: net cost increase for Federal portion of the system ranges from $500 million to $700 million; could save as much as $400 million in at-reactor storage even if repository is on time	• Cost-effective contingency storage at about $20 per kilogram • Incremental expansion of required capacity
Option 3: repository with backup MRS facility for contingency storage	• Performance of pre-waste-emplacement functions begins only when emplacement begins • Gradual buildup to full operations by 2003 • Acceptance rate dependent on repository operations	• Transportation: more cask-miles; entire system dependent on reactor handling limitations; more cross-country shipments • Utilities: 7300 MTU of dry storage required at 54 reactors • System cost: less expensive with on-time repository since the backup MRS facility is not built	• Utilities provide backup for short delays in repository; MRS provides backup for longer delays • Cost to store at backup MRS facility greater than that of storage at integral MRS facility

corresponding functions from the repository. The differences between these systems are due to the separation of the pre-waste-emplacement functions (waste acceptance, transportation, and packaging) from the emplacement function and the addition of storage capacity to the system. This separation allows the pre-waste-emplacement functions to operate at or near full scale (approximately 3000 MTU per year) by 1998 and increases the potential for maintaining the repository schedule by allowing repository development and licensing activities to focus on geologic issues.

Transportation will be the primary means whereby the majority of the public will become aware of the waste-management system. Performing the waste-preparation function at an integral MRS facility in the east, where most of the reactors are located, significantly reduces cross-country transportation. An integral MRS facility would reduce cask-miles by as much as 40 percent, which would lessen transportation-related impacts, simplify the required procedures for notifying States, and diminish activities related to emergency-response capabilities. This redistribution of shipments would decrease the number of shipments seen by some states but would likely increase the number of shipments for the MRS host State and some adjacent States.

The primary cost differences between the two system options are due to moving the waste-acceptance and handling functions from a repository site to the site of an integrated MRS facility. While this does not change the direct cost of performing these functions, there are additional indirect costs for the support of these functions at the MRS site. A new receiving facility with substantially reduced capabilities is required for the repository. This facility would annually receive approximately 200 rail casks containing clean, standard packages rather than receiving up to 2000 casks per year and packaging all of the spent fuel. This simplified facility at the repository would also require less support than the original facility at the repository.

With an integral MRS facility, the net increase in the cost of the Federal portion of the waste-management system is currently estimated to range from $500 million to $700 million, which is about 2 percent of the projected total-system cost. This cost may be partially or totally offset by a reduction in at-reactor storage requirements with the integral MRS facility, which could save utilities as much as $400 million. Therefore, the net cost effect on the overall waste-management system is very slight, while the benefits of improving system performance is major, and in addition there are reductions in transportation.

If schedule difficulties occur and there is a delay of several years in the startup of the first repository, a waste-management system with an integral MRS facility would continue to accept spent fuel, prepare it for disposal, and store it until the repository can accept it. For option 1--a repository-only waste-management system--a new facility, a backup MRS, could be required to fulfill the DOE's commitments to accept spent fuel.

As shown in Table 4-1, option 3--a waste-management system with a backup MRS facility--would realize little or none of the system operating, performance, and transportation advantages described above, but it would incur costs for an incremental facility that has the capability to receive and handle the great number of casks originating from reactors and the capability to consolidate and package spent fuel for storage. This facility would essentially duplicate the receiving, handling, and packaging capability of the repository since, once the system was fully operational, spent fuel would be shipped directly to the repository.

Therefore, if the startup of the first repository is delayed, a system with a backup MRS facility performs the required system functions less efficiently, since it provides fully redundant capability with the repository, and costs more than a waste-management system with an integral MRS facility that does not fully duplicate the surface facilities of the repository.

4.2 SYSTEM OPERATIONS AND EFFICIENCY

The integral MRS facility enhances overall system performance by adding flexibility in the functions necessary for disposal. This added flexibility, in comparison with a system without an MRS facility, results from the separation of waste acceptance, transportation, and packaging from the waste-emplacement function. Also, the MRS facility provides the capability for a storage function that can be used to serve a variety of system needs. The MRS facility also provides a central hub for transportation and simplifies it. By separating the pre-waste-emplacement functions from the repository, the integral MRS facility would provide an early focus for the DOE to develop and integrate these key functions. This focus will enable the total system to be operational on or before 1998, as mandated by the Act, and will ensure early productivity for the resources of the Nuclear Waste Fund. These advantages are discussed in more detail below.

4.2.1 Operating Flexibility--Waste Acceptance and Emplacement

By providing a buffer between waste acceptance from utilities and waste emplacement in a repository, the integral MRS facility allows the waste-acceptance function to operate independently of waste emplacement, thus adding flexibility to the system. The acceptance of spent fuel will not be tied directly to repository emplacement capabilities--acceptance will not be affected by temporary slowdowns or shutdowns in emplacement operations. Consequently, spent-fuel receipts can be scheduled to accommodate the contractual commitments to the utilities paying fees into the Nuclear Waste Fund. Commitments can be made to receive fuel on a firm schedule--one not subject to the uncertainties of operating a geologic repository, which is a first-of-a-kind project. This provides greater flexibility in the early years of system operation than can be achieved by relying solely on surge storage at the repository.

An integral MRS facility would also improve the disposal operations. By providing a buffer between waste acceptance and emplacement, the DOE will have greater control over the flow of material to be emplaced. The waste-emplacement configuration in a repository will depend on the heat output of the waste packages, among other factors. Variations in the heat output may require changes in the emplacement configuration or overly conservative emplacement strategies, which would increase mining requirements and costs. Since the heat output decreases with time, the buffer provided by the integral MRS facility would allow the DOE to optimize the heat output of the waste packages. By matching the heat output with the needs of the repository, the repository can be operated more efficiently.

The number of shipping casks received annually by the repository would be reduced from more than 1000 truck and rail casks of varying sizes to between 200 and 300 standard rail casks. As a result, operations at the surface facilities of the repository would be greatly simplified. The integral MRS facility would be dedicated to receiving and preparing the spent fuel for disposal. The spent fuel would be consolidated and loaded into uniform containers before shipment to the repository. Thus, the repository would be designed to handle spent-fuel containers with standardized physical characteristics.

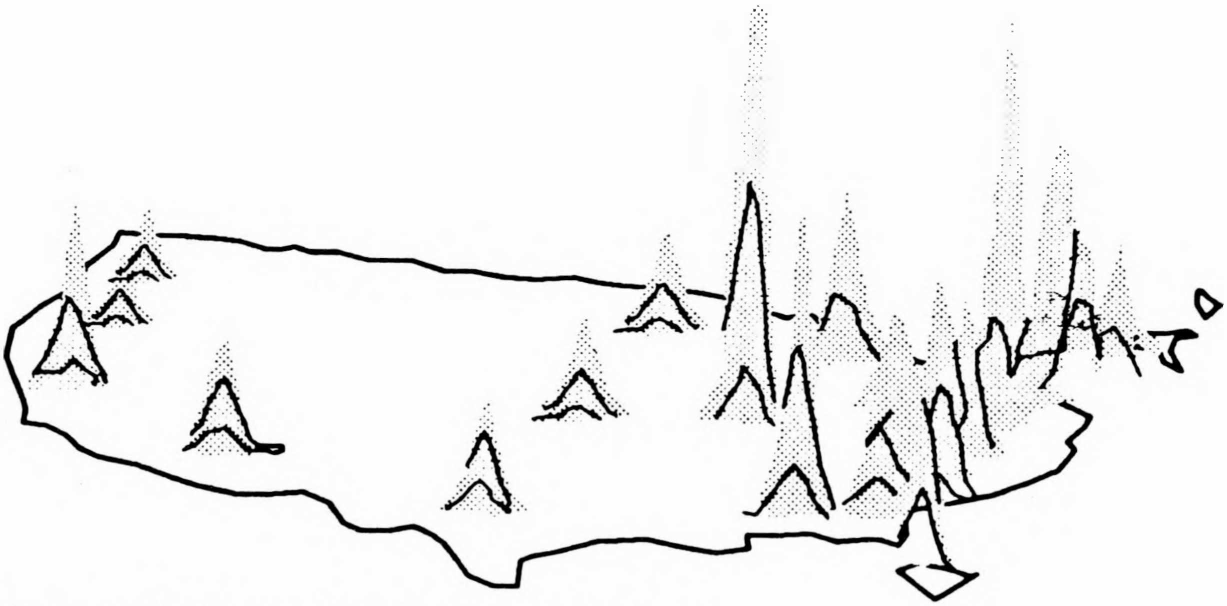
4.2.2 Transportation System

An integral MRS facility would provide a central staging area for managing cask-fleet operations, system logistics, and cask-fleet servicing. To enhance transportation operations, the integral MRS facility should be centrally located with respect to existing spent-fuel inventories. Figure 4-1 shows the distribution of the first 70,000 MTU of spent fuel that would be accepted by the Federal waste-management system. (Some of this fuel may eventually be emplaced in the second repository.) The peaks in Figure 4-1 indicate the relative quantities of spent fuel requiring shipment from each State. As shown in Figure 4-2, the shipments will originate mainly from the eastern one-third of the country, where most of the operating reactors are located. Since the three candidate locations for the first repository are in the west, an MRS facility in the east divides the transportation function into two segments: the transportation of spent fuel from reactors to the centrally located MRS facility, and a longer leg from the MRS facility to the repository.

The transportation segment that serves reactors is constrained by the cask-handling capabilities of the reactors. Some reactors can ship spent fuel only in truck casks, which have a lower capacity than rail casks. Reactors with capabilities for handling rail casks differ in the size of rail casks that can be used. These variations lead to a fleet of casks either constrained in size by the reactor with the most limited handling capability or a fleet made up of a variety of cask sizes. These constraints are present whether there is an MRS facility in the system or not. With a centrally located MRS facility, however, the dependence on this transportation segment is significantly reduced. The central location of the MRS facility shortens the trips required for these less-efficient truck and rail casks: average shipment distance would fall from 1400-2200 miles without an MRS facility (depending on the location of the repository) to 700-800 miles with an MRS facility. This reduction decreases the requirement for such casks and the number in use at any point in time.

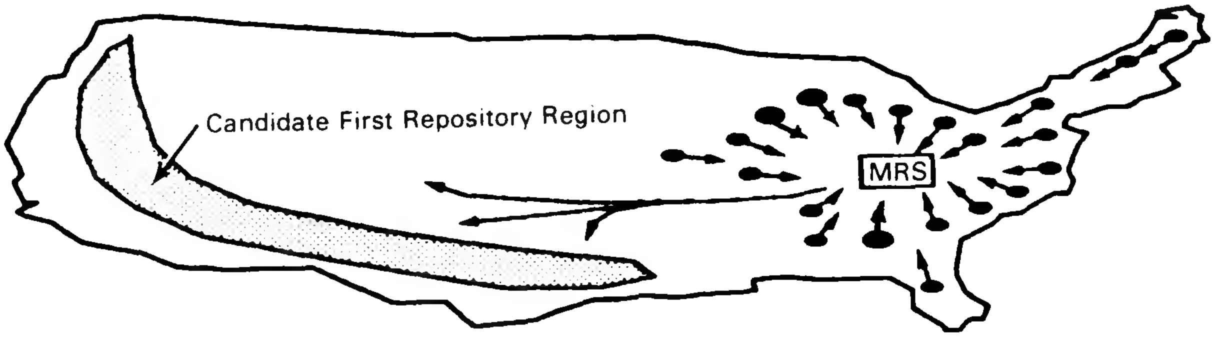
The transportation segment that connects the MRS facility with the repository would use casks specially designed for the fuel and package characteristics provided at the MRS facility. The MRS facility would prepare relatively uniform packages in terms of size, heat output, and radiation output. Consequently, cask designs would be optimized with regard to the waste packages

Figure 4-1
Distribution of the First 70,000 MT of Spent Fuel



Weighted Distribution of First 70,000 MT of Spent Fuel

Figure 4-2



Movement of Spent Fuel

that would be shipped while still complying with rigorous safety requirements. In addition, the use of dedicated trains for this transit leg would reduce potential layovers in switchyards and increase average travel speeds. The use of these optimized casks and dedicated trains to ship spent fuel to the repository would improve the efficiency of the transportation system. To provide the appropriate casks and services, the DOE is pursuing a program intended to foster private-sector participation.

