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Volume 3 of 3

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Monitored Retrievable Storage Submission to Congress

Volume III

Monitored Retrievable Storage Program Plan

March 1987

U.S. Department of Energy
Office of Civilian Radioactive Waste Management

DOE/RW-0035/1-REV 1
Volume 3 of 3

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U.S. Department of Energy
Office of Civilian Radioactive Waste Management
Washington, D.C. 20585

PREFACE

On January 7, 1983, President Reagan signed the Nuclear Waste Policy Act (NWPA) of 1982, which establishes the federal policy for disposal of commercial spent nuclear fuel and high-level radioactive waste. The NWPA instructs the Secretary of Energy to start accepting spent fuel and high-level waste for disposal in a deep geologic repository by January 1998. The NWPA also states that storage of high-level radioactive waste or spent fuel in a monitored retrievable storage (MRS) facility is an option for providing safe and reliable management of such waste or spent fuel.

Section 141 of the NWPA instructs the Secretary of Energy to prepare a proposal for construction of one or more MRS facilities. The NWPA states that the proposal to Congress shall include the establishment of a federal program for the siting, development, construction, and operation of such facilities; a plan for funding the construction and operation of such facilities; a plan for integrating the facilities with other storage and disposal facilities authorized in the NWPA; and site-specific designs and cost estimates. The proposal is to be accompanied by an environmental assessment.

In response to these requirements, the Office of Civilian Radioactive Waste Management in the Department of Energy (DOE) has prepared this submission to Congress. The submission consists of three volumes, described below. The required site-specific designs and cost estimates are incorporated by reference.

The first volume, The MRS Proposal, describes the DOE's proposal to construct and operate an MRS facility at the Clinch River Site in Roane County, Tennessee. The proposed MRS facility would be an integral part of the federal waste management system and would perform most of the waste-preparation functions before emplacement in a repository.

The second volume, The Environmental Assessment, is divided into two parts. Part 1 examines the need for and feasibility of constructing an MRS facility as an integral component of the waste management system. Part 2 includes descriptions of two facility design concepts at each of three candidate sites, and a detailed assessment and comparison of the environmental impacts associated with each of the six site-design combinations.

The third volume, The Program Plan, describes the activities, costs and schedules for establishing a federal program to site, develop, construct, and operate an MRS facility, if approved by Congress. It includes plans for funding the construction and operation of an MRS facility and for integrating the facility with other waste management facilities authorized in the NWPA.

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1.0 INTRODUCTION

This Program Plan has been prepared in response to the requirements of Section 141 of the Nuclear Waste Policy Act (NWPA) of 1982. It describes the Department of Energy's (DOE) proposed program for developing, constructing, and operating a monitored retrievable storage (MRS) facility. The MRS facility, if approved by Congress, will be an integral part of the federal waste management system and will perform the necessary waste preparation functions for spent fuel prior to its emplacement in a repository.[a]

This document presents the current DOE program objectives and the strategy for implementing the proposed program for the integral MRS facility. If the MRS proposal is approved by Congress, DOE will periodically review the need to revise or update this Program Plan. Any needed revisions to the Program Plan will be made available to the Congress, the State of Tennessee, affected Indian tribes, local governments, other federal agencies, and the public.

The NWPA requires that the proposal for constructing an MRS facility include:

1. the establishment of a federal program for the siting, development, construction, and operation of MRS facilities [Section 141(b)(2)(A)]

2. a plan for funding the construction and operation of MRS facilities [Section 141(b)(2)(B)]

3. site-specific designs, specifications, and cost estimates for the first such facility [Section 141(b)(2)(C)]

4. a plan for integrating MRS facilities with other storage and disposal facilities authorized by the NWPA [Section 141(b)(2)(D)].

This plan includes the information required in Items 1, 2, and 4, and a summary of the cost estimates required in Item 3. Detailed site-specific designs, specifications, and cost estimates for an MRS facility are provided in the DOE's Conceptual Design Report (Ralph M. Parsons Company 1985).

Chapter 2.0 of this Program Plan provides an overview of the proposed MRS Program. It describes the functions of an MRS facility and includes a discussion of schedules, costs, and management approaches for implementing the Program. Chapter 3.0 identifies the elements which will comprise the MRS

(a) Present and future verb tenses are used for ease in describing this Program Plan and do not imply that an MRS facility will be approved or built.

Program and provides further details on proposed program activities and schedules. Chapter 4.0 contains schedule information on the integration of the MRS Program with other DOE programs and with other waste management facilities authorized by the NWPA. Chapter 5.0 describes the funding plan proposed for MRS facility development, construction, operation, and decommissioning. The source of funding and funding needs are both discussed. Detailed information to support the Program Plan is provided in the appendices.

The DOE's fiscal year 1987 and 1988 budget requests for the MRS Program activities has been developed from the information contained in this plan. The request includes funds to cover: 1) the specific costs identified in this plan, adjusted for escalation; 2) prefinancing; and 3) institutional related expenditures, the costs of which will be the results of future negotiations with the host state and community.

2.0 PROGRAM OVERVIEW

This chapter provides an overview of the MRS Program by presenting and discussing the proposed functions and site for the MRS facility, a proposed schedule for key program activities, the estimated costs of the program, and the proposed DOE management approach and responsibilities for implementing the program, if the MRS proposal is approved by Congress.

2.1 MRS FACILITY FUNCTIONS

The MRS facility will be an integral part of the federal waste management system. Its primary functions will be to receive spent fuel assemblies from commercial nuclear power plants, consolidate them (i.e., disassemble them to reduce their volume), package them in sealed canisters, and ship them to the repository for disposal. It will also provide temporary storage for up to 15,000 MTU (metric tons uranium) of the canistered spent fuel, if required. It will receive, consolidate, and package between 2500 and 3000 metric tons of uranium (MTU) of spent fuel annually. The facility will be licensed by the Nuclear Regulatory Commission (NRC). Figure 2.1 depicts the operation of the MRS facility.

2.2 PROPOSED MRS SITE

The proposal to Congress for the MRS facility recommends that the facility be constructed at the Clinch River site in Tennessee. The Clinch River site, located 25 miles west of Knoxville, is adjacent to the DOE's Oak Ridge reservation and lies within the Roane County portion of the city of Oak Ridge. The proposed MRS facility site covers only a portion of the site area for the canceled Clinch River Breeder Reactor project.

2.3 PROGRAM SCHEDULE

The deployment schedule, shown in Figure 2.2, presents major events that must occur prior to operation of the MRS facility. The proposed MRS facility will be operational approximately 10 years after the date of congressional approval. Initial operation will be at a reduced capacity. Operation at full capacity will be achieved about 7 years after initial operation depending on the repository acceptance schedule. The MRS facility will service the first repository and will operate for approximately 31 years. Decommissioning of the facility will be completed approximately 4 years after operations cease.

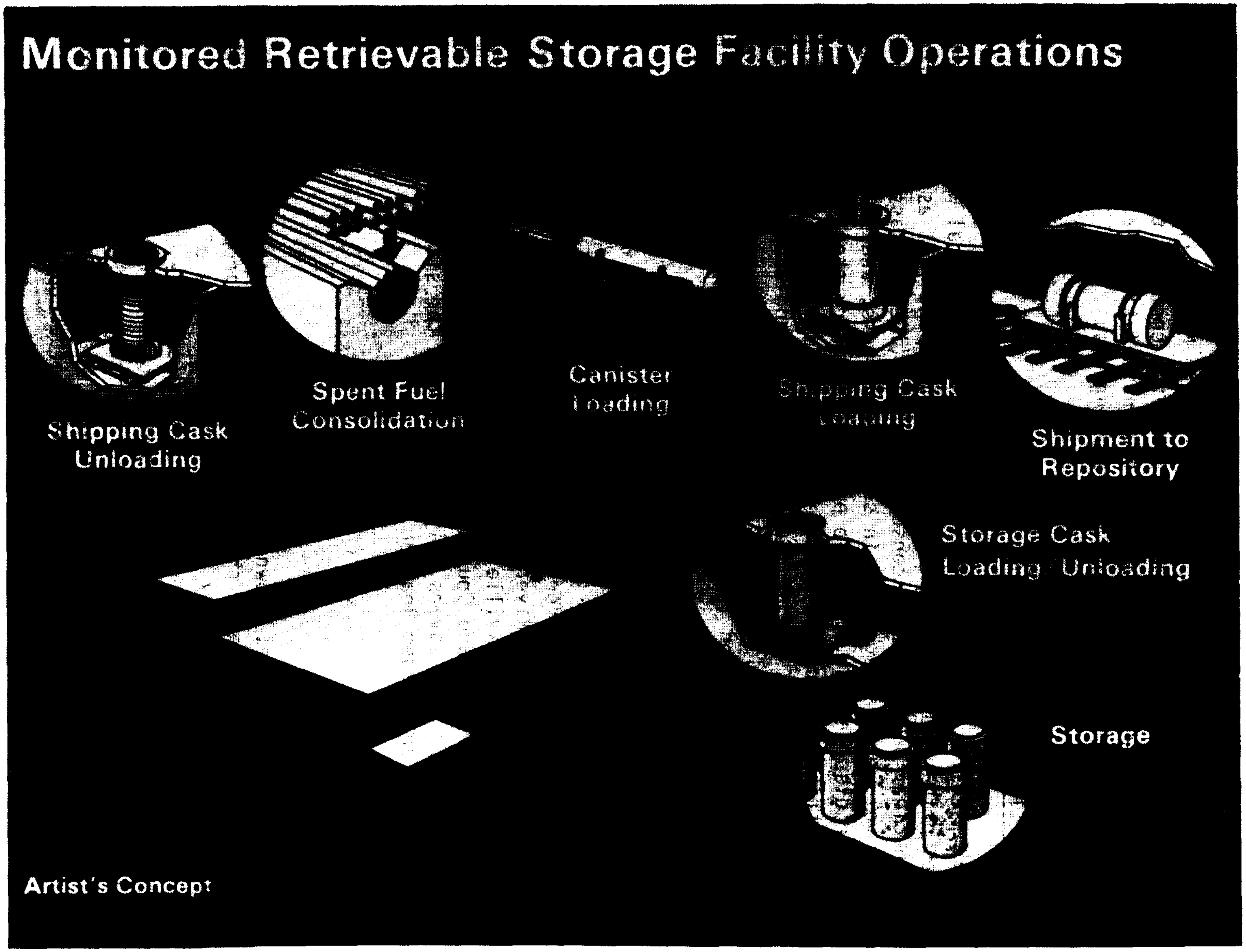
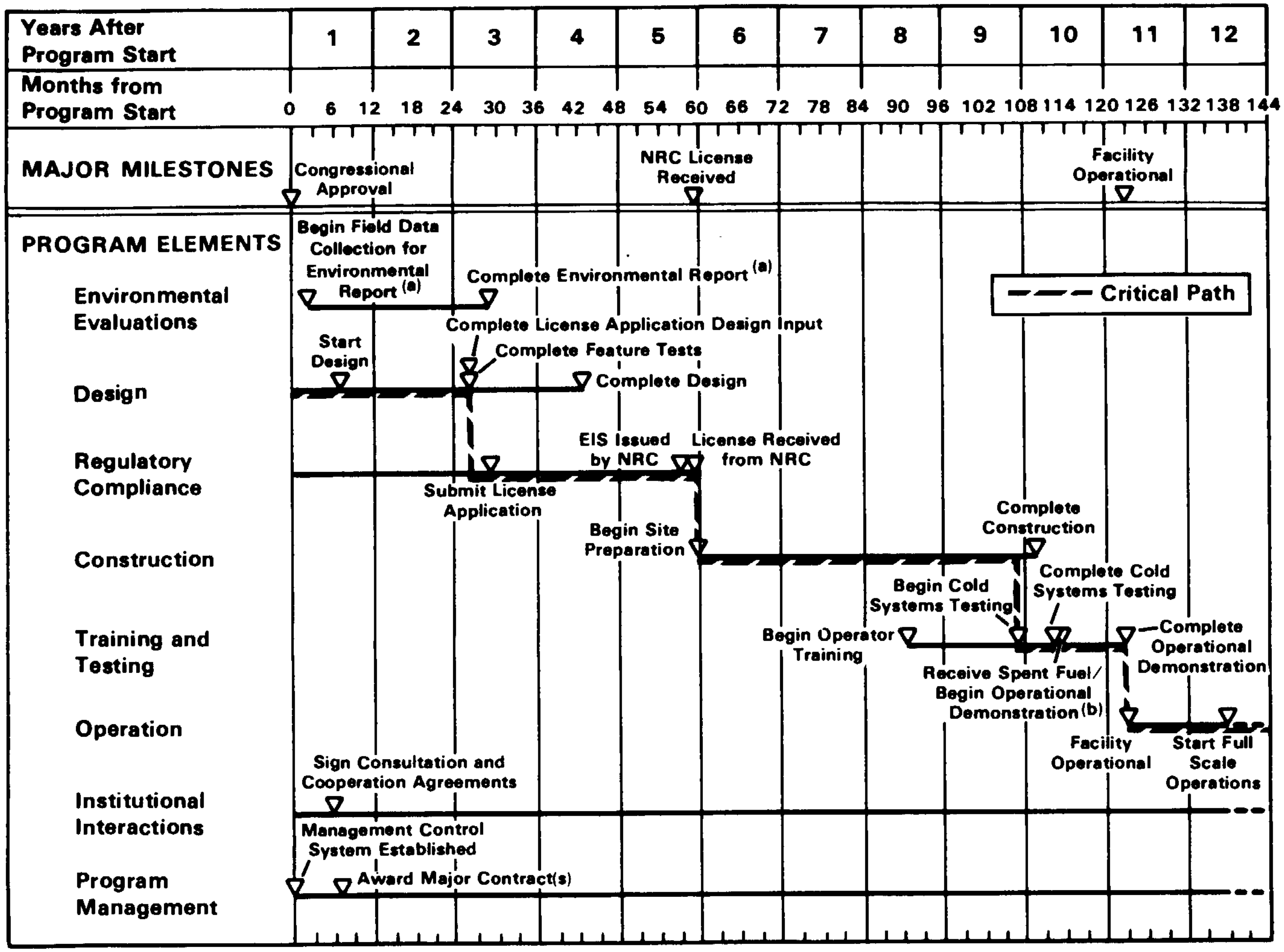


FIGURE 2.1. Monitored Retrievable Storage Facility Operations



(a) The precise nature of this document will be dependent on the provisions of any authorizing legislation.

(b) The shipment of spent fuel to the MRS facility is contingent upon receipt of a construction authorization for the first repository. The revised schedule for the first repository in the Draft Mission Plan Amendment contemplates receipt of such authorization by the first quarter of 1998.

FIGURE 2.2. MRS Deployment Schedule

Figure 2.2, the MRS deployment schedule, identifies key milestones and the critical path to operation of the MRS facility. The following discussion describes the activities that correspond with the milestones on the deployment schedule.

Early activities in the Environmental Evaluations and Design elements support the preparation of a license application to the NRC for construction and operation of the MRS facility. In order to submit a license application, the DOE must have sufficient information on facility design and expected performance and on the potential environmental effects of the facility so that the NRC can make a judgment on whether to grant a license. The license application does not require a complete definitive design of the entire facility, only those portions that affect safety or environmental impact. Design of other portions of the facility (e.g., the administration buildings) will continue after the license application is submitted.

Two other elements that will be initiated immediately upon receipt of congressional approval of the MRS proposal are the Institutional Interactions element and the Program Management element. An initial activity in the Institutional Interactions element will be the establishment of binding Consultation and Cooperation Agreements with the State of Tennessee. These agreements will specify the processes and procedures for interactions between the State of Tennessee and the DOE relative to MRS facility development. The Program Management element will adapt state-of-the-art management control systems to support sound and efficient management of the program.

As shown on the Regulatory Compliance line of the deployment schedule, 30 months are allowed for the NRC review, issuance of the Environmental Impact Statement (EIS), and the granting of a license. Following receipt of the license from the NRC, the approximately 4-year construction effort for the facility will begin. After construction is completed there will be approximately 1 year of testing and demonstration before the facility becomes operational.

2.4 ESTIMATED COSTS

The costs for implementing the MRS Program were estimated using information developed as a part of the conceptual design effort (Ralph M. Parsons Company 1985) which also supports the MRS submission to Congress. Analysis of other program activities necessary to deploy and operate the MRS facility provided supplemental information that was used in the cost estimate.

The cost estimate is based on development of an MRS facility that uses the sealed storage cask design and is located at the Clinch River site in Tennessee.

The facility functions and schedule used in the cost estimate were briefly described in Sections 2.1 and 2.2. All costs are in constant 1986 dollars. The estimates do not include costs for financial assistance to state and local governments or for land acquisition.

The cost of the program from the time of congressional approval until the facility becomes operational, plus decommissioning, will be approximately $990 million. From this total, approximately $710 million of capital funds will be used for facility design and construction. The annual operating costs of the facility, which will employ about 600 workers, will be approximately $73 million. The costs are higher during the initial years of operation when the sealed storage casks must be procured and lower in the later years when the MRS facility stops receiving spent fuel and is only shipping spent fuel canisters to the repository. The cost of decommissioning the facility following completion of operations will be approximately $83 million.

It should be noted that inclusion of an integral MRS facility in the waste management system will reduce the costs of other components of the system (e.g., the repository). These cost reductions are discussed in Chapter 5 and Appendix E of this Program Plan and in Volume 2 of this submission to Congress, Environmental Assessment for a Monitored Retrievable Storage Facility.

2.5 MANAGEMENT APPROACH AND RESPONSIBILITIES

The NWPA assigned responsibility for the permanent disposal of spent fuel and high-level waste to the DOE, which created the Office of Civilian Radioactive Waste Management (OCRWM) to carry out this responsibility. The OCRWM is headed by a Director appointed by the President, by and with the advice and consent of the Senate. The Director reports directly to the Secretary of Energy and is responsible for carrying out the functions assigned to the Secretary under the NWPA.

The OCRWM's operations are consistent with the DOE's overall philosophy of program planning, guidance, and control by DOE Headquarters, with project execution being accomplished through the DOE operations offices and project offices established within the operations offices. Accordingly, the OCRWM provides policy guidance, program direction, and technical review, while the project offices and their contractors are responsible for the execution of projects and the day-to-day management of project performance. This section describes the organizational structure of the OCRWM and the approach and responsibilities for implementating the MRS Program, if approved by Congress.

As shown in Figure 2.3, the OCRWM is organized by staff responsibility and functional responsibility. The Office of Policy and Outreach provides

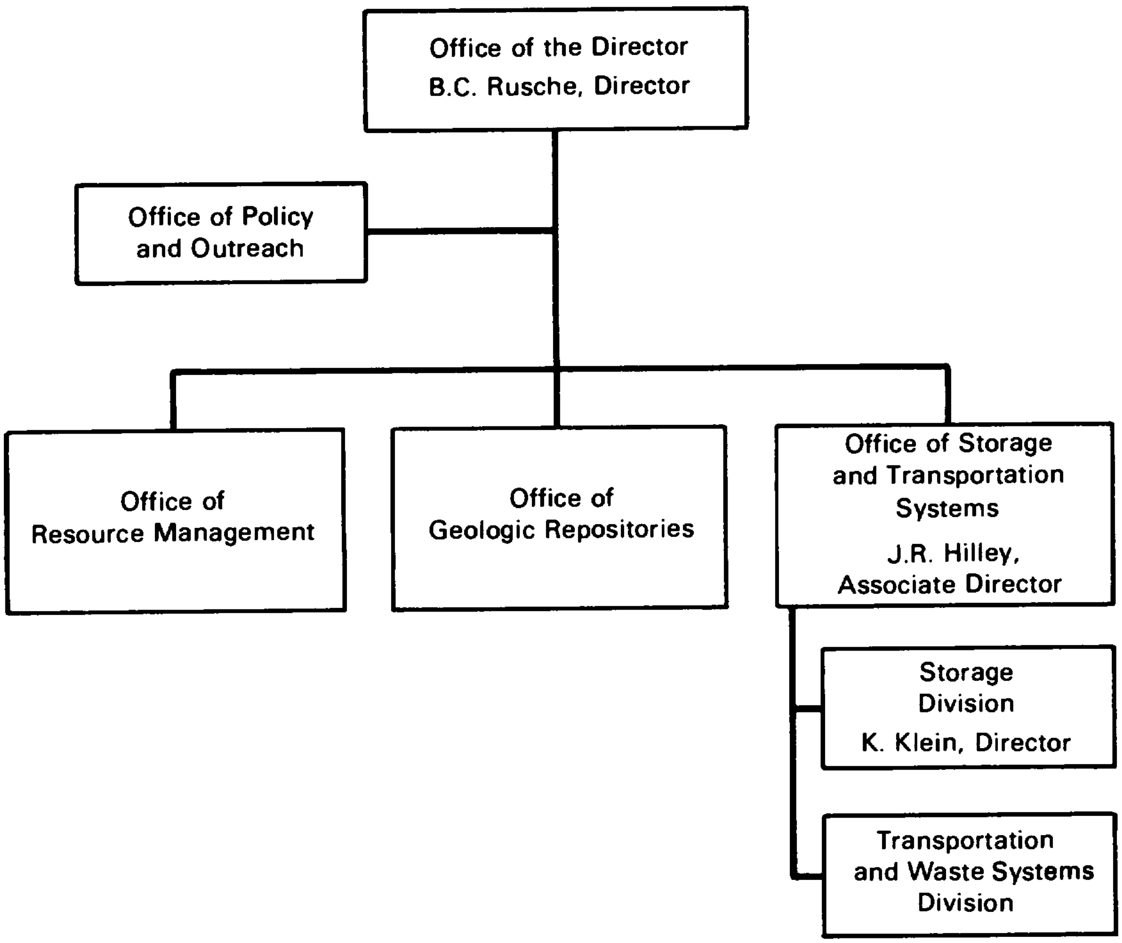


FIGURE 2.3. The Office of Civilian Radioactive Waste Management

staff support. The three major functional components are 1) the Office of Resource Management, 2) the Office of Geologic Repositories, and 3) the Office of Storage and Transportation Systems.

The Director of the OCRWM interacts regularly with the Secretary of Energy in establishing overall policy and ensuring that the activities of OCRWM components are properly focused, paced, and integrated. His associate directors and their staff guide the project offices in implementing major program decisions.

The Office of Policy and Outreach has primary responsibility for providing central staff support to the OCRWM Director and Associate Directors in policy formulation, program planning, and the general oversight of program execution.

The associate director for Resource Management and his staff administer the Nuclear Waste Fund and the Interim Storage Fund. This responsibility encompasses fee collections and payments, annual reviews to determine the adequacy of the fee collected from the owners of the waste, and contract-management activities.

The associate director for Geologic Repositories and his staff have primary responsibility to site, design, construct, operate, close, and decommission geologic repositories for spent nuclear fuel and high-level waste.

The associate director for Storage and Transportation Systems and his staff implement all storage and transportation activities. The Office is responsible for developing: 1) a systems integration approach that coordinates all activities for the entire federal waste management system; 2) R&D to support increased at-reactor storage and a federal capability to provide interim storage for up to 1900 metric tons of spent nuclear fuel if utilities determined eligible by the Nuclear Regulatory Commission submit a request for such storage; 3) an MRS facility, if approved by Congress; and 4) a transportation system that will meet the requirements of the waste management system.

The Storage Division of the Office of Storage and Transportation Systems has developed the Monitored Retrievable Storage submission to Congress and will be responsible for policy and direction of the MRS Program, if the MRS proposal is approved by Congress.

The responsibility for implementation of this Program Plan will be assigned to the Oak Ridge Operations Office. An MRS Project Office will be established within the Operations Office.

3.0 DEPLOYMENT PLAN

This chapter describes the activities and schedule for implementing the MRS Program. The activities and schedules are discussed in terms of program elements. These elements were developed by analysis and grouping of the many and diverse activities that are required to develop, operate and decommission an MRS facility. The following elements make up the MRS Program:

- Environmental Evaluations
- Design
- Regulatory Compliance
- Construction
- Training and Testing
- Operation
- Decommissioning
- Institutional Interactions
- Program Management.

The chapter is organized by program element in the same order as listed above. For each element, the objective and scope are stated, and the status at the time of proposal submittal is provided as background information. Planned activities and schedules within each element and the interfaces with other activities and program elements are described. Anticipated interactions with other government organizations, regulatory agencies, state and local governments, and the public are included. A master schedule, which combines the individual program element schedules, is given in Section 3.10.

3.1 ENVIRONMENTAL EVALUATIONS

The objective of the Environmental Evaluations element is to evaluate the environmental effects of proposed MRS Program activities and to provide guidance to other program elements on monitoring for and control of these effects. Work in this element includes collection of any additional environmental data determined to be needed on the Clinch River site and surroundings, evaluation of impacts on the environment, monitoring and guidance of other program elements whose activities could potentially affect the environment, and preparation of all environmental documentation related to the development, operation, and decommissioning of an MRS facility.

3.1.1 Background

The NWPA directs the Secretary of Energy to prepare an Environmental Assessment (EA) on at least 5 alternative combinations of proposed MRS sites and facility designs. The NWPA further specifies that "the Secretary shall recommend the combination among the five site/design alternatives that the Secretary deems preferable." The EA (Volume 2, MRS Proposal to Congress, Environmental Assessment of a Monitored Retrievable Storage Facility) includes a comprehensive analysis of the relative advantages and disadvantages of the 6 site/design combinations that the DOE has considered. The EA is based on a conceptual design for a facility that is an integral component of the federal waste management system, with a design capability to receive, prepare, and ship up to 3600 MTU per year.[a]

The NWPA is also explicit regarding compliance with the National Environmental Policy Act of 1969 (NEPA) in the event that Congress authorizes the MRS facility. In this case, it specifies that "the requirements of [NEPA] shall apply with respect to construction of such facility except that any environmental impact statement prepared ... shall not be required to consider the need for such facility or any alternative to the design criteria ... set forth in subsection (b)(1)." The DOE recognizes that the specific actions which must be taken to fulfill its NEPA obligations will depend in large measure on the provisions of the congressional authorization. In anticipation of discharging its NEPA responsibilities, in the MRS proposal the DOE is providing for the preparation of a comprehensive environmental document, which will be submitted to the NRC in support of the DOE license application. The procedures that will govern the preparation of this document will depend on the decisions that the DOE must make in implementing any authorizing legislation. The document could take the form of an environmental impact statement (EIS) but is referred to as an Environmental Report in this program plan.

Other documents related to environmental evaluations for the MRS facility include the following:

- Environmental Assessment on 10 CFR 72 Proposed Revisions (NRC 1984)
- Reference-Site Environmental Document (Silviera 1985)
- Site Screening and Evaluation Report (Golder Associates 1985)

(a) Within this program plan, the MRS receipt, preparation and shipment of spent fuel is referred to as throughput. The design throughput for the MRS facility operating 4 shifts, 7 days a week, is 3600 MTU per year of spent fuel. The planned throughput of 2500 to 3000 MTU per year can be achieved with a 3-shift, 5 day-per-week operation. The larger throughput was analyzed in the EA to assure that the maximum potential impacts were considered.

- Regulatory Assessment Document (Ralph M. Parsons Company, Vol. II 1985).

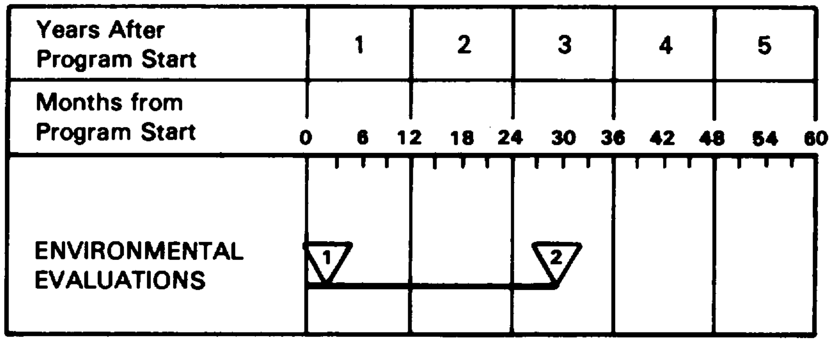
3.1.2 Planned Activities

Discussions will be held with the NRC to confirm the scope of environmental data needed to support the license application. In addition, discussions with state and local officials will assist DOE in scoping the issues that need more detailed evaluation. Based on these discussions, any additional field data needed to estimate the environmental impacts will be identified. These data will be collected by a contractor for use in the preparation of an Environmental Report that will accompany the license application to the NRC. Other activities will be to monitor and guide other program elements such as design, construction, and decommissioning, whose activities could potentially affect the environment. The key document produced will be the Environmental Report which is discussed in more detail below.

Environmental Report

The schedule of activities to support the Environmental Report is shown in Figure 3.1. Upon congressional approval to proceed with deployment of an MRS facility, verification of environmental characteristics of the site and surroundings will begin by identifying specific characterization needs. Detailed environmental data was collected for the Clinch River site to support the Environmental Report for the Clinch River Breeder Reactor Plant (PMC 1975 and Amendments through 1982). Much of this data is applicable to the Environmental Report for an MRS facility at the Clinch River site. An early activity will be detailed evaluation of this existing data to determine the additional data needs. These needs may include the collection of baseline environmental data about meteorology, air quality, geologic and hydrologic characteristics and use; surface-water quality; and natural background radiation. Other types of site and regional data that may need to be updated include ecological conditions and socioeconomic characteristics.

The NRC requires that an Environmental Report be submitted with the license application for the MRS facility. In accordance with NRC requirements, the Environmental Report will discuss the potential environmental impacts (and mitigation of those impacts) resulting from construction and operation of an MRS facility at the Clinch River site. The Environmental Report will also discuss alternative designs, consistent with the requirements of the NWPA and with any additional requirements that Congress may impose as conditions for approving the MRS proposal.



Milestones

Environmental Evaluations

1 Begin Field Data Collection for ER[a]

2 Complete ER[a]

(a) The precise nature of this document will be dependent on the provisions of any authorizing legislation.

FIGURE 3.1. Schedule for Environmental Evaluations

Field data collection at the site will begin after obtaining any permits that may be required. This activity will result in an updated collection of environmental information obtained through both environmental monitoring and verification of available site data. This updated site data, together with design information related to construction, operation and decommissioning, will be used to prepare the Environmental Report.

3.2 DESIGN

With the MRS facility conceptual design (Ralph M. Parsons Company 1985) as a starting point, the objectives of the Design element are 1) to develop an MRS facility definitive (detailed) design that emphasizes safety, cost effectiveness, operability, and reliability; and 2) to verify performance of the design for key MRS systems. Work in this element includes collecting site engineering data; performing design optimization studies; identifying quality requirements for procurement and construction; developing technical specifications; identifying limiting operating conditions; and preparing design documents required for licensing, equipment procurement, installation, and acceptance, and for facility construction and acceptance. Tests and demonstrations will be performed to verify performance of key systems and the results will be factored into the final design.

3.2.1 Background

In order to select a storage concept for MRS, eight dry storage concepts[(a)] employing passive cooling of spent fuel were identified and design studies were performed for each using a common set of design requirements. These concepts were then evaluated and compared in terms of a set of criteria that included safety, environmental and socioeconomic impacts, siting, cost, technological maturity, and facility flexibility.

Based on these evaluations, two storage concepts were selected (DOE 1984a). The sealed storage cask (SSC) concept was selected as the primary storage concept. Its design is simple, economical, and sufficiently flexible to accommodate all proposed waste forms and packages in any incremental quantity required, and it is relatively independent of site characteristics. In addition, the accumulated experience with cask storage provides assurance of safe, reliable operations and accurate cost estimates. The field drywell was selected as the alternative storage concept for similar reasons; however, the drywell is more dependent on site characteristics and requires more land area than the sealed storage cask for equivalent amounts of storage.