The logistics of scheduling and accepting the spent fuel from the various reactors would be handled at the MRS facility. Moreover, shipments to the repository would be controlled and coordinated from the MRS facility. With a centrally located MRS facility, the number of shipments in progress at any one time would be reduced by 40 to 60 percent, in direct proportion to the reduction in the average shipment distance. As few as two or three cross-country shipments per month would be required from the MRS facility to the repository depending upon the number of casks carried by a train.

4.2.3 System Development, Deployment, and Integration

Without an integral MRS facility, the schedule for the pre-waste-emplacement functions (waste acceptance, transportation, and packaging) depends on the progress of repository siting and licensing activities. Performing these functions at a location other than at the repository breaks that schedule linkage and allows their development and deployment to proceed independently. In comparison with a geologic repository, which must be demonstrated to provide safe isolation for thousands of years, these functions are short-lived and have been routinely performed for the last 20 years. Their separation thus provides very high confidence that they can be provided and fully operational by 1998. This approach makes effective use of Waste Fund resources for these essential functions.

Developing these functions separately from the repository allows the repository development process to focus on demonstrating the safety of long-term isolation. This should enhance the potential for starting the repository on schedule.

The development of the transportation system could be significantly accelerated by including an MRS facility in the system. Without an MRS facility, the destination of the spent fuel will not be known for several years because the first repository site is not to be selected until 1991. By designating an MRS site as soon as possible, transportation requirements, including the necessary cask fleet and the routes from reactors to the MRS site, can be identified and the necessary steps taken to fully develop that part of the system. Moreover, since private industry will develop the transportation system, the designation of an MRS site will allow industry to proceed with cask and other technology development on a firm schedule. Early development of the transportation system will contribute to the cost effectiveness of the program and improve its overall progress.

4.3 SYSTEM IMPACTS

This section summarizes the primary impacts relevant to comparing the alternative system options--transportation impacts (public interactions), utility impacts (requirements for additional storage) and system costs. Safety and environmental impacts are also important in evaluating potential system options, but, preliminary analyses and comparisons indicate that there are no significant safety or environmental differences between the three options analyzed in this report. Each of the system options can be developed and operated safely.

4.3.1 Transportation Impacts

The primary link between the waste-management system and the public is the shipment of spent fuel. The transportation of radioactive materials continues to be of concern to many parties despite the regulations and enforcement procedures that are in place to protect the health and safety of the public.

An integral MRS facility would, on a national basis, decrease interactions between waste transportation and the general public. This decrease, as noted earlier, is expected to result from the central location of the MRS facility, which will shorten the transportation segment from reactors and allow the long cross-country shipments to the repository to be in large rail casks and dedicated trains. The number of shipments from reactors would be the same with or without an MRS facility, but the number of cross-country shipments to the repository would be significantly reduced. Figure 4-3 illustrates the change in the pattern of shipments.

The centrally located MRS facility would become the hub for spent-fuel transportation. As a result, the MRS host State and some adjacent States would see more shipments than they would if all reactors shipped directly to the repository. Other States, however, would see fewer shipments. There would be fewer corridor States to the repository because there would be at most a few distinct routes between the MRS site and the repository. In addition, the number of shipments that would pass through those corridor States would be significantly reduced (see Figure 4-3). While the number of shipments in the vicinity of the MRS site would be greater, this increase would be mitigated to some extent because shipments would arrive from several directions. Shipments would not be as concentrated along a single incoming route as they would with direct shipments from reactors to the repository.

An integral MRS facility would significantly reduce the total miles traveled by spent fuel casks. Figure 4-4 shows this effect for each of three candidate repository locations. Total cask-miles* are reduced 20 to 40 percent, depending on the location of the repository. This benefit is achieved

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*Cask-miles are a conservative measure of the benefits of an integral MRS facility because relatively greater reductions in shipment-miles could be attained with dedicated-train shipments from the MRS facility. Both cask-miles and shipment-miles are defined in Section 3.4.2.

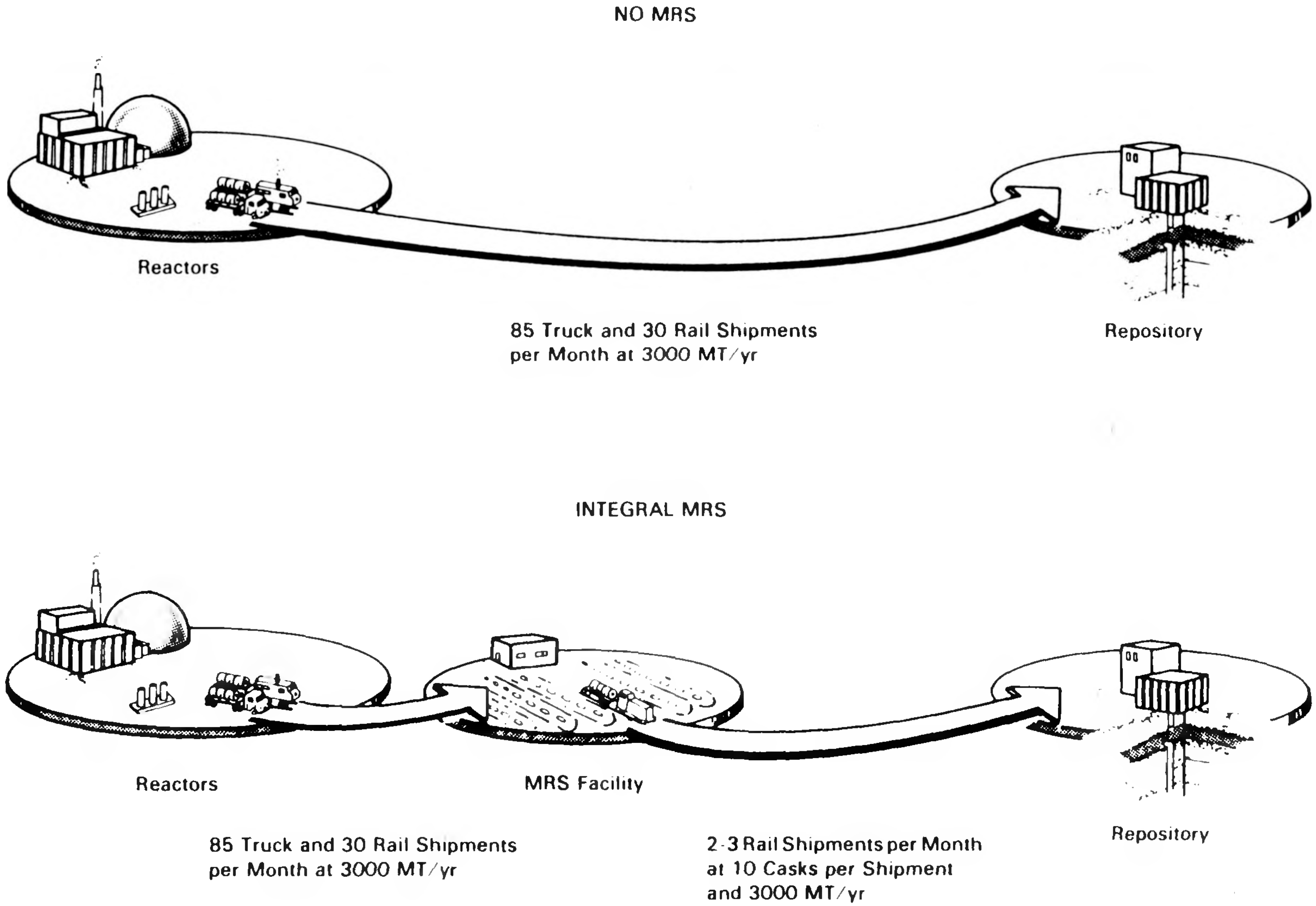
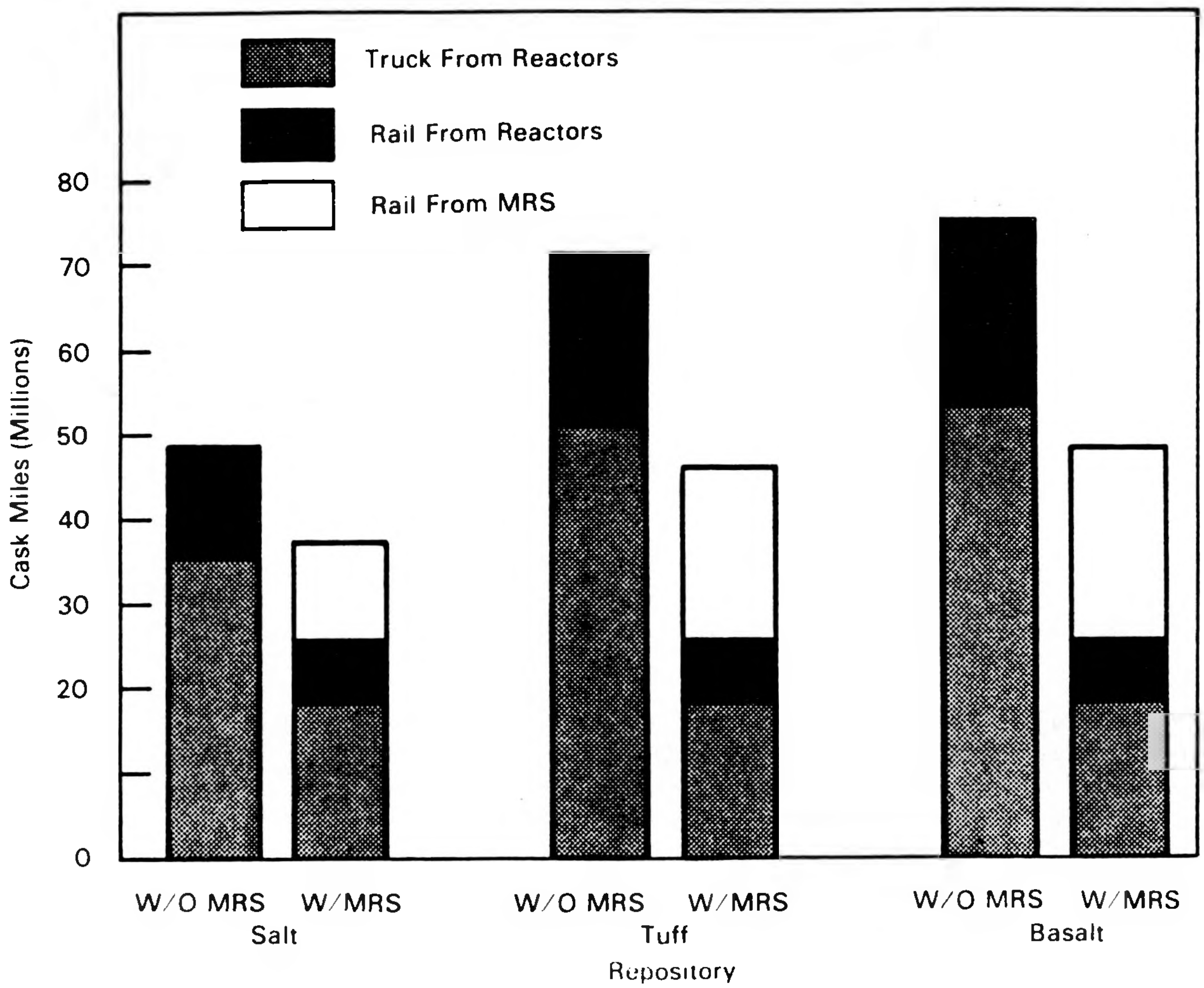


Figure 4-3
Typical Monthly Shipment Rates

Figure 4-4
Cask-Miles with and without an MRS Facility



by consolidating fuel elements and by using larger rail casks exclusively for the long trip to the repository. Truck cask-miles would be significantly reduced in all cases.