Conceptual designs were developed for both storage concepts located at three different sites. These conceptual designs are for facilities that receive, unload, disassemble and consolidate, canister, and temporarily store or directly ship spent fuel to a geologic repository.

The conceptual designs are documented in the MRS Facility Conceptual Design Report (Ralph M. Parsons Company 1985). The conceptual design was performed under stringent quality assurance requirements consistent with the ANSI/ASME Standard NQA-1 (ASME 1983). The Conceptual Design Report describes the design features and operations of the facility; documents how expected licensing requirements were incorporated in the design; and includes the conceptual drawings, design calculations, cost estimates, and design studies performed to date. Also identified in the Conceptual Design Report are areas that require further design study. These and additional studies that may be identified during review of the present conceptual design will be performed during the definitive design.

The conceptual design encompasses a number of technologies that must be interfaced to provide a facility that will safely, reliably and efficiently

(a) The Monitored Retrievable Storage Proposal Research and Development Report (DOE 1983a), which was required by the NWPA and submitted to Congress in June 1983, concluded that all of these storage concepts were sufficiently mature to allow development of an MRS proposal without additional research and development.

receive, handle, disassemble, package, temporarily store and ship commercial spent nuclear fuel. Although each of the principal subsystems or "features" of the MRS design is derived from a mature technology, they have not been demonstrated as combined systems under the operating conditions or at the production rates required for the MRS facility. Therefore, there is a need for limited design verification testing that includes tests of individual features of the MRS design as well as prototype MRS systems demonstrations.

3.2.2 Planned Activities

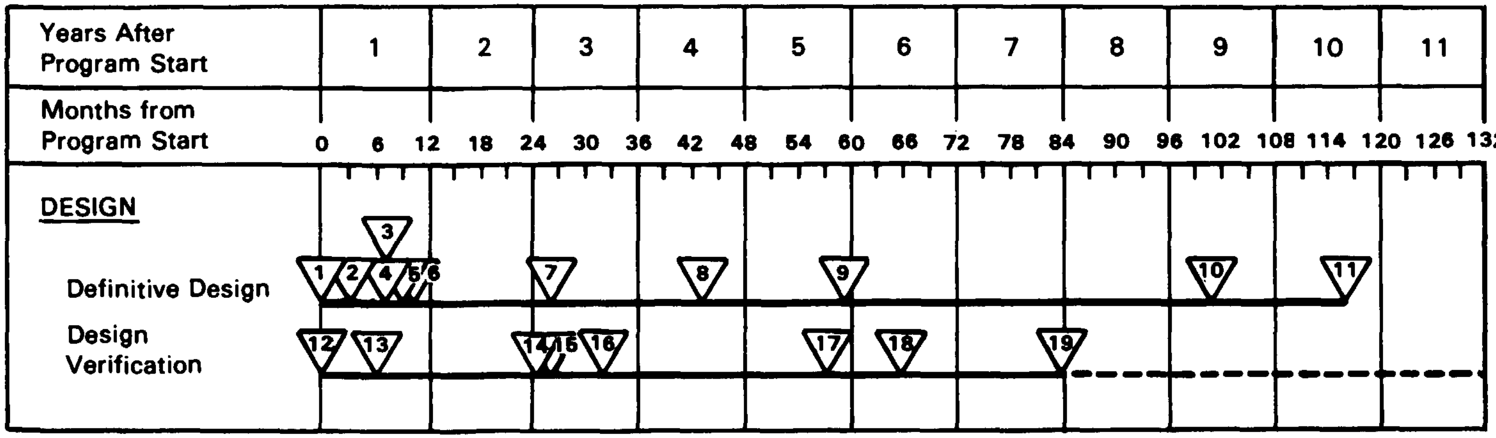
Activities for the Design element are discussed in terms of those required for preparation of the definitive design and those required for verification of the design. The schedule for these activities is shown in Figure 3.2. The scope and schedule of work has been developed to provide timely input to support the license application to the NRC, and to provide the drawings and specifications necessary for construction of an MRS facility.

Definitive Design

Detailed identification and confirmation of site data required for the design will be initiated immediately following congressional approval. Collection of site data (such as soil and rock characteristics needed to design building foundations) will start after obtaining any required site investigation permits.

The initial design activity will be a review of the conceptual design to identify any outstanding needs. There were a few instances in the conceptual design activity where a particular process or design feature was selected because it was a demonstrably safe and feasible method of meeting the design requirements. In the definitive design, additional studies will be undertaken to determine if other approaches or design features also meet the safety and feasibility requirements, but are preferable because they offer lower cost or higher reliability. One area that has been identified for evaluation is the methodology for volume reduction of the spent fuel hardware that remains after the fuel rods are removed and consolidated. Additional studies and a decision on the volume reduction concept are planned early in the definitive design.

The MRS Program will coordinate with the other DOE waste management programs to establish design interfaces for system components common to these programs (e.g., the canister and the transportation cask). These interfaces will be put under baseline control, so that no changes will be made in features that affect another program without full review and analysis of impacts by all programs involved. As designs become further advanced the design baseline will become more complete and specific. The MRS facility design will have sufficient flexiblity to accommodate any uncertainties in the interfaces.



Milestones

Definitive Design

1. Begin Site Data Confirmation
2. Canister Configuration Interface Baselined
3. Start Design
4. Transportation Cask Interface Baselined
5. Decision on Waste Volume Reduction Concepts
6. Complete Site Data Collection
7. Complete License Application Design Input
8. Complete Design
9. Begin Field Inspection
10. Begin As-Built Drawings
11. Complete As-Built Drawings

Design Verification

12. Begin Test Plan Development
13. Begin Feature Tests
14. Start SSC Testing
15. Complete Feature Tests
16. Complete SSC Performance Testing
17. Begin Prototype Consolidation Equipment Tests
18. Complete Prototype Consolidation Equipment Tests
19. Complete 5 Year SSC Tests

FIGURE 3.2. Schedule for Design

Other early design work will include optimization and tradeoff studies for the purpose of identifying and evaluating approaches which would lead to reduction of radiological exposure (including application of the ALARA principle to occupational and public exposure), reduction of costs, or improvements in operability and reliability. Quality standards for structures, systems, and components important to safety as defined by 10 CFR 72 will be designated to ensure that safety and reliability goals are met. To meet the requirements of applicable NRC regulations and DOE orders, technical specifications will be developed and limiting conditions for operations will be identified. Sufficient design information will be available to support submission of the license application to the NRC prior to completion of the definitive design.

Documents needed for construction of the MRS facility, including detailed drawings and procurement, construction, and installation specifications for the facilities and equipment, will continue to be developed after submittal of the license application. As part of the remaining design, a systems description document will be completed. The systems description document will describe in detail the specific process systems and equipment used in the MRS facility and their methods of operation and maintenance. The document will become the basis for the operations and maintenance manuals. Once the construction documents are completed, the detailed acceptance test plan for the facility will be prepared. The total time required for definitive design is 3 years.

The final activities performed in the design consist of field engineering inspection to verify that construction is in accordance with the design drawings and specifications, processing and approving design changes made during construction, and preparing as-built drawings.

Design Verification

Several types of tests are planned for design verification. These tests, which are briefly described below, are described more fully in Appendix C and Section 3.5 of this Program Plan.

- Feature Tests - tests performed to verify conceptual design choices for individual components, equipment, processes, and materials.

- Systems Development Tests - tests to assist in the design of the disassembly and consolidation equipment.

- Prototype Demonstrations - tests to verify operability of major systems.

- Preoperational Tests - tests performed on MRS systems installed in the facility before receipt of spent fuel (described in Section 3.5, Training and Testing).

Feature Tests. Feature tests are planned for components or subsystems of the disassembly, packaging and storage systems. Equipment components for which feature tests are currently planned include:

- Robotics - tests of equipment for automated remote operations, such as cask handling, sampling, and unbolting.

- Canisters - tests to verify the integrity of canisters during storage or after an accidental drop.

- Welding - tests of equipment selected to weld canisters and cask liners.

- Volume Reduction - tests of equipment to shred, melt, or incinerate contaminated materials.

Wherever possible the feature tests will be done "cold" (i.e., without use of radioactive materials). Verification of "hot" performance (i.e., with radioactive materials) will be achieved in subsequent system demonstrations. Preparation of test plans will be initiated upon congressional approval of the MRS proposal and feature tests will start shortly thereafter.

System Development Tests. The spent fuel disassembly and consolidation system is a mechanical system that must operate remotely. Although spent-fuel rods have been pulled from assemblies in large quantities and some few assemblies have been consolidated, this MRS system must operate on a production basis in a hot cell. Development tests already included in the DOE's Prototypical Consolidation Development Project will be performed concurrently with design of this system to assure its operability and reliability. The current schedule for these tests (see Chapter 4.0 and Appendix C) calls for completion of most tests in time to provide confirmation of designs to be submitted with the MRS license application.

Prototype Demonstrations. Prototype demonstrations are planned for the sealed storage cask and the spent fuel consolidation/packaging systems. The sealed storage cask demonstration will consist of two phases. The first phase will be a short-term verification of the cask thermal, shielding, and structural performance. The thermal and shielding tests will be done with a cask containing consolidated spent fuel. The structural performance tests will include drop and impact tests. The second phase involves long-term tests to monitor the thermal and shielding performance with periodic inspections to measure any material or performance degradation.

A spent fuel disassembly and consolidation demonstration is planned to demonstrate the capability of achieving the operability and reliability goals. All key subsystems will be tested, including fuel disassembly and packaging, radioactive scale collection, volume reduction of hardware, canister decontamination, and associated handling apparatus. The scope and extent of any hot tests that may be needed will be determined from the results of cold tests.

3.3 REGULATORY COMPLIANCE

The objective of the Regulatory Compliance element is to obtain 1) applicable permits from the State of Tennessee, local governing bodies, and the Environmental Protection Agency (EPA); and 2) a license from the NRC to receive, prepare, and store spent nuclear fuel. This element identifies permitting and licensing requirements, ensures that the applications and supporting information for the required permits and licenses are filed with the EPA, state and local agencies, and the NRC at the earliest feasible time and ensures that appropriate regulations and agency standards applicable to the MRS facility are met.

3.3.1 Background

The MRS Program must comply with the requirements of the National Environmental Policy Act (NEPA), the regulations of the EPA and the NRC, and many specific federal, state, and local statutes, regulations, and standards. In addition, the DOE has developed standards for DOE-owned nuclear facilities that are applicable to the MRS facility. The DOE and other federal requirements are enumerated in Volume 2, Appendix C of this submission to Congress, Environmental Assessment for a Monitored Retrievable Storage Facility. The DOE will also comply with the applicable statutes and requirements of the State of Tennessee and the local governmental entities.

The DOE is committed to provide a safe and environmentally acceptable facility. The independent reviews and inspections specified in the regulatory requirements will provide additional assurance that public health and safety, environmental values, and socioeconomic impacts are adequately addressed during design, construction, and operation of the MRS facility. The permitting and licensing processes described below provide for review and approval by the agencies involved and for involvement of the public and other interested parties at various points in the processes.

The NWPA requires that the MRS facility, if approved by Congress, be licensed by the NRC. The NRC has indicated that they intend to use 10 CFR 72 as the basis for licensing the MRS facility (NRC 1984). The purpose of the licensing requirements is to protect the health and safety of the public and the environment. The licensing process used by the NRC provides for information dissemination to the public through NRC public document rooms and for review and comment on the NRC draft Environmental Impact Statement by federal agencies, affected state and local governments, and other interested parties. In addition, the regulations provide for public hearings, as needed, before a license is issued.

Since the NRC requirements pertain to all activities from site characterization through design, construction, operation, and decommissioning, the DOE has consulted with the NRC, as directed by the NWPA, during preparation of the conceptual designs and the proposal. In addition, the NRC observed and provided comments on a DOE design review and a quality assurance audit of the design process.

As a part of the conceptual design, a Regulatory Assessment Document was prepared to document, to a degree commensurate with this stage of the design process, the design features provided to ensure compliance with each requirement in 10 CFR 72. The Regulatory Assessment Document, Volume II of the Conceptual Design Report (Ralph M. Parsons Company 1985), references a preliminary evaluation of off-normal events and the design features that will provide for safe operation in spite of malfunctions or operational errors. The radiological impacts of postulated accidents are documented in Volume 2 of this submission to Congress, Environmental Assessment of a Monitored Retrievable Storage Facility. The conclusions drawn from these studies are that the facility design will provide the requisite level of safety, and the radiological impacts on the public will be well below EPA and NRC regulatory limits.

The reasons for these conclusions are:

- The radioactivity content and heat release of the five- (or more) year-old spent fuel to be handled at the MRS facility are much lower than that of freshly discharged fuel handled at reactors.

- The release of significant quantities of radioactive material can result only from an energetic driving force such as high temperatures or pressures which will not be present in an MRS facility.

- The multiple barriers used to prevent release of radioactivity are metallic containers, reinforced concrete, and highly efficient ventilation filters which are carefully engineered and tested and which have been routinely used for this purpose for more than 40 years.

- The facility is designed to limit any dispersal from 1) very unlikely events such as major earthquakes and 2) events which must be anticipated, such as dropping a spent fuel assembly.

The activities planned for regulatory compliance are summarized below. A more detailed description of the plans for licensing the MRS facility with the NRC is contained in Appendix D.

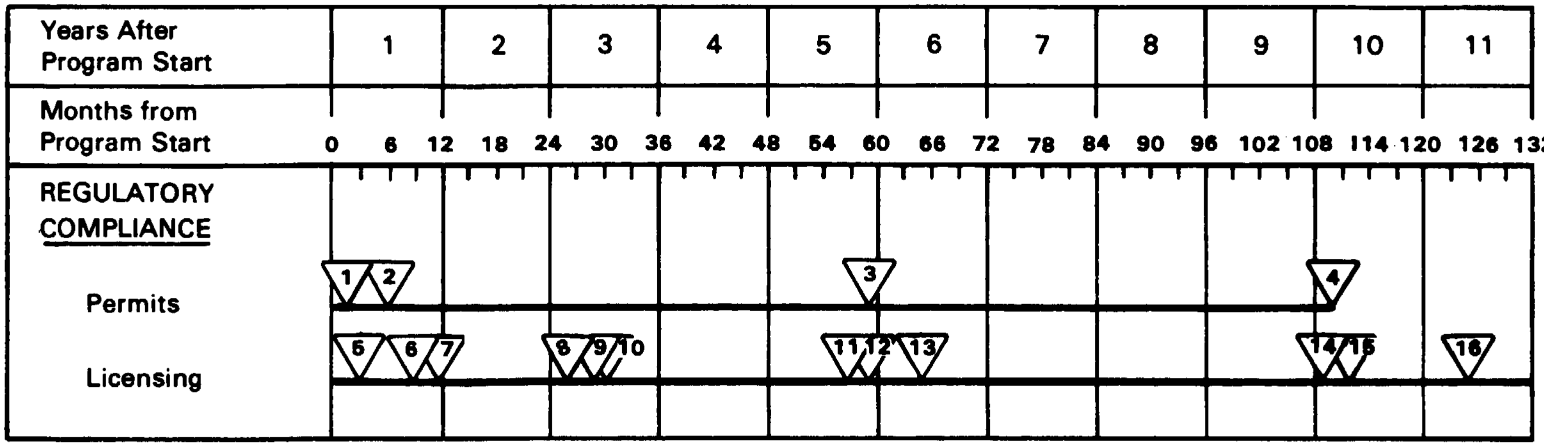
3.3.2 Planned Activities

The schedule for the Regulatory Compliance element is shown in Figure 3.3. After approval of the MRS proposal by Congress, the DOE will arrange meetings with the EPA, the NRC, and the State of Tennessee and local governments to discuss the plans for the facility and to obtain guidance on the requirements to be met and the permits or licenses to be obtained. A regulatory compliance plan will be prepared that will identify the times at which applications for various permits and licenses are needed, the data that must be provided in the applications, and the agencies that will issue the permits and licenses. The schedule of activities to obtain the necessary data and to make applications will be included in the plan. This plan will be the primary mechanism for providing guidance on regulatory matters to other program elements and for monitoring progress toward compliance.

State and Local Governments

State and local governmental requirements to which the MRS facility must conform include land-use and zoning laws; air, water, noise, and solid waste pollution control laws; hazardous waste disposal laws; transportation laws and ordinances, including carrier statutes and vehicle permit laws; state and local occupational and public health and safety laws; state environmental review statutes; and specific statutes pertaining to preservation of environmental values.

Specific permits and requirements will be identified early so that they can be factored into plans for site and regional data collection, for facility design, and for supporting utilities and the local infrastructure. Meetings with state and local officials in the early stages of the program will establish lines of communications that will promote mutual understanding of needs and requirements.



Milestones

Permits

1. Receive Site Investigation Permits
2. Complete Regulatory Compliance Plan
3. Receive Site Utilization Permits
4. Complete Permitting

Licensing

5. Establish Procedural Agreement with NRC
6. Begin Preparation of SAR
7. Submit First Topical Reports to NRC
8. Complete Safety Assessment and SAR
9. Submit License Application
10. LA Docketed
11. EIS Issued by NRC
12. License Received from NRC
13. Submit First Semiannual SAR Update
14. Submit Final Semiannual SAR Update and Final Technical Specifications
15. Submit Preoperational Test Criteria and Test Results to NRC
16. Submit First Annual SAR Update to NRC

FIGURE 3.3. Schedule for Regulatory Compliance

The Environmental Protection Agency

The EPA is responsible for protection of the general environment and has issued regulations for control of offsite releases of radioactivity, emissions of pollutants to the air or water, and disposal of solid wastes.

The environmental standards for the uranium fuel cycle and management of spent nuclear fuel and high-level wastes are contained in 40 CFR 190 and 191. These EPA standards are implemented by the NRC through their regulations, specifically 10 CFR 72, and through issuance of a license for the MRS facility.

The EPA has responsibility for implementing the Clean Air Act, the Clean Water Act, and the Resource Conservation and Recovery Act. Since the EPA delegates its regulatory authority to their regional offices and in some cases to individual states, coordination with these offices will be required. A listing of the related federal statutes and regulations is given in Volume 2, Appendix C of this submission to Congress, Environmental Assessment for a Monitored Retrievable Storage Facility.

Interactions with the NRC

To ensure that the MRS facility is deployed on a planned schedule, it is necessary that the DOE and the NRC reach agreement on the activities related to licensing that will be required of each agency. As soon as possible after congressional approval, the DOE will seek to enter into a Procedural Agreement with the NRC on plans and actions that will foster cooperation on planning of licensing activities including NEPA, and establish an open information exchange between the DOE and the NRC. The existing Procedural Agreement between the DOE and the NRC for the conduct of the geologic repository program serves as a precedent for agreements on the MRS Program.

One objective of the Procedural Agreement is to provide for meetings, prior to submitting a license application, at which appropriate management and technical personnel of both agencies could discuss plans, review progress, and facilitate the resolution of problems. The meetings will be open to the public. Another objective is to obtain agreement that NRC staff will review and comment on Topical Reports submitted to the NRC. The purpose of these reports will be to receive an NRC staff evaluation before completion of design and submittal of the license application, that the technical plans and analytic techniques are adequate to meet the requirements foreseen by the NRC.

Based upon interactions with the NRC, the EPA, and the State of Tennessee, the Regulatory Compliance element will develop guidance for the site investigation studies and definitive design. This guidance will be included in the Regulatory Compliance Plan, and used as input to update the bases for definitive design and to prepare a systems studies plan that specifies the optimization and design trade-off studies to be performed during the design.

Preparation of the NRC License Application

It will take about two and one-half years to develop all of the information required for the NRC License Application. Part 72 of 10 CFR requires that the application contain a Safety Analysis Report (SAR), an Environmental Report, and a number of plans for operations. The design and safety studies will be carefully planned and scheduled so that the SAR contains a safety assessment of the final design of all structures, systems, and components important to safety. The Regulatory Compliance element will ensure that the information required is available for preparation of the SAR at about the midpoint in the design process. The license application will be submitted about 4 months later.

The MRS Program schedule assumes that the NRC review process will take 30 months from application to issuance of a license. Although a longer review period may be required in the event of serious contentions which require extensive hearings and appeals, a shorter period may be sufficient in the absence of unresolved issues. The DOE believes that the scheduled 30 months is reasonable in view of the proposed pre-licensing interactions with the NRC.

NRC Requirements During Construction and Testing

After receipt of a license, the DOE will proceed with site preparation and construction. During this period, the major NRC requirements that will need to be addressed involve inspection and the assurance that quality standards specified in the design are met for purchased materials and equipment, and for major construction and installation and that the conditions of the license are met. The NRC also requires that an updated SAR be submitted semiannually throughout the period.

The final semiannual SAR update must be delivered to the NRC no later than 3 months before spent fuel is to be received at the MRS facility. The final semiannual SAR update will be followed by a report to the NRC containing the acceptance criteria and test results of the preoperational tests. This report must be submitted at least 1 month before the intended date for receipt of spent fuel.

After receipt of spent fuel, the preoperational tests will be continued in one cell at a time to test each component and system required in normal operation. The throughput rate of the facility will be judiciously increased during the hot demonstration period as more experience is gained in the use of the operating procedures and in the operating characteristics of the processes and equipment. All operations with spent fuel will be in accordance with the Technical Specifications approved by the NRC. In addition, the SAR will be updated on an annual basis in accordance with NRC requirements throughout the operational phase.

3.4 CONSTRUCTION

The objective of this element is to construct a licensed MRS facility from the drawings and specifications prepared by the Design element. Work to be undertaken in the Construction element includes procurement of equipment; selection of contractors; improvements to the site; and construction of the Receiving and Handling (R&H) building, the storage facility, and the support buildings.

3.4.1 Background

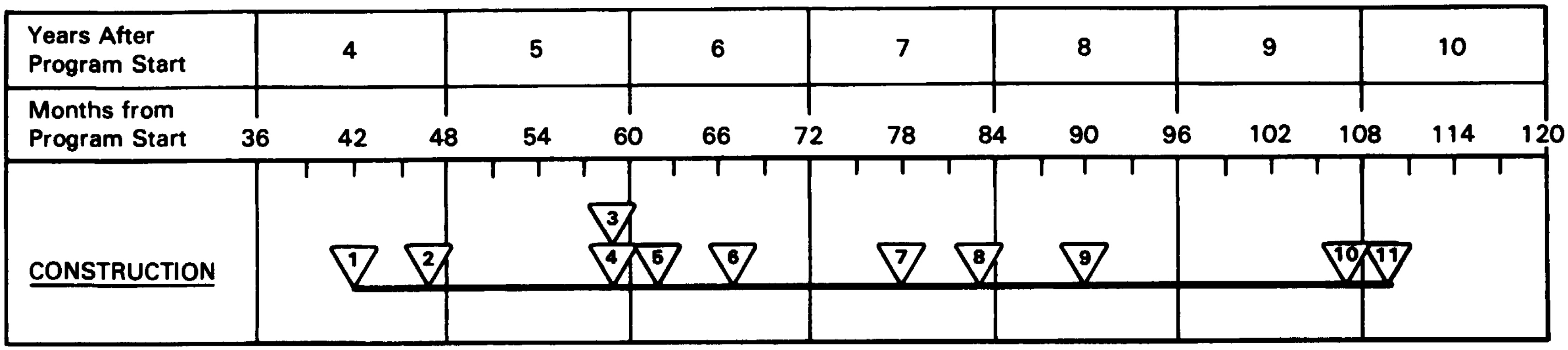
The conceptual design completed for the MRS proposal includes drawings, outline specifications for construction, cost estimates, and a construction schedule. Evaluation of the information developed in the conceptual design process leads to the conclusion that the facility can be successfully constructed at any of the candidate sites. The construction schedule and plans described below are based on the information developed in the conceptual design.

3.4.2 Planned Activities

The schedule for the Construction element is shown in Figure 3.4. Construction field work is not scheduled to start until the NRC issues a license for the MRS facility. Prior to receiving the license, procurement activities will be initiated for specialized equipment that require long lead times to obtain, particularly the R&H building equipment. This will ensure that material and equipment are available to support field work.

Construction will begin immediately upon receipt of the license from the NRC. The first step will be field work to improve the site so construction of the R&H building, the storage facility, and the support buildings can commence. Improvements to the site include clearing the land, constructing roads and railroads onsite and offsite, grading, installing drainage, installing fences, and landscaping. Fabrication of special equipment to be installed in the R&H building will also be initiated at this time.

Construction of the R&H building, the storage facility, and the support buildings will follow site improvement activities. Design work to date shows that the R&H building is on the critical path to completion of construction.



Milestones

1. Prepare Long Lead Item Bid Package
2. Solicit Bids for R&H Building Equipment
3. Begin Site Preparation
4. Begin R&H Building Equipment Fabrication
5. Begin Concrete Pours
6. Begin Consolidation Equipment Procurement
7. Complete Site Mockup Facility
8. Begin R&H Building Equipment Installation
9. Complete Consolidation Equipment Installation in Mockup Facility
10. Complete Equipment and Controls Installation
11. Complete Construction

FIGURE 3.4. Schedule for Construction

Therefore, R&H building construction will begin as soon as the needed site improvements are completed. Actions to procure consolidation equipment will also be initiated at that time.

Construction of the storage facility and the support buildings will be coordinated with construction of the R&H building. Included with the storage facility construction are the concrete cask support pads to be used with the sealed storage casks. The site services building will be constructed early since it will contain a mockup area of the R&H building hot cell. Prototype equipment will be installed in the mockup area for equipment testing and staff training in a nonradioactive environment.

Construction is estimated to be completed in about 50 months. The R&H building is on the critical path. This schedule is based on 2 shifts per day and 40 hours per week for each shift involved in constructing the R&H building. The schedule assumes no major work interruptions caused by bad weather or labor disputes. Construction of the other support buildings and storage areas is scheduled to be completed within the time-frame required for the R&H building.

The equipment and structures of the MRS facility are designed to be constructed using standard materials and normal construction practices. There will be no specialty items used in construction of the facility. There are many construction contractors with the experience and capabilities required to build the MRS facility. The quality requirements identified during the design period will be implemented by the construction contractors. Inspections will be planned and performed to conform with the QA plan and procedures. Quality assurance requirements will meet or exceed ANSI/ASME Standard NQA-1.

3.5 TRAINING AND TESTING

The objective of the Training and Testing element is to provide a trained staff and a tested facility that can function together to meet the MRS operating goals. Work to be undertaken in this element includes reviewing the design for operability and maintainability, preparing operations and maintenance manuals and procedures, monitoring construction, performing construction acceptance tests, preparing training manuals, and conducting preoperational systems tests.

3.5.1 Background

The Draft Mission Plan Amendment for the OCRWM Program proposed that an MRS facility receive 1200 MTU of spent nuclear fuel annually, starting in 1998 (DOE 1987a). To accomplish this mission, it will be necessary to have a trained and experienced operating staff and an operating facility ready for routine spent-fuel receiving and handling operations before commencement of facility operations. All handling, processing, and storage equipment must also have been tested and operated successfully.

3.5.2 Planned Activities

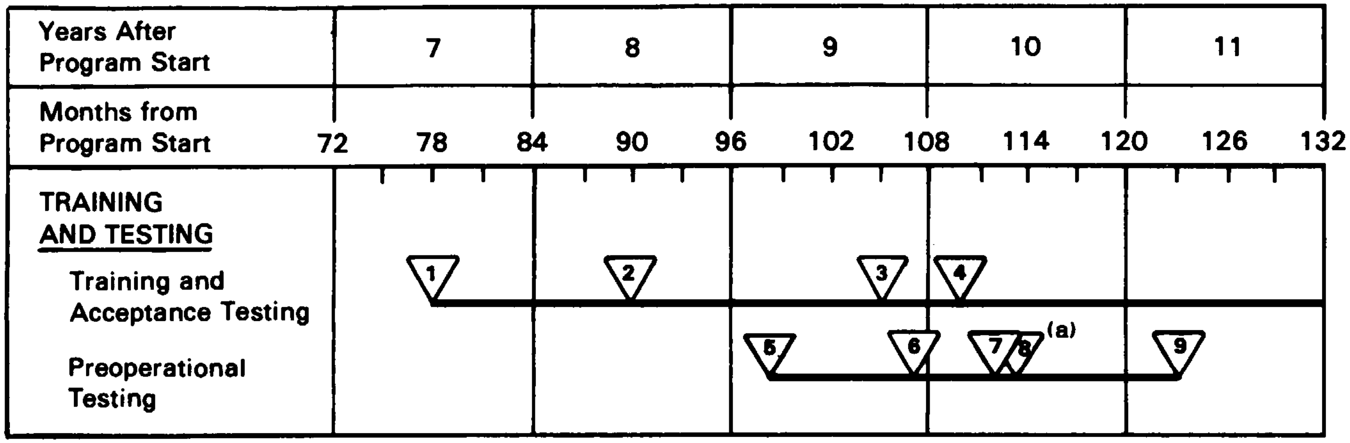
The schedule for the Training and Testing element is shown in Figure 3.5. Activities in this element are designed to ensure that the MRS facility and operations staff can safely perform their intended functions at the required throughput rates and in a manner that is consistent with product quality requirements. The training and testing plans will be part of the NRC license application and will be reviewed by the NRC.

Experienced operating and maintenance personnel will review the design for operability and maintainability. They will then prepare the training documents, operating and maintenance manuals, and operational test procedures. A number of these people, after becoming familiar with operation of the various systems and components, will be assigned to train additional operating and maintenance staff who will perform the preoperational tests. Others will be assigned to follow construction of the various MRS buildings and systems, to witness acceptance testing of these buildings and systems, and to become familiar with their functions, features, and installations.

To allow early testing of fuel-handling equipment and systems and training of the operators, the design of this equipment will be scheduled to permit early procurement. Construction of the mockup area in the site services building will be completed and the mockup fuel handling equipment installed early in the construction sequence to support the onsite training and testing program.

The first stage of training and testing related to the fuel handling operations will take place in the mockup area of the site services building. This area will be equipped with a full complement of cask and fuel handling equipment upon which operators and maintenance staff will be trained in remote handling and remote maintenance procedures. Using this mockup will allow remote handling operations to be tested at full scale in a nonradioactive environment. These prototypic tests will also permit modifications to be made to either the equipment or the operating procedures.

A team of operating personnel who have been trained in the mockup area will be qualified to perform the same tests and operations on a full complement of equipment installed in one of the hot cells. The first tests and demonstrations in the hot cells will not use spent fuel assemblies. If any problems with operating or maintaining the equipment are observed, the deficiencies will be corrected and the tests rerun until reliable operation is demonstrated.



Milestones

Training and Acceptance Testing

1. Begin Preparation of Training Documentation
2. Begin Operator Training
3. Begin Construction Acceptance Tests
4. Complete Construction Acceptance Tests

Preoperational Testing

5. Begin Preparation of Systems Test Plan
6. Begin Cold Systems Testing
7. Complete Cold Systems Testing
8. Receive Spent Fuel/Begin Operational Demonstration
9. Complete Operational Demonstration

[a] Contingent upon receipt of a construction authorization from the NRC for the first repository

FIGURE 3.5. Schedule for Training and Testing

These cold tests and demonstrations will be performed in succession in each of the remaining cells until each functions reliably. In addition, the operation of the radwaste and other systems and utilities will be tested. The test acceptance criteria and test results will be submitted to the NRC for review at least 30 days prior to planned receipt of irradiated fuel.

After operation of the equipment in a cell has been successfully demonstrated using dummy (nonradioactive) spent fuel, hot tests and demonstrations will be performed using spent fuel, again demonstrating successful operation in one cell at a time. All systems will be demonstrated to be operational. Operating procedures and manuals will be revised, as required, throughout testing and demonstration.