As noted earlier, the number of shipments in progress at any one time would be reduced by 40 to 60 percent, depending on the location of the repository. This reduction would facilitate the coordination of waste shipments, including the scheduling of receipt from specific reactors, the legally required notification of States and the provision of emergency-response capabilities.

4.3.2 Utility Storage Impacts

A primary purpose of providing storage capacity at an integral MRS facility is to facilitate the timely demonstration and performance of the pre-waste-emplacement functions of the waste-management system. However, an additional benefit of this storage capacity is the potential for reducing requirements for additional storage capacity at the reactors.

Future spent-fuel storage requirements at individual reactors will depend on their rate of spent-fuel generation, (which, among other factors, will be affected by the degree to which extended burnup levels are achieved), the capacity of their spent-fuel pools, whether they can rerack their pools to store more fuel assemblies, and whether the utility can or will "transship" fuel to pools of other reactors it owns. All of these factors have uncertainty associated with them. Appropriate assumptions can be made for the purpose of projecting requirements for additional storage capacity for alternative configurations of the waste management system. The resulting projections, however, should be viewed as indications of the effect of system changes on at-reactor storage requirements rather than as firm estimates of the actual magnitude of future at-reactor storage requirements.

Table 4-2 summarizes the results of projections of requirements for additional at-reactor storage capacity for waste-management systems with a repository only and with a repository and an integral MRS facility. These projections are based on reactor-by-reactor comparisons of projected spent-fuel generation, pool inventory, and pool capacity. The reactor spent-fuel discharge projections* are based on the EIA "middle case" forecast,** which is the DOE's planning base for the waste-management system. Reactor-pool capacities and inventories are based on data collected by the DOE from each utility.***

*C. M. Heeb, G. M. Holter, and R. A. Libby, Reactor-Specific Spent Fuel Discharge Projections: 1984 to 2020, PNL-5396, Pacific Northwest Laboratory, Richland, Wash., 1985.

**M. Gielecki et al., Commercial Nuclear Power 1984: Prospects for the United States and the World, DOE/EIA-0438, U.S. Department of Energy, Washington, D.C., 1984.

***U.S. Department of Energy, Spent Fuel Storage Requirements: An Update of DOE/RL-83-1. DOE/RL-84-1, U.S. Department of Energy, Richland, Wash., 1984.

Table 4-2

Effect of an Integral MRS Facility on the Requirements for Additional At-Reactor Storage Capacity

	Repository Only		Integral MRS	
	Number of Reactors	Storage Requirement[a]	Number of Reactors	Storage Requirement[a]
No transshipment	54	7300	33	3300
Transshipment	55	6700	31	2700

[a]Storage requirements are in metric tons of uranium. They are based on the waste acceptance schedule shown in Table 3-1.

Future projections will take into account trends toward increased burnup which could significantly affect storage requirements. The projections in the table assume that sufficient storage capacity for a full reactor core is maintained in each pool to allow a complete discharge of the core if required. Reactor-pool capacity is assumed to be that which is achievable by reracking to the maximum extent possible. Therefore, the term "additional storage capacity" refers to the amount of fuel that would require either consolidation for continued storage in the reactor pool, or storage in dry storage casks in order for the utility to maintain a full-core capacity in its reactor pool.

The table shows both the number of reactors requiring additional storage capacity and the total amount of additional capacity for the alternative configurations of the waste-management system. These results are shown for both transshipment and no transshipment between the reactors owned by a utility. For the transshipment case, fuel is assumed to be shipped to another reactor of the same type (pressurized water reactor or boiling-water reactor) when possible rather than adding additional storage capacity. For purposes of making these projections, it is assumed that fuel requiring additional at-reactor storage capacity to maintain full-core capacity would be accepted into the Federal system. This priority could be set through negotiations among utilities. If spent-fuel acceptance is allocated in some other manner, the effect of an integral MRS facility on the requirements for additional at-reactor storage would vary.

The table shows that, with only a repository, 54 reactors would require additional at-reactor storage capacity, and 7300 MTU of additional capacity would be required in the initial years of system operation if utilities do not transship fuel. By contrast, with an integral MRS facility, only 33 reactors require additional capacity, and only 3300 MTU of storage capacity would be required. An integral MRS facility would relieve 21 reactors from adding storage capacity in the initial years of system operation and would decrease the total requirement for additional at-reactor storage capacity by 4000 MTU.

The number of reactors requiring additional storage capacity and the total requirement for additional capacity are decreased if the utilities transship. An integral MRS facility can relieve about 24 reactors from adding storage capacity and decrease the total requirement for capacity by 4000 MTU. Thus, the net effect of an integral MRS facility on at-reactor storage capacity is about the same with or without transshipment. In addition, once an MRS facility is operating, the need for transshipments could be eliminated because shipments could be made directly to the MRS facility.

4.3.3 System Cost Impacts

The authorized Federal waste-management system includes the first and the second repository (yet to be authorized) and the transportation system for moving spent fuel from the reactors to the repositories. The DOE's assessment of the adequacy of the fee for the Nuclear Waste Fund estimated that the life-cycle costs for developing, deploying, and operating this system would be between $24 and $30 billion.* In addition to the Federal portions of the system, which the Fund covers, the total waste-management system also includes the storage of fuel at reactors. The DOE has an obligation to execute and manage technically sound, cost-effective programs within the revenue constraints of the Waste Fund and to consider the impact of its programs on utility ratepayers. Consequently, the following discussion of the cost impacts of deploying an integral MRS facility considers the costs for both the Federal and the utility portions of the system.

Deploying an integral MRS facility would add an additional site to the Federal waste-management system for waste preparation and packaging; change the functional requirements for the surface facilities at the first repository; reduce system transportation requirements; and reduce at-reactor storage requirements. The cost impacts of these changes in the waste-management system are discussed below.

Facility and Operating Cost Impacts

The addition of an integral MRS facility to the Federal waste-management system would effectively transfer the facility for receiving, handling, and packaging spent fuel received from utilities to a site separate from the first repository. The first repository would require only a simplified surface facility for receiving a reduced number of large rail casks containing uncontaminated, disposal-ready packages from the MRS facility. These modifications in the waste-management system would change requirements for waste-handling facilities, change site support requirements at the first repository, and introduce a new site requiring site-support capabilities. In addition, the capability to add incremental storage capacity is added to the system at the MRS site.

More-detailed cost estimates of the integral MRS facility and the simplified repository surface facility are being prepared. These estimates will be available to support the MRS facility proposal to Congress. Very preliminary estimates based on comparisons of repository and MRS facility conceptual designs were used for illustrating potential system cost impacts. The estimates discussed should not be considered definitive, but rather as representative of the approximate magnitude of the key cost effects. To reflect the preliminary nature of these estimates, a cost range rather than a single cost estimate is described.

Four significant changes in waste-management facilities would result from an integral MRS facility. These changes are as follows:

1. The primary pre-waste-emplacement packaging functions are performed at the MRS site. The transfer of these packaging functions, and appropriate facilities and operations, to the MRS site would involve no incremental cost to the system; the direct cost of these is generally independent of where they are performed.

*U.S. Department of Energy, Nuclear Waste Fund Fee Adequacy: An Assessment, DOE/RW-0020, Washington, D.C., 1985.

2. Some currently envisioned receiving and handling facilities are no longer required by the system. Current repository plans include a facility to receive and package a limited amount of unconsolidated fuel from utilities for the first few years of repository operation while the main surface facilities are completed. This facility would not be required with an integral MRS facility.

3. A "new" reduced-scale receiving and handling facility is required at the repository for unloading rail casks containing packaged fuel from the MRS facility. Rather than receiving spent fuel directly from utilities, the repository would receive from the MRS facility rail casks that contain consolidated, packaged fuel. This would require a smaller, simpler repository surface facility than those currently envisioned.

4. Provision must be made for storage capability at the MRS site. In addition to the waste acceptance, handling, and packaging functions transferred from the repository site, the integral MRS facility would have the capability to provide storage. Incremental costs to the waste-management system would be incurred for site preparation and the facilities needed to provide this capability.

Preliminary estimates show that the cost impact of MRS and repository facility changes is an increase of approximately $300 million. This result incorporates the cost implication of each of the four changes listed above. On balance, this net cost increase results from the addition to the system of receiving and handling capability and storage capability.

The reduction in surface-facility operations at the first repository with the transfer of the primary pre-waste-emplacement packaging operations to the site of an integral MRS facility would cause a corresponding reduction in repository requirements for support services and utilities. The transfer of the waste acceptance, consolidation, and packaging functions to the integral MRS facility would create site support and utility requirements for the new site. Preliminary estimates show that the costs of providing these support functions at the integral MRS site would exceed the corresponding costs avoided at the repository by approximately $300 million. This increase is due to the redundant facilities and services that are required to support two sites rather than one.

The cost impacts described above indicate that a net overall waste system cost of approximately $600 million would be incurred for changes in waste-handling facilities and operations, system storage capability, and site support and utilities if an integral MRS facility is added to the waste-management system. Since this estimate is based on very preliminary design data for both the repository and an MRS facility, a range of costs from $500 to $700 million is probably a more appropriate representation of the cost for deploying an integral MRS facility than a single point estimate. To put this range in perspective, the total life cycle system cost for the currently envisioned Federal waste-management system is $24 to $30 billion; hence the cost of adding an integral MRS facility would potentially increase facility costs for the Federal portion of the waste-management system by approximately 2 percent. This increase could be offset by the cost changes for spent-fuel transportation and storage discussed below.

Changes in Transportation Costs

The impact of an integral MRS facility on transportation costs will depend on several important factors, such as the location of the first repository and the design of the cask for transporting packaged fuel from the integral MRS facility to the repository. As previously discussed, the number of cask-miles for the waste-management system decreases with an integral MRS facility, but the fuel is moved in two segments (reactor to MRS facility and MRS facility to repository), rather than one segment (reactor to repository). These two considerations trade off in terms of cost. Preliminary analyses indicate that an integral MRS facility will reduce system transportation costs if the casks used for shipping fuel from the MRS facility to repository can carry 2 to 2.5 times as much packaged, consolidated fuel as rail casks shipping unconsolidated fuel from the reactors to the MRS facility. This payload increase appears to be technically feasible.

Changes in At-Reactor Storage Costs

The other key cost impact of an integral MRS facility is the reduction in requirements for additional at-reactor storage capacity. As already noted, an integral MRS facility can reduce, by as much as 4000 MTU, requirements for storage capacity beyond what can be achieved by fully reracking existing pools. Such additional capacity would likely require utilities to either consolidate spent fuel for more compact storage in the pools or store spent fuel in dry storage casks.

Estimates of the total incremental cost for these alternatives range from $50 to $125 per kilogram of storage capacity. The lower costs are achieved with fuel consolidation and higher costs are associated with cask storage.* Unit cost estimates (in dollars per kilogram) for consolidating spent fuel are typically lower than this, but to increase pool capacity a given amount, slightly more than twice as much fuel must be consolidated to make the required space (e.g., if storage space is needed for 10 MTU of spent fuel approximately 20 MTU of fuel must be consolidated to open up sufficient space in the pool). Therefore, the cost of required storage capacity is about double the actual cost of consolidation. However, not all utilities may be able to use this option. Cost estimates for dry storage casks are on the order of $60 per kilogram. Other costs, such as the costs for the cask storage area and for loading and unloading the storage cask, account for the rest of the cost range.

On the basis of this cost range, a 4000-MTU reduction in the requirements for additional at-reactor storage would decrease at-reactor storage costs by $200 to $500 million. The corresponding incremental cost for storing this fuel at the integral MRS facility is estimated to be about $20 per kilogram, so storing 4000 MT would cost approximately $80 million. The use of the storage capability at the integral MRS facility could reduce storage costs to utility ratepayers by $120 to $420 million. If these savings can be realized, they can partially offset the costs previously discussed for deploying the integral MRS facility.

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*E. T. Merril and J. F. Fletcher, Economics of At-Reactor Spent Fuel Storage Alternatives, PNL-4517, Pacific Northwest Laboratory, Richland, Wash., 1983.

Similarly, the effects of extended burnup could decrease at reactor storage requirements. This would reduce the at reactor storage cost savings postulated above that would otherwise offset some of the MRS costs. This effect will be considered in future analysis.

4.4 SYSTEM CONTINGENCY

Each of the three system options provides some contingency to protect the system in the event of a significant repository delay. This section compares the relative merits of these options when there is a delay in repository startup. Both MRS options, the integral and the backup, are compared with option 1, in which contingency storage is provided at the reactor sites. The DOE's assessment of the adequacy of the fee for the Nuclear Waste Fund estimated that the total-system life-cycle costs for a 5-year delay in the program would be between $27 and $33 billion.

Without an MRS facility, repository delays would significantly add to utilities' storage requirements. Figure 4-5 shows the cumulative out-of-pool storage requirements--assuming the maximum reracking of pools, maintenance of a full-core reserve, and no in-pool consolidation of fuel. These requirements are shown for repository-delay assumptions of 0, 5, and 10 years. As noted earlier, an on-time repository would necessitate over 7300 MTU of at-reactor storage. A 5-year delay would cause out-of-pool storage to reach a maximum of about 16,100 MTU and a 10-year delay would increase storage requirements to over 24,600 MTU. For each year of repository delay, there is between 1500 and 1900 MTU of additional storage required beyond what can be handled in the reactor storage pools.

Figure 4-6 shows the number of reactors that exceed their in-pool storage capabilities for the same sets of repository-delay assumptions. Fifty-four reactors would require out-of-pool storage with no delay; 72 reactors with a 5-year delay; and 89 reactors with a 10-year delay.

If these additional storage requirements are met with an integral MRS facility, significant cost savings can result. Figure 4-7 illustrates this relationship. The figure shows the unit cost of storage at an integral MRS facility as a function of the amount of fuel stored. The costs shown on the figure allocate *all* of the additional costs of the Federal waste management system (noted earlier in Section 4.3.3) for deploying the integral MRS facility to the storage function. This implicitly assigns no monetary value to the advantages of the integral MRS facility for improving system performance and efficiency and decreasing transportation impacts. Any "value" assigned to those improvements would decrease the storage costs shown.

Also shown on the figure is a range of $50 to $125 per kilogram for incremental at-reactor storage, based on representative costs for in-pool consolidation and cask storage technology at the reactor site. The actual costs would vary from utility to utility. Since few utilities would consolidate to the fullest extent, a cost of $75 per kilogram is also shown for at-reactor storage. For the $75 to $125/kg range, the cost for integral MRS facility storage and at-reactor storage overlap between approximately 4,000