After the operating personnel are trained and qualified in the mockup area for hot operations in the R&H building, the throughput rate of the facility will be prudently increased. As the operating personnel become more familiar with operation and maintenance of the receiving and handling equipment and with load-out procedures to the storage facility, the processing times will be reduced and the throughput will be increased to rates that conform to full-scale routine operations.

3.6 OPERATION

The objective of the Operation element is to safely operate and maintain the MRS facility. The MRS facility operations consist of all activities associated with spent-fuel receipt, consolidation and canistering, temporary storage, and shipment to a repository.

3.6.1 Background

As part of the conceptual design activities, the operations and maintenance characteristics of the MRS facility were analyzed. The analyses included evaluations of operating and maintenance activities, equipment reliability and maintainability, operating staff size and skills, materials and equipment needed during operation (e.g., canisters, casks), and operating costs. These analyses, which were independently reviewed by persons with experience in the design, construction and operation of nuclear facilities, formed a large part of the basis for the planned activities identified for this element.

3.6.2 Planned Activities

The schedule for operation of the MRS facility is shown in Figure 3.6. The facility will become operational following completion of hot systems testing.

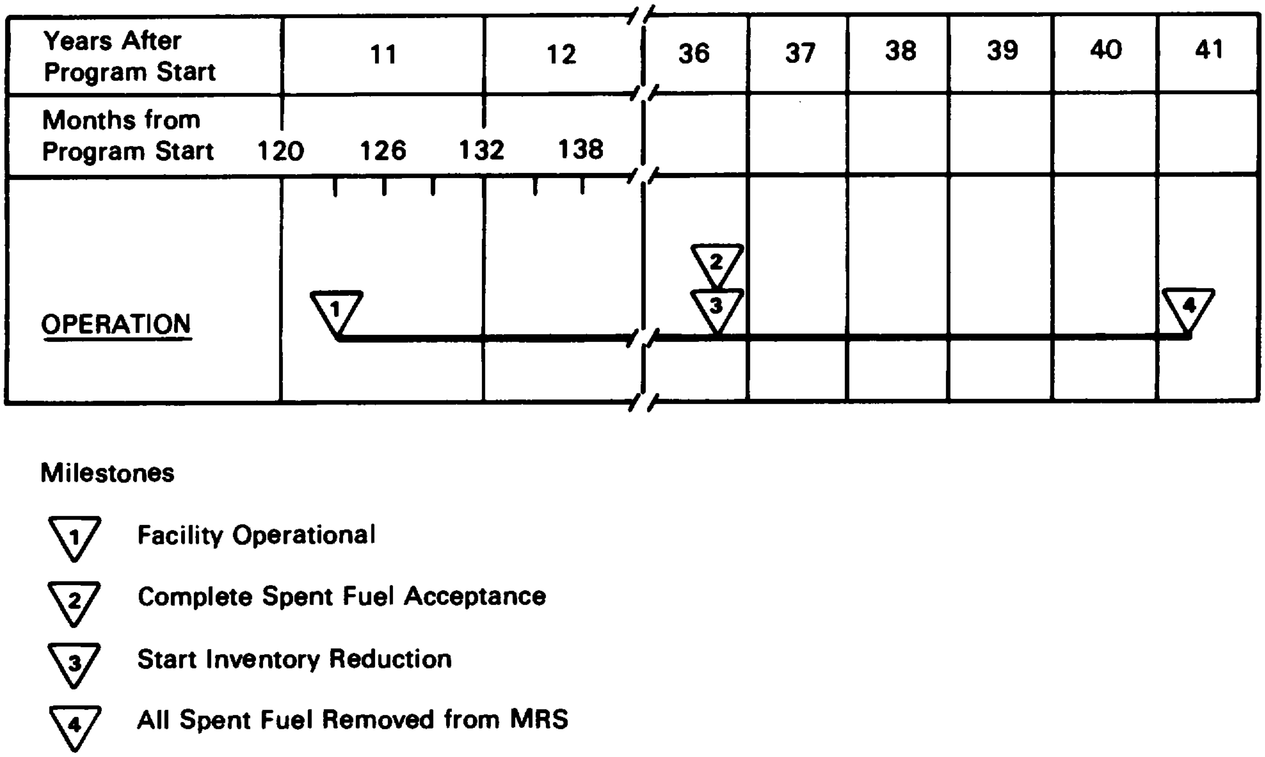


FIGURE 3.6. Schedule for Operation

The facility receipt rate will be 1200 MTU per year for 5 years, and then increase over the next two years to the planned throughput rate of 2500 to 3000 MTU per year (full-scale operation).

Spent fuel shipments from the MRS facility to the repository will commence in 2003 and will gradually increase to the planned rate of 2500 to 3000 MTU per year in 5 years. Full-scale MRS facility operation will continue for 19 years when spent fuel acceptance will cease and inventory reduction will begin. Operations will cease when all waste stored at the MRS facility has been removed, about 5 years after initiation of inventory reduction.

Shipments of spent fuel arriving at the MRS facility will enter the site through an inspection gatehouse. Following inspection, the shipment will be transported to the receiving and shipping area of the R&H building. Here the cask handling crew will remove the impact limiters, personnel barriers, tie-downs, etc. from the cask and vehicle. The cask will be lifted from the rail car or truck trailer and placed upright onto a cask transfer cart. The rail car/trailer will then be surveyed for radioactive contamination and decontaminated if necessary.

The loaded transfer cart is moved into the cask unloading room and mated to a shielded process cell loading port. A shadow shield is closed around the top of the cask, personnel leave the room, and a shielding door is closed, thereby shielding the cask unloading operation from the rest of the building. The remotely operated in-cell crane then removes the cell loading port shield plug and the cover of the shipping cask. The fuel assemblies are then remotely removed from the cask, identified, inventoried, and placed in an in-process lag storage vault. After all fuel has been removed from the shipping cask, the cask interior is checked for contamination, and cleaned if necessary. The cask lid is then returned to the cask and the cell access port is closed. The cask is surveyed for contamination and decontaminated if necessary before being placed on the rail car or truck trailer for shipment.

In the shielded process cells, spent fuel assemblies are remotely removed from the in-process lag storage vault, identified, and disassembled. The disassembly operation consists of cutting off the end fittings and pulling the spent fuel rods from the spent fuel assembly. The fuel rods are then consolidated into a tight bundle and placed in a canister. The fuel assembly hardware is shredded and placed in sealed drums for interim storage onsite in sealed storage casks.

The canister of consolidated fuel is then filled with an inert gas. The end cap is then welded on and the canister decontaminated, leak tested and ultrasonically tested for weld integrity. The canisters of consolidated fuel are then moved either to an adjoining lag storage vault for temporary retention, to a cask discharge port for loading into a sealed storage cask for onsite interim storage, or to a cell discharge port and loaded directly into a shipping cask for shipment to the repository. The disassembly, consolidation, welding and testing operations, and handling of fuel assembly hardware are performed remotely using cranes, robots, and master-slave manipulators. Viewing windows and closed-circuit television are used to observe operations and for visual inspection.

Decontamination and maintenance of in-cell equipment will be performed remotely either in the process cells or in the maintenance cell. Contact maintenance will be permitted in those instances when equipment can be successfully decontaminated to an acceptable level.

Radioactive wastes generated during operation of the MRS facility will fall into two general classifications: 1) high-activity wastes (HAW) requiring remote handling and shielded storage, and 2) low-level wastes (LLW) and contact handled TRU wastes (CHTRU) permitting contact handling and nonshielded storage. Wastes requiring shielded storage will be packaged in sealed drums or canisters and stored in sealed storage casks similar to those used to store spent fuel, until they can be retrieved and shipped offsite for disposal. Low-level wastes and CHTRU wastes that do not require shielded storage will be stored in a covered, compartmentalized vault until shipment. All liquid radioactive wastes resulting from decontamination or other onsite operations, will be concentrated, solidified in a concrete matrix, and packaged in sealed drums. No radioactive liquid effluents will be discharged from the MRS facility.

To ensure that all spent fuel and waste packages are properly constructed, tested, identified, documented, and inventoried, a dedicated staff of operations inspectors, quality control inspectors, and quality assurance personnel will observe R&H building operations and ensure that operating procedures adequately provide for quality.

A staff of health physicists will be assigned to the R&H building to monitor operations in radiation zones, perform radiation surveys, direct decontamination operations and prescribe special procedures and attire to be used when performing work in radiation or contamination zones.

Storage facility operations consist of transporting empty concrete storage casks from the cask manufacturing plant (not a part of the MRS facility) to the R&H building, welding the outer lid on the cask after loading it with fuel or waste, transporting the cask to the storage facility, and placing it on a storage pad. As appropriate, casks will be connected to a monitoring system with remote displays in the R&H building control room. The monitoring system will monitor the cask liner temperature. In addition, gas samples and pressure readings will be taken periodically from representative casks to verify continued integrity of the canisters of consolidated fuel. Removal of the canisters from the concrete storage casks for loading into a shipping cask prior to transport to the repository will be the reverse of the above operations. Air samples for radiation monitoring will be taken both inside and at the perimeter of the storage facility to detect any unexpected release of airborne radioactive materials.

To support the storage operation, a sealed storage cask manufacturer will be required to fabricate, cure, age, inspect and deliver up to a maximum of about 30 casks per month to the MRS facility over a period of about 10 years. It is likely that the manufacturer will construct a fabrication plant adjacent to or at least near the MRS facility. It is estimated that a work force of about 115 people will be required to perform these activities during this time period in order to provide storage casks for 15,000 MTU of spent fuel and associated waste.

The three major parts of the MRS facility are the receiving and handling (R&H) building, the support facilities, and the storage facilities. A total plant operating staff of about 600 employees will be required when the plant is operating at the planned throughput rate. About half of the operating staff will work in the R&H building. Their work assignments will be in the following areas: hot cell operations; cask and material handling operations; maintenance and plant operations; nuclear material accountability; quality assurance, quality control and inspection; health and safety; process analytical sampling and laboratory operations; general support and administration.

The other half of the operating staff will work in the various support facilities. Their work assignments will be in the following areas: maintenance and shops; safeguards and security; fire protection; quality assurance; quality control; health and safety; environmental sampling and laboratory operations; training; facilities operations, transportation and general support; and plant management, administration, and support. An operating staff of about 5 people will be assigned to the storage facilities for emplacement and retrieval operations.

During routine operation at the design throughput rate the MRS facility will be operated continuously on a 24 hours-per-day/5 days-per-week schedule. The facility will be in a standby mode 2 days per week. However, the MRS facility design includes sufficient flexibility to allow the facility to adapt to reasonable mission changes and/or operational perturbations. For example, the four disassembly/consolidation stations permit routine operation at the design throughput rate on a 3 shifts-per-day/5 days-per-week operating schedule. If need be, a cell can be taken out of production for an extended period to permit equipment modifications, or it may be set up to accommodate a special batch of fuel while the other three cells, operating on a 7-day week, can keep up the throughput until the fourth cell becomes available for routine operation again.

3.7 DECOMMISSIONING

The objective of the Decommissioning element is to release the site for unrestricted use after MRS operations are completed by decommissioning (and decontaminating as necessary) all facilities and equipment.[a] **Work involved in this element includes decommissioning the**

(a) The present plan for decommissioning the MRS facility assumes a starting point when the facility is no longer needed to accept spent fuel from utilities for packaging and shipment to the first repository. This plan may change depending on whether the MRS facility is used to service another approved repository or if the facility is put on a standby basis for possible involvement in waste retrieval operations as required under Section 122 of the NWPA.

sealed storage casks, the storage area, the R&H building, the protected area, the radwaste treatment facility, the analytical laboratory, the support facilities, and the limited access area for the MRS facility, as well as disposal of the residual radioactive materials.

3.7.1 Background

The Criteria for Decommissioning, 10 CFR 72.76, state that an MRS facility shall be designed for decommissioning. In consideration of this, the conceptual design for the MRS facility includes provisions to:

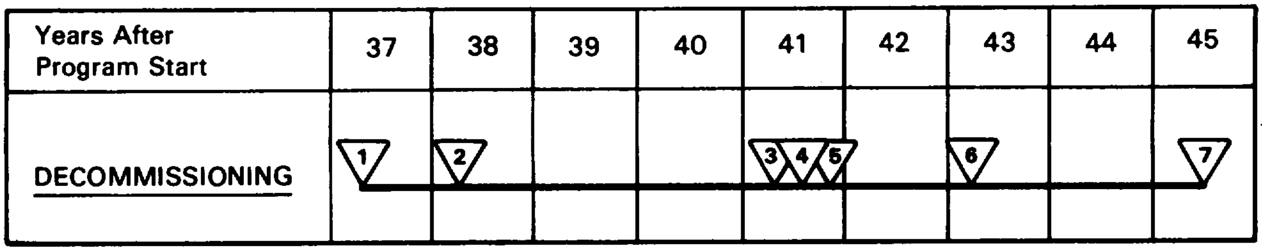
- facilitate decontamination of structures and equipment
- minimize the quantity of radioactive wastes and radioactively contaminated equipment
- facilitate the removal of radioactive wastes and radioactively contaminated materials at the time the facility is being permanently decommissioned.

To identify how the decontaminating and decommissioning could be accomplished, a decommissioning plan for the conceptually designed MRS facility was prepared. The decommissioning plan describes practices and procedures for decontaminating the site and facilities and for the disposal of residual radioactive materials. The proposed decontamination practices and procedures are designed to ensure that the decommissioning activity and the decommissioned facility will not jeopardize the safety of the public.

3.7.2 Planned Activities

The schedule for decommissioning the MRS facility is shown in Figure 3.7. All buildings and internal components will be decommissioned after all spent fuel and waste packages have been removed. However, complete removal of all structures, particularly the R&H building, is not planned. The R&H building will be designed to facilitate the entire decontamination and decommissioning efforts. Those facilities and equipment that cannot be decontaminated will be packaged and shipped to a final disposal site. Following thorough decontamination of the R&H building and disposal of items that cannot be decontaminated, permanent decommissioning will be accomplished by disposal of the major equipment that is not contaminated.

The decommissioning effort is divided into phases. The phases overlap to provide continuity of the decommissioning work. The first phase consists of decontaminating and decommissioning the sealed storage casks and those portions of the R&H building that are not needed for the load-out operations (e.g., the



Milestones

1 Start SSC Decommissioning

2 Start Disassembly Cell Decontamination

3 Start R&H Building Decommissioning

4 Complete SSC Decommissioning

5 Complete Storage Facility Decommissioning

6 Start Support Facility Decommissioning

7 Complete MRS Facility Decommissioning

FIGURE 3.7. Schedule for Decommissioning

disassembly cells). As the waste is removed from the sealed storage casks for shipment to the repository, the casks will be decontaminated and decommissioned. Since the spent fuel and waste are placed in sealed canisters before being emplaced in the sealed storage casks, it is expected that little or no decontamination of the casks will be required. The radioactive waste treatment facility and analytical laboratory within the R&H building will be kept in service to support this decommissioning effort. This phase is expected to take 4 years to complete.

The next phase consists of decommissioning the remainder of the R&H building including the radwaste treatment facility and the analytical laboratory. This phase is not expected to start until all spent fuel has been removed from the MRS facility. Also included in this phase will be the decommissioning of the remainder of the protected area. This phase is expected to require approximately 4 years beyond completion of the first phase.

The final phase consists of decommissioning the support facilities and the limited access area for the MRS facility. Since radioactive materials will be excluded from this area of the MRS facility during the life of the facility, the decommissioning effort for this area is expected to consist of simply dismantling and removing these facilities and restoring the site.

Disposal of the decontamination and decommissioning wastes will be consistent with the requirements for disposal and the disposal methods in existence at the time decommissioning begins. The details for decommissioning activities will be described in the decommissioning plan to be submitted to the NRC as a part of the license application.

3.8 INSTITUTIONAL INTERACTIONS

The objectives of the Institutional Interactions element are: 1) to ensure timely and full information exchange and appropriate participation between and among the DOE, the public, the state, and local officials relative to the further development and operation of the MRS facility; and 2) to ensure that state and local governments receive fair and reasonable financial assistance for the effects of construction and operation of the MRS facility, as described in the MRS proposal to Congress.

3.8.1 Background

Information exchange on the MRS Program between the DOE, the State of Tennessee and local officials, and the public began in the spring of 1985. At that time a grant was given to the State of Tennessee (which subsequently shared it with potentially impacted local governments) to study the DOE basis for, and proposed actions in, the MRS Proposal to Congress. The intent of this grant was to allow the DOE to benefit from comments from the state and to enable the state to provide a studied judgment on the MRS Proposal to Congress.

The DOE has shared information with state and local officials and has participated in a number of public meetings and meetings of task forces established by state and local governments to study the MRS Proposal. In return, the state and local governments have provided the DOE with information that was considered in development of the proposal. Documentation for the MRS Proposal was provided to the State of Tennessee for early review before it was submitted to Congress.

3.8.2 Planned Activities

The activities in the Institutional Interactions element are of such importance that they have been thoroughly described in the MRS proposal to Congress. They include initiating and establishing Consultation and Cooperation (C&C) Agreements with the State of Tennessee as required by the NWPA;

establishing an effective working relationship with state and local governments; providing mechanisms to assure the public that safety and environmental quality will be protected during the operation of the facility and transportation of spent fuel; and providing appropriate and reasonable assistance to affected government units.

Immediately following congressional approval of the MRS Proposal, the DOE will initiate interactions with the State of Tennessee directed toward establishing formal C&C Agreements for MRS activities. These agreements are expected to be signed within six months after approval of the proposal, as shown in Figure 3.8. It is anticipated that the local governments will work with the state to determine the nature and extent of their involvement in these agreements.

A public information program will be established to provide information on the MRS facility. This public information program will not be limited to the State of Tennessee, but will also address the national public information needs of the improved-performance waste management system, which includes the MRS facility. The MRS public information activities will be part of the coordinated OCRWM public information plan.

For specific details of the proposed interactions, the MRS Proposal to Congress should be reviewed.

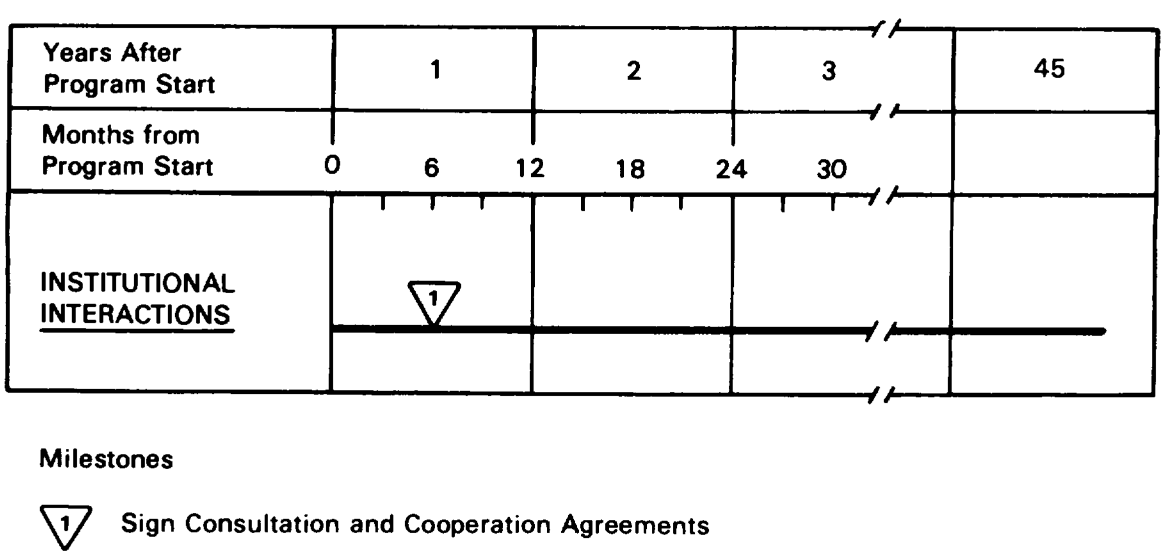


FIGURE 3.8. Schedule for Institutional Interactions

3.9 PROGRAM MANAGEMENT

The objective of the Program Management element is to manage the MRS Program in such a manner that program objectives are met within safety, quality, cost, and schedule goals. The work involves organizing, staffing, monitoring, controlling, and reporting all program activities.

3.9.1 Background

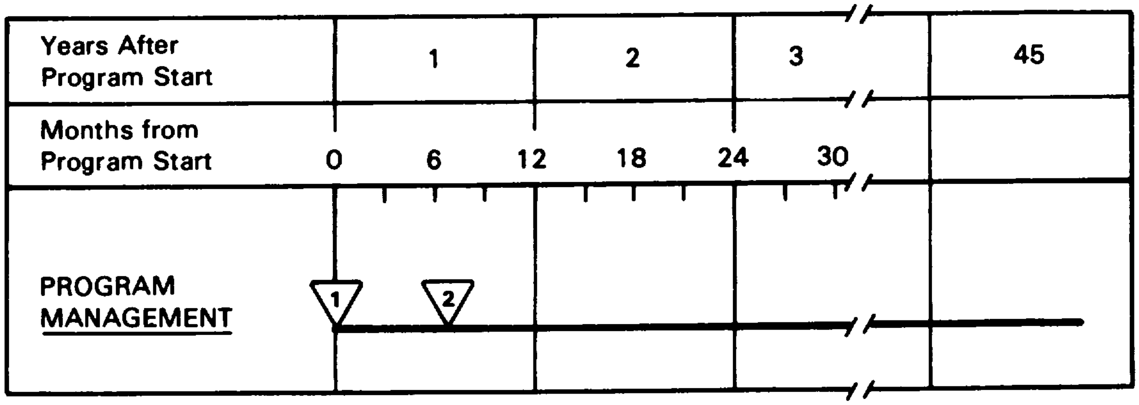
The DOE has established a project management system for programs that have a special significance in terms of national importance, exceed a specific dollar value (normally facilities with acquisition costs of $200 million or more), and are identified by DOE upper management as requiring special attention in project planning and control. Such projects are designated as Major Systems Acquisitions. The MRS Program has been designated as a Major Systems Acquisition and thus will be managed in accordance with the requirements of the DOE Project Management System (DOE 1983b). The DOE project management system was developed primarily for the management of projects that are executed by the DOE Operations Offices, and is therefore well suited to the management and control of the MRS Program.

3.9.2 Planned Activities

A schedule of planned activities for the Program Management element is shown in Figure 3.9. An MRS Project Office within the Oak Ridge Operations Office will be established and staffed upon congressional approval of the MRS proposal. Initial activities of the MRS Project Office will include finalization of the acquisition strategy for contracts involving design, construction, and operation of the facility. Maximum utilization of the private sector will be assured through competitive procurements for contractor-supplied goods and services, where possible.

A DOE management structure was established and staffed for development of the MRS proposal. This structure will require expansion and additional staffing for implementation of the MRS program if it is approved by Congress. The principal addition will be the creation and staffing of the MRS Project Office in Oak Ridge, Tennessee. These staffing additions will not result in a significant increase in the overall management resources required for OCRWM activities and will not deplete the management resources for the other OCRWM programs (e.g., repository program).

The principal contractor manpower needs are for design, construction and facility operation. Nuclear related experience will be necessary. Designers



Milestones

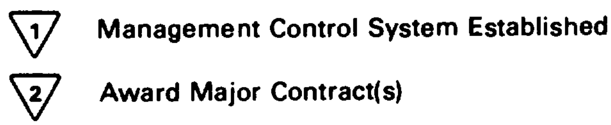


FIGURE 3.9. Schedule for Program Management

(about 250) will be needed primarily in the initial 4 years of the program. The maximum manpower required for construction is about 700 workers. Construction will extend over about a 4-year period. For operation of the MRS facility a staff of about 600 individuals will be required. These manpower requirements are modest and there are many firms qualified to perform these functions. A significant pool of qualified workers already exists in the area of the proposed MRS site.

A project management system will be developed and implemented that meets the requirements of the DOE Project Management System for major system acquisitions (DOE 1983b). Supporting management procedures will be developed and implemented for control, monitoring, and reporting progress of program activities.

A Quality Assurance Program consistent with the applicable QA criteria of DOE Order 5700.6A (Quality Assurance), the NRC's 10 CFR 50, and ANSI/ASME Standard NQA-1 will be established and implemented. All quality-related activities of the program will be planned, scheduled and documented to provide objective evidence of procedural adequacy and compliance. Quality overview will be provided by the OCRWM headquarters Quality Assurance Manager. To ensure that the proper degree of attention and authority are provided to QA in all MRS Program activities, the Quality Assurance Manager will report directly to the MRS Program Manager and will not be given any competing assignments. A clear line of responsibility and authority for QA throughout the program will be established and maintained.

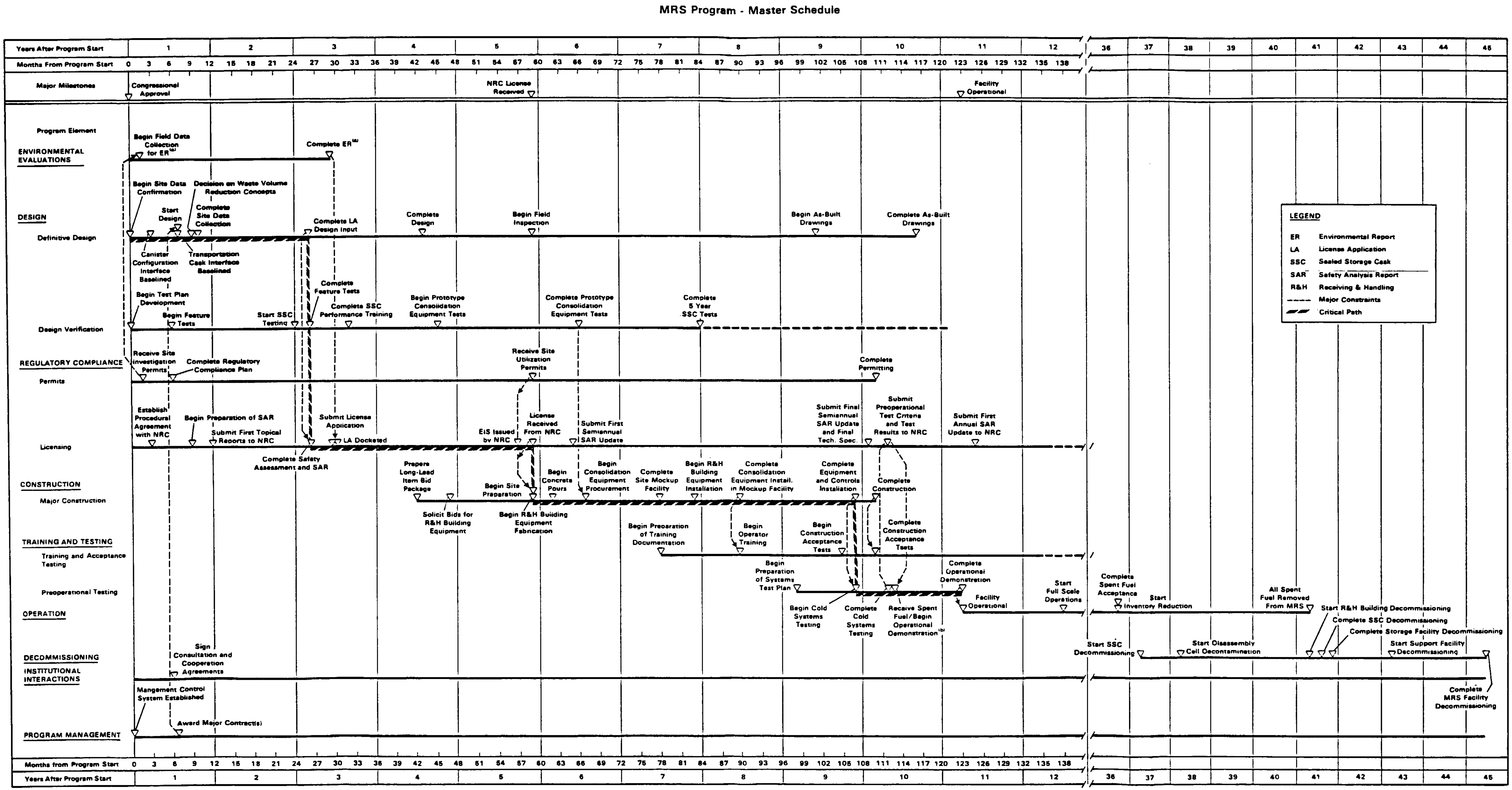
The OCRWM has developed an overall Systems Engineering Management Plan for all of its activities. A System Engineering and Configuration Management activity will be established to implement the OCRWM Systems Engineering Management Plan and to expand and extend it to the MRS Program. This activity is responsible for developing and maintaining the MRS Program technical baseline documentation. These baselines will initially consist of the Systems Requirements Document, the System Design Description, and a System Studies Plan. The MRS Program technical interfaces with the transportation program and the repository program will be documented and subjected to change control procedures to ensure that proper, up-to-date design information is available to all system participants.

A Program Planning and Control activity will be established to maintain program schedules, measure and analyze performance, and provide budget and schedule forecasting. This activity will support the Systems Engineering and Configuration Management function in analyzing schedule compatibility with the transportation system and the repository programs.

3.10 MASTER SCHEDULE

This section describes the MRS Program master schedule, and discusses the critical path. The schedules discussed in Sections 3.1 through 3.9 were taken from the program master schedule shown in Figure 3.10. They showed the program milestones by program element. The program elements are all interdependent, so that information developed in one element is needed to complete milestones in other elements. The program master schedule, Figure 3.10, shows major constraints as vertical dashed lines. The milestones at arrowheads cannot be completed until after the connected milestones are complete. The figure also shows the critical path to facility operation. For activities on the critical path, extensions of the time for their completion potentially delays facility operation day-for-day.

For these activities, extra effort was expended to verify the reasonableness of the time estimates. The construction schedule is based upon a detailed analysis by the architect-engineer of the many parallel and sequential activities that would occur during construction. The licensing schedule and its uncertainties were discussed with the NRC staff. The NRC staff agrees that 30 months is a reasonable planning base, recognizing that only their review schedule, and not the schedule for public hearings, is under their control.



(a)The precise nature of this document will be dependent on the provisions of any authorizing legislation

(b)The shipment of spent fuel to the MRS facility is contingent upon receipt of a construction authorization for the first repository. The revised schedule for the first repository in the Draft Mission Plan Amendment contemplates receipt of such authorization by the first quarter of 1998.

FIGURE 3.10. MRS Program Master Schedule

The MRS facility, as designed, does not require research in unproven areas of technology. Thus, the DOE has confidence in the schedule.

Sections 3.1 through 3.9 provide detailed discussions of the milestones for the individual elements. Discussion here will concentrate on the critical path and the constraints which led to identification of the critical path. Following congressional approval, the critical path intially goes through the Design element. The two critical early activities are 1) confirmation and collection of site data for design and 2) award of major contract(s). While extensive site data is on hand and needs only to be verified, additional geotechnical data will need to be collected for the foundation designs and for the Safety Analysis Report to the NRC. Site investigation permits might be required to collect the additional environmental, geologic, and hydrologic data. Data collection is scheduled to take approximately ten months. The ten-month period is considered to be a reasonable amount of time to obtain this standard design information because extensive data already exists from excavation and design for the canceled Clinch River Breeder Reactor.

Procurement of the major contractor(s) is scheduled to be initiated immediately upon congressional approval of the MRS proposal. Procurement is on an expedited schedule. The initiation of design activities is not dependent upon having complete site data, so that design and data collection can proceed simultaneously for several months.