Figure 4-5

Cumulative Post Basin Storage Requirements
EIA Mid-Case Growth Scenario

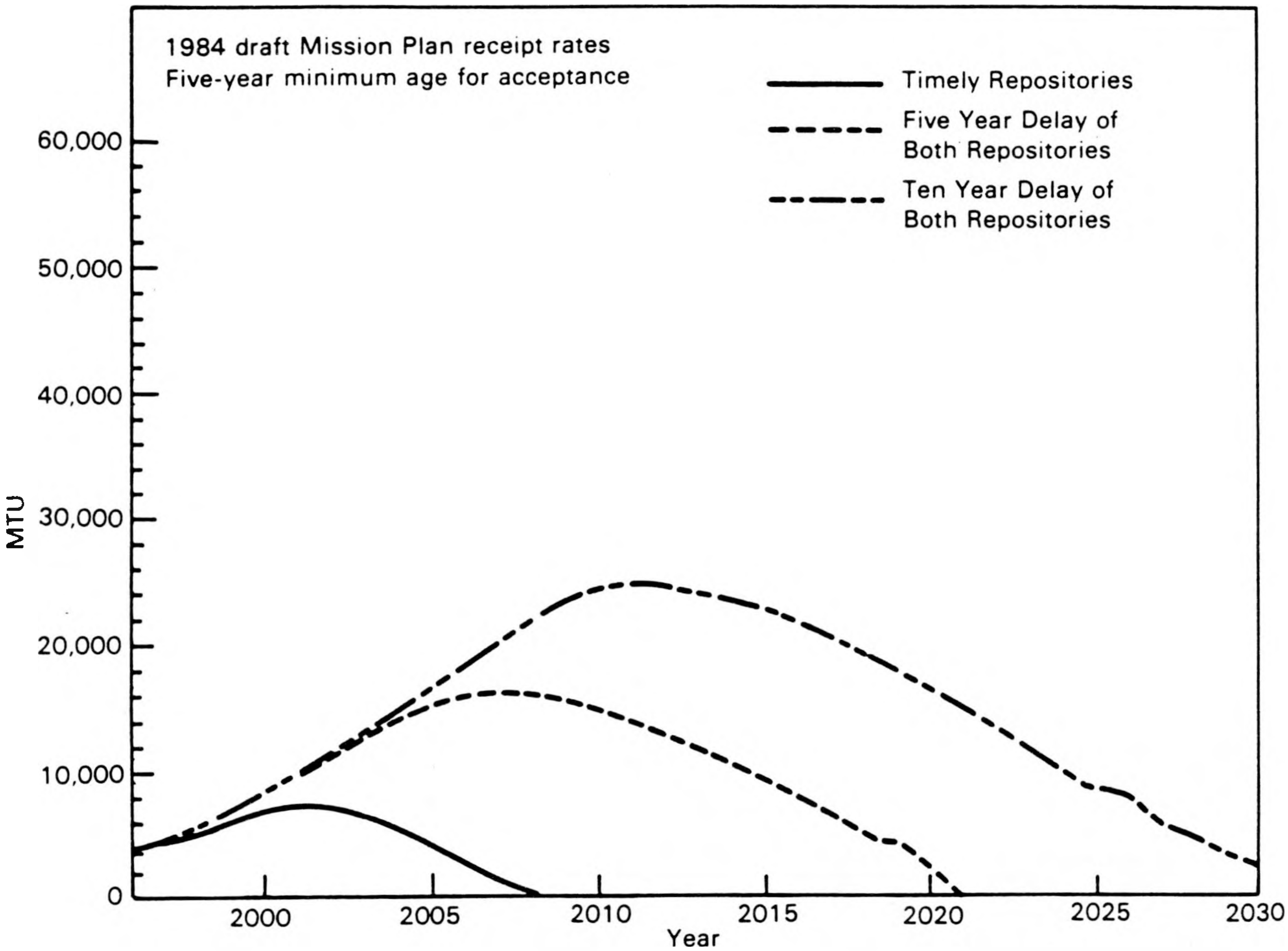


Figure 4-6

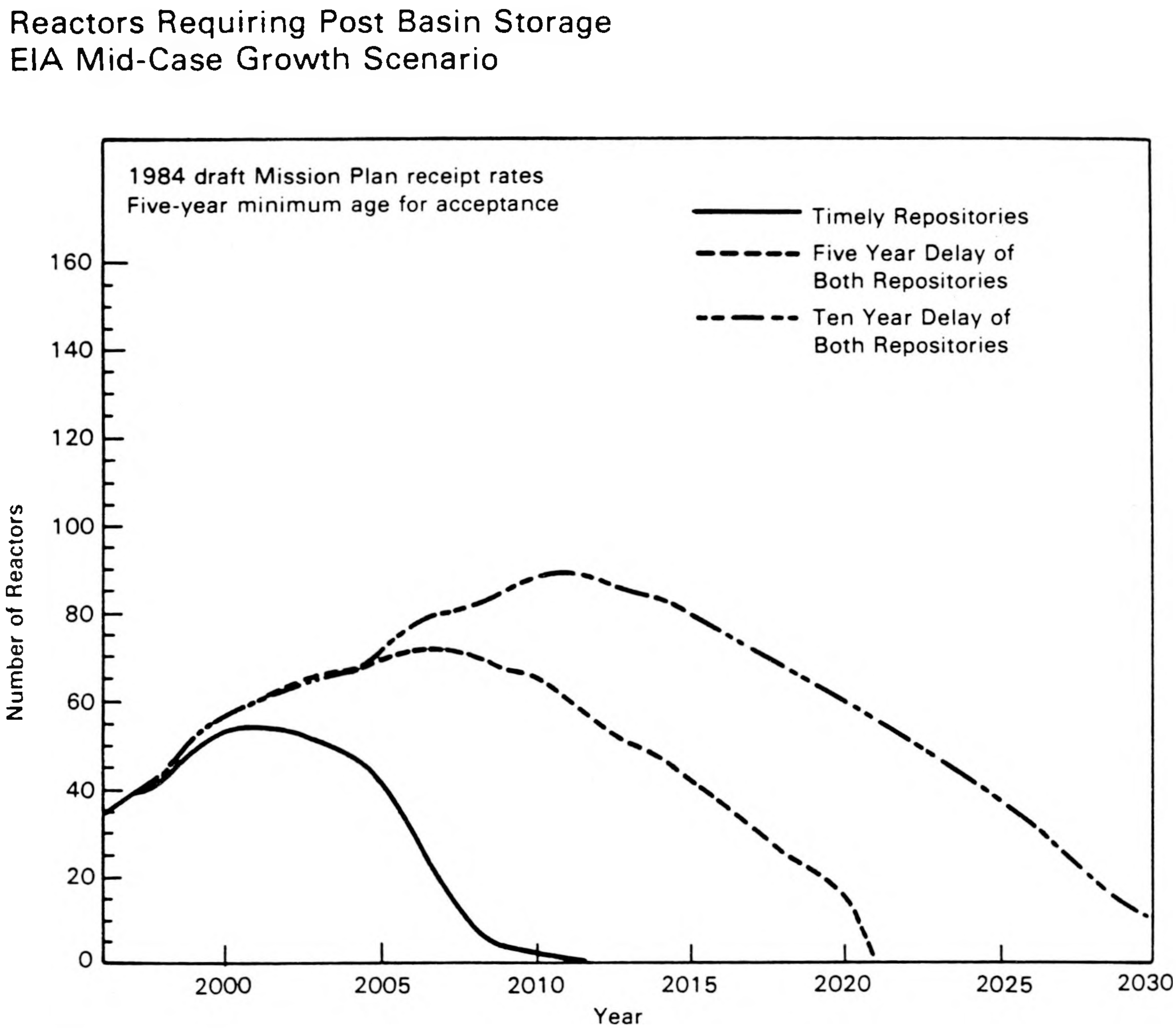
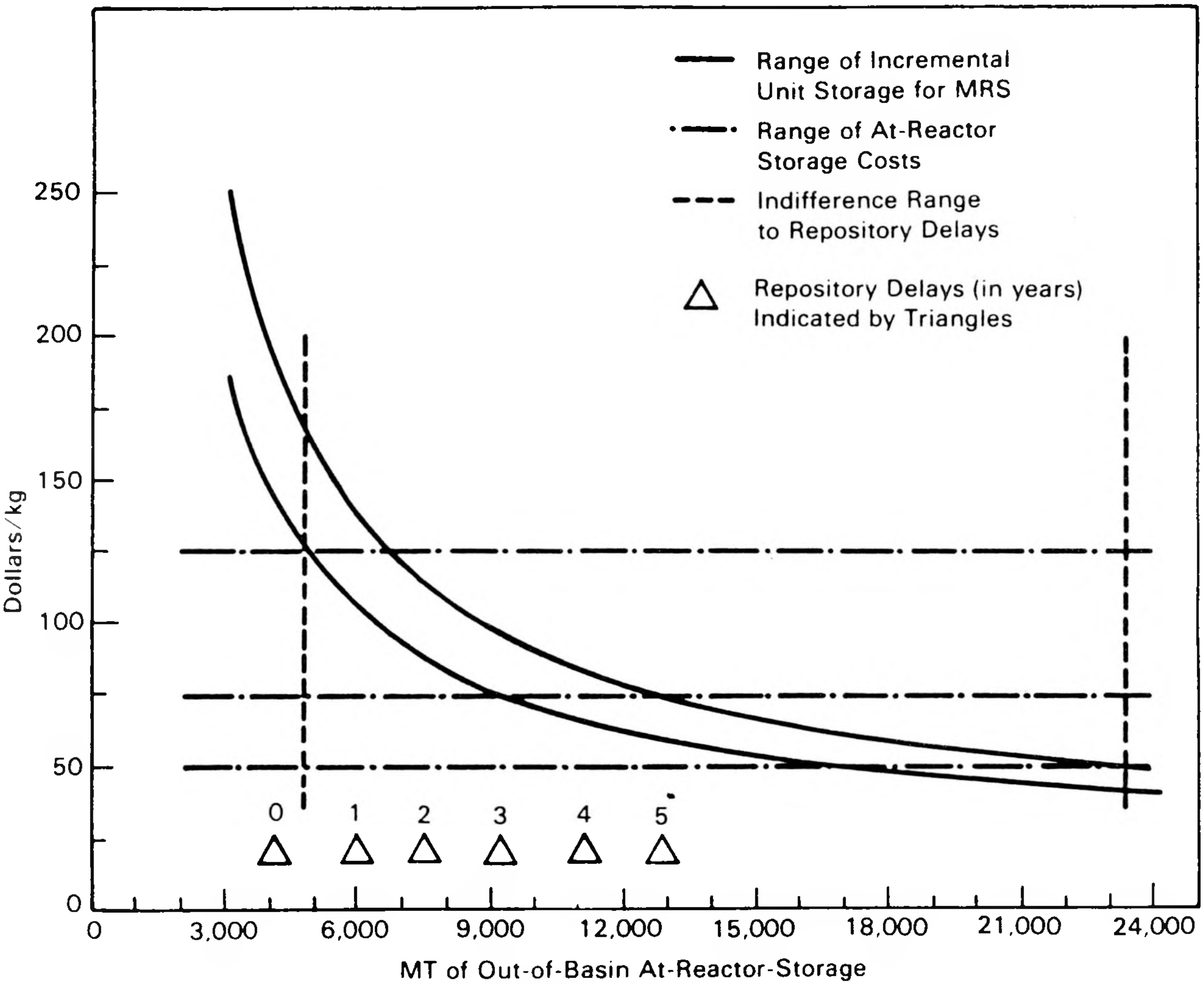

Reactors Requiring Post Basin Storage
EIA Mid-Case Growth Scenario
1984 draft Mission Plan receipt rates
Five-year minimum age for acceptance
Timely Repositories
Five Year Delay of Both Repositories
Ten Year Delay of Both Repositories
Number of Reactors
160
140
120
100
80
60
40
20
0
2000
2005
2010
2015
2020
2025
2030
Year

Figure 4-7

Comparison of At-Reactor Storage and Integral MRS Storage Costs for Repository Delay

EIA Mid-Growth Scenario



and 13,000 MTU. Since 4,000 MTU of additional at-reactor storage is required for a 1998 repository startup and an additional 1500 to 1900 MTU is required for each year of repository delay, the unit cost overlap can occur with repository delay of 0 to 5 years.

These calculations indicate that there may be a slight system cost penalty for deploying an integral MRS facility if the repository is on time or is delayed a few years, ignoring the other system benefits provided by the integral MRS facility. The potential cost penalty can be viewed as "insurance" that pays off if there is a slight repository delay. The "premium," the slight cost penalty if the repository is on time, buys the system advantages discussed in the preceding sections.

The backup MRS facility could also provide this contingency storage, but it would do so less cost effectively than would an integral MRS facility. The backup MRS facility is redundant with the repository in terms of its capability to receive truck and rail casks from reactors and to consolidate the fuel before storage or disposal. Therefore, the total MRS and repository facility costs would exceed those for the integral MRS facility, and, as discussed earlier, the improvements in system performance and transportation interface with the public would not be attained.

Appendix A

DESCRIPTION OF AN INTEGRAL MRS FACILITY

The integral monitored retrievable storage (MRS) facility serves as a centralized receiving and packaging facility for spent fuel and limited quantities of other wastes associated with the commercial nuclear fuel cycle and also provides incrementally expandable storage capacity for those materials, if needed. Spent fuel from the nation's commercial nuclear power plants is shipped to the centrally located MRS facility, is prepared for final disposal, and is either shipped by train to the geologic repository or, if necessary, is temporarily stored at the MRS facility. The facility has two main components--the receiving and handling (R&H) building and the storage area. In the R&H building, the materials are prepared and packaged so that they can be safely shipped to the repository or stored and retrieved for future shipment. The storage system (1) provides adequate shielding and containment of the radioactive materials; (2) allows monitoring to ensure that isolation is maintained during storage; and (3) allows easy retrieval of the stored materials for further processing or disposal. An artist's conception of an MRS site is shown in Figure A-1.

A.1 WASTE CHARACTERISTICS

The MRS facility is designed principally to receive spent reactor fuel, with the possibility of receiving small quantities of solidified high-level waste (HLW) for temporary storage. These materials are described briefly below.

Spent Reactor Fuel

Almost all of the material handled at an MRS facility will be spent fuel from commercial nuclear power reactors. This material consists of assemblies of sealed metal tubes containing the uranium oxide pellets that previously powered the reactors. While most of the fuel tubes will have retained their integrity throughout their service life, some will have suffered damage during service and will require special handling. Some 13 different assembly designs, fabricated by six different manufacturers, will be handled in the facility.

High-Level Waste

Limited quantities of high-level waste (approximately 300 canisters) are expected to be generated during the cleanup of the West Valley Fuel Reprocessing Plant in New York State. These wastes, generated several years ago during the reprocessing of commercial reactor fuel, will be solidified in a glass matrix material and sealed in stainless steel canisters before shipment from the West Valley site. Shipment will be made to the repository if the repository is ready to receive them or the canisters may be shipped to the MRS facility for additional packaging or temporary storage.

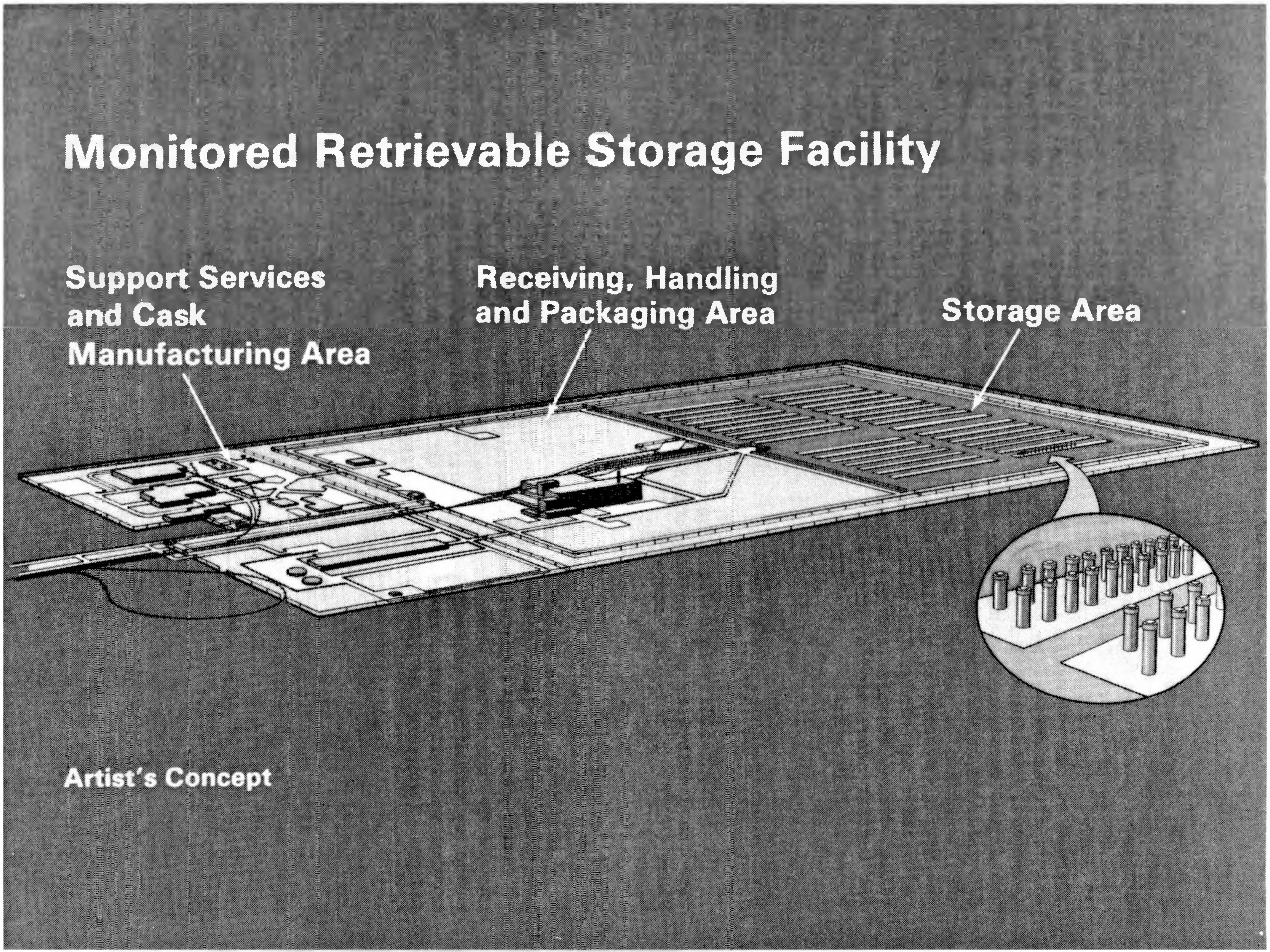

Monitored Retrievable Storage Facility
Support Services and Cask Manufacturing Area
Receiving, Handling and Packaging Area
Storage Area
Artist's Concept

Figure A-1

A.2 RECEIVING AND HANDLING BUILDING

The R&H building is the main operating area at the MRS facility. Spent fuel (and limited quantities of other wastes) arrive by either truck or rail in heavily shielded transportation casks. These materials are unloaded into the R&H building, are prepared and packaged for shipment to a repository for disposal, or for transfer to the storage area for temporary storage. A cutaway view of the R&H building is shown in Figure A-2, illustrating the various activities carried out therein.

The packaging operations in the R&H building are performed remotely inside "hot cells" to protect the workers from direct contact with the highly radioactive materials. Hot cells are compartments enclosed with thick concrete walls and with highly efficient filter systems that collect and capture any airborne radioactive particles that may be released during disassembly, consolidation, and packaging. The R&H building is designed to confine the radioactive materials within the facility, keeping radiation exposure to the public and to the facility workers well below applicable federal safety limits. The packaged material is either shipped directly to a repository or is stored temporarily at the MRS site until shipment is possible.

Consolidation

The principal operation within the R&H building is the disassembly of spent-fuel assemblies and the consolidation of the fuel tubes into tightly packed bundles. In consolidation, the upper and lower fuel-assembly tie plates are removed, the assembly spacer grids and any other assembly structural members are removed, and the fuel tubes are collected and formed into a closely packed bundle for insertion into a canister. The nonfuel structural members of the fuel assemblies will be reduced in volume and placed in containers for shipment and disposal in the repository.

A small portion of the fuel assemblies will contain fuel tubes with cladding defects that could complicate and potentially lead to further cladding damage during the consolidation operation. These defective assemblies are placed directly into canisters in the as-received condition.

Packaging

Packaging in the R&H building consists of inserting the spent fuel into the canisters, evacuating and backfilling the canisters with an inert atmosphere (probably argon with a helium tracer), welding the canisters closed, leak testing and examining the weld quality, and decontaminating the exterior surface of the canister as necessary. At this point, the canisters are ready to be either shipped to the repository for disposal or stored temporarily at the MRS facility. Canisters could be overpacked at the MRS prior to shipment or at the repository if determined to be preferable. Canisters are expected to range from 12 to 30 inches in outside diameter, and from 12 to 16 feet in height.

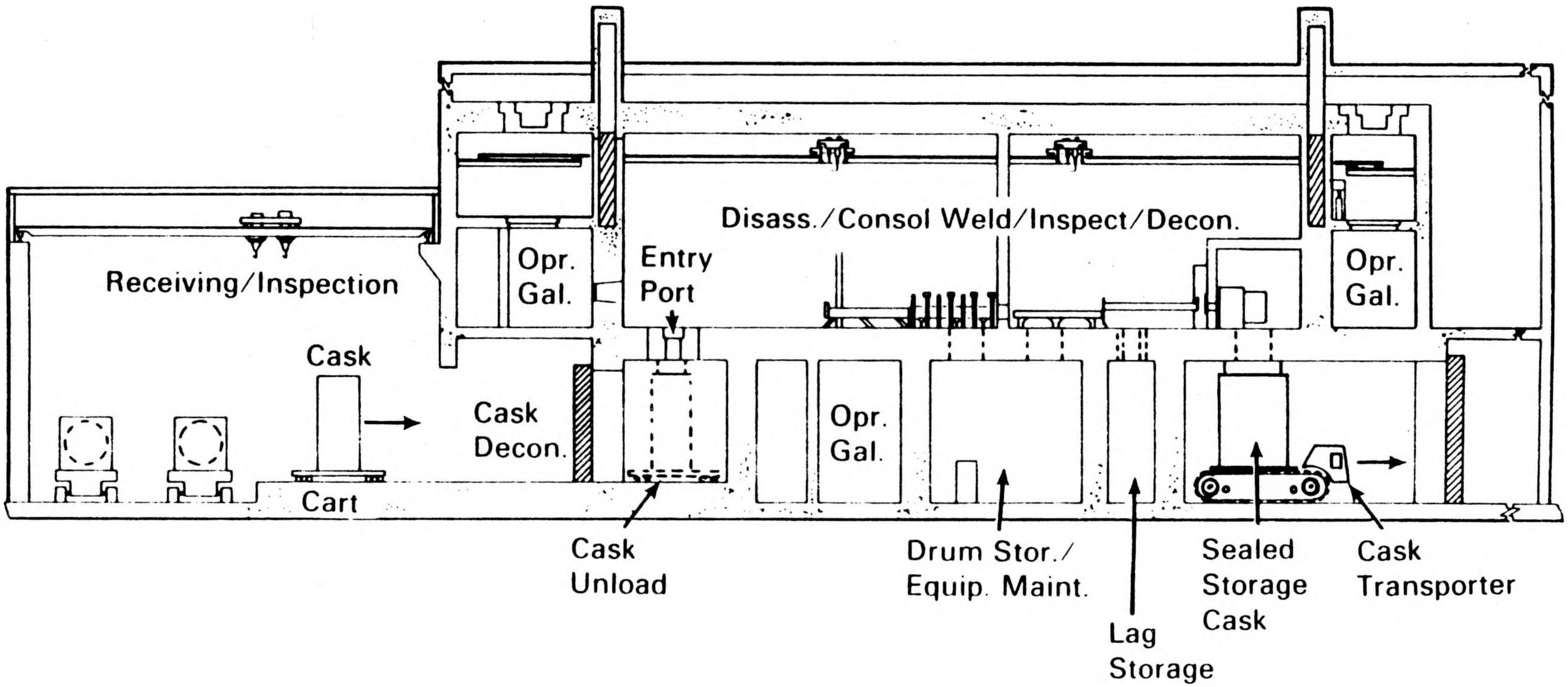


Figure A-2
Receiving and Handling Building

A.3 STORAGE

In 1983 the Department performed a thorough evaluation of eight alternative storage technologies to identify the two that would be most suitable for further design as part of the MRS proposal. The evaluations indicated that all eight of these concepts could satisfactorily serve in an MRS facility.

In January 1984, the DOE selected sealed storage casks as the preferred method for storage at an MRS facility. Field drywells were selected as the alternative concept. Both concepts have been used safely in similar applications for a number of years, and offer relatively low costs and simple, flexible design. In addition, both concepts can be expanded in small increments, to provide storage capacity only as it is required. The MRS facility is also designed to accommodate large metal casks that may be used by some nuclear utilities for at-reactor dry storage of spent fuel.

This selection has been subjected to a re-evaluation, particularly in light of the change in the MRS role from a backup facility to an integral component of the waste system. The integral MRS design incorporates an operational storage capacity in the receiving and handling building to facilitate the flow of materials to the repository. The results of the re-evaluation supported the initial selection of the sealed storage cask and field drywell as the technically suitable storage concepts for the development of the MRS proposal. These storage units could be enclosed or modified to address local environmental conditions or other concerns.

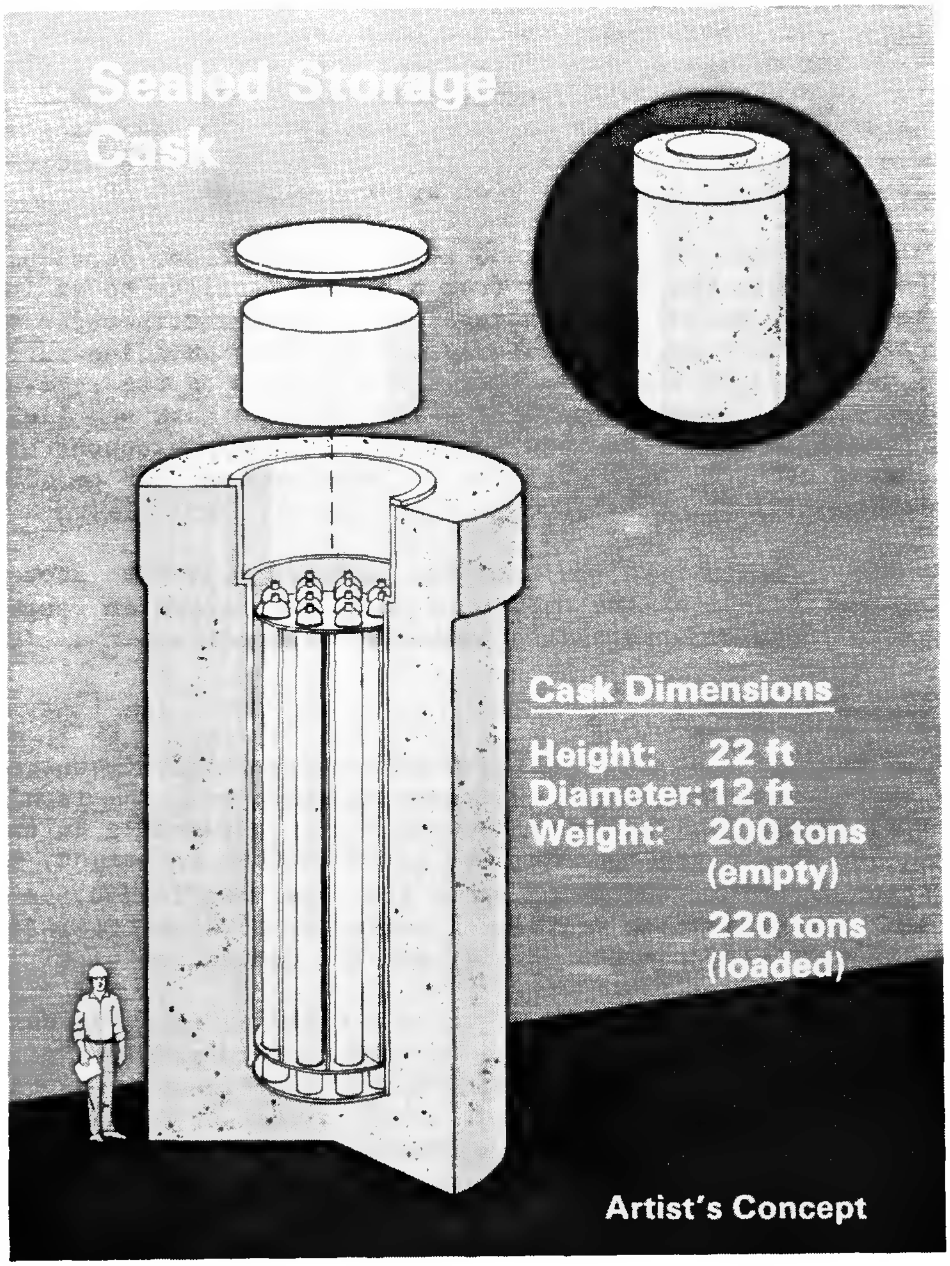
If the MRS is authorized the specific technology used to store the prepared packaged materials at the MRS, site could be changed in response to evolving systems requirements and technology developments.