It is planned that sufficient information will be available by the midpoint in the design to complete the design input to the license application. The key inputs are safety assessments of the site and the MRS facility. These assessments are required to complete the Environmental Report and the Safety Analysis Report. These reports are the most time-consuming of the efforts required to prepare the license application. The NRC review of the license application and the potential hearings held by the licensing board then become the critical path activities. They are expected to take about 30 months, during which time the remainder of the design work will have been completed. Extensive coordination and consultation between the NRC and DOE staffs, which was begun during the preparation of the MRS proposal, is expected to limit the number of environmental and safety issues which will arise during the license review.

The DOE will not initiate construction of the MRS facility until a license is received from the NRC. After receipt of the license, site preparation and construction can begin. Construction of the R&H building becomes the critical path because of its size and the need to sequentially pour concrete for one floor of the R&H building at a time and then cure and remove the shoring of the upper floors before installation of services in the lower floors. The completion of the building constrains the installation of the handling, disassembly, and consolidation equipment in the R&H building.

The procurement and demonstration of reliability of the disassembly and consolidation equipment is important to achieving the schedule. However, it is not on the critical path because it appears that sufficient time exists from the completion of design (which constrains procurement of all long-lead-time items) to installation of the equipment in the R&H building.

Operator training cannot take place in the mockup training facility until the equipment is installed. However, there is sufficient time for training, so that construction remains on the critical path until the major equipment, services, and controls are completely installed in one of the R&H building receiving and handling cells. At this point the operators will have been trained on prototype equipment in the training facility and will be ready for a complete systems check on the first receiving and handling cell. The preoperational systems tests then remain on the critical path through the completion of the operational demonstration. During this testing and demonstration period, construction of other facilities will proceed, and each building or system will be accepted from the construction contractor as it is completed.

Operational testing and demonstration is scheduled to take 16 months. Demonstration activities include both cold and hot testing: a series of cold systems tests; operations using spent fuel to test the waste treatment systems, shielding, and remote operations; and the ramp-up to significant processing rates. The facility is scheduled to be operational 123 months after congressional approval. The ramp-up to full-scale operations is scheduled over a six year period.

4.0 INTEGRATION PLAN

This chapter discusses the interfaces and integration of the MRS Program with the schedules of other OCRWM programs and with other storage and disposal facilities authorized in the NWPA.

The analysis of the integration of the MRS schedule for compatibility with the schedules of the other DOE waste management programs, e.g., the reference schedule for the first repository (DOE 1985b and DOE 1987a) and the transportation program schedule (DOE 1986a), is based on an assumption that congressional authorization will be received in July 1987 and that the MRS Program will be initiated immediately thereafter. Both technical and administrative interfaces were considered. The schedules of the other programs were reviewed to determine their compatibility and constraints. In some instances, integration of the MRS facility into the waste management system will require additional or changed activities in the other programs. For example, additional early definition and configuration control of technical interfaces involving waste forms and shipping casks will be required.

To ensure the required and continued functional integration of the waste management programs, the DOE is preparing a Systems Engineering Management Plan. This plan will implement a systems engineering approach to the integration of the repository program, the transportation program, and the MRS Program. The plan includes preparation of documents and management procedures to describe the waste management systems in terms of its component facilities; the allocation of functional requirements of the system to its components; establishment of technical baselines, including interface requirements, and change control procedures for each component; and provision for management assessments and reviews. In addition, the current OCRWM management system provides a disciplined cost and schedule control capability that ensures effective program management. The following discussion of interfaces and schedule integration is based on the integrated waste management schedule presented in Figure 4.1.

The Idaho National Engineering Laboratory is conducting a Prototypical Consolidation Demonstration Project which will demonstrate rod consolidation, canister welding, and non-fuel bearing component volume reduction techniques. Although this project was initiated to support the design of the surface facilities at the first repository, its results will be used for the MRS facility, if approved by Congress.

The Prototypical Consolidation Demonstration Project will provide confirmation of MRS design concepts and identify potential problem areas requiring resolution. The Prototypical Consolidation Demonstration Project test plans

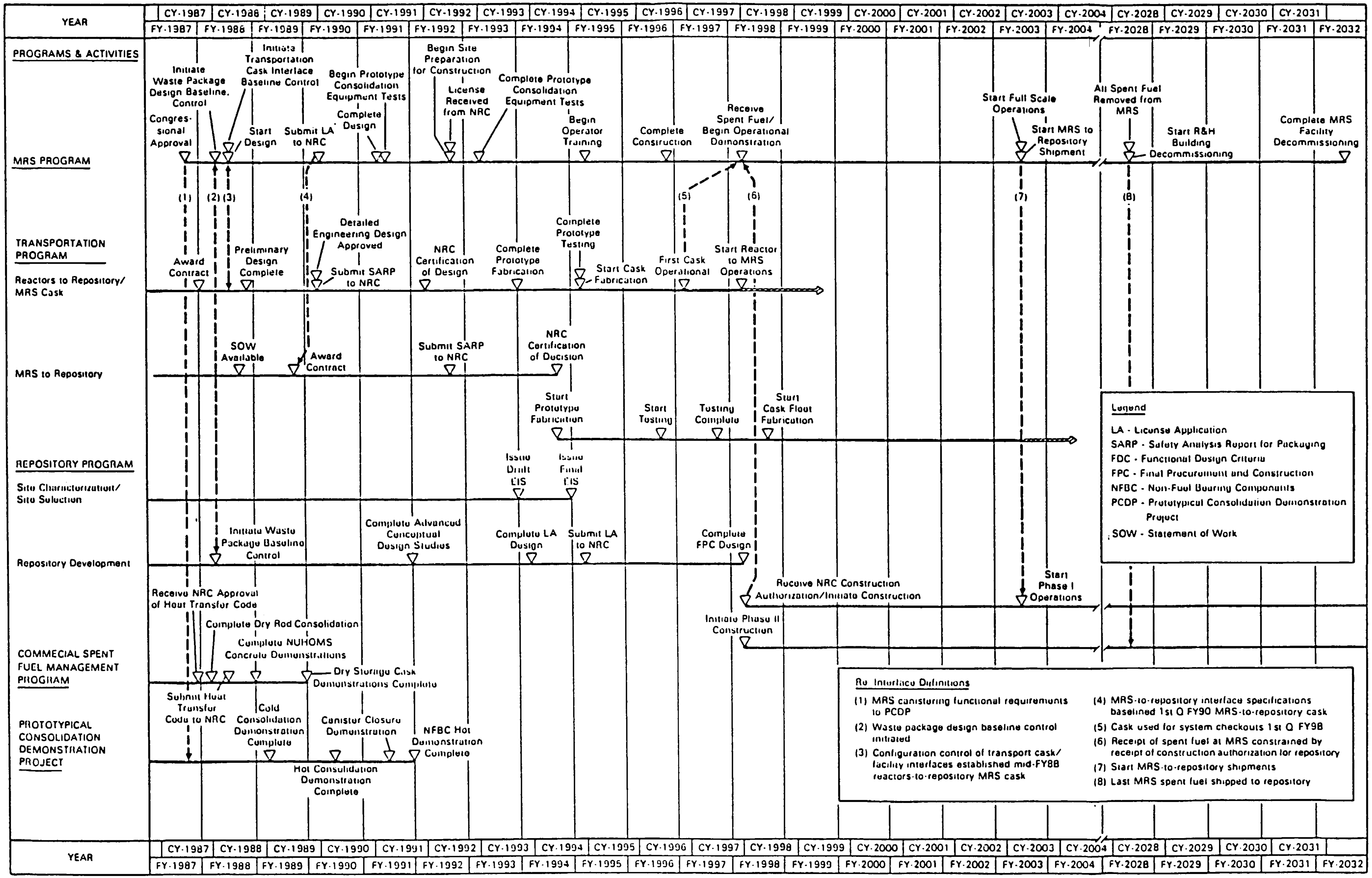


FIGURE 4.1. OCRWM Integrated Schedule (assumes MRS Program starts July 1986)

and schedule will be closely monitored and changes made if necessary to support MRS definitive design. The MRS facility design will be completed shortly after the completion of the demonstration project.

The transportation system schedule for the design of shipping casks is compatible with the MRS design data needs for cask interface and handling information. However, joint control with the transportation program of cask interface configurations must be established at the start of MRS design.

The schedule for the advanced conceptual designs for the repository will not be affected by the integration of an MRS facility into the system. However, the surface facility design requirements will be simplified because the MRS facility will do much of the spent fuel packaging currently included in the repository program plans. The site for the repository will not be selected until 1998. Currently, each repository program is considering a different configuration of waste canister and disposal container. The MRS design will be sufficiently flexible to accept whichever physical configuration is required for the selected geologic medium. An OCRWM Waste Package Coordination Group is currently studying the possible design of a common canister. An agreement between the MRS Program and the repository program on an envelope of possible waste canister designs can be reached by December 1987 and would meet MRS and repository schedule requirements.

The DOE's Civilian Radioactive Waste Management Program is developing spent fuel storage and consolidation information. The particular areas of interest to the MRS Program are:

- The NUHOMS[a] dry storage demonstration (part of the Commercial Spent Fuel Management Program and in conjunction with Carolina Power and Light Co.) in concrete modules. This program was started in March 1984 and will be completed in 1988. The program will demonstrate dry storage of PWR spent fuel assemblies in metal canisters inside concrete modules. Confirmation of heat transfer, shielding design, and dry storage will be obtained.

- The Prototypical Consolidation Demonstration Project. This engineering development program was started in 1985 and will be completed in 1990. The program will demonstrate dry consolidation of about 100 PWR and 100 BWR spent fuel assemblies at INEL, followed by dry storage. An early (1987) technology activity in this program will consolidate 48 PWR assemblies and store them in canisters and dry

(a) NUTECH Horizontal Modular Storage (NUHOMS) is a concrete storage module housing a double-sealed metal cask containing up to seven intact PWR assemblies.

metal storage casks. This activity will provide early consolidation process data and the consolidated fuel in casks will be used to validate and qualify heat transfer codes for application to dry storage of consolidated spent fuel rods.

The MRS Program will monitor these programs for compatibility with MRS designs.

In early 1984, the DOE issued a broad Program Research and Development Announcement aimed at identifying and researching various concepts that would enhance the overall performance of the waste management system. The majority of the concepts being evaluated under the Program Research and Development Announcement address various hardware developments that could be applied on a system-wide basis to enhance system efficiency and reduce system costs. These concepts include the use of various spent fuel canister shapes and configurations, the system-wide usage of extra large shipping casks, the evaluation of a mobile fuel rod consolidation system for at-reactor consolidation, and the feasibility of metallic cask systems for storage, transportation and disposal purposes. The preliminary results from these studies indicate that system benefits can potentially be accrued from the implementation of some of these concepts. Of the seven PRDA cask and canister concepts submitted for evaluation, the dual-purpose (transportable storage) cask and square/half-square canisters were selected for further investigation regarding their potential utilization in the waste management system. Definitive conclusions have not been reached at this time. However, those concepts appear to have merit in either the authorized system or the improved-performance system.

The transportation program schedule for providing the first operational reactor-to-MRS facility shipping cask is compatible with the MRS Program schedule. The MRS Program will work with the transportation program to ensure that the transportation system cask fleet procurement schedule meets the waste management system shipping needs.

The shipment of spent fuel from the MRS facility to the repository is dependent upon the existence of the large rail casks suitable for dedicated trains. The date by which the transportation program will be ready to initiate such shipments (see Figure 4.1) is also compatible with the MRS Program schedule. MRS facility spent-fuel shipment rate requirements will be coordinated with the transportation program upon approval of the MRS proposal by Congress.

The MRS facility operation will conclude with shipment of the last stored spent fuel to the repository. The MRS facility will then be decommissioned.

In summary, the schedule for the waste management system with an MRS facility as an integral component of the system has been thoroughly analyzed and the MRS schedule integrates well with those of the other system components.

The DOE has also established management systems and procedures for controlling the interfaces in the development and operation of an improved performance waste management system.

5.0 FUNDING PLAN

The NWPA requires that the MRS proposal shall include "...a plan for the funding of the construction and operation of such facilities, which plan shall provide that the costs of such activities shall be borne by the generators and owners of the high-level radioactive waste and spent nuclear fuel to be stored in such facilities." The NWPA also establishes "...a separate fund, to be known as the Nuclear Waste Fund"..."for purposes of...the identification, development, licensing, construction, operation...of any...monitored retrievable storage facility constructed under this Act."

The DOE has considered different approaches to fund the MRS Program including the imposition of special charges on owners and generators of high-level waste and spent fuel in lieu of using funds from the Nuclear Waste Fund. Based on the analyses and supporting information presented in Appendix E of this Program Plan, the DOE is recommending that the MRS Program be financed through the Nuclear Waste Fund. With this approach, all generators and owners of high-level waste and spent fuel will pay for the MRS facility through the fee of 1.0 mill per kilowatt hour of electricity generated as specified in Section 302(a)(2) and (3) of the NWPA.

The proposed approach of financing the MRS facility through the Nuclear Waste Fund is administratively simple and conforms with the philosophy and provisions of the NWPA. Furthermore, the MRS facility confers benefits directly or indirectly to all contributors to the Nuclear Waste Fund through improvements in waste management system development, deployment, integration and performance, and through provision of a cost-effective capability to accommodate potential repository schedule changes (Volume 2, of this submission to Congress, Environmental Assessment for a Monitored Retrievable Storage Facility, Part 1, "Need for and Feasibility of Monitored Retrievable Storage").

The plan for funding the MRS Program is as follows:

1. The MRS Program will be financed through the Nuclear Waste Fund.

2. Although the federal waste management system is self-financing, the amount of money allowed to be spent from the Nuclear Waste Fund is governed by the federal budget process. The NWPA requires that a budget be submitted for the Nuclear Waste Fund and that appropriations be subject to triennial authorization. A Fund Management Plan (DOE 1984b) has been developed for implementation. The budgeting and financial management of the MRS Program will be in accordance with the DOE Fund Management Plan.

3. Each year, the annual costs from the most recent update of the MRS Program cost estimates will be converted into a budget request and incorporated into the overall Nuclear Waste Fund budget request. This budget request will go through the federal budgeting process and be subject to congressional authorization and appropriation.

4. Disbursement of authorized and appropriated funds for the MRS Program will be controlled and reported according to DOE Order 2200, "Financial Management of Civilian Nuclear Waste Activities" (DOE 1984c).

5. The DOE will continue to conduct an annual review of the 1-mill per kWh fee for waste disposal to determine whether the revenues will be sufficient to finance the total system costs of the federal waste management system, including the cost of the MRS facility. If it is determined that the fee is inadequate to assure full cost recovery, an adjustment to the 1-mill per kWh fee will be proposed.

The life-cycle costs of deploying, operating, and decommissioning an MRS facility employing the sealed storage cask design at the Clinch River site in Tennessee are estimated in the DOE total system life-cycle cost (TSLCC) estimates (DOE 1987b) which are updated annually. The TSLCC analysis estimates the costs of the total waste management system including development and evaluation costs, first repository costs, second repository costs, and MRS costs applied to a variety of combinations of repository sites. These cost estimates are used to evaluate the adequacy of the waste fund fee that finances the waste program. For the six combinations considered by the TSLCC analysis, the inclusion of an MRS facility in the waste management system reduced the first repository costs by approximately $0.9 to $1.4 billion depending on the specific repository site. Transportation costs for these scenarios ranged from a reduction of $0.3 billion to an increase of $0.1 billion. For the combinations analyzed, the costs for MRS resulted in a net increase in system costs from $1.5 to $1.6 billion or, translated to percentages, a 4% to 5% increase in total system costs.[a]

Based on results of the 1986 fee adequacy review (Engel 1986), and the DOE's assessment of the projected growth of the U.S. nuclear economy, the Nuclear Waste Fund generated by the current 1-mill per kWh fee will be adequate for funding the improved-performance waste management system (including an integral MRS facility). Consistent with the funding plan described above and with past practice, the annual review of fee adequacy for FY-1987 is currently being conducted, using updated waste management system cost estimates and revenue projections. If this review should indicate that the 1-mill per kWh

(a) All costs and funding requirements presented in this chapter are quoted in 1986 dollars.

fee does not generate sufficient revenue to achieve full-cost recovery for the approved program, an adjustment to the fee will be submitted for congressional approval. Past analyses have shown that the current 1 mill/kWh is adequate to recover program costs for a reasonable range of nuclear electric generation, interest, inflation, and program cost forecasts. These analyses also show that at some future time an adjustment to the fee, such as indexing it to an inflation or other cost index, may be necessary to keep pace with increased costs due to inflation. The addition of the MRS facility is not expected to be a major factor in causing an increase in the fee because its relatively small (4% to 5%) cost impact on the system is well within the uncertainty bounds of the other factors affecting fee adequacy.

Table 5.1 presents the estimated annual costs for the proposed MRS Program. The cost of the program from the time of congressional approval until the facility becomes operational, plus decommissioning, will be approximately $990 million. From this total, approximately $710 million of capital funds will be used for facility design and construction. The total annual costs will be heaviest during the construction and initial operation years, ranging from about $50 million to about $190 million. When the MRS facility is in steady-state operation, the annual cost is estimated to be about $73 million per year. The total cost for facility decommissioning is about $83 million.

Cost data for the six site-design combinations, and the methods and assumptions used for cost and funding evaluations are discussed in Appendix E.

TABLE 5.1. Estimated Annual Costs for the MRS Program[a]

Stage or Item	Year	Millions of 1986 Dollars[b]
Program start[c]	1	24
	2	36
	3	41
	4	35
	5	53
Construction begins	6	158
	7	186
Training begins	8	189
	9	139
Construction complete	10	36
Operation starts	11	108
	12	90
	13	111
	14	100
	15	111
	16	120
Full-scale operation	17	99
	18	73
	19	73
	.	.
	.	.
	34	73
	35	74
	36	63
Start decommissioning	37	26
	38	26
	39	26
	40	27
All spent fuel removed	41	28
	42	22
	43	21
	44	15
Complete facility decommissioning	45	13
TOTAL MRS FACILITY		3225

(a) Source: Appendix E.
(b) Rounded.
(c) Congressional approval of MRS Proposal.

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7.0 GLOSSARY

ALARA - as low as reasonably achievable.

ANSI - American National Standards Institute.

ANSI NQA-1 - American National Standards Institute Quality Assurance Requirements for Nuclear Facilities.

ASME - American Society of Mechanical Engineers.

canister - The first material envelope surrounding a waste form (e.g., spent fuel rods) to provide containment for handling and storage purposes.

CFR - Code of Federal Regulations.

consolidation - The disassembly and packaging (reconfiguration into a close-packed array) of spent fuel rods to achieve volume reduction, thereby reducing the space required for storage, transportation, or disposal.

container - A metal barrier placed around a waste canister prior to disposal to meet the requirements of 10 CFR 60. The container provides the second level of containment.

containment - The sealed isolation (complete retention) of radioactive waste within a designated boundary or vessel in a manner that prevents its release to or contact with the surrounding environment.

decommissioning - The removal from service (at the end of its useful life) of an MRS facility and its related components in accordance with regulatory requirements and environmental policies.

decontamination - The removal of radioactive material from an MRS facility, its surrounding soils, and its equipment by washing, chemical action, mechanical cleaning, or other techniques.

disposal package - The primary container that holds, and is in contact with, solidified high-level radioactive waste, spent nuclear fuel, or other radioactive materials, and any overpacks that are emplaced at a repository.

DOE - U.S. Department of Energy.

DOE-OCRWM - Office of Civilian Radioactive Waste Management, U.S. Department of Energy.

dry storage - Storage of spent nuclear fuel or high-level waste surrounded by one or more gases (e.g., air, argon, helium) and no use of cooling liquids (e.g., water).

EA - Environmental Assessment.

EIS - Environmental Impact Statement.

ER - Environmental Report.

field drywell - An individual, stationary, inground, metal-lined cavity for storing one or more canisters or drums containing high-level waste or spent nuclear fuel. Shielding is provided by the surrounding earth and a shield plug. Heat dissipation is by conduction through the plug and earth to the atmosphere and also by thermal radiation.

high-level waste (HLW) - High-level radioactive waste. The highly radioactive waste material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in the first processing cycle in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations. Also, any other radioactive material that requires permanent isolation, as determined by the U.S. Nuclear Regulatory Commission.

integral MRS concept - The concept whereby an MRS facility would receive, process, package, store, and ship to the repositories all spent fuel and certain other wastes requiring permanent disposal, and thus serve as an "integral" part of the federal waste management system. In this role, sufficient storage would be provided to accommodate disruptions in operations.

MWD/MTU - megawatt days per metric ton uranium.

MRS - monitored retrievable storage.

MRS facility operations - All functions at an MRS site leading to and involving the handling and/or storing of radioactive waste and spent fuel in the facility, including receiving, onsite transport, handling, packaging, consolidating, canistering, emplacement, retrieval, and load-out for equipment to a repository.

MRS support facilities - All permanent facilities constructed to support the operation of the MRS receiving and handling building, including structures, utility lines, roads, railroads, and similar facilities, but excluding the storage facility.

MTU - metric tons of uranium.

NRC - U.S. Nuclear Regulatory Commission.

NWPA - Nuclear Waste Policy Act of 1982.

package - The act of preparing spent nuclear fuel for storage, shipment, and/or final disposal. Includes disasembly and consolidation of the spent fuel, placement of the consolidated spent fuel in canisters, and placement of canisters into disposal containers.

R&D - research and development.

receiving and handling (R&H) building - The primary operating building of an MRS facility. The R&H building is designed to physically contain and control all radioactive material being handled or generated by process operations and includes space and equipment for all spent fuel operations (e.g., receiving, disassembly, packaging) and all HLW and RHTRU operations (e.g., canister receiving, handling, and shipping).

repository - A facility consisting primarily of mined cavities in a deep geological medium and associated support facilities for the permanent disposal of spent nuclear fuel and high-level waste.

site evaluation - Activities undertaken to establish the environmental, meteorological, socioeconomic, and geologic conditions and the ranges of the parameters of a site relevant to the location of an MRS facility, including borings, surface excavations, and in-situ testing needed to evaluate the suitability of a site.

spent nuclear fuel - Irradiated nuclear reactor fuel that has reached the end of its useful life.

storage - The retention of radioactive waste in a retrievable manner that requires surveillance and institutional control.

throughput - The average rate at which an MRS facility can receive, inspect, consolidate, and package spent fuel.

translocading - The transfer of freight from one carrier to another; specifically, the transfer of a cask containing spent fuel or high-level waste from a transport truck to a rail car either by "piggybacking" the truck trailer on the rail car or by physically transferring the cask from the truck to the rail car.

APPENDIX A

OPERATIONAL CHARACTERISTICS OF THE IMPROVED-PERFORMANCE SYSTEM

APPENDIX A

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The Mission Plan for the Civilian Radioactive Waste Management Program (DOE 1985a) discusses two alternative federal waste management systems for spent nuclear fuel and high-level radioactive waste. In the first, the "authorized system," the primary federal facilities are two repositories, the first of which has been authorized by Congress, and a federally managed waste-transportation system. The second system, the "improved-performance system," contains, in addition, an integral MRS facility such as the DOE is proposing to construct. The Draft Mission Plan Amendment (DOE 1987) further discusses the federal waste management system with an MRS facility as an integral component of that system. This appendix describes the operational characteristics of the improved-performance system, with emphasis on the MRS facility's role in that system.

The basic facilities and materials flows involved in the improved-performance system are shown in Figure A.1. The components involved in operating this system are:

- The nation's commercial power reactors, owned and operated by U.S. utilities.
- Two geologic repositories: the first, authorized by Congress, is scheduled to begin operation at a western site in 2003; the second is not as yet authorized, but is assumed to start up at an as yet unselected site in about the year 2020.
- An MRS facility which the DOE proposes to be located at the Clinch River Breeder Reactor site near Oak Ridge, Tennessee.
- A federally managed transportation system, utilizing commercial carriers, for shipments of spent fuel and high-level waste.

Based on evaluations of environmental assessments for several candidate geologic repository sites, three locations were recommended by the DOE and approved by the President for site characterization: 1) Yucca Mountain, Nevada, which features tuff as the geologic medium; 2) Hanford, Washington, with basalt; 3) and the Deaf Smith site in Western Texas, with salt. These three sites were considered in the analyses of the improved-performance system. The second repository was not considered in the analyses.

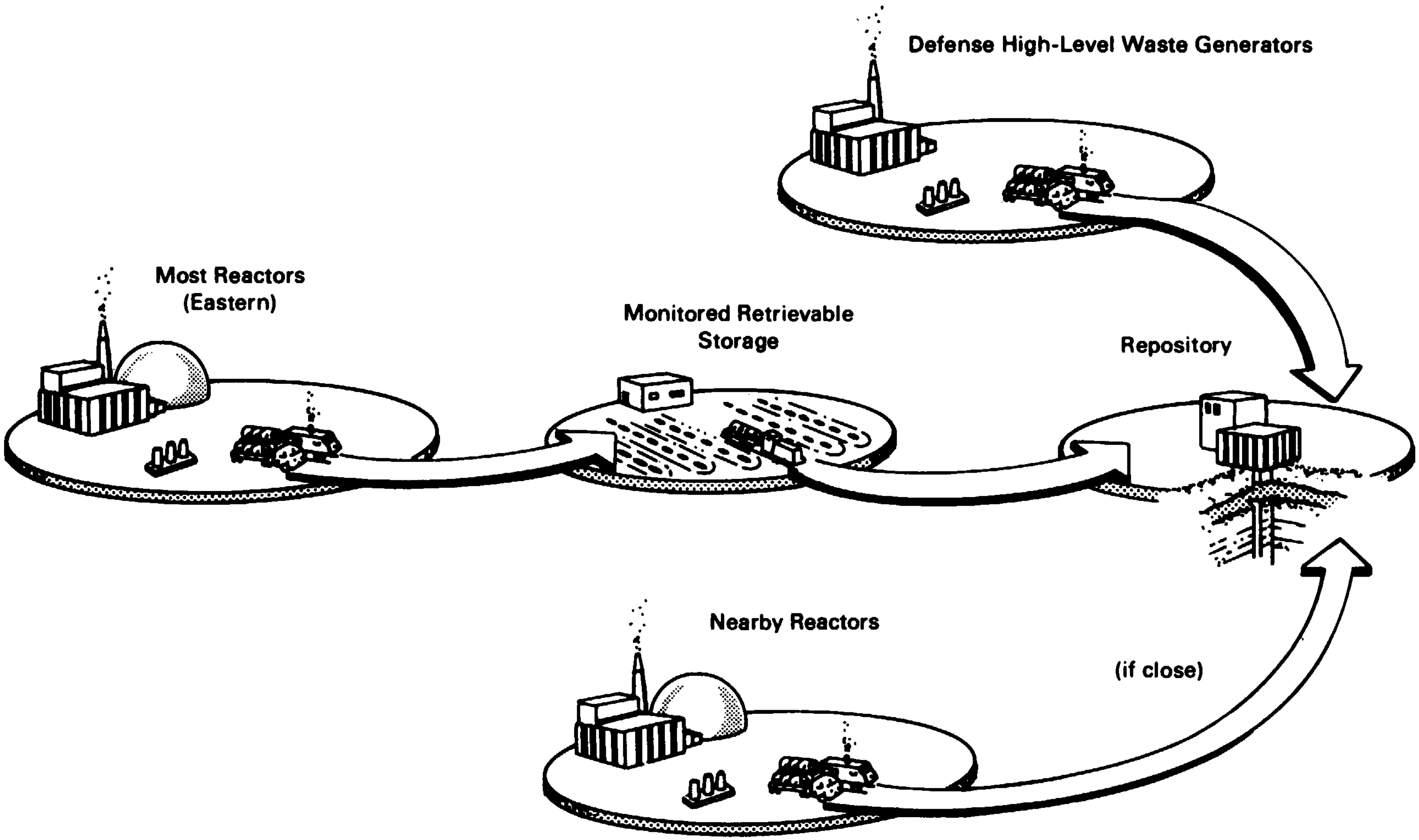

FIGURE A.1. Improved-Performance System

As proposed, the MRS facility would be capable of receiving spent fuel from reactors, disassembling the fuel assemblies, consolidating the fuel rods and encasing them in canisters, and shipping the canisters to a repository for final packaging (i.e., the addition of an overpack, which is the repository-specific barrier to radionuclides) and disposal. Current planning assumes the use of the MRS facility only in conjunction with the first repository; discussions in this appendix follow that assumption. Alternatively, depending on the location and geologic conditions of the second repository, it may prove advantageous for the MRS facility to serve the second repository as well.

The current plan, shown in Figure A.1, is to ship spent fuel from reactors near the repository (in the case of a western repository, reactors in Arizona, California, Oregon and Washington) directly to the first repository. An alternative scenario considered was to ship all spent fuel destined for the first repository to the MRS facility for consolidating and sealing in canisters.

Defense wastes and other high-level wastes will be shipped directly to the repository.

A.1 RECEIPT RATES, SHIPPING RATES, AND INVENTORIES

Under the current assumptions, about 65,000 metric tons of uranium (MTU) in the form of spent fuel would be accepted for disposal by the first of the two repositories.[a] Current assumptions are that only spent fuel will be received and handled at the MRS facility. The facility is designed, however, to handle both spent fuel and high-level waste. If desired it can accept, after vitrification in steel canisters, the high-level waste currently in storage at West Valley. This waste, from the reprocessing of 228 MTU of spent fuel prior to 1972 (DOE 1985b), is scheduled to be vitrified during 1988-1989; it is estimated that about 300 waste canisters, 24 inches in diameter, will be produced.

Projected system flows and inventories of spent fuel are shown in Table A.1 assuming western fuel goes directly to the first repository.

The rate of acceptance of spent fuel at the MRS facility can only be projected at this time. The DOE/utility spent-fuel disposal contract (10 CFR 961 1985) calls for acceptance schedules to be specified beginning in the year 1991. Based on current projections of spent-fuel-generation rates and of increases in need for at-reactor storage, it is currently estimated that 2500 to 3000 MTU/year of spent fuel would be accepted for storage or disposal during

(a) The repository will also receive additional defense high-level waste.

TABLE A.1. Projected System Flows and Inventories with Western Spent Fuel Shipped Directly to the First Repository (in MTU)

	MRS Facility			First Repository
Year	Spent Fuel Received	Inventory	Spent Fuel Shipped to First Repository	Spent Fuel Received From MRS Facility
1998	1,200	1,200		
1999	1,200	2,400		
2000	1,200	3,600		
2001	1,200	4,800		
2002	1,200	6,000		
2003	2,000	7,600	400	400
2004	2,650	9,850	400	400
2005	2,650	12,100	400	400
2006	2,650	13,850	900	900
2007	2,650	14,700	1,800	1,800
2008	2,650	14,700	2,650	3,000[a]
2009	2,650	14,700	2,650	3,000
2010	2,650	14,700	2,650	3,000
2011	2,650	14,700	2,650	3,000
2012	2,650	14,700	2,650	3,000
2013	2,650	14,700	2,650	3,000
2014	2,650	14,700	2,650	3,000
2015	2,650	14,700	2,650	3,000
2016	2,650	14,700	2,650	3,000
2017	2,650	14,700	2,650	3,000
2018	2,650	14,700	2,650	3,000
2019	2,650	14,700	2,650	3,000
2020	2,650	14,700	2,650	3,000
2021	2,650	14,700	2,650	3,000
2022	2,650	14,700	2,650	3,000
2023	1,410	13,460	2,650	3,000
2024		10,460	3,000	3,000
2025		7,460	3,000	3,000
2026		4,460	3,000	3,000
2027		1,460	3,000	3,000
2028		0	1,460	1,460
TOTAL	59,760		59,760	65,360

(a) In years when the repository acceptance does not match MRS facility shipments, the difference is attributable to shipments from nearby reactors directly to the repository.

and after 1998. The acceptance rate at the MRS facility is assumed, after the initial few years of operation, to be 2650 MTU/yr spent fuel, whereas 350 MTU/yr, and 5600 MTU total, are assumed to be shipped directly to the first repository from nearby reactors. Shipments from the MRS facility to the repository, once the repository is operating at full scale, would be at a rate of 2650 MTU/yr, maintaining a repository receipt rate of 3000 MTU/yr.

The MRS facility is currently envisioned to receive spent fuel in January 1998. The projected amount of fuel received in each year from 1998 through 2002 is 1200 MTU. In 2003 the acceptance of spent fuel would increase to 2000 MTU, and in 2004 the amount for full-scale operation (2650 MTU) would be received. In its current state of conceptual design, the MRS facility is capable of receiving (and concurrently shipping to the repository) 3600 MTU/yr on a 7 day/week, 4 shift basis, or 3000 MTU/yr on a 7 day, 3 shift basis. Before definitive design, the MRS design capacity will be finalized, after consideration of the economics of facility capital cost and various modes of facility operation.

The MRS facility is planned to have a storage capability of 15,000 MTU, including storage of fuel in sealed storage casks and a lag storage vault in the receiving and handling building. The lag storage capacity is intended as a buffer for decoupling fuel-acceptance activities from shipment to the repository for disposal. It would compensate for operational mismatches or for short-term disruptions in the system without resort to retrieval from the sealed storage casks. The cask storage capability is expected to be used primarily to permit fuel acceptance before and during the startup period of the first repository. As discussed later, the cask storage system would also permit "tailoring" of the heat generation rates of fuel shipped to the repository, by aging fuel in the storage casks, to provide canisters with a more uniform heat output for disposal in the repository.

A.2 TRANSPORTATION CHARACTERISTICS WITH MRS

The transportation link for shipping spent fuel from the utility reactors to the MRS facility, and from the MRS facility to the repository, is planned as a system of NRC-certified shipping casks transported by commercial truck and rail carriers. The mode of shipment from the reactors will be governed primarily by the capabilities of each reactor; currently some 40 reactors either have no rail capability or have some degree of restriction on rail capability. Recently completed reactors have full rail capability; presumably, all reactors to be built in the future will also have this capability. Thus, shipments from the reactors are assumed to be a mixture of truck and rail. In past studies it was assumed that about 70% (by weight) of the fuel would be shipped by rail. The use of marshaling yards or transloading of shipping casks could increase the rail shipments.

It is planned that shipments of canistered spent fuel from the MRS facility to the repository will be by dedicated train, in groups of five or more large casks (100- to 150-ton weight).

A.3 TIME REQUIREMENTS FOR TRANSPORTATION AND MRS OPERATIONS

The time required to ship spent fuel from the utility reactors to the MRS facility, and from the MRS facility to the repository, plays an important role in determining the size of the cask fleet required for system transportation. The cask turnaround times (loading or unloading and associated idle time) at the MRS or repository are also important. The time required to handle the received fuel and prepare it for reshipment affects the lag storage size requirements and the basic throughput capability of the MRS facility.

Transport times for shipments between reactors and the MRS facility vary considerably with differing distances and routes, but are estimated to average 1 to 2 days for truck shipments and 9 to 10 days by rail. From the MRS facility to the repository, by dedicated train, transport times will vary from 2 to 10 days, depending on the location of the repository. Return trips in each case would require equivalent times. In addition, turnaround times at each facility (the time from receipt of a cask until it is returned to the carrier) average 1.5 days for truck casks and 2.5 days for rail casks at reactors; equivalent times are assumed at the MRS facility. For shipment from the MRS facility to the repository, turnaround times of 4.5 days for a five-cask dedicated train at each facility are projected.

Based on the above assumptions, it is estimated that a total fleet would consist of about 15 to 20 truck casks and 20 to 25 rail casks for shipments from the utility reactors, and 30 to 40 100-ton rail casks (or 10 to 15 150-ton casks) for shipments from the MRS facility to the repository. The ranges in numbers of casks servicing the reactors reflect uncertainties in priority allocations of fuel shipments in a given year; thus the fleet would tend to the high side of that range. For the MRS-to-repository casks, the ranges depend on the shipping times to the repository location. The actual fleet requirements for the waste system will depend on the results of ongoing cask procurements and the shipping capabilities existing at the reactors and the waste system facilities when the spent fuel shipments commence in 1998.

A.4 PLANNED OPERATIONAL MODE FOR MRS

The MRS facility is intended to receive spent fuel from utility reactors at rates to be determined by the final DOE/Utilities contract (10 CFR 961), to consolidate and canister the fuel, and to reship the canistered fuel to the first repository for final packaging and disposal. The excess fuel accepted in the early years of MRS facility operation, before full operation of the repository, would be temporarily stored in sealed storage casks until it can be shipped to the repository without disrupting the acceptance from utilities. The basic flows and inventories for this operation are shown in Table A.1.

A.5 PLANNED REPOSITORY OPERATING MODE

The first geologic repository is scheduled to begin operation in 2003, initially receiving fuel at the rate of 400 MTU per year. This rate would be gradually increased, as indicated in Table A.1, until it reaches a full-scale rate of 3000 MTU per year in the year 2008. The 3000-MTU-per-year rate would be continued until the repository reaches a total of about 65,000-MTU of spent fuel.

In shipments from the MRS facility, the repository is expected to receive about 2650 MTU per year of spent fuel consolidated into canisters. The canisters would be packaged (overpacked) as appropriate for the geologic medium, lowered to the disposal area, and emplaced.

The fuel shipped directly to the repository from nearby reactors, nominally at 350 MTU per year, is expected to be received primarily as intact spent-fuel assemblies; some utilities, however, may choose to consolidate and canister fuel. Upon arrival at the repository, the fuel would be packaged for disposal, with or without an inner canister as appropriate, and disposed of underground.

In an alternative plan, all fuel would be shipped to the MRS facility; the only functions of the repository would be to receive, package and dispose of the consolidated and canistered fuel from the MRS facility. No "bare" (uncanistered) fuel would be handled in routine operations.

With the repository filled to capacity, backfilling of the emplacement tunnels would be completed after approval is received from the NRC. Fuel receipt and disposal activities would then be focused solely at the second repository.

A.6 ALTERNATIVE MRS OPERATIONAL MODES

Inventory-management techniques within the MRS facility can be varied, if desired, to modify the characteristics of the canistered fuel shipped to the repository. The MRS storage facilities can be used to age the accepted fuel, thus providing the repository with fuel exhibiting lower and more uniform heat-generation rates.

In accordance with 10 CFR 961, the DOE is committed by contract with the utilities to receive fuel as young as five years after discharge. Such fuel would have heat-generation rates more than 50% greater than the 10-year-old fuel on which many repository design studies have been based. Fuel exposed to higher burnup than today's levels would have similar characteristics. Disposal of fuel with higher heat output, depending on the disposal medium, could require development of larger underground facilities, at increased cost, to permit greater dispersal of the heat. However, the fuel inventory in MRS will provide additional aging of the fuel, reducing the heat-generation. In addition, spent fuel may be selected such that repository packages of nearly uniform heat output may be deposited in the repository.

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10 CFR 961. 1985. Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste. Title 10, Part 961, Code of Federal Regulations, U.S. Office of Federal Register.

APPENDIX B

DESCRIPTION OF MRS FACILITY OPERATIONS

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DESCRIPTION OF MRS FACILITY OPERATIONS

This appendix provides a brief description of MRS facility operations based on the conceptual design (R. M. Parsons Company 1985).[a] Section B.1 presents an overview of the requirements and capabilities of the MRS facility. Section B.2 describes the receiving and handling building, which contains the main operating areas in the MRS facility, and Section B.3 discusses MRS storage facilities and related operations.

The MRS conceptual design satisfies the design criteria stipulated in the NWPA and the functional requirements for an integral component of the waste management system. The latter requirements are documented in the Functional Design Criteria (PNL 1985).

B.1 OVERVIEW OF MRS REQUIREMENTS AND CAPABILITIES

The integral MRS facility is intended to serve as a centralized receiving and packaging facility for commercial spent nuclear fuel. In addition, the facility will provide contingency storage capability to accommodate surges or disruptions in any operational element of the federal waste management system.

To achieve these goals and the design criteria above, the facility is designed to receive, process and ship offsite or store onsite, a minimum of 3600 metric tons of uranium (MTU) per year primarily as spent fuel and a small amount (less than 300 canisters total) as high-level waste (HLW).[b] The MRS facility will have in-building lag storage capacity for up to 1000 MTU of consolidated fuel in canisters, plus outdoor storage capacity for up to 15,000 MTU of spent fuel. The design assumes a spent fuel mix of 60% PWR/40% BWR by weight, based on 0.462 MTU per PWR assembly and 0.186 MTU per BWR assembly. It will also be capable of retrieval, overpacking as required, and shipment of at least 3600 MTU or equivalent per year of canistered spent fuel and waste to a geologic repository for disposal. Capability will be maintained

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(a) Design verification activities, see Appendix C, may result in some changes in specific processes or equipment; however, the general operations will be as described in this appendix.

(b) The design criteria in the NWPA require that the MRS facility be capable of handling commercial HLW. Although there exists a small amount of commercial HLW at the closed West Valley, New York, reprocessing facility, the DOE plans to receive only commercial spent fuel at the MRS facility.

to receive and ship concurrently at those rates. Surge capacity will be included in the design of receiving, handling, and storage systems to obviate the impacts of credible offsite and onsite disruptions of spent fuel, waste, and material flows.

Hot cell space will be included to accommodate overpack equipment capable of sealing consolidated fuel canisters in a repository-type overpack suitable for disposal. However, the equipment for overpacking is not included in the design.[a]

The MRS facility must be licensed by the NRC. In addition, the design, construction and operation of the facility will be performed in conformance with all applicable industry codes and standards and in compliance with applicable state laws and federal regulations.

The principal operations to be performed in the MRS facility are receipt, disassembly, consolidation and packaging of spent fuel for interim storage, as needed, and ultimately shipment offsite for disposal. The facility provides short-term lag storage capability for intact and consolidated fuel in the R&H building vaults. Long-term storage capability is provided externally in concrete sealed storage casks. The overall layout of the MRS facility, including administrative and support buildings, is shown in Figure B.1. The general layout of the R&H building including the process cells and lag storage vaults is illustrated in Figure B.2.

Reference heat generation rates and levels of radioactivity of spent fuel that will be received, handled and shipped or stored in the MRS facility are listed in the FDC. The facility is designed for spent fuel having exposures of about 30,000 MWD/MTU and having been cooled at the reactor for 10 years. However, the facility can handle up to 10% of the spent fuel with only 5-year cooling with this exposure and 10-year-cooled spent fuel with up to 55,000 MWD/MTU exposure.

B.2 R&H BUILDING DESCRIPTION

The receiving and handling (R&H) building contains the main operating areas of the MRS facility. The general layout of the R&H building is essentially symmetric about a line passing between the canyon cells in the center of the building and in the general direction of material flows. Approximately half of the R&H building is illustrated in the cut-away view in Figure B.2.

(a) At this time it appears to be operationally preferable to perform the overpacking at the repository site.

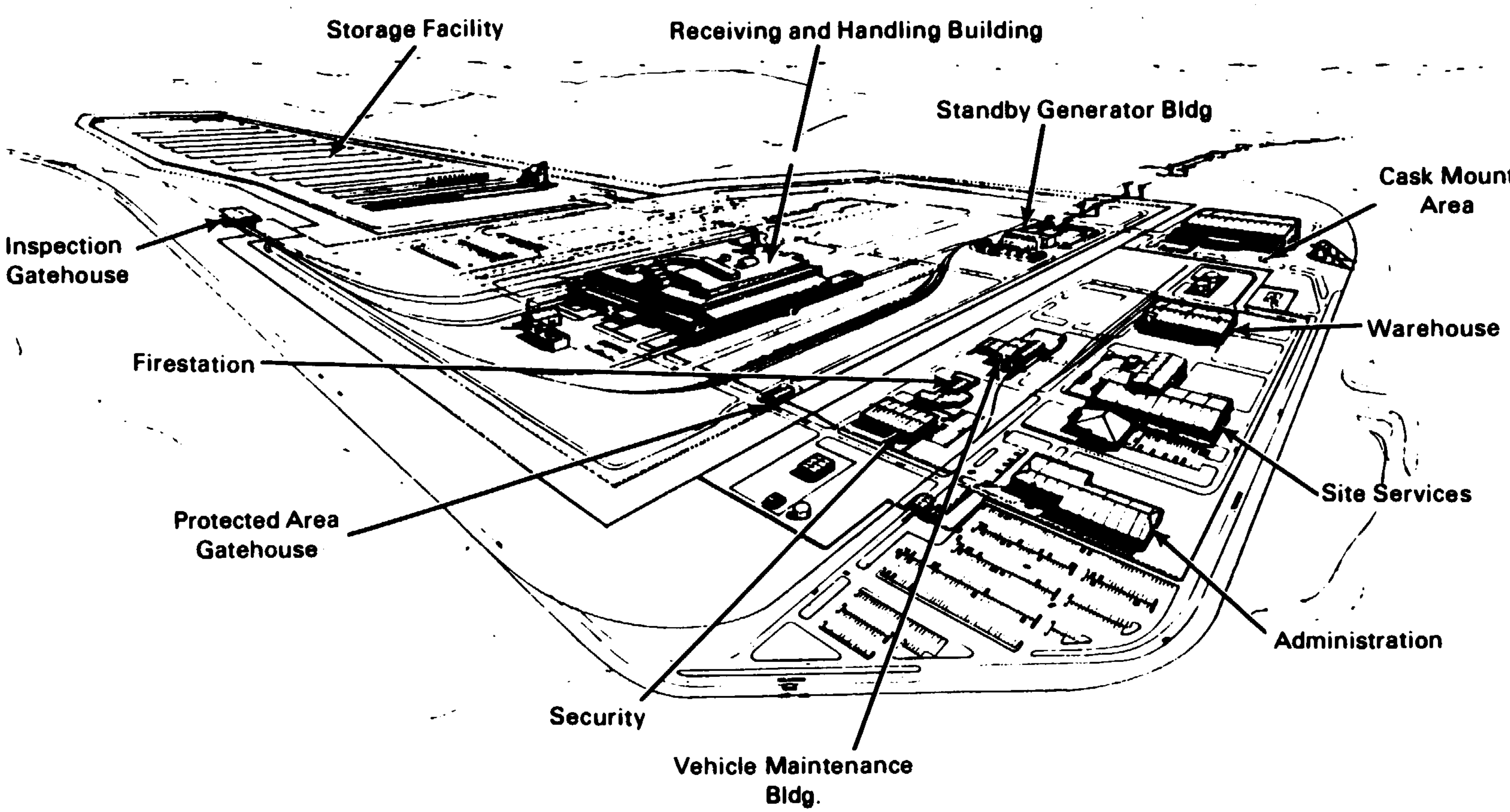


FIGURE B.1. Overview of the MRS Facility Layout

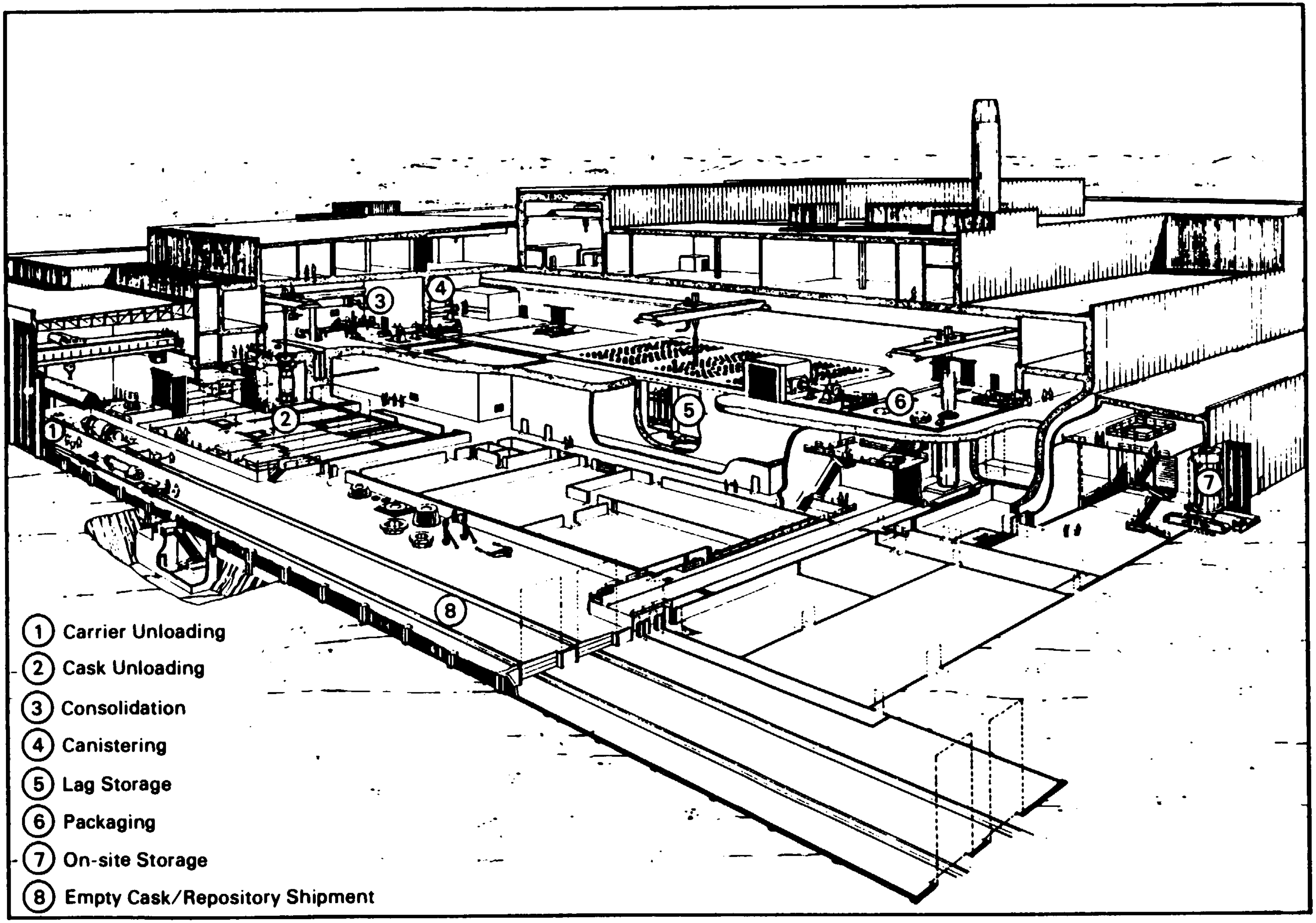


FIGURE B.2. Overview of the MRS Receiving and Handling Building

The principal operating areas and associated operations are as follows:

- fuel receiving and handling areas
- main process cells
- canister weld stations
- lag storage vaults
- sealed storage cask loadout/retrieval areas
- overpack installation area (optional)
- transport cask loadout areas.

As previously noted, only the space (no equipment) needed for the installation of overpacks for disposal is provided in the current design.

Other areas of the building include: administration, radwaste treatment, and building services. The administration area contains offices, a lunchroom, a conference room, change rooms and toilet rooms, and the health physics facilities. These areas provide services specifically for the operations and management and support personnel housed within the R&H building.

The radwaste treatment area is separated into two areas: the high-activity waste (HAW) area, for processing highly radioactive wastes, and the low-level waste (LLW) area. The LLW area is further divided into liquid and solid waste treatment areas. The liquid LLW treatment system reduces the volume of the waste by evaporation. The non-radioactive liquid effluent is recycled within the R&H building; the sludge is sent to the solid LLW treatment system. The solid wastes, except HEPA filters, are mixed with a cement grout and placed in 55-gallon drums. The sludge from the liquid radwaste is added to the grout. The drums of waste are cured, decontaminated as necessary and sent through a drum interrogator that determines the presence of transuranic (TRU) material by gamma pulse height analysis. Drums with TRU material (CHTRU) are sent to the onsite CHTRU storage facility. Drums without TRU material (LLW) are sent to the temporary storage area before being shipped to an offsite disposal area. The second- and third-stage HEPA filters are compacted and placed in 55-gallon drums without the cement grout. These drums go through the same decontamination and interrogation process as the grouted drums.

The HAW materials, including the in-cell and first-stage HEPA filters, are processed generally similarly to the LLW materials but are processed within a shielded area using totally remote methods.

The building service areas include:

- analytical laboratory
- aqueous and chemical makeup rooms
- HVAC equipment room

- mechanical equipment rooms
- laundry room
- maintenance rooms
- material receiving and storage rooms.

These areas are typical of most nuclear-related facilities and are not described here.

Spent fuel transport vehicles (trucks and rail cars) enter the R&H building by means of rail lines and paved roads on either side of the building. There are four independent processing cells, two on either side of the canyon cells, each with its own receiving and handling area. Two independent weld stations, accessible from any of the four process cells, are installed in the canyon near the "input" end of the R&H building. The majority of the central canyon is occupied by the air-cooled canister storage vaults. There are two independent canister loadout areas for loading of transport casks for shipment to a repository. These are situated beside the process cells and facing into the canyon near the "output" end of the building. Two independent sealed storage cask loadout/retrieval areas are located at the extreme output end of the canyon cells from which sealed storage casks are loaded for emplacement in the storage facility. The area reserved for canister overpacking is also located in the canyon. Brief descriptions of operations performed in each of the principal operations areas are presented in the subsequent subsections.

B.2.1 Fuel Receiving and Handling

Four independent transport cask unloading areas are located under each of the main process cells, as illustrated in Figure B.3. The R&H cells connect to the rail/truck receiving areas on either side of the R&H Building. Spent fuel casks arriving at the facility are inspected, lifted from the transport vehicle and mounted vertically on a cask transport cart. This cart is then moved into the cask handling and decontamination room where gas samples are taken, the outer cask lid removed, and other preparation tasks completed. The cask is then moved into the cask unloading room, the cask is mated to the operating cell fuel input port, a special "skirt" is lowered over the cask to provide contamination control for fuel unloading operations, and the shield door is closed and sealed.

The cell port cover and cask inner lid are then removed. Fuel assemblies are removed from the cask one at a time, inspected and transferred either to the disassembly table or to the in-cell lag storage pit using a crane in the cell.

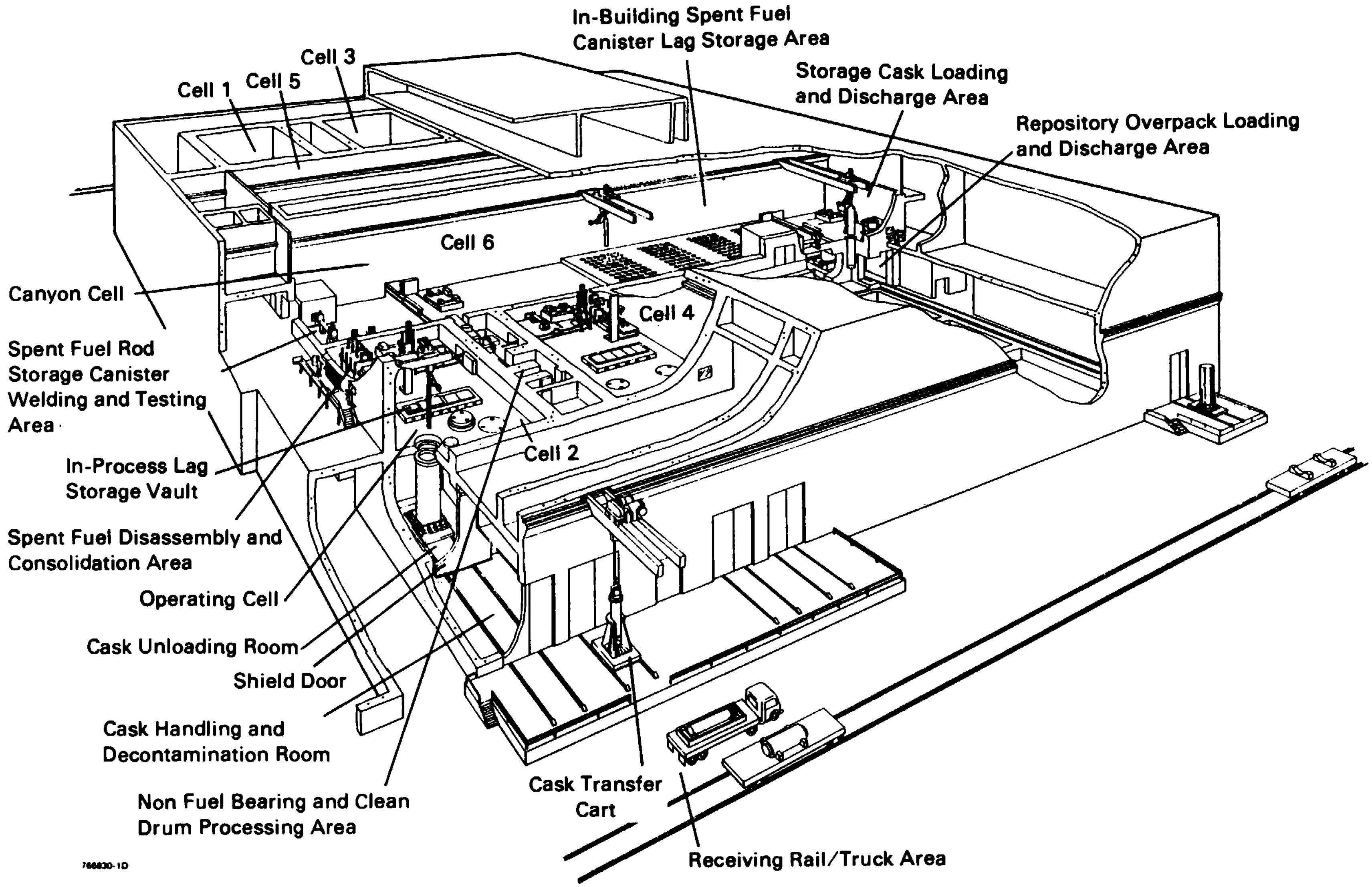


FIGURE B.3. Illustration of the Transport Cask Receiving, Handling and Unloading Facilities

After unloading is completed, the inner cask lid is replaced and sealed, and the port cover is replaced. The unloading port skirt is then withdrawn and the cask disengaged from the cask unloading port. The unloading room door is then opened and the cask is transferred to the cask handling and decontamination room where the cask surfaces are checked and decontaminated if needed and the outer lid is replaced. The cask is then moved to the receiving area where it is lifted off the cart, placed on a transport vehicle and released for dispatch to a reactor for another load. Once the cask is transferred out of the cask unloading room, the room is inspected and decontaminated if needed.

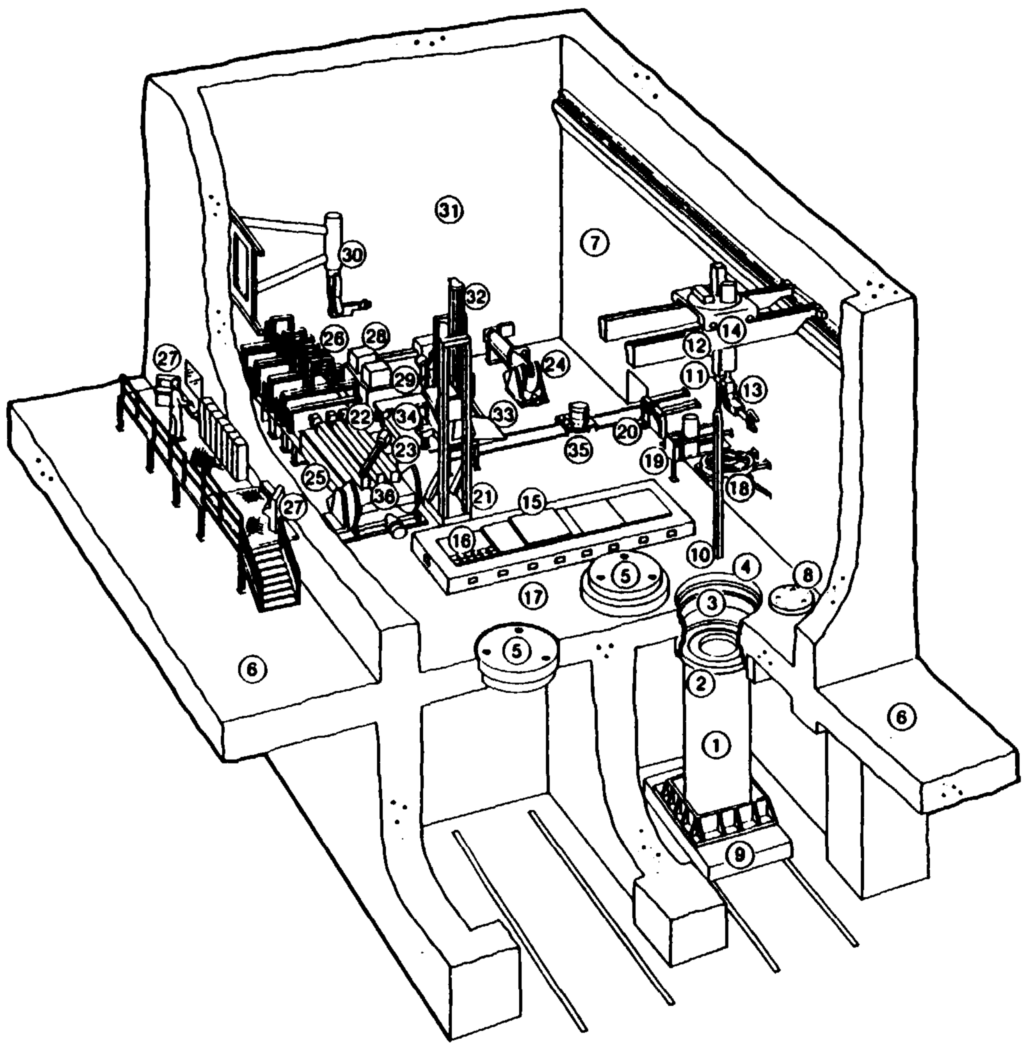
B.2.2 Main Process Cells

The principal operations performed in the four heavily shielded process cells are the disassembly of fuel, bundling and insertion of the rods into a canister and compaction and packaging of the residual fuel hardware. All of these operations are performed remotely. The disassembly equipment is illustrated in Figure B.4. Although each cell can handle either PWR or BWR fuel, they would normally be set up such that two cells would handle PWR fuel and two cells BWR fuel.

Fuel assemblies removed from a cask or from in-cell lag storage are first placed in the fuel assembly upender/disassembly clamping fixture. The fixture will hold either 3 PWR or 7 BWR assemblies for simultaneous processing. The upper fuel rod tie plate/nozzle assemblies are then removed with the upender fixture in the vertical orientation using a computer-controlled laser cutter. The upender fixture is then rotated to the horizontal orientation and the lower fuel rod tie plate/nozzle fixtures are removed using the laser cutter.

The fuel rods are then removed by a mechanical pulling operation in which mechanical grippers or collets individually engage the ends of all rods in either the 3 PWR or the 7 BWR assemblies in the fixture. A system of vertical and horizontal combs is inserted between the rods to support them during the pulling operation. Each rod gripper is designed to release if pulling forces exceed preset limits, thus preventing damage to stuck rods. Special equipment and procedures will be provided to remove and handle stuck or damaged rods.