Sealed Storage Cask

A sealed storage cask is a large steel-lined reinforced-concrete cylinder that holds welded stainless-steel canisters of spent fuel and is closed with a thick concrete shield plug and a welded steel lid. Depending on the type of waste being stored, the casks range from 17 to 22 feet in height, measure 12 feet in outside diameter, and weigh up to 220 tons when loaded. A cutaway view of a sealed storage cask containing canisters of spent fuel is shown in Figure A-3, illustrating the top shield plug and the welded steel lid.

Canisters or other containers of waste are loaded into the casks inside the R&H building, and the cask is moved to the storage area and placed upright on a concrete pad. The heat resulting from radioactive decay in the stored materials is conducted through the cask walls to the surrounding atmosphere, temperatures within the cask will be maintained below levels that could result in damage to either the cask or the stored sealed canisters. The thick cask walls also keep the radiation levels at the cask surfaces within safe limits. Each storage module is capable of being routinely monitored to detect any loss of canister integrity. In addition, the environment of the storage area is continuously monitored to detect any failures in storage unit confinement.

Figure A-3



Sealed Storage Cask
Cask Dimensions
Height: 22 ft
Diameter: 12 ft
Weight: 200 tons (empty)
220 tons (loaded)
Artist's Concept

Field Drywell

The field drywell is an in-ground sealed metal enclosure for storing canisters of waste. The drywells can be bored to different sizes as required to accept different sizes of canisters. The drywell enclosures extend no more than 21 feet into the ground. The essential features of the field drywell concept are illustrated in Figure A-4.

Waste canisters are loaded into a shielded transporter vehicle while inside the R&H building. The transporter carries the canister to the drywell and places the canister and the drywell top shield plug into the drywell. The drywell final closure plate is then welded onto the cavity liner. The drywell's metal cavity and the surrounding soil provide both a radiation shield and a medium to conduct the heat from radioactive decay away from the stored materials. Drywell storage of radioactive materials has been carried on safely in many parts of the world for the last twenty years.

As with the sealed storage cask, each drywell can be routinely monitored to detect any leakage from the stored containers so that a leaking container can be returned to the R&H building for testing and corrective action. The environment of the storage area will also be monitored continuously to detect any failure in the confinement of the radioactive material.

Transportable Metal Casks

Large metal casks are currently being considered by a number of nuclear utilities for the dry storage of spent fuel at reactor sites. Since those utilities may one day wish to ship those casks to an MRS facility, the facility is designed to receive these casks and package their contents, as received. If necessary, these casks could be stored. The current design for storing these casks is illustrated in Figure A-5, showing the concrete "saddles" that would support the cask in a horizontal position.

A.4 SAFETY FEATURES

A wide range of safety features would be incorporated into the design of the MRS facility to protect the health and safety of the facility workers and the general public. In addition to the standard fire and industrial safety regulations, the facility will operate under the radiation protection standards established by the U.S. Environmental Protection Agency and the Nuclear Regulatory Commission. An initial safety analysis report (SAR) will be prepared and submitted with the application for an NRC license. Updates of the SAR will be provided to the NRC at 6-month intervals during the construction and preoperational testing phases. Once normal operations begin, the SAR will be updated annually.

The principal design features and system characteristics of the MRS that would keep radiation exposures within permissible limits are described briefly below.

- The radioactive fission products are principally contained in solid pellets in sealed zirconium tubes.

Figure A-4

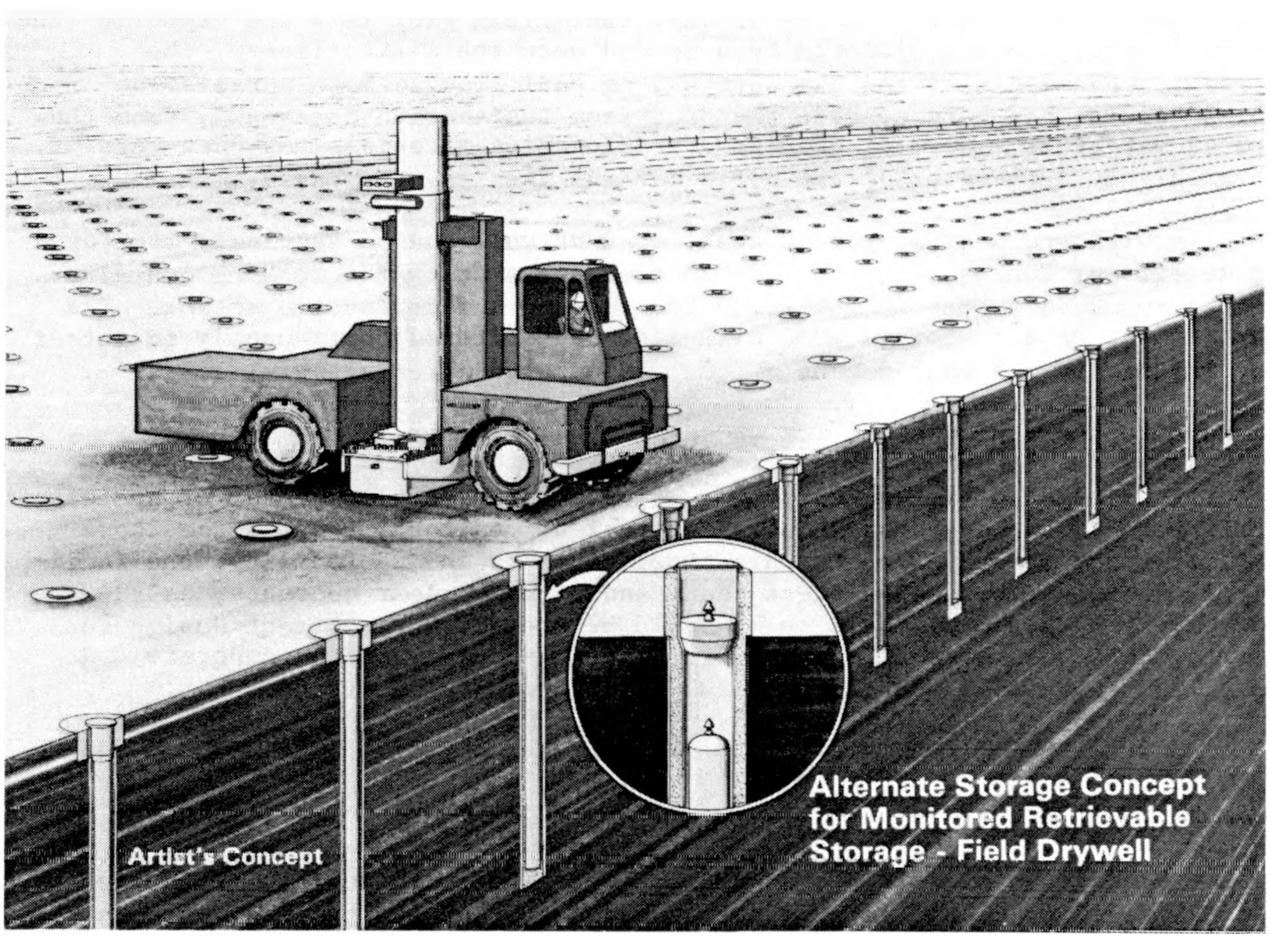
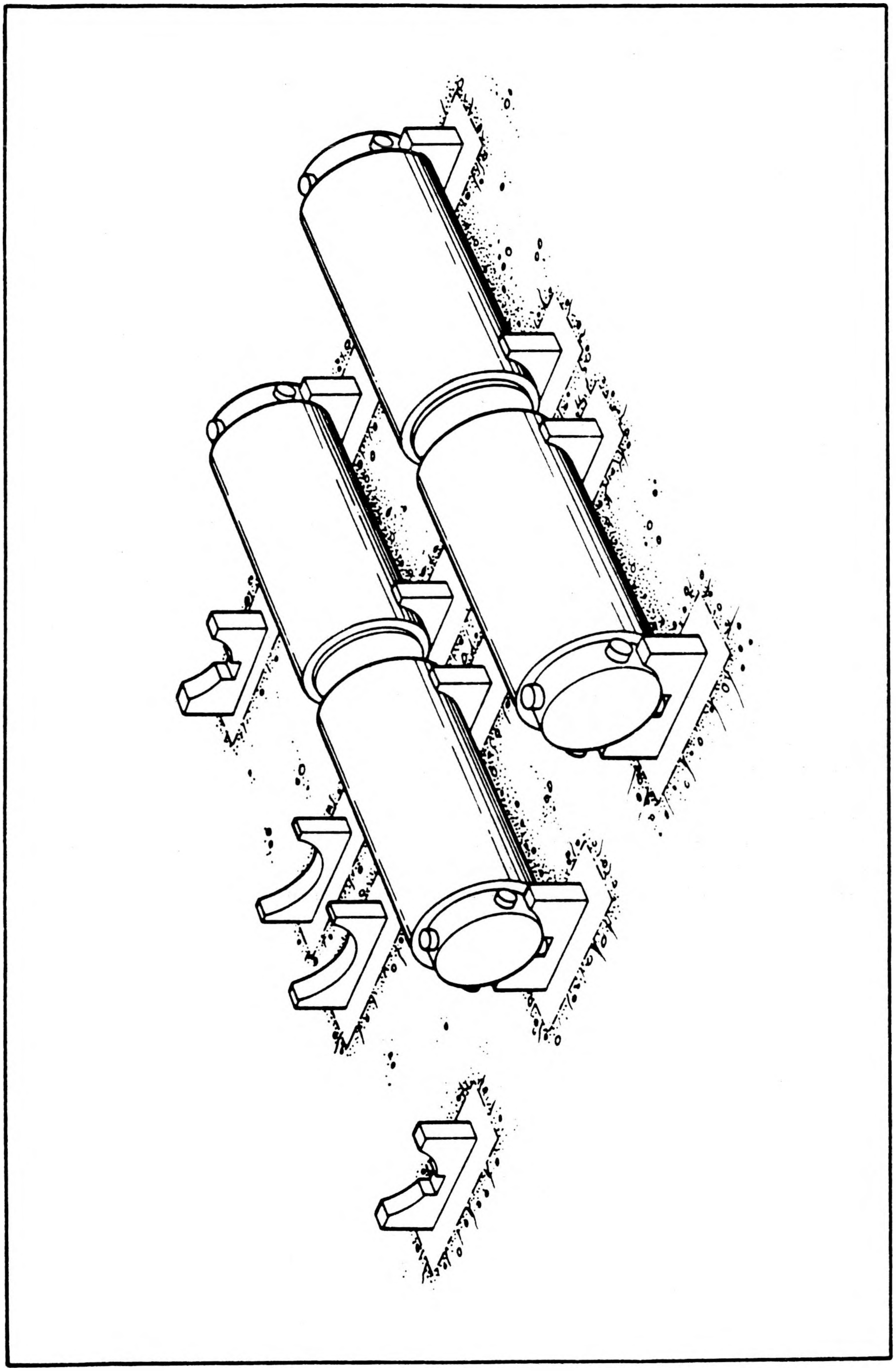

Alternate Storage Concept
for Monitored Retrievable
Storage - Field Drywell
Artist's Concept

Figure A-5
Transportable Metal Casks



- Any commercial high-level waste will be in a solid glasslike form, resistant to leaching by moisture, and sealed inside stainless steel canisters.