When the pull is completed, the horizontal combs are removed allowing the loose rods from all of the disassembled fuel assemblies to drop a short distance vertically downward into a semicircular sling-and-die rod reconfiguration system. This device reconfigures and holds the rods in a cylindrical close-packed bundle for insertion into the canister. The cover on the process cell fuel outlet port is then removed. A "pusher" moves the compacted bundle of rods through the process cell outlet port into an empty canister that is mated



1. Shipping Casks
2. Cask Adapter for Contamination Barrier
3. Contamination Barrier
4. Entry Port
5. Entry Port Shield Plugs
6. Operating Gallery
7. Shielded Process Cell #2
8. Shipping Cask Cover
9. Cask Cart
10. Spent Fuel Element
11. Spent Fuel Grapple
12. Power Mast
13. Manipulator
14. 20 Ton Hot Cell Crane
15. Lag Storage Covers
16. Lag Storage
17. Lag Storage Cooling Ducts
18. Port Grapple
19. Fuel Assembly and Pintle Grapples
20. Module Lifting Yokes
21. Laser Cutting System
22. Laser Cutting Head
23. Robotic (Auxiliary)
24. Intact Fuel Assembly Upender
25. Fuel Disassembly Station
26. Fuel Rod Consolidation Station
27. Process System Control Console
28. Maintenance Hatch Jacking Mechanism
29. Maintenance Hatch
30. Wall Mounted Manipulator
31. Shielded Process Cell Contamination Barrier
32. Secondary Waste Shredding System
33. Drum Lidding Station
34. Grid Infeed Chute
35. Drum/Filter Cart
36. Fuel Disassembly Module

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FIGURE B.4. Illustration of the Fuel Disassembly Equipment and Operation to the port and held in a fixture in the central canyon area. After closure of the cell port cover, the canister is removed and transferred to the canister weld station for final closure.

The hardware remaining after fuel disassembly is reduced in volume and packaged in drums in the process cell, as illustrated in Figure B.5. The spacer grids, instrument tubes and other relatively "light" hardware are placed into a shredder that reduces them to smaller pieces and feeds them vertically downward into a drum. The massive end fittings are placed in the drums intact. The drums are then sealed and transferred into the drum decontamination cell for further processing, loadout or storage.

B.2.3 Canister Weld Stations

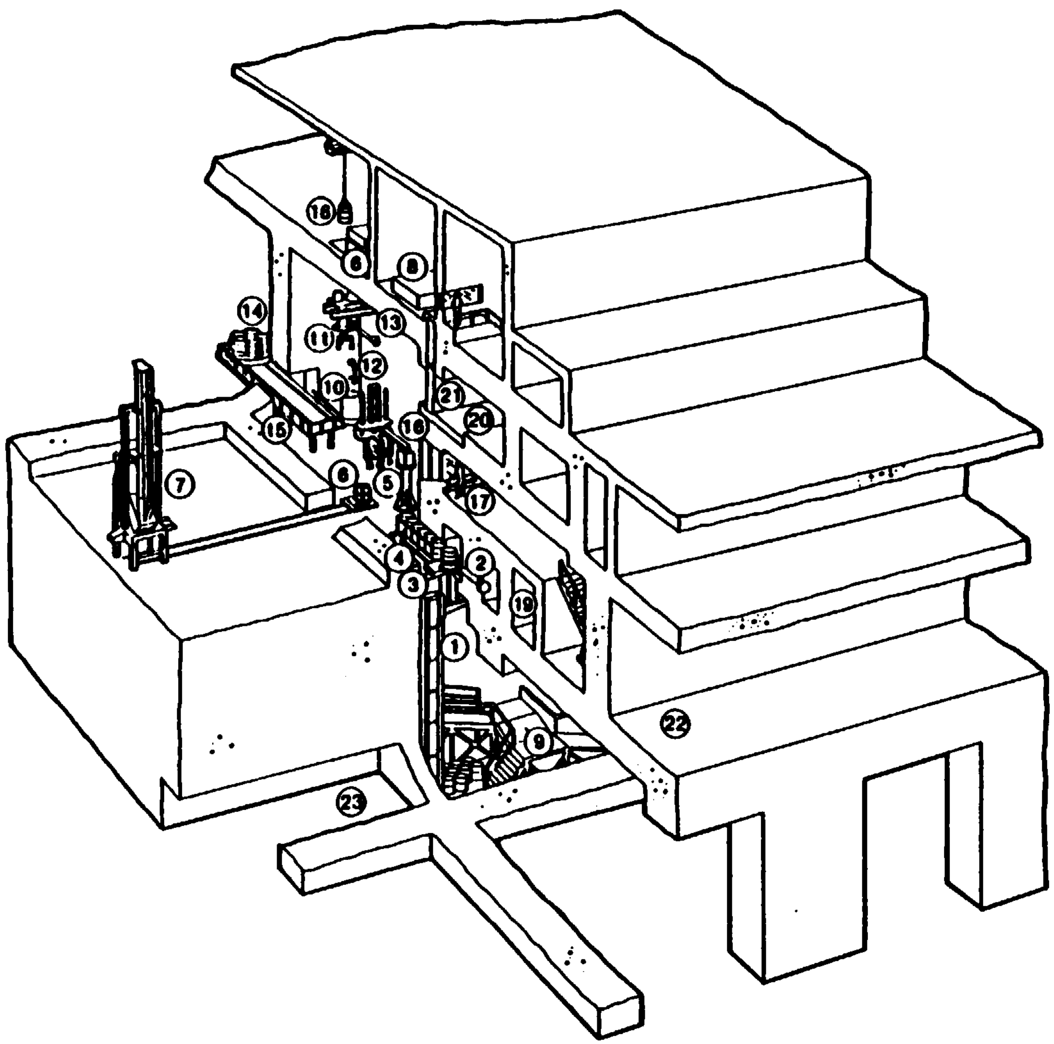
The filled canisters received from the process cells are seal-welded, decontaminated and inspected at the welding stations. Each weld station normally serves the two nearest process cells; however, either station can serve any of the four cells if necessary.

In the canister closure system, illustrated in Figure B.6, loaded canisters are shuttled from the process cell to the weld station on a remotely controlled transfer cart. The canister is inserted into a weld station chamber and the chamber is closed for canister welding operations. The air in the chamber is purged and replaced with an inert gas. The canister lid is installed and seal-welded using a resistance-upset welding device. The welder generator, controls and associated hardware are housed in a shielded room behind the weld station where they are routinely accessible for operation and maintenance. Only the canister clamps and electrodes are located in the weld chamber.

After welding is completed, the canister is decontaminated and leak-tested while still in the weld chamber. The chamber is then opened, the canister withdrawn into the canyon, checked for contamination, and examined with an acoustic NDT system to verify weld integrity. When certified as sealed and free of contamination, the canister is transferred to the vault for short-term storage, to the sealed storage cask loadout cell for emplacement in long-term storage, or to the transport cask loadout area for shipment to the repository.

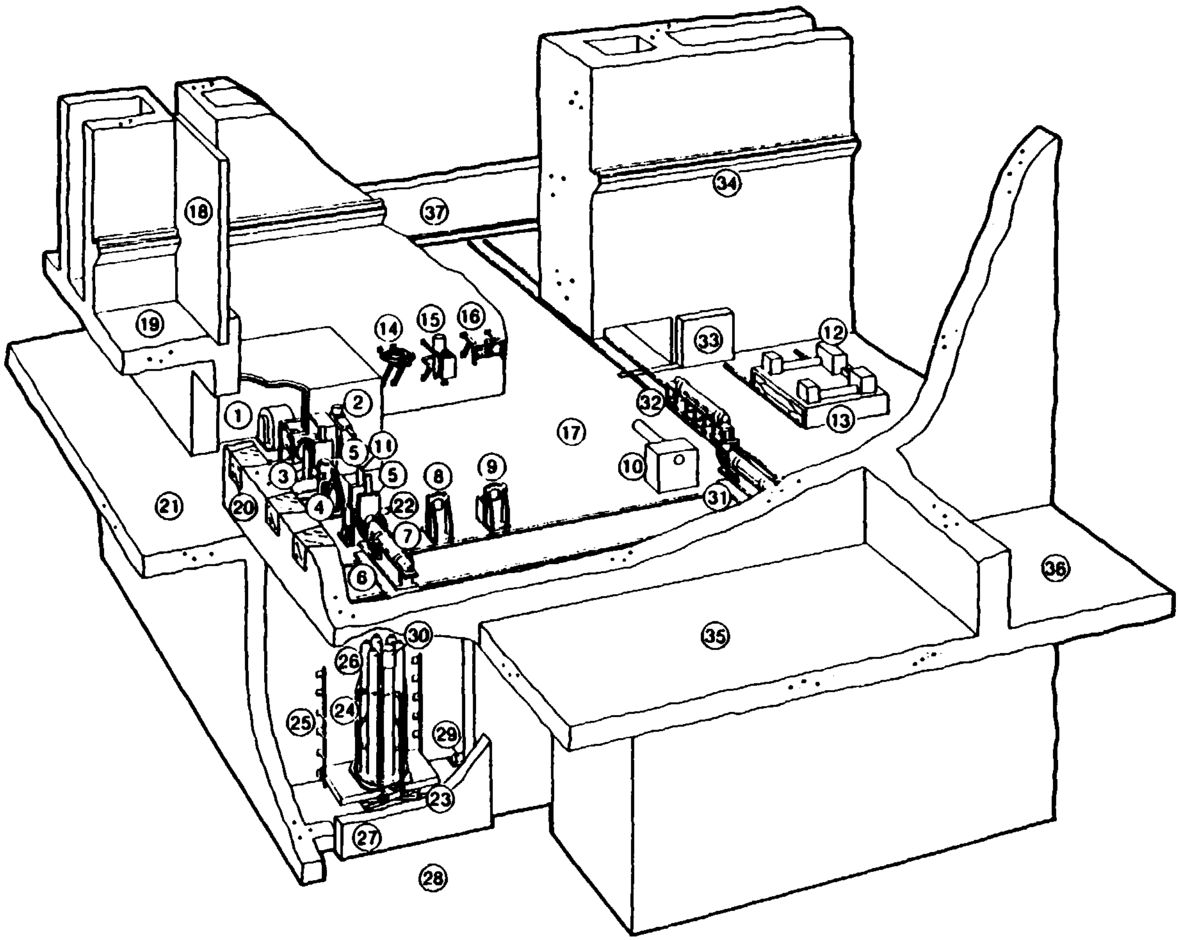
B.2.4 Lag Storage Vault

Air-cooled lag storage vaults for temporary storage of consolidated fuel canisters occupy the bulk of the central operating canyon cells. There are eight canister compartments in the vault, each designed to hold 16 canisters.



1. Clean Drum Elevator
2. Drum Push Mechanism
3. Shield Valve
4. Drum Guidance System
5. Jib Crane w/Drum Grapple
6. Drum Transfer Cart
7. Secondary Waste Shredding System
8. Maintenance Hatch
9. Ramp
10. Drum Decontamination Station
11. Drum Grapple w/Decontam. Station Lid
12. Drum Swipe Arm
13. Overhead Crane w/Manipulator
14. Filled Drum Transfer Cart
15. Filled Drum Transfer Platform
16. HVAC Filter Drum
17. Secondary Waste Processing and Decon System Control Station
18. Observation Window
19. Airlock
20. Crane Maintenance Room
21. Crane Maintenance Shield Door
22. Operating Gallery
23. Clean Drum Storage

FIGURE B.5. Illustration of Fuel Hardware Shredding and Packaging Equipment



1. Welding Power Generator/Equipment Room
2. Canister Lid Supply System
3. Canister Welding Station
4. Canister Decon/Helium Leak Test Chamber
5. Chamber Isolation Valves
6. Canister Upender No. 1
7. Storage Canister
8. Ultrasonic Test Station
9. Canister Cutting Station
10. Fuel Rod Bundle Push Rod System
11. Forge Press Restraint
12. Maintenance Hatch Jacking Mechanism
13. Maintenance Hatch
14. Plug Grapple
15. Pintle Grapple
16. Equipment Lifting Yoke
17. Shielded Canyon Cell #6
18. Maintenance Area Shield Door
19. Crane Maintenance Room
20. Observation Window
21. Operating Gallery
22. Clean Canister and Lid Supply Port
23. Carousel Lift Mechanism
24. Carousel Canister Rack
25. Guide Rail Lift Mechanism
26. Clean Canisters
27. Shield Door
28. Access Corridor
29. Lift Mechanism Hydraulic Pump System
30. Canister Lid Supply Support Tube
31. Canister Upender No. 2
32. Canister Pass-Thru Cart
33. Canister Pass-Thru Shield Door
34. 35 Ton Crane Rails
35. Shielded Process Cell #2
36. Decon Cell
37. Shielded Canyon Cell #5

FIGURE B.6. Illustration of Canister Welding System

Cooling air from a central supply is individually ducted to each compartment and then recollected into a common exhaust. Air is circulated through the vaults by means of fans in the exhaust leg of the circuit. The air is filtered at the inlet to remove dust particulates and insects to keep the ducts clean and at the outlet to preclude the possible spread of contamination from a leaking or contaminated canister. To further protect against the possible spread of contamination, the pressure in the cooling system is maintained below atmospheric but above canyon pressure. In this way, any air leakages that occur will be inward and ultimately into the plant HVAC filters, thus assuring containment of any potential releases from the fuel.

Cooling of fuel canisters is provided by forced ventilation. Heat is removed from the compartments by continuous circulation of cooling air, with cool air entering at the bottom and warm air exiting from the top. Cooling air also passes around the outside of the compartments to keep the concrete wall temperature below specified limits.

Fuel canisters are loaded into and unloaded from the vault through ports in the floor of the canyon cell. Each port is fitted with a removable shield plug. In loading operations, the shield plug is first removed and set aside using the canyon overhead crane. A fuel canister is then obtained from a weld station, transported to the open port, lowered into the vault and the plug is replaced using the same overhead crane. The reverse procedure is used for removing canisters from the vault prior to sealed storage cask or transport cask loadout operations.

B.2.5 Sealed Storage Cask Loading Area

The facilities for loading sealed storage casks are on the extreme output end of the R&H building canyon cells. There is one loading area in each of the canyon cells and canisters from anywhere in the canyon cells can be loaded through either loading area. Loading may occur directly from the canister weld stations or from lag storage. In retrieval operations, canisters removed from sealed storage casks can go back to lag storage or to the transport cask loading areas for shipment to a repository.

In the sealed storage cask loading operation, the casks are first loaded onto a crawler/transporter and transported from the cask staging area into the R&H building. The loading area shield doors are opened to admit the crawler and closed during loading operations. The cask, prepared for loading, is positioned beneath the loading port, engaged to the loading port interface and the outer shield lowered around the top of the cask. The in-cell overhead crane is used to remove the loading port plug and the shield plug of the cask, which are set inside the cell during the loading. Canisters brought in from the weld stations or from lag storage using the crane are loaded one at a time into the sealed storage cask until it is full. The shield plug and loading port plug are replaced and the cask is disengaged from the loading port. The cask is then prepared for closure, with a metal lid installed, seal welded and inspected, and the cask inspected for contamination prior to transfer to the storage facility for emplacement. Retrieval follows essentially the reverse of the above operations.

B.2.6 Transport Cask Loading Area

Two independent transport cask loading areas are located beside the primary operation cells on either side of the canyon cells. Fuel canisters can be brought to either of these cells from the weld stations, from lag storage or from the sealed storage cask loadout areas using the canyon cell overhead crane systems. The procedure for loading transport casks are analogous to those identified above for loading sealed storage casks. However, the lids on the transport casks are mechanically sealed, not welded. When loaded, inspected and certified for release, the cask is removed from the loading cell, lifted off from the transfer cart, laid down horizontally and secured on a railcar for shipment to the repository.

B.3 STORAGE FACILITIES AND OPERATIONS

The MRS facility provides facilities for short-term "lag" storage and longer-term storage to accommodate surges in receipt, processing and/or loadout of spent fuel that may result from routine operating variability and from disruptions in various portions of the waste management system. Facilities in the R&H building for in-cell lag storage of intact fuel and the air-cooled lag storage vault for storage of canisters are described in Section B.2. Facilities provided for long-term storage in sealed storage casks are described here.

The sealed storage cask design developed for the MRS Program for storage of canisters of consolidated spent fuel is illustrated in Figure B.7. The design of sealed storage casks for storage of other materials are similar but with varying cavity dimensions.

The sealed storage cask is a cylindrical vessel with steel reinforced concrete walls, a concrete shield plug, a carbon steel cavity liner and a carbon steel lid. The outside diameters of all sealed storage cask designs are 12 ft except for the top 36 in., which is stepped to 12.7 ft to provide a circumferential lifting surface. The exterior height of a sealed storage cask is 22 ft.

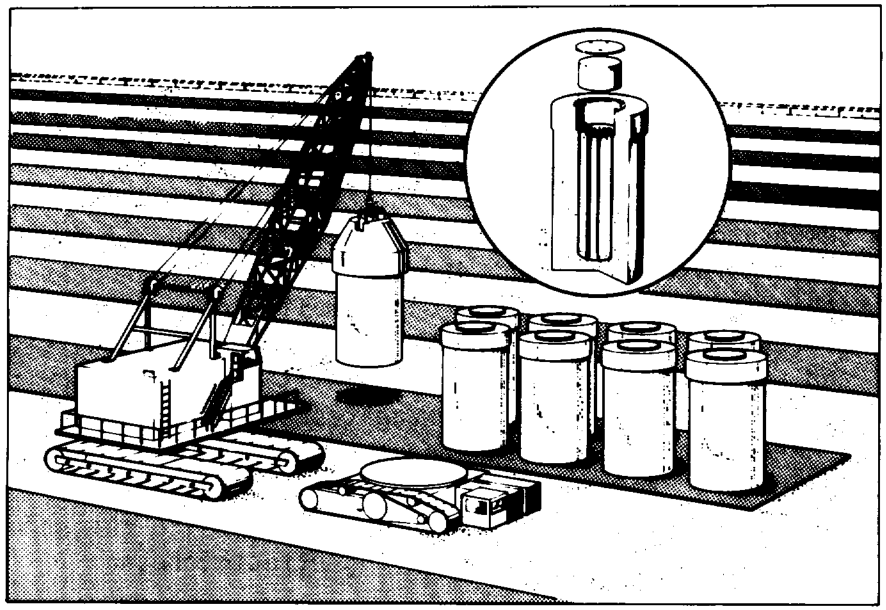


FIGURE B.7. Illustration of Storage Facility Operation and Emplacement for the Sealed Storage Cask

The cavity of the spent fuel cask is 68 in. ID by 194 in. long. The thickness of the walls and bottom of the carbon steel cavity liner are 2 in. and 1/2 in., respectively. The 2-in.-thick carbon steel lid is seal-welded to the top of the cavity liner after the sealed storage cask is filled. The principal function of the liner is to provide containment. However, the 2-in.-wall thickness was established to enhance shielding and heat transfer functions.

Canister support plates are located near the top and bottom of the cavity to laterally constrain the canisters. The canisters rest on the bottom of the cavity liner, but are not otherwise vertically constrained.

Both the inside and outside of the cavity are finned to enhance heat transfer. There are four short and four long 1.5-in.-thick aluminum fins in the cavity between the two support plates. These fins are bolted to the cavity wall. In addition, there are sixteen 3/4 in. by 3.5-in.-long carbon steel fins or ribs on the outside of the liner embedded in the concrete.

The walls and bottoms of sealed storage casks are made of carbon steel reinforced concrete. The rebar cage consists of vertical, radial and circumferential hoop members that are attached to each other and to the fins on the liner surface. The normal functions of the reinforced concrete are shielding and physical protection of the stored wastes. However, the quantity of radial rebar was established primarily to enhance heat transfer through the concrete walls. The carbon steel-encased shield plug fills the top of the cavity resting on a step in the inside diameter of the cavity liner.

Each sealed storage cask contains features to facilitate monitoring of its condition. Three thermowells attached to the liner wall are provided to monitor the temperature at the concrete/liner interface. These temperature measurements will permit assessment of whether the fuel and cask materials are maintained within acceptable limits. Gas sampling ports are also provided on each sealed storage cask to permit periodic sampling and analysis of the cavity gas content and pressure. The gas analyses will be used to monitor canister containment by the presence/absence of tag gases and/or radioactive gases or particulates. Pressure (vacuum) can be used to determine sealed storage cask containment integrity. Area monitors and air monitors in the storage field will be provided to continuously monitor any releases to the atmosphere or degradation of sealed storage cask shielding effectiveness.

The equipment and operations used in sealed storage cask loading/emplacement operations are briefly described in Section B.2 and illustrated in Figure B.7. In a typical loading operation, a sealed storage cask is loaded on the crawler in the cask staging area using a crane; the crawler transports the sealed storage cask to the R&H building where it is loaded with canisters and sealed, and then the crawler transports the loaded sealed storage cask to the storage area where it is lifted off the crawler and emplaced on a pad beside previously emplaced sealed storage casks. Retrieval operations follow essentially the reverse procedure.

REFERENCES

Pacific Northwest Laboratory (PNL). 1985. Functional Design Criteria for an Integral Monitored Retrievable Storage (MRS) Facility. PNL-5673, Richland, Washington.

Ralph M. Parsons Company (Parsons). 1985. Integral Monitored Retrievable Storage (MRS) Facility. Conceptual Design Report. Design Description, Vol. I, Book II. MRS-11, Ralph M. Parsons Company, Pasadena, California.

APPENDIX C

DESIGN VERIFICATION PLAN

APPENDIX C

DESIGN VERIFICATION PLAN

This appendix summarizes the tests and demonstrations needed to optimize the design and support the licensing of the proposed MRS facility. Section C.1 outlines the objectives of MRS design verification testing. In Section C.2, testing needs for each of the MRS functions are identified and discussed. Section C.3 describes several DOE waste management programs that potentially may interface with MRS development. A schedule for the planned MRS design verification tests is provided in Section C.4.

C.1 OBJECTIVES

The MRS system, if approved by Congress, will be designed, licensed and constructed in accordance with the DOE's plans outlined in the June 1985 Mission Plan. Although current plans for MRS indicate that these goals are achievable, the schedule for design, licensing, construction, and preoperational testing of the MRS facility must be carefully planned and integrated to ensure operability and reliability of all components and systems.

The objectives of MRS design verification testing are to support licensing of the MRS facility and to optimize the design for cost and operability. The goal of verification testing is to identify and verify design improvements that will increase safety, reduce complexity, improve operability and efficiency, reduce costs of construction and operation, and demonstrate operability of the facility at the required throughput rates. Although no specific tests have been identified as being critical to the safe design of an MRS facility, verification testing will reduce the design conservatism that licensing considerations would otherwise require. In turn, this would reduce costs. Results of the planned tests will be reflected in final design, equipment procurement, and operational procedures. Verification of the procured systems will be provided during preoperational testing of the facility.

Two principal types of tests are planned for design verification: feature tests and systems demonstrations. Feature tests comprise those tests of individual components or processes before their incorporation into the final MRS facility design. Systems demonstrations are tests of major subsystems or complete systems of the MRS facility intended to demonstrate systems operability under the typical operating conditions.

If Congress approves of the MRS proposal, the DOE will develop detailed test plans and coordinate these plans with other interfacing testing and development activities being performed by the DOE or by private utilities. These DOE activities are the Commercial Spent Fuel Management Program (including the DOE/utility cooperative agreements), the Prototypical Consolidation Demonstration (PCD) Project, the Defense Waste Management Programs, and the Nuclear Waste Treatment Program.

C.2 TECHNOLOGY STATUS AND NEEDS ASSESSMENT

The discussions in the following subsections identify testing needs for each of the MRS functions, such as spent fuel handling, packaging, and storage. Specific areas are identified where experience or data are lacking and general descriptions are given of tests that will be performed to obtain the needed data.

C.2.1 Spent Fuel Receiving and Handling

The operations for receiving, handling, and packaging spent fuel that will take place at the MRS facility are similar to current industry practice, except for the expected size and numbers of casks and spent fuel assemblies to be handled. The scope of these MRS facility operations is illustrated in Figures B.2 through B.6, Appendix B.

Preliminary calculations of occupational radiation exposure indicate that the current MRS design meets the NRC regulatory limits. However, the design may not meet the DOE design objective (20% of the NRC limit) for occupational exposure for certain groups of workers. The analyses also indicate that the highest exposure arises from handling large numbers of shipping casks. The application of the ALARA (As Low as Reasonably Achievable) principle to the definitive design will probably result in automation of this task that has traditionally been a "hands-on" operation. An interface with the transportation program will be maintained so that the design of the fleet of shipping casks is compatible with the final design of the MRS handling systems. Design prudence dictates that, if found to be economically feasible, the automated or "robotic" systems for handling casks be tested to verify operability and reliability prior to their installation in the MRS facility.

Robotics could be beneficially employed at the MRS facility in removal of cask covers, gas sampling, and other preparation activities prior to unloading the casks. Potentially related testing is currently in progress in the DOE's defense waste program. Incorporation of MRS needs for specific feature testing into existing programs will be deferred until the MRS facility is approved by Congress.

Tests are needed to demonstrate optimum techniques for dealing with radioactive scale that coats the surfaces of the fuel assemblies. There is evidence from West Valley operations that the scale spalls during dry shipment of spent fuel, which may require cleaning of the interior of shipping casks prior to their return to service. Tests will be performed to establish the nature and extent of contamination during dry shipment of spent fuel so that processes and procedures can be developed to clean the casks' interior, if necessary, before their release from the MRS facility. This information is needed to reduce worker radiation dose at the MRS facility as well as at the utilities and to optimize the waste treatment systems.

C.2.2 Spent-Fuel Disassembly and Consolidation

The principal functions of the spent-fuel disassembly operation are: removal of the fuel assembly end-fittings and nozzles, extraction of the fuel rods from the remaining grids and support structure, reconfiguration of the loose rods, and insertion of the rods into a suitable canister. The MRS design that has been submitted with the proposal contains conceptual designs for equipment to perform these functions.

The PCD project at the Idaho National Engineering Laboratory (INEL) will develop prototypic spent-fuel disassembly and consolidation equipment that will be used at the authorized repository projects. Therefore, this program will also support the MRS Program. If Congress approves the MRS proposal, specific needs identified by the MRS conceptual design will be incorporated into the PCD project. The objective is to provide testing of disassembly/consolidation equipment and processes before development of the final designs of this equipment.

The PCD project will also provide data on the nature, frequency, and consequences of rod sticking and breakage for representative types of spent fuel. Data will also be obtained on properties, behavior, and quantities of radioactive scale that may be scraped off during disassembly and handling. In addition, data will be obtained on the possible quantities of zirconium fines generated during disassembly and on the related risk of fires. These data and experience will help optimize the design of radioactive waste collection and treatment systems as well as spent-fuel disassembly/consolidation equipment.

A full-scale demonstration of spent-fuel disassembly and consolidation is proposed that will consist of a prototype production line like that to be used at the MRS facility. This test will demonstrate the capability of achieving the reliability and production rate goals for a large sample of fuel and fuel types. These tests will be done cold (without use of radioactive materials). A decision on the nature and extent of hot tests that may be needed can be delayed until after the PCD project tests and cold tests are completed.

C.2.3 Spent-Fuel Packaging

The design of the canister to be used to store consolidated fuel at the MRS facility will be influenced by repository needs. One option is to package spent fuel into small triangular or rectangular canisters whose shape would allow them to be efficiently bundled into larger packages for disposal. Another option is to package the fuel into large round canisters of a size and type suitable for disposal at a specific repository. The MRS receiving and handling (R&H) building design can remain flexible to adapt to a wide range of canister sizes and types, but canister design reflects back directly to the design of the disassembly and consolidation equipment. Interface drawings for spent-fuel packages will be developed in concert with the repository program and baselined under change control, as shown in the MRS Program Master Schedule (Figure 3.10, Chapter 3).

Important aspects of consolidated fuel packaging are canister welding, weld inspection and leak detection, canister decontamination processes, and integrity under impact loads. Specific processes will be selected for cold feature testing in the PCD project. The selection will be governed by the needs of the MRS conceptual design if construction of the facility is approved by Congress.

The technique selected for the MRS conceptual design for canister welding is upset resistance welding. Although this method has been used in industrial applications and for high-level defense waste canisters, it has not been used for the large-size welds needed for MRS canisters. Demonstration of the quality of weld, process rate, and reliability is needed to support the MRS design. Other welding processes may be identified in definitive design and tested in the PCD project. The welding concept finally selected will also be verified in the disassembly and consolidation systems demonstration described above.

Processes for inspection and leak testing of canister welds will be developed and tested in conjunction with the welder design in the PCD project. These tests will be done as cold feature tests. Again, however, the optimized processes for MRS will be included in the prototypic systems demonstrations.

Freon has been selected as the most promising decontaminating agent for the MRS facility. Radiolytic and thermal decomposition of Freon may result in corrosion that could compromise the long-term integrity of the canister. Therefore, an experimental study will be conducted of Freon decomposition at the temperature and radiation levels that would be experienced in MRS canister decontamination operations. A hot prototypic demonstration will be performed to establish the efficiency and reliability of the canister decontamination system. These tests will also provide data on the necessary size of the waste treatment equipment.

Tests will also be performed to determine the integrity of canisters and welds under impact-loading conditions. Such conditions could occur at the MRS facility as a result of canisters being dropped or otherwise impacted during handling.

C.2.4 Waste Volume Reduction

The principal concerns in the area of volume reduction are the cost and safety of the processes that will be finally selected and the waste acceptance requirements at the repository. Also important are the related problems of collection and control of radioactive wastes during volume reduction and packaging.

The conceptual MRS design specifies a mechanical shredder for volume reduction of the fuel assembly hardware. The shredder is designed to reduce the grids and other hardware, less the end-fittings, into small pieces that can be efficiently packaged for disposal. Shredders of the type needed for MRS have been developed and demonstrated for volume reduction of low-level waste. A potential safety concern to be addressed by further testing is the possible production of zirconium particles sufficiently small to be ignited and thereby cause a zirconium fire. Another concern is the control of radioactive scale that will be dispersed in this mechanical operation. Testing will examine the effectiveness and cost of shrouds and vacuum or airflow systems in collecting the scale material, and will determine filtration needs and filter change frequencies. These data are needed to estimate dose rate buildup within the hot cells and its effect on worker dose. However, other means for volume reduction of fuel assembly hardware may prove to be preferred. In particular, a melting process being developed by DOE in their Nuclear Waste Treatment Program may be superior to shredding. Further design studies will examine all options for cost, safety, and reliability. Tests on appropriate processes will be done as cold and hot feature tests in the PCD project. Final tests of the MRS-specific design will be done in the MRS prototype systems demonstrations.

Volume reduction of combustible waste streams may be cost effective for the MRS facility. Organic materials in the ventilation filters could be oxidized to provide compact packages for the repository. Removal of organics may turn out to be necessary if the final repository acceptance criteria excludes organics. A decision on design and testing of this equipment will be made in consultation with the repository program within one year after MRS approval.

C.2.5 Sealed Storage Casks

At the MRS facility, sealed storage casks are recommended for the long-term storage of spent fuel canisters and drums of compacted fuel hardware.

Tests are needed to optimize and demonstrate the shielding, structural and thermal performance of these casks. The sealed storage cask concept is illustrated in Figure C.1.

The principal performance requirements for the sealed storage casks are that they safely contain and protect the stored materials while dissipating the decay heat and attenuating the direct radiation. The casks must be able to perform these functions during an extended period of storage and during design basis earthquakes and tornadoes. Both short- and long-term performance tests of sealed storage casks are needed to verify that design objectives have been

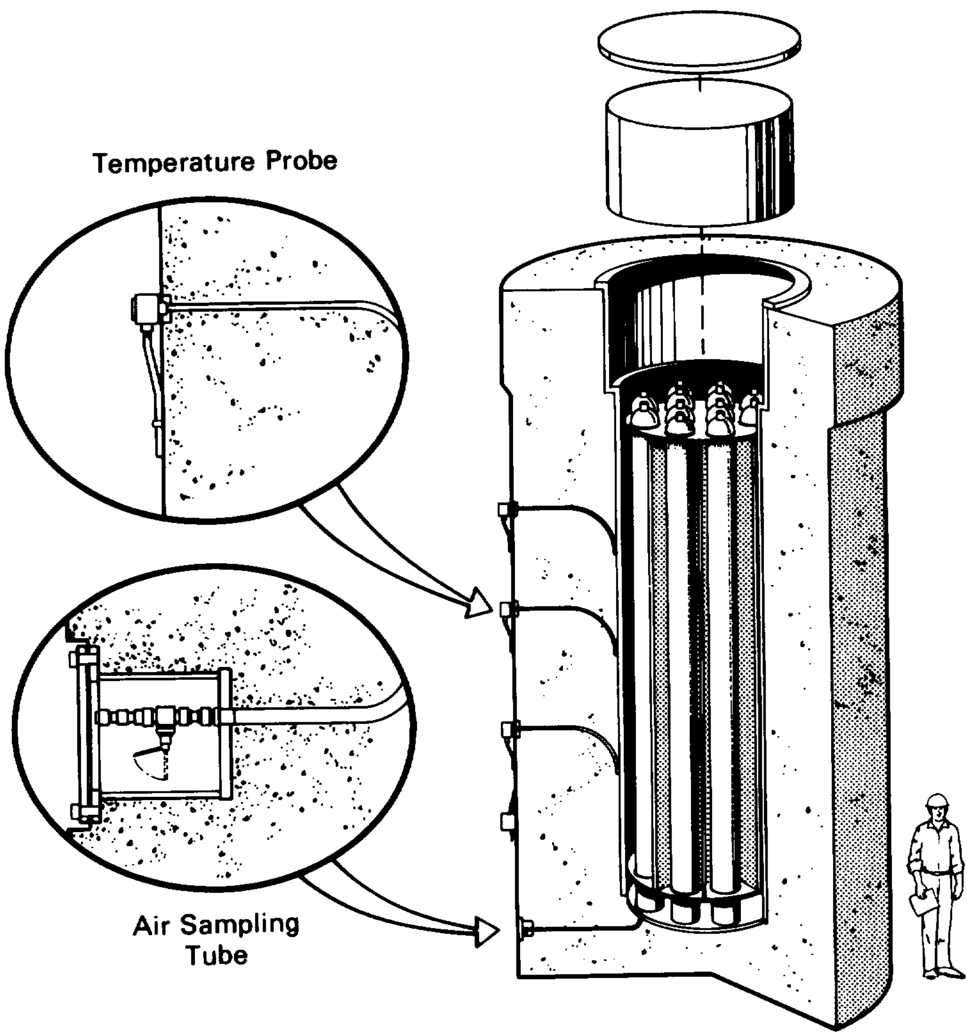


FIGURE C.1. Sealed Storage Cask Concept

achieved and that any degradation over time will not impair their safety function. This information is needed to support the license application and to optimize cost and reduce occupational exposure.

In the short-term tests, sealed storage casks will be filled (at least in part) with instrumented canisters of spent fuel. Measurements will include surface radiation dose and temperature distributions in the fuel canisters and casks. After completing the short-term performance measurements, observations will be continued over the long term to detect degradation of the casks. Samples in the form of plugs will be tested to establish the degradation within the cask body. After a number of years, supplemental heat will be added to determine the limits of satisfactory operation. These performance tests will provide evidence of problems, if any, before MRS operations begin. Information gained from these measurements will be incorporated into the designs.

Structural tests of prototype sealed storage casks will be performed to demonstrate their capability to ensure containment and retrievability under a number of hypothetical accidents. These tests will include drops from heights consistent with cask handling operations and impacts from tornado-generated missiles. The results of the tests will support licensing and design optimization.

C.2.6 Concrete Selection

Concrete is used in the R&H building and in the sealed storage casks. These applications require separate, and different, considerations. The seismic Category I structure surrounding the lag storage vault is designed to remain below the limit of 150°F specified in ANSI/ACI 349-76, the industry standard for concrete. In the event of complete loss of power to the ventilation fans, the wall temperatures would rise slowly, but are not predicted to reach temperatures which, over the short term, would damage their strength. Power outages do not normally last more than a few minutes, or hours at most. However, portable generators could be procured if the outage continued for a few days. The walls of the in-process lag storage vaults, though not a containment barrier, will reach temperatures of about 200°F when they are filled with spent fuel assemblies. The vaults are cooled by natural convection. Although the walls appear to be structurally adequate, the specification of a high temperature concrete may afford a cost saving.

The second concrete component, the sealed storage cask, is designed to operate at temperatures far above the normal structural limit of 150°F over much of its volume. However, the function of the concrete is to provide shielding, while the steel rebar and steel liner carry the normal structural and hypothetical impact loads from tornado-generated missiles. Although confirmation of this design has been discussed in the prior section on long-term testing, there are potential economic advantages in selecting high-density, high-thermal conductivity, high-temperature concrete. The design optimization studies to be conducted as a first part of definitive design should have the benefit of a series of short-term accelerated temperature testing in the laboratory to justify the final selection of additives and mix. These tests will be conducted as soon as possible after congressional approval of the MRS proposal.

C.3 RELATED DEVELOPMENT AND TESTING PROGRAMS

The DOE is currently supporting development and testing activities in a number of related waste management programs that interface with MRS development. If the MRS proposal is approved by Congress, MRS design verification test plans will be coordinated with these programs. Brief descriptions of the major related programs and potential areas of commonality with the MRS Program follow.

Transportation Systems Development Program: Spent fuel and waste transport casks developed in the DOE's Transportation Systems Development Program will need to interface with the MRS cask receiving and handling facilities. Cask designs evolving from this program will be issued under change control and used in the final MRS design and design verification tests.

Geologic Repository Programs: The design of spent fuel disposal packages, including the canister shape and size, may be dependent upon the chosen geologic repository media. Thus, MRS design and design verification planning will encompass the needs of all three repository programs until a repository site has been selected for the first repository. The canister type and size, overpack design, and the facility chosen for overpack installation could influence MRS design and design verification needs. Therefore, interface design requirements will be jointly baselined with the repository programs.

Commercial Spent Fuel Management (CSFM) Program: The DOE's CSFM Program is pursuing a number of activities to assist utilities with storage of spent fuel until the MRS facility or repositories become available. These activities include fuel integrity tests to establish spent fuel degradation mechanisms and consequences for dry storage, performance tests of dry storage casks, computer code qualification, fuel consolidation demonstrations, and other potentially applicable studies. The CSFM Program is also supporting a number of DOE/utility cooperative agreements covering a wide range of waste management activities which could be applicable, at least in part, to the MRS design verification program. International agreements coordinated by the CSFM Program could provide useful input to the MRS Program. These activities will be integrated with the MRS design to minimize duplication of effort.

DOE-PRDA Studies: The DOE's Program Research and Development Announcements (PRDA) are currently supporting a number of studies for improving the waste management system. These range from unique, efficient designs of canisters, consolidation systems, casks and other equipment, to alternatives encompassing the entire waste management system. Of the seven PRDA cask and canister concepts submitted for evaluation, the dual-purpose (transportable storage) cask and square/half-square canisters were selected for further investigation regarding their potential utilization in the waste management system. Definitive conclusions have not been reached at this time. However, those concepts appear to have merit in either the authorized system or the improved-performance system.

Prototypical Consolidation Demonstration Project: The PCD project was recently initiated by the DOE to develop and test dry spent fuel disassembly, consolidation, packaging, and hardware compaction equipment for use at geologic repositories. The project is managed by DOE-Idaho at the Idaho National Engineering Laboratory. The objective of the project is to test, at or near prototypic scale, a fuel consolidation system. If Congress approves the MRS proposal, the MRS Program will participate by incorporating its testing needs into the PCD project.

C.4 SCHEDULE

The schedule for MRS design verification has been integrated with the design, licensing, and procurement activities. The relationship of the MRS test program to other DOE R&D activities depends upon the timing of congressional approval of MRS. The schedule for MRS design verification testing is shown in Figure C.2.

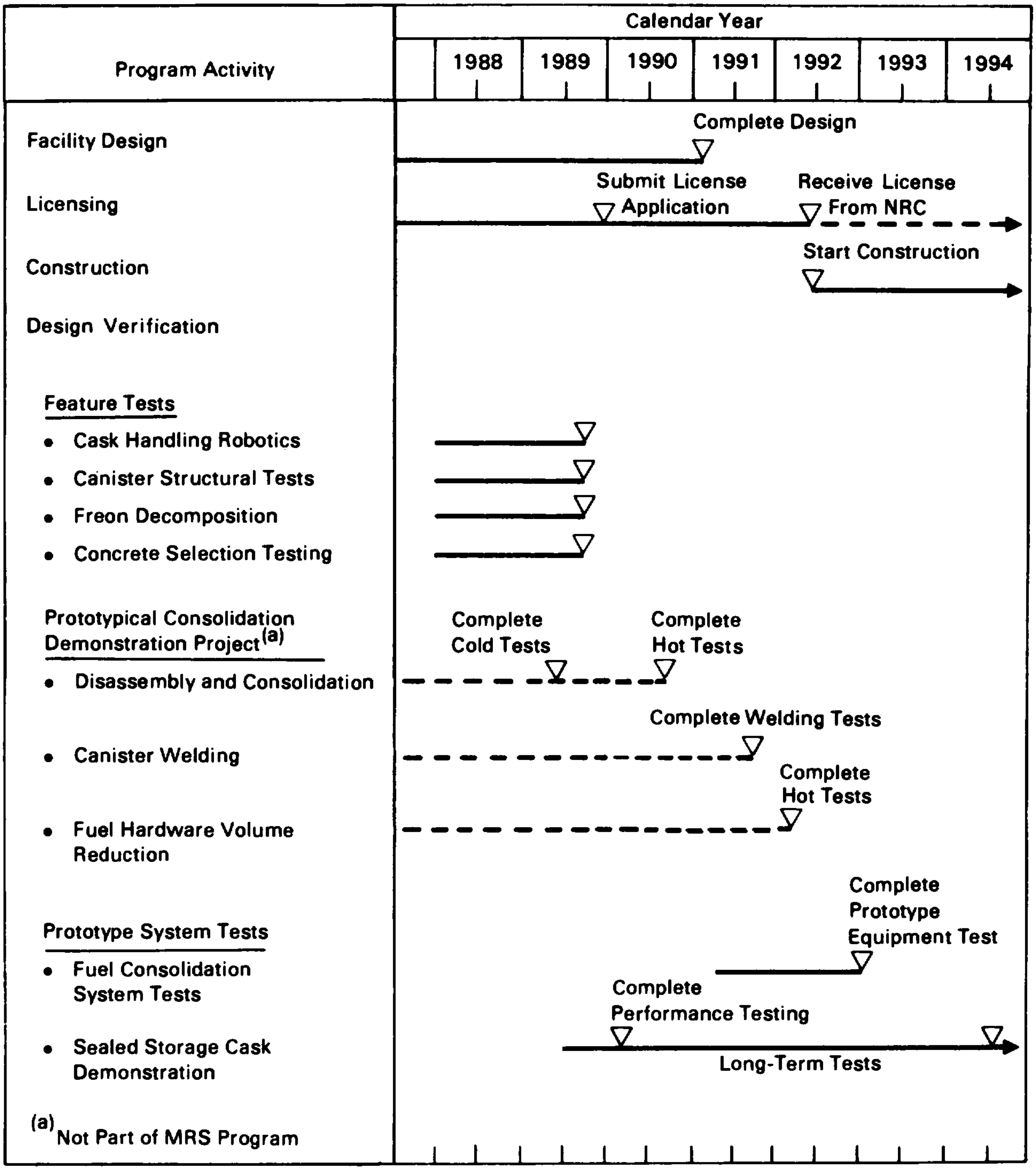


FIGURE C.2. Schedule for MRS Design Verification Testing (Assuming a July 1987 Program Start)

APPENDIX D

LICENSING PLAN

APPENDIX D

LICENSING PLAN

The NWPA requires that the MRS facility, if approved by Congress, be licensed by the NRC. The DOE, as the applicant for a license, will be responsible for the design, licensing, construction, operation, and quality assurance of the facility.

The regulations contained in Title 10, Part 72 of the Code of Federal Regulations will be used by the NRC to license the MRS facility. These regulations contain requirements for all project activities from conceptual design to the end of decommissioning. Although the license issued by the NRC will authorize the receipt, possession, and transfer of spent fuel and high-level waste, the requirements of Part 72 relate mainly to the features of the facility and site that afford protection to the public, the working staff, and the environment during operation. The license application provides an assessment of the safety of all structures, systems, and components that are important to safety; it cannot be prepared and submitted to the NRC until after design of these features is complete. The issuance of a license will therefore depend upon actions taken prior to submittal of the application.

This plan summarizes the efforts of the DOE to comply with the requirements of Part 72, mainly by reference to published documents, and the activities planned to obtain a license and to adhere to the conditions of the license. The plans for postlicensing activities are only summarized, since they will be described in detail in several reports that are enclosures to a license application.

The major documents that describe recent accomplishments related to licensing are the MRS Functional Design Criteria (PNL 1985); the MRS Conceptual Basis for Design (R. M. Parsons Company 1985a); the MRS Conceptual Design Report in seven volumes (R. M. Parsons Company 1985b), but especially Volume II, "Regulatory Assessment Document" and Volume VII, Geotechnical Description of the Clinch River Site; the MRS Environmental Assessment (Volume 2 of this submission to Congress); and the Design Verification Plan, Appendix C of this document. All work performed to date has been done in accordance with the quality assurance requirements of the DOE for their nuclear facilities. These requirements are derived from 10 CFR 50 - Appendix B and were incorporated, as applicable, into the programs of each DOE contractor.

It is the nature of the design process to iterate between design and evaluation of the design. First, a conceptual design is performed of structures, equipment, and processes that will accomplish the functions desired, and a preliminary evaluation is made of its safety, cost, and operability. The MRS Program is at this stage of the design process. Then, succeeding phases of design entail 1) the optimization of the design relative to the above evaluation factors and 2) the preparation of detailed information for construction and equipment to be procured. Thus, it is inherent in the design process that a preliminary evaluation of the performance of the MRS facility relative to safety, cost, and operability has been determined during the conceptual design, with later refinements to come as the design matures. For the MRS Program the design yet remaining is called definitive design and has two major milestones. The early design activities will concentrate on optimization of the conceptual design and the final design of structures, systems, and components that are important to safety. This design phase will produce complete information for the license application. The remainder of design will complete the drawings and specifications for construction and procurement.

Section D.1 of this appendix summarizes the content of a license application that must demonstrate how the Part 72 requirements have been or will be satisfied. In addition, the corresponding acceptance criteria of Part 72 that the NRC uses in their evaluation of the application are noted. A summary comparison of a preliminary assessment of the MRS performance with the NRC requirements is also made. Section D.2 describes the activities the DOE plans to undertake to provide a license application that will result in a favorable licensing decision by the NRC. In Section D.3 the postlicensing activities that will be needed to adhere to the requirements of Part 72, including probable conditions of the license, are summarized.

This plan cites data for the Clinch River Breeder Reactor (CRBR) site when specificity is required. The conclusions for the other two sites are not significantly different.

D.1 REQUIREMENTS FOR A LICENSE AND MRS COMPLIANCE

The license application (LA) contains a description of what the applicant proposes that he be licensed to do, and how and where the activities will be performed; it also contains an assessment of the compliance of the proposed operations to the requirements of Part 72.

The form and content of an LA for the MRS facility is shown in Figure D.1, and is described in paragraphs 72.14 through 72.20 in Subpart B of Part 72 (boxes 1-9 of the figure). The LA provides general information (box 1) about

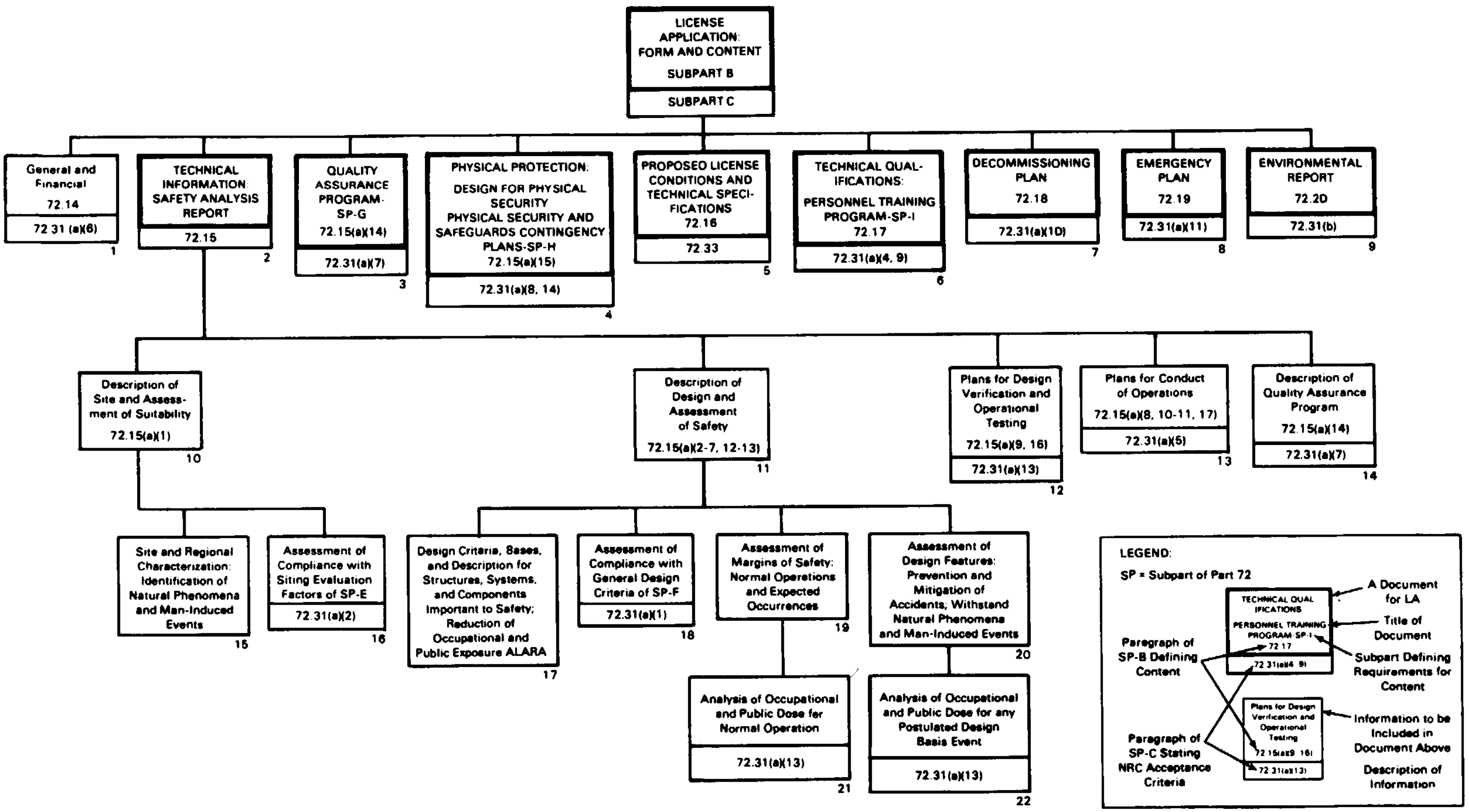


FIGURE D.1. Content and Requirements for a Part 72 License Application the applicant, including his financial capability to construct, operate and decommission the proposed facility; and also summarizes the information contained in other documents (boxes 2-9). These documents are identified by a dark outline in Figure D.1, and are submitted as enclosures to the application. The Safety Analysis Report (SAR) contains the information shown on the third and lower levels. The technical requirements to be fulfilled by the site, facility design, or by the applicant are contained in Subparts (SP) E through I, identified in appropriate boxes in Figure D.1. In an extension below each box (except those containing descriptive information), reference is made to the paragraph in Subpart C, which states the acceptance criteria the NRC will use in making their findings on the acceptability of the related information.

Only two reports, the SAR and the proposed License Conditions and Technical Specifications (boxes 2 and 5), are dependent in large part upon the detailed design of the MRS facility. The site and design information (boxes 10-11) in the SAR are subdivided into site characterization (box 15) and assessment of site suitability (box 16) and into facility description (boxes 17-18) and assessment of facility safety (boxes 19-20). The safety assessment is composed of two parts: the safety under normal operations as measured by the anticipated radiation doses to occupational workers and the public, and the safety under accident conditions or abnormally severe natural events as measured by the calculated doses to the public.

D.1.1 NRC Findings

The regulations require the NRC to make three major findings in their evaluation of acceptability of the LA. These findings relate to public health and safety, and protection of the environment. These findings are described below and are the focus of the discussions in the ensuing sections.

First, on the basis of their review of the application, and especially the analysis of occupational and public radiation doses presented in the SAR (boxes 21-22), the NRC must find that there is reasonable assurance that the operation will protect the health and safety of the public and will be conducted in compliance with Part 72, subject to appropriate conditions on the operations.

Second, on the basis of their review of the application, and especially the Environmental Report (ER) (box 9), the NRC must weigh the benefits and environmental costs of the proposed facility design and construction against the benefits and costs of available alternatives. In accordance with provisions of the NWPA, the NRC may not consider the need for the facility or any alternative to the design criteria stipulated in the NWPA. After these considerations, the NRC must find, pursuant to NEPA, that a license should be issued, subject to appropriate conditions that will protect the environment.

Third, on the basis of the proposed plans for Physical Protection (box 4), the NRC must find that the operation will not be inimical to the common defense and security.

D.1.1.1 Environmental Report

As stated in Sections 3.1 and 3.3 of the MRS Program Plan, the DOE will prepare an ER to be submitted to the NRC with the LA. The environmental information required by 10 CFR Part 51 will be included, as required by paragraph 72.20.

The plans to obtain site and regional data for the ER and facility design will be developed immediately after Congress approves the MRS proposal. These must be obtained before starting definitive design. The dates for obtaining these data are given in the MRS Program Master Schedule (Figure 3.10, Chapter 3).

The 10 CFR regulations require the NRC to evaluate the impact of issuance of a license on environmental values after review of the LA. The DOE will support their efforts by providing additional information as necessary during their review or the environmental hearings.

D.1.1.2 Safety Analysis Report

The SAR will provide the bulk of the information related to the safety of the MRS site, facility, and proposed operations. It also provides a description of the Quality Assurance Program (box 14) that has been used to obtain this information.

The assessment of the suitability of the site (box 16) is made with respect to the requirements presented in Subpart E. NRC's acceptance criterion is stated in 72.31(a)(2), which refers to the requirements of Subpart E. The suitability of the site is based upon the magnitude and certainty of the projected radiological dose to real individuals living outside the controlled area during normal operation and the potential dose to an individual at the boundary of the controlled area after the occurrence of any design basis accident (the maximum hypothetical accident) (boxes 21-22). The maximum acceptable radiological doses given in Subpart E are shown in Table D.1. However, the NRC acceptance criteria require additional assessments by the applicant, especially the possible further reduction of doses to the public during normal operation to values that are as low as reasonably achievable (ALARA).

The assessment of the safety of the facility design is made with respect to (box 18) the requirements of Subpart F, General Design Criteria, which apply to the structures, systems, and components important to safety (SIS), and with

TABLE D.1. Radiological Dose Limits of 10 CFR 72

General Public	Normal Operation (rem, annual)	Design Basis Accident (rem, each)
Real Individual		
Whole Body	0.025	
Thyroid	0.075	
Other Organs	0.025	
Person at Edge of Controlled Area		
Whole Body		5.0
Other Organs		5.0
Occupational Workers		
Operating Personnel[(a)]		
Whole Body	5.0	
Other Organs	5.0	

(a) Referenced from 10 CFR 20.

respect to (boxes 21-22) the dose limits of Table D.1. The NRC safety criteria, stated succinctly in 72.31(13), are that there is reasonable assurance that the activities to be licensed will not endanger the health and safety of the public and will be conducted in compliance with the applicable regulations of Part 72. In addition to compliance with the above requirements, the regulations require consideration of various design features to meet the objective of reducing the dose to occupational workers during normal operation to values that are ALARA.

D.1.2 Preliminary Assessment of MRS Compliance

A SAR is not required at this stage of the MRS Program. However, a preliminary assessment of site suitability and facility safety has been performed to assure a safe facility is being designed and to identify SIS. The final design of SIS (box 17) must meet the requirements of Subpart F of Part 72 (box 18).

An overall summary of the site and facility assessments performed to date is presented here with reference made to documents that provide the detailed results.

D.1.2.1 Site Assessment

Consideration of environmental protection is the responsibility, under NEPA, of both the DOE and the NRC. The DOE has issued an Environmental Assessment (Volume 2 of this submission to Congress) of the six site-design combinations as directed by the NWPA. The conclusion is that the construction, operation, and decommissioning of an MRS facility for any of the combinations would not significantly affect the quality of the environment. The DOE expects that the NRC would be able to make a similar finding for the selected site and final design after review of the LA.

Similar conclusions have been reached in previously published studies on storage of spent fuel and high-level waste. Among them are the DOE's *Final Environmental Impact Statement on Management of Commercially Generated Radioactive Waste* (DOE 1980) and two NRC studies: *Final Generic Environmental Impact Statement on Handling and Storage of Spent Light Water Power Reactor Fuel* (NRC 1979) and *Environmental Assessment for 10 CFR Part 72* (NRC 1984). The conclusions of both NRC studies are conditioned, however, upon compliance of any proposed operations with the requirements of Part 72, particularly with respect to the safe handling of spent fuel and the engineered confinement features. The last cited study was prepared to specifically assess the impacts of licensing the long-term, dry storage of consolidated or unconsolidated spent fuel and high-level waste in an MRS facility for a 70-year period of time.

The safety assessment of the site is based upon a characterization of the site and its surrounding region (box 15). The magnitude of natural phenomena and the certainty with which they may be predicted, for example, bears on the safety of a site. The DOE used site suitability as a dominant factor in its site screening process by recommending 3 out of 11 sites which had previously been considered for nuclear activities. Data on the preferred Clinch River Breeder Reactor (CRBR) site has been obtained from the CRBR files, including that documented in their preliminary SAR (PMC 1975) and amendments to the PSAR (PMC 1982), and some additional information published in the open literature since their PSAR was filed. A description of the geology and hydrology of the site has been prepared as Volume VII of the Conceptual Design Report (R. M. Parsons Company 1985b). It characterizes the seismic, flooding, and ground stability of the site and region and confirms the applicability to the CRBR site of the corresponding design parameters specified in the Functional Design Criteria for the MRS.

The safety of the site is assessed (box 16) with respect to the limits of Table D.1. The radiological impacts on the public have been calculated, documented in the EA, and are presented for the CRBR site in Table D.2 for comparison with the limits of Table D.1.

TABLE D.2. Radiological Doses at CRBR Site

General Public	Normal Operation From Annual Release (rem)[a]	Design Basis Accident From Each Occurrence (rem)[a]
Real Individual		
Whole Body	0.00024	
Thyroid	0.0013	
Other Organs	0.00024	
Person at Edge of Controlled Area		
Whole Body		0.0044
Other Organs		0.03
Occupational Workers		
Operating Personnel		
Whole Body	3.7-4.9[b]	

(a) 50-year dose commitment.
(b) Maximum dose for two crafts.

The calculated maximum doses to individuals living outside the controlled area from normal operation and from anticipated abnormal operation given in the table are 0.00024, 0.0013, and 0.00024 rem per year for doses to the whole body, thyroid, and other organs, respectively. These doses are to be compared to the limits of Table D.1 of 0.025, 0.075, and 0.025 rem per year, respectively. Any assumptions that are made in the calculations are believed to be conservative. The doses from MRS operations are realistically expected to be more than forty times less than the regulatory limits. For comparison, the annual background dose at the CRBR site is approximately 0.15 rem per year.

The EA also describes the maximum hypothetical accidents postulated at the MRS facility and presents their radiological consequences. For the CRBR site and the sealed storage cask concept, the maximum potential release of radioactivity results from dropping a PWR fuel assembly, having a 55,000 MWD/MTU irradiation exposure. Assuming that all the fuel rods are broken and using conservative assumptions, the whole body dose to a person at the edge of the controlled area is calculated to be 0.0044 rem and 0.03 rem to the thyroid. This dose is only 20 times higher than that resulting from normal operation over a year's period of time, and less than one-hundredth of the regulatory limit.

For the drywell concept there is one hypothetical accident that could result in substantially higher doses, which are still below the NRC limit. In this accident it is postulated that an earthquake occurs as a fully loaded canister is being lowered into a drywell. It is further assumed that the transport vehicle is shifted in such a manner that the canister and its fuel assemblies are sheared with the escape of volatile fission products. The probability of such an accident would be very low and could be made vanishingly small by added design features.

A description of the manner in which the site and design complies with each requirement of the Siting Evaluation Factors of Subpart E is described in the Regulatory Assessment Document (RAD), Volume II of the Conceptual Design Report referred to earlier.

D.1.2.2 Facility Design Assessment

The MRS design and its intended manner of operation (box 17) are described in the Conceptual Design Report, Volume I, Book II, Design Description. Book I of Volume I contains an Executive Summary. The RAD, as discussed earlier, contains a preliminary assessment (boxes 18-20) of its safety. The material presented in these volumes is detailed, even if only conceptual.

The RAD presents the MRS design criteria and describes the way in which they meet the NRC General Design Criteria of Subpart F. The RAD also establishes a basis for later assessments of the margins of safety by developing a preliminary set of expected occurrences, abnormal events, and potential accidents that the conceptual design should, and does, accommodate with appropriate design features. From this analysis the structures, systems, and components important to safety (SIS) were preliminarily identified and the criteria of Subpart F were applied, as appropriate for conceptual design.

The SIS were classified, using engineering judgment at this early stage of design, in accordance with their importance to safety: as Category I if they must remain functional after a design basis earthquake or tornado; and as Quality Assurance Level I or II, according to whether their failure could have offsite radiological consequences beyond the limits of Table D.1 to the public (Level I) or whether their failure would affect the immediate area of, and have consequences beyond Table D.1 to, the working staff (Level II). The exact definitions of these terms and the preliminary classification of the SIS are in the RAD.

The features of the facility which provide the primary boundary for containment of radioactive material are of the most importance to safety. They are the shipping casks, concrete walls of the hot cells in the receiving and handling (R&H) building, filters and tornado dampers in the R&H building ventilation system, and the steel canisters into which the spent fuel is placed for storage. Safe design of these features is well understood from many years of experience inside and outside the nuclear industry. They are neither novel nor new. A favorable assessment of their safety therefore depends upon 1) the quality of their construction and installation, 2) their testing during operation to assure their continued performance, and 3) an acceptable backup or margin of safety in the event of their unexpected failure.

The results of analyses of the maximum occupational doses to two classes of workers from exposure to radiation performed to date are presented in Table D.2, and are to be compared to the NRC limits of Table D.1. The calculated occupational doses are not very meaningful at this stage of design since optimization for ALARA is performed in definitive design (see Sections D.2.1.5 and D.2.2.2). The indicated occupational doses, although less than the limits of the NRC, are above the guidelines of 1 rem per year in the DOE Orders for facilities under their ownership. During definitive design additional shielding, remote operations, and other design features will be provided so that expected occupational doses will be as low as reasonably achievable.

The DOE believes that the conceptual design, described in the seven volumes of the Design Report, provides a detailed starting point for definitive design; and that its safety can be demonstrated in a future license application.