- The spent-fuel tubes are hermetically sealed within stainless steel storage canisters.

- Facility operations are designed to avoid breaching of the containment barriers (i.e., cladding or canisters).

- Radiation shielding is placed throughout the facility as appropriate to keep exposure of the facility workers within prescribed limits and as low as reasonably achievable.

- The facility heating and ventilation system would employ high-efficiency filtration and other equipment to collect and remove essentially all of the particulate radioactive material from the air streams, allowing those materials to be collected, treated and disposed of safely. Emissions from the facility will be restricted to levels far below Federal standards.

- In cask storage, the thick concrete walls of the cask would keep the external radiation levels in the storage area within permissible limits.

- In drywell storage, the top shield plug and cover plate, the drywell cavity steel liner and its grout, and the surrounding soil provide sufficient shielding to keep the storage area radiation levels within permissible limits.

- Monitoring of the atmosphere within the storage unit cavities provides detection of any leaks in the storage canisters so that corrective action can be taken promptly, and without any leakage to the environment.

- Monitoring of the facility environment assures that any significant releases of radioactive material, either from the R&H facility or from the storage area, are detected promptly and action taken to reduce or eliminate those releases, as appropriate.

Appendix B

FEASIBILITY OF MONITORED RETRIEVABLE STORAGE DEPLOYMENT

This appendix briefly describes the steps being taken to develop a proposal to Congress for the construction of an MRS facility and the schedule for putting such a facility into operation should Congress authorize its construction. Monitored retrievable storage has been found to be a feasible option for the safe, reliable storage of spent fuel and high-level waste. Its feasibility has been demonstrated through extensive experience in the storage and handling of spent fuel over the last 20 years. An MRS facility could be built and safely operated at any of a large number of sites throughout the country.

B.1 PROPOSAL TO CONGRESS

The Department of Energy (DOE) intends to submit in January 1986 a proposal to Congress requesting authorization for an MRS facility. To provide a technical basis for the Congressional decision, the following documents will be included in or will accompany the proposal to Congress:

- o Site-specific facility designs.
- o Need and feasibility report.
- o Program plan (funding, integration, deployment).
- o Environmental assessment.

To establish a sound basis for decisions about an MRS facility, the DOE has undertaken the following activities:

- o An assessment of research and development needs.
- o The selection of storage concepts for MRS facilities.
- o The design of MRS facilities.
- o The identification of candidate sites.
- o An assessment of environmental impacts.
- o Interactions with States, Indian tribes, and the public.

These activities are briefly described below.

B.1.1 Assessment of Research and Development Needs

No additional research and development is required for the completion and submittal of the proposal to Congress. This finding has been reported to Congress in a report issued by the DOE in June 1983 (DOE/RW-0021). This report was prepared in accordance with the Nuclear Waste Policy Act (the Act), which requires the DOE to prepare a report describing the research and development required for a proposal to construct an MRS facility.

B.1.2 Selection of Storage Concepts for MRS Facilities

The Act specifically directs the DOE to include in its proposal to Congress "at least three alternative sites and at least five alternative combinations of such proposed sites and facility designs." In response to this requirement, the DOE has decided to select two alternative concepts for the storage function of the MRS facility: (1) sealed storage casks and (2) field drywells.

The selection of these concepts resulted from a comprehensive evaluation of eight storage concepts. The technical feasibility of both concepts is supported by prior demonstrations and use. Designs for both sealed storage casks and field drywells will accompany the proposal to Congress. Both designs can accommodate the transportable metal storage casks that might be received from utilities using dry at-reactor storage. The storage units can be enclosed or modified to address local environmental conditions.

B.1.3 Design of Facilities

Concurrently with the selection of storage concepts, functional design criteria for the MRS facility were developed to guide the design effort. These functional design criteria include the applicable Federal standards; definitions of facility scope and purpose; requirements for accommodating transportation casks; design requirements for protecting the facility from storms, earthquakes, floods, and other natural phenomena; design requirements for the receiving and handling facility; heat loads; throughputs; requirements for mechanical and electrical systems; performance requirements for the storage facility; requirements for support facilities; and requirements for site improvements and utilities.

Since three alternative sites have been identified, an architect-engineer is now preparing the required site-specific MRS facility designs with associated specifications, cost estimates, and engineering and construction schedules.

Facility designs and supporting data are being developed in compliance with the quality assurance requirements for licensed nuclear facilities.

B.1.4 Identification of Candidate Sites

The Act requires that the proposal include "at least three alternative sites." In meeting this requirement, the DOE has identified one preferred site and two alternative sites.

Because the MRS facility relies on engineered systems and equipment for the containment of the radioactive materials, the safety of such a facility is largely independent of the natural characteristics of a site. An MRS facility could be built and safely operated at any of a large number of sites. Since suitable sites can be found throughout the country, other overall waste-system considerations are important.

The primary considerations in screening sites for suitability were the following:

- o Ability to construct an MRS facility in a safe, cost-effective, and timely fashion, with minimal adverse impacts on the local community or the environment.

- o Ability to enhance the role of the MRS facility as an integral part of the Federal waste-management system.

A key factor in identifying suitable MRS sites was a reduction in the total shipment-miles involved in waste transportation. An analysis of the relationship between MRS location and the total shipment-miles involved in waste shipments identified a region of the United States where the total shipment-miles tended to be lower, on a national scale, than in other regions. This region of minimized total shipment-miles was further evaluated. A preliminary screening of a large number of sites in this region led to the selection of 11 sites for further evaluation. The 11 sites are either controlled by the DOE or have been docketed with the Nuclear Regulatory Commission (NRC) for licensing under 10 CFR Part 50 as "production and utilization facilities." Each site has 1100 available acres without known land-use conflicts such as operating or planned commercial nuclear power plants. Continuation of the evaluation and screening process will result in the identification of one preferred site and two alternative sites for the proposal. After more-detailed evaluations and discussions with the affected States and Indian tribes, these sites will be the basis for the site-specific designs to be submitted to Congress for approval. If Congress approves the construction of an MRS facility, the site evaluation will continue to provide information for the environmental impact statement and the application for a license from the NRC. The site evaluation would be carried out in consultation with the affected State and local governments and tribal organizations.

B.1.5 Assessment of Environmental Impacts

The Act requires that an environmental assessment accompany the MRS proposal to Congress. This document will analyze the relative advantages and disadvantages of six alternative combinations of sites and facility designs; it will be based on available information regarding alternative technologies for the storage of spent fuel and high-level radioactive waste. The design information needed for this assessment is being developed by an architect-engineer. Information about the alternative sites will be gathered from existing sources (e.g., previous environmental reports and impact statements, NRC findings and evaluations, and Federal, State, and local records). The environmental assessment will be published and released to the public several weeks before the proposal is submitted to Congress.

If Congress authorizes the construction of an MRS facility, the DOE will prepare a draft and a final environmental impact statement. In accordance with the Act, these environmental documents will not consider the need for the facility but will comply with all other requirements of the National Environmental Policy Act of 1969, including the provision of opportunities for public participation.

B.1.6 Interactions with States, Indian Tribes, and the Public

The Act (Section 141(h)) provides that any authorized MRS facility shall be subject to the provisions of Sections 115; 116(a), (b), and (d); 117; and 118. Section 115 provides the specific mechanisms for Congress to override a "notice of disapproval." Sections 116 and 118 require the DOE to notify States and affected Indian tribes if they have potentially acceptable sites and provide for the submittal of a "notice of disapproval" by a State governor or legislature. Specific guidance for consultation and cooperation is provided in Section 117.

The preparation and release of information concerning the need for an MRS facility and the impacts associated with the facility are critical to the development of public understanding during the Congressional decision process. The DOE recognizes its responsibility to provide complete and timely information to meet these needs and proposes to approach this responsibility in several ways. Briefing materials on policy and special issues will be prepared for public distribution. Information briefings for candidate host States, affected Indian tribes, and local governments will be held to help their representatives and constituencies to have sufficient understanding for independent judgments on the acceptability of an MRS facility in their State. The DOE will consult with States, Indian tribes, and local governments to define the briefing agendas that will meet their information needs. For example, it is expected that MRS candidate States will have different information needs than other interested States. Briefings emphasizing different subject areas may be advisable and will be conducted if needed.

The participation of candidate host-State governments is particularly important to an efficient and effective MRS program. The DOE feels that the use of grants for this purpose is appropriate. Grants will be awarded to candidate States specifically to facilitate their participation in preproposal interactions. Funding for these grants will be drawn from the Nuclear Waste Fund.

B.2 MRS DEPLOYMENT SCHEDULE

The currently estimated schedule for an MRS facility, if authorized, would allow the DOE to start operations by the end of fiscal year 1996. Implementation of MRS according to this schedule will provide assurance that the DOE's acceptance of fuel in 1998 and subsequent years will be at sufficient rates to meet obligations. Table B-1 shows the currently projected timing of major milestones in the development of an MRS facility.

The estimated schedule is based on the use of sealed concrete casks for storage, with the submittal of a site-specific proposal to Congress in January 1986. The timing of the Congressional decision with regard to MRS is critical in setting the remainder of the schedule.

If Congress decides to construct the MRS facility, a notice of intent to prepare an environmental impact statement (EIS) will be issued. The DOE would consult with affected States and Indian tribes in accordance with the MRS siting plan, to ensure that their needs and concerns are considered. Public comments on the draft EIS would be addressed during the preparation of the final EIS. The final EIS would be issued by April 1, 1988, and a record of decision would be published 1 month later.

The definitive design of the facility would begin after the Congressional decision and would be completed 36 months later. When the design of safety related facilities and equipment is completed, a safety analysis report (SAR) would be prepared. At that time a license application would be submitted to the NRC. During the NRC review of the license application, the DOE will respond to NRC questions and, as required, provide any additional explanation and technical analysis necessary to support positions taken in the license application.

License issuance is projected to occur by July, 1 1991. Construction would be initiated immediately upon notification of granting of the license and is scheduled for completion at the end of fiscal year 1995. Design verification activities, supporting operational capability validation, would continue throughout construction. These activities would include extensive testing of critical MRS components in appropriate facilities under simulated operating conditions. This testing would validate operator training and operational procedures before the completion of construction and would allow early operation at full capacity. After the completion of construction, a 3-month period of hot-systems testing involving all MRS facility operations would commence, concluding by January 1, 1996. Pilot-scale operations involving all components of the waste-management system up to shipment to the repository would then commence, and the facility would start operating at production levels 9 months later, by October 1, 1996. Waste retrieval from temporary storage for shipment to the first repository would start in January 1998, at a rate compatible with the repository receipt rate.

This schedule is believed to be sufficiently flexible to accommodate some delays. Appreciable delays in critical events would delay the deployment of the facility.

Table B-1
Currently Projected Major Milestones After Congressional Authorization to Deploy an MRS Facility

Milestone	Date	
Congressional authorization	Third quarter	1986
Site selected	Third quarter	1986
Consultation-and-cooperation agreements completed	Fourth quarter	1986
Final environmental impact statement issued	Mid	1988
License application submitted to the NRC	Mid	1988
Design verification and definitive design completed	Mid	1989
License issued by the NRC	Mid	1991
Construction begun	Mid	1991
Construction completed	Fourth quarter	1995
Testing of "hot" systems completed	First quarter	1996
Pilot-scale operation begun	First quarter	1996
Production operation begun	Third quarter	1996