D.1.2.3 Assessment of the Design for Physical Protection

The details of the design and plans for security of the plant and the radioactive materials possessed (box 4) are withheld from the public by the NRC as a deterrent to potential sabotage. However, the measures that are used to provide physical protection are not withheld. The conceptual design report and the RAD describe the features to be provided and their compliance with the requirements. Figure D.2 shows the fence that is the boundary of the controlled area of the CRBR site and the two security fences, with an alarm zone between them, which surround the protected area. Nuclear materials are not handled or stored outside of the protected area.

Since these matters are common to all licensed facilities, they are not discussed further in this plan. The detailed designs and plans will be provided to the NRC with the LA.

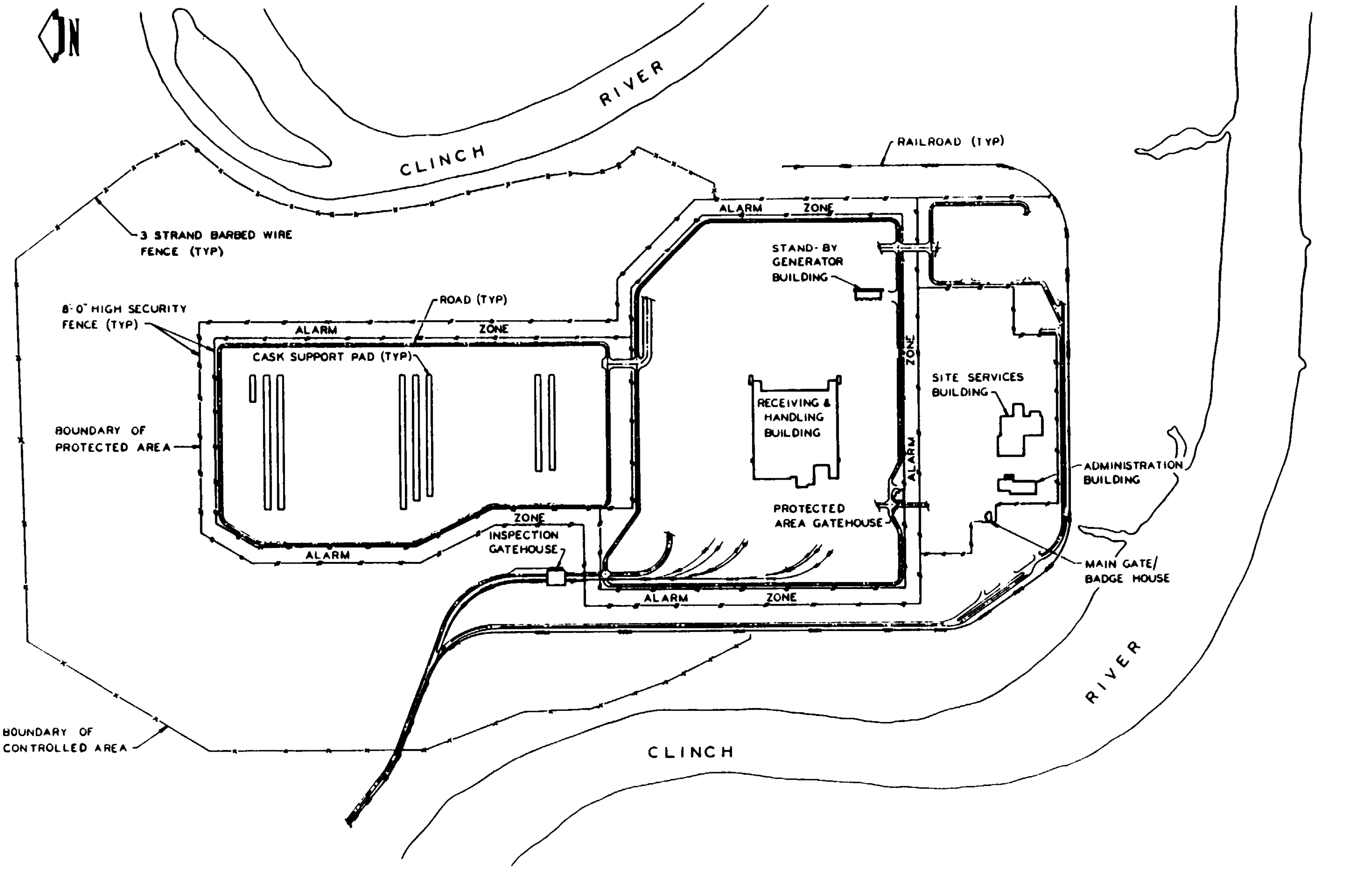


FIGURE D.2. Layout of MRS Installation at CRBR Site

D.2 PRELICENSING PLANS

This section describes the major activities that are planned to develop an LA for the MRS facility, if approved by Congress. The activities are discussed according to the time sequence in which they will be performed. In contrast, Section D.1 presented the informational needs and site and facility design requirements that the activities must satisfy.

The activities needed to obtain a license span almost the entire breadth of the project activities, so that brief, or no, mention is made of some activities which, though important, are not unusual for the MRS facility. The activities will be described with reference to Figure D.3, which shows the general sequence of activities related to licensing. Since the figure is not a detailed logic network, only major interfaces of activities are shown, and the detailed feedback of information within an activity or, from one activity to another, will take place as needed. The schedule for these activities are shown in the MRS Program Master Schedule (Figure 3.10, Chapter 3).

The activities described will be performed by the DOE and their contractor(s). The DOE will obtain expert services for the design, procurement, construction, technical support during design and licensing, and operation of the facility.

The preproposal activities are shown to illustrate the DOE's intent to adhere to the NRC requirements in performance of these activities.

D.2.1 Preparation for Definitive Design and Environmental Report

The purpose of the first column of activities after congressional approval, shown in Figure D.3, is to plan and collect data for development of the ER and the facility design. These activities are summarized, from the top down. They are then described in more detail in subsequent sections.

Early interactions with the NRC staff will provide input to a Regulatory Compliance Plan, which will provide guidance to other program activities, and will contain detailed plans and schedules for the assessment of site and facility safety. In parallel, site and regional data will be confirmed, and new data obtained where necessary, for the ER and facility design. The scope of environmental data to be contained in the ER will be determined after consultation with the State of Tennessee, the NRC, and the EPA. Finally, to prepare for definitive design, the Mission Plan, guidance from Congress, and the existing EA and conceptual design documents will be used to establish the technical baseline for the approved MRS facility.

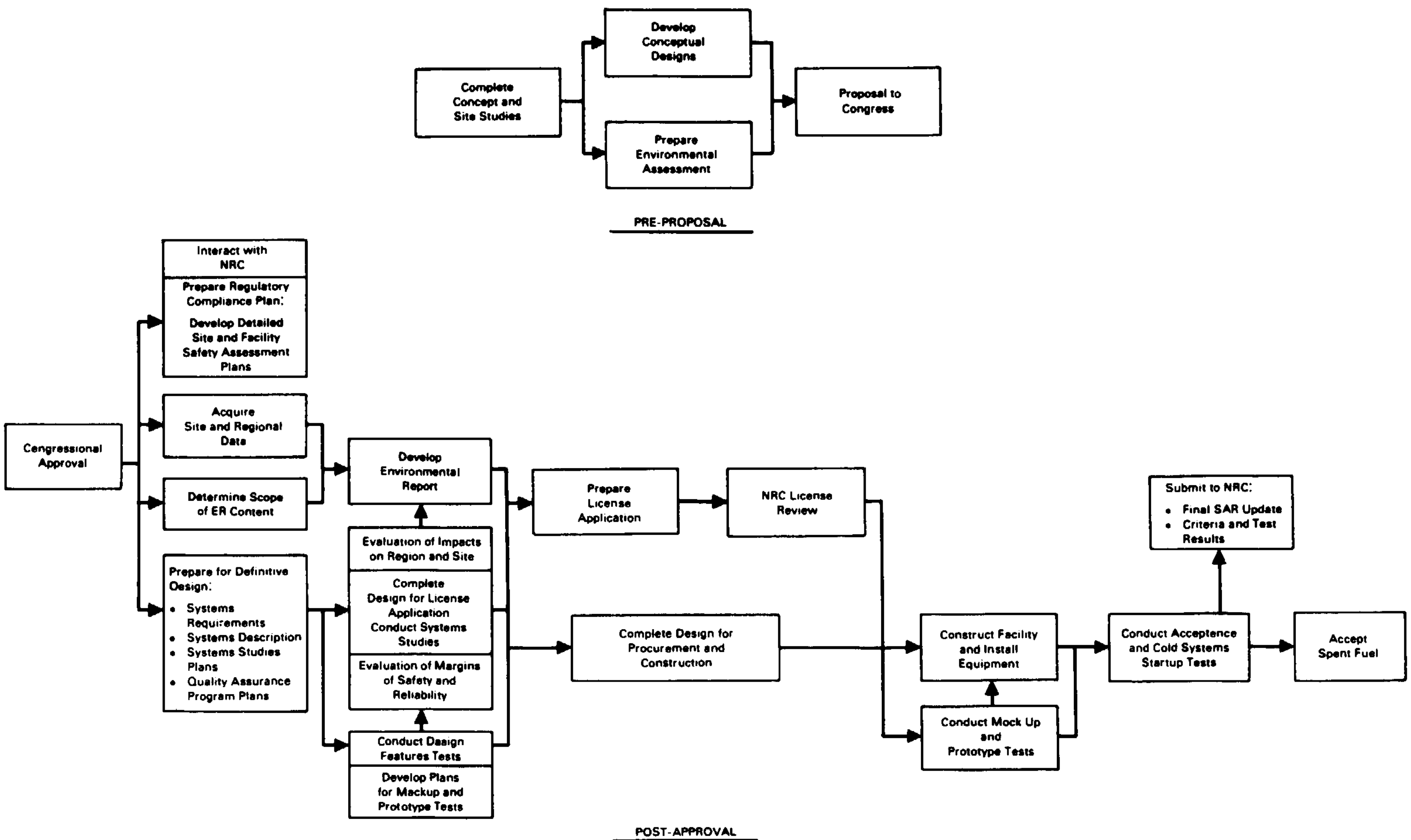


FIGURE D.3. Activities Related to NRC Licensing of an MRS Facility

D.2.1.1 Interactions with the NRC

As soon as possible after congressional approval, the DOE proposes to enter into a Procedural Agreement with the NRC to foster cooperation on planning of licensing activities and an open information exchange between the DOE and the NRC. The Procedural Agreement will provide for agreement on plans, schedules, and the responsibilities, including NEPA, of each agency. The existing Procedural Agreement (NRC 1983) between the DOE and the NRC for the conduct of the geologic repository program could be extended to include the MRS Program.

The Procedural Agreement will provide for meetings prior to submittal of a license application at which appropriate management personnel of both agencies could discuss plans, review progress, and facilitate the resolution of problems. Similarly, provisions will be made for technical meetings for review and discussion of technical matters, such as interpretations of requirements, design data or options, and the adequacy and sufficiency of information or data. The schedule for meetings will be published in advance, and they will be open to attendance by interested parties. Summary minutes of the meetings will be made available to interested parties.

Any meetings to be held after submittal of an application for a license will be conducted in accordance with existing NRC procedures since the DOE would then be an Applicant subject to NRC regulations.

The Procedural Agreement will also provide for exchange of documents and other information or data developed by either party. NRC observers will be encouraged to review the progress of design and development activities. The DOE will request that the NRC staff review and comment on topical reports that the DOE and the NRC mutually agree upon. The purpose of these reports will be to receive a degree of assurance from the NRC staff, before submittal of the license application, that the DOE efforts are meeting the requirements foreseen by the NRC. In turn, review of these reports will provide the NRC with early information on the MRS Program. Examples of such reports that would facilitate early activities and later NRC review of the license application are:

- the MRS Quality Assurance Program
- Quality Assurance Plans for: acquisition of site and regional data, definitive design, procurement, construction, and design verification testing
- seismic design methodology and codes
- design for prevention of criticality

- validation and verification of heat transfer codes

- canister and storage cask designs and testing

- hypothetical accidents for analysis for SAR.

D.2.1.2 Regulatory Compliance Plan

In parallel with discussions with the NRC, a Regulatory Compliance Plan will be developed to provide guidance to other program elements on the 1) requirements each is to satisfy and 2) plans, in the form of a logic network, of information and data that will be needed for the preparation of the LA, particularly for the safety assessment of the site and facility design. The Regulatory Compliance Plan will contain schedules and identify feedback loops for the iterative sequence of: development of data used as input to the design, validation of design methods, identification of structures, systems, and components important to safety (SIS), performance of design studies, and evaluation of the margins of safety during operation. These activities are interdependent and are essential to the timely preparation of the LA. The plan will need to be maintained up-to-date as the program develops.

D.2.1.3 Site and Regional Data Acquisition

From many prior studies of the CRBR site and surrounding region, a broad scope of data is available. The additional needs are 1) confirmation of the validity and applicability of existing data, 2) updating of data that may have changed with time, and 3) development of some detailed data not now in hand, such as an engineering characterization of site properties for the placement and foundation design of MRS facilities. Part of this information will be obtained immediately upon the start of definitive design to confirm the acceptability of the layout and conceptual design of the MRS facilities. Baseline environmental data for the ER, if current data is found to be insufficient, would take one year to span a complete cycle of seasonal variations of meteorology and climatology.

After collecting and analyzing the data, the results will be input to the ER and definitive design. The information required in box 15 of Figure D.1 can be assembled and submitted as a topical report. The report would characterize the geology, hydrology, seismology, meteorology, demography, and nearby industrial or other activities in the region and interpret the information in terms of design criteria for earthquakes, flooding, tornados, and protection against man-induced events. An NRC review of the report would reduce the risk of later design changes, provide the MRS staff with experience in interacting with NRC staff, shorten the time required for review of the LA, and promote early understanding of MRS design criteria by NRC staff.

D.2.1.4 Scope of Environmental Report Content

An early series of discussions with the state and local entities and federal agencies will scope the issues that may need to be addressed in the ER that are additional to those in the current MRS Environmental Assessment (Volume 2 of this submission to Congress). The data needed to consider these issues or to update data already available will be factored into the site investigation studies. In addition, some of the data may need to be considered in the layout and design of the MRS facility. The ER will contain a comprehensive discussion of the impacts of construction and operation on the environment.

Consultation with the NRC in the early identification of environmental data needs will provide added certainty to the completeness of the ER.

D.2.1.5 Preparation for Definitive Design

A revised and expanded set of project documents will be needed for management and technical control of the definitive design. In accordance with OCRWM policy, this need will be satisfied at the top level by developing an MRS Systems Requirements document. This document will contain the functional requirements and performance criteria for the MRS facility and its subsystems. In addition, a System Description document will be prepared that will describe the design criteria and bases, the system configuration, and the interfaces between each of the MRS subsystems. These documents will be based upon the conceptual design documents listed on page D.1. The documents will be baselined, under change control, for use in the definitive design. Changes will be made in the documents as the iteration between design definition and design evaluation proceeds toward a final design.

A Systems Studies Plan will be developed to schedule and guide the optimization of the MRS system design. Optimization may be performed with respect to any one or more factors such as cost, safety, product performance, and schedule. A number of such studies were identified during conceptual design and deferred to definitive design. These studies are presented in the Conceptual Design Report, Volume I, Appendix G.

Preparation of quality assurance documents, expanded beyond those currently in use, to cover the collection of field data and performance of design and testing will be scheduled for the earliest possible date. The first of such documents will cover the overall DOE management of the program for an MRS facility, and the DOE contractors' program for technical support activities, including design, field investigations, and design features and materials testing. Submittal of these documents to the NRC for review and comment will add to the certainty that the management and technical control of MRS activities meet the NRC requirements.

D.2.2 Development of the Environmental Report and Definitive Design

The activities depicted in the second column of boxes in Figure D.3 will produce the ER and complete the final design information required for a license application. All of the design that bears upon the LA, including the ER, will be planned for completion at the earliest possible time. However, the LA requires complete designs and specifications for all SIS. Therefore, careful planning and sequencing of the design studies are needed to ensure acceptance of the LA by the NRC for review.

D.2.2.1 Development of the Environmental Report

Within one year after the start of definitive design, the conceptual design will have been confirmed and any changes in the magnitude of the impacts on the environment of construction, operation, and decommissioning will be known. The radiological impact on the public, expected to be below acceptable regulatory limits on the basis of the conceptual design, will have been reviewed, with the ALARA concept being the criterion for mitigation of radiological impacts. Information on the use of land and of other resources and the studies of demography, meteorology, background radiation, rare and endangered species and other subjects will also have been developed. The ER will be prepared with particular attention to the requirements of the NRC, as given in 10 CFR 51.

D.2.2.2 Completion of Design for License Application

The first activity in definitive design will be a review of the DOE's Systems Requirements document, System Studies Plans, other baseline management and technical documents, and the plans for site and facility safety assessment. (These documents were discussed earlier.) In parallel, the contractor performing the design will prepare his quality assurance program and procedures for DOE approval. With this understanding, the design activities will concentrate on the optimization of design by performance of studies identified in the Systems Studies Plans or by review of the conceptual design. Three of the more important studies which are related to safety considerations are:

- a study of the wall thickness and steel reinforcement of the sealed storage cask versus the resulting changes in occupational exposure of workers in the storage field, in the temperature and perhaps the lifetime of the concrete, in its ability to withstand tornado-generated missile impacts, and in the cost of manufacture (ALARA and margins of safety).

- a study of the use of additional remotely controlled equipment versus the resulting decrease in occupational exposure but at increased capital and, perhaps, at increased operating cost and lower availability (ALARA).

- a study of the capacity of the lag storage vault versus the resulting changes in operational flexibility, in the vault cooling requirements or changes in lifetime of the concrete walls, in changes in the margins of safety in the event of loss of multiple power sources, and in the cost of the building and support equipment (margins of safety).

In addition to the systems studies, a large number of safety questions will be addressed in this phase of the design. They obviously overlap in an iterative fashion with the evaluation of the margins of safety described in a later section, but are described here for clarity. Some of these have been documented in the RAD or Appendix G of the Conceptual Design Report. A few of those involving considerations of safety are listed in Table D.3. Close inspection of the items listed and comparison with the current conceptual design will reveal that many of the items also pertain to potential cost reduction, or value-engineering studies. As in the usual design process, conservative decisions were made during MRS conceptual design in the absence of final studies on the effects of failures and on existing margins of safety.

Concurrent with the design, parts of the LA will be prepared that are not dependent upon the detailed and final safety analyses. These may be submitted for early NRC review if it appears likely that this would reduce the license review time or would assist in making design decisions. In rough order of their dependence upon final safety assessments, they are:

- Technical Qualifications: Personnel Training Program
- Physical Security Plan
- Safeguards Contingency Plan
- Design for Physical Security
- Decommissioning Plan
- Emergency Plan.

Each of these is described below, following Table D.3.

TABLE D.3. Safety Considerations for License Application Design

- Magnitude of radioactive particulate deposited in cells and on filters and methods of reducing their quantity
- Methods of waste collection, decontamination, and volume reduction of both liquids and solids
- Agreement with repository program on acceptability of encapsulation of contaminated organic materials
- Re-evaluation of need and placement of monitoring equipment for radioactive gaseous effluents, sanitary sewer system, and seismicity
- Re-evaluation of need for various monitoring and control functions to be supplied by uninterruptible power, i.e., rather than offsite or backup generator power
- Re-evaluation of need for various functions to be controlled at both local and remote control rooms under off-normal conditions or design basis accidents
- Re-examination of the basis for the CHTRU building to be resistant to severe earthquakes for operating flexibility or public safety
- Re-examination of possible causes of fires or explosions and any further design features to mitigate their effects
- Final determination of shielding wall thickness to result in occupational doses that are ALARA

The nucleus of an operations staff will review the design for operability and maintainability, providing input to the design. Using this experience, the staff will develop the Personnel Training Program. Training will begin as soon as the full set of prototypic systems are installed in the training cell, as described in Section 3.5 of Chapter 3.

The Physical Security and Safeguards Contingency Plans can, likewise, be prepared after confirmation of the conceptual design and performance of some design work not involving the SIS.

The Design for Physical Security, the Decommissioning Plan, and the Emergency Plan rely on more information than exists in the conceptual design, but could be prepared for the NRC in advance of submittal of the LA.

D.2.2.3 Design Feature and Systems Tests

Some features incorporated into the conceptual design need further testing to justify their choice, may not be optimum among all the choices, or have been assigned operating limits that need to be confirmed by testing. The information needed generally relates to achievement of an acceptable margin of safety. In addition to the tests identified in the conceptual design report, additional tests may be identified during definitive design. Those feature tests that were identified in the conceptual design are described in the Design Verification Plan, Appendix C. Some of these tests will determine performance limits, such as concrete testing at high temperatures, and some will determine the capacity and shielding needed for systems to treat wastes generated at the MRS facility.

In addition to the feature tests, a series of tests will be performed on the disassembly and consolidation system. These are planned to be completed before the LA is submitted to the NRC, as described in Appendix C.

At this stage of design, plans can be developed for mockup and prototype tests to verify operability of the final components to be procured. There are tests already identified in Appendix C that will be considered for completion during design and construction. Augmenting these plans with those for operational testing of the MRS facility after construction will provide information for the SAR (box 12 of Figure D.1).

Planning for the operation of the facility will also be completed to satisfy another of the items in the SAR, Plans for the Conduct of Operations (box 13 of Figure D.1).

D.2.2.4 Evaluation of Margins of Safety and Reliability

After sufficient design information is available on portions of the design of the SIS to warrant reassessment of their importance to safety and their margins of safety, studies of reliability and operability will be performed to assure that the operability goals of the DOE (stated in the Systems Requirements document) and the safety performance requirements of the NRC are met. Some of the input data will be obtained from failure modes and effects analyses. In turn, the results provide input to assessments of the margins of safety between normal operations and operations under either severe natural phenomena or design basis accident conditions. The results will be used in an assessment of the likelihood, and analysis of the effects, of improbable events and design basis accidents. A description of these studies is needed for the SAR (boxes 19 and 20 of Figure D.1).

The conceptual design effort used engineering judgment instead of failure and reliability studies to proceed to the identification of possible off-normal and serious accidents. More than eighty events of varying severity were considered and are presented in the MRS conceptual design report. As mentioned earlier, these considerations allowed a preliminary identification of the SIS.

The quantitative analyses discussed above will be performed using reliability and other data for specific components and systems defined during definitive design. Some of the more important of such studies are listed in Table D.4, although it is acknowledged that, at times, it is difficult to distinguish between design studies like those in Table D.3 and design assessments like those in Table D.4. Again, Table D.4 is derived in part from references already cited.

TABLE D.4. Failure Modes and Effects and Reliability Studies

- Effects of the successive loss of sources of alternative power
- Dynamic analyses to determine pressures versus time upon failure of tornado valve; and to determine their importance to safety and testing requirements
- Consequences of exceeding yield strength of reinforced concrete under high temperature, seismic, or tornado-generated missile stresses
- Human factors study to identify effects of potential operator responses
- Modes and consequences of fuel cladding and canister failure and ultimate temperature limits for safe storage
- Consequences of a design basis earthquake and tornado-generated missile on storage cask and canisters in the storage field and final classification of their importance to safety, including the steel liner in the cask
- Effects of multiple failures, including human

At the conclusion of these studies the information will be used for performing the final analysis of the radiological effects of exceeding the margins of safety (boxes 21 and 22 of Figure D.1). The information will also be used to confirm the final classification of structures, systems and components that are important to safety. This classification is subsequently used in designation of the quality standards to be used in procurement, construction, and testing of the SIS.

D.2.3 Completion of the License Application

The next column of activities in the sequence shown in Figure D.3 involves the use of design and other information to develop the LA. Upon completion of the safety assessments described in previous sections, the SAR will be assembled.

The information for the development of the remaining enclosure to the LA, Proposed License Conditions and Technical Specifications (box 5 of Figure D.1), will be available at varying times during design, but the final specifications can be confirmed only after the analysis of the hypothetical design basis accidents. For example, the license condition which specifies the maximum quantity and characteristics of fuel to be stored under the license will be known early, but specification of the set-points and range for radiation monitors on the stack must await the final determination of the rate and magnitude of the radioactive gaseous effluent from hypothetical accidents.

The LA and its accompanying reports will then be submitted to the NRC and, after their review for completeness, the NRC will docket the application.

D.2.4 Review of License Application

The NRC review process is scheduled to take 30 months from application to issuance of a license. Although a longer review period may be required in the event of serious contentions which require extensive hearings and appeals, a shorter period would be needed in the absence of contentious issues. The DOE believes that the scheduled 30 months is a reasonable allowance of time in view of the proposed extensive prelicensing interactions with the NRC and the opportunities for the public to be involved in the review of technical documents.

Questions from the NRC staff are expected during their review and will be responded to in a timely manner to expedite the license review.

The remaining design of items not important to safety, including detailed drawings and specifications for procurement, construction, and installation, will be completed during NRC review of the application.

D.3 POSTLICENSING PLANS

The requirements prescribed for a licensee are found in Subparts C and D of Part 72. They relate to Conditions of Licenses; and Records, Reports, Inspections and Enforcement, respectively. The activities planned for the MRS Program are shown in Figure D.3. More detailed descriptions and milestones are given in Chapter 3.

After receipt of a license, the DOE will proceed with site preparation and construction. During this period, inspections will be performed to assure that quality standards specified in the design are met for purchased materials and equipment, and for major construction and installation; and that the conditions of the license are met. Resident NRC staff from the Office of Inspection and Enforcement will be housed at the construction site to facilitate their inspection of the work in progress. Inspection and acceptance services will also be provided by the contractor who designed the facility.

Construction of the MRS facility will be scheduled so that the mockup and training cell in the site services building will be completed at the earliest time that is compatible with orderly construction and economy. Advanced procurement of prototypic spent fuel handling equipment will allow installation of these prototypes as soon as the mockup and training cell is complete. After installation, these prototypes will be operated for the dual purposes of training operators and maintenance staff and of operating and testing the equipment under simulated operating conditions. Any desirable design changes may be made during procurement of MRS equipment, or be back-fit if necessary.

During completion of construction and testing, the SAR will be updated and submitted to the NRC every 6 months, with the final submittal not later than 3 months before spent fuel or high-level waste is to be received. The acceptance criteria and test results of the preoperational tests using cold or simulated spent fuel will be submitted to the NRC for their review at least 30 days before spent fuel or high-level waste is to be received.

After the receipt of actual spent fuel, the preoperational tests will be repeated, but under radioactive conditions, sequentially in one cell at a time. The throughput rate of the facility will be judiciously increased during the operational demonstration, as more experience is gained in the use of the operating procedures and in the operating characteristics of the processes and equipment. A ramp-up of the throughput to full operations is expected to take approximately one year after the start of hot operations.

All radioactive operations of the MRS facility will be in accordance with the limits prescribed in the Technical Specifications, which are part of the conditions of the license.

After completion of its mission, the MRS facility will be decontaminated and decommissioned in accordance with the Decommissioning Plan approved by the NRC.

REFERENCES

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APPENDIX E

COST AND FUNDING ANALYSES

APPENDIX E

COST AND FUNDING ANALYSES

The purpose of this appendix is to provide further details on the cost estimates and funding plan included in the body of the MRS Program Plan. Section E.1 describes the basic approach and assumptions for cost estimation. Sections E.2 and E.3 present and discuss the details of the cost estimates for the preferred site-design case and the five alternative cases. Section E.4 presents an analysis of cost sensitivities. Section E.5 discusses the alternative funding approaches considered, explains the selected approach, and details the plan for funding the MRS Program. The change in the total cost of the federal waste management system, due to addition of the MRS facility, and a summary of the costs by funding category are also provided in Section E.5. Section E.6 presents additional detailed cost and data tables.

E.1 COSTING APPROACH AND ASSUMPTIONS

The approach to estimating the costs for deploying, operating, and decommissioning the MRS facility is discussed and an explanation of cost categories and economic assumptions is provided. This is followed by a discussion of the basic assumptions for costing, such as site-design combinations, waste logistics, facility design, and costs not included.

E.1.1 Approach to Cost Estimation

In developing the cost estimates for the MRS facility, the activities in the facility deployment, operations, and decommissioning processes are evaluated and information on the manpower, materials, and capital equipment are developed from the conceptual design of the MRS facility. The assumptions used are consistent with the system described in the OCRWM Draft Mission Plan Amendment (DOE 1987a) and in Appendix A of this document.

Costs were estimated for activities in each of the nine MRS program elements: 1) Environmental Evaluations, 2) Design, 3) Regulatory Compliance, 4) Construction, 5) Training and Testing, 6) Operation, 7) Decommissioning, 8) Institutional Interactions, and 9) Program Management. The costing framework is shown below:

Costing Framework

1. Environmental Evaluations
   - Environmental report
   - Environmental data

2. Design
   - R&H building
   - CHTRU facility
   - Support facilities
   - Storage facility
   - Site design data
   - Site improvements
   - Utilities
   - Design verification
   - Design management support

3. Regulatory Compliance
   - NRC license application
   - Permits
   - License review and amendments
   - License amendments during construction
   - Operational reporting
   - Decommissioning amendment

4. Construction
   - R&H building
   - CHTRU facility
   - Support facilities
   - Storage facility
   - Site improvements
   - Utilities
   - Construction management and support

5. Training and Testing
   - Operating procedure and training
   - Preoperational testing
   - Fire protection and security training

6. Operation
   - R&H building
   - CHTRU facility
   - Support facilities
   - Storage facility
   - Environmental surveillance

Operations management & support
Capital modifications/additions

7. Decommissioning
   R&H building
   CHTRU facility
   Support facilities
   Storage facility
   Site improvements

8. Institutional Interactions
   Public information programs
   Consultation and cooperation agreements
   Financial assistance

9. Program Management
   System engineering and configuration management
   Intergovernmental relations
   Project planning and control
   Subcontract management
   Management services
   Quality assurance

Cost Categories

The nine cost categories represent the nine program elements. A description of activities in each category is presented below.

Environmental Evaluations costs are those associated with the compilation and verification of ecological, hydrological, meteorological, and socioeconomic site data for the preparation of the Environmental Report (ER) and the interactions with NRC required for preparing the ER. Site data collection and evaluations in this cost category include all data except those needed only for design and construction purposes, such as rock and soil mechanics. Manpower requirements for each activity and associated cost were estimated in accordance with the proposed deployment schedule.

Design costs encompass all activities that are required to complete design documents, including drawings, descriptions, specifications, and engineering studies for R&H building, CHTRU facility, storage facility, support facilities, site improvements and utilities. The engineering studies include analyses required for the development of the Safety Analysis Report and other documents needed for an NRC license application. Other preconstruction costs included under this element are those for site data confirmation, design verification, and design management and support. Costs for design engineering support after initiation of operations are included in the Operation element. A contingency of 20% is also included.

Regulatory Compliance costs pertain to permitting and licensing activities throughout the life span of the MRS facility. These activities support applications at local, state, and federal levels. Licensing and permitting fees, if any, are not included in the cost estimates.[a] Preconstruction activities include preparation of the license application to NRC and various permit applications as required, and licensing review support. License amendment support is required throughout construction and operation. Finally, costs for preparing and submitting a decommissioning amendment are also included.

Construction costs cover actual construction of the MRS facility based on the drawings and specifications prepared in the Design element.[b] They include labor, materials, equipment, contingencies, support services, site improvements, utilities and construction contractor management. Construction costs are considered capital investments. These expenditures are of three types: 1) direct costs - paid to construction contractors for expenses on behalf of the project, such as construction of the R&H building (including receipt and inspection facility), CHTRU facility, support facilities, storage facility, utilities and other site improvements; 2) construction management costs - costs for performing construction management and support services; and 3) contingency costs - a reserve for unexpected events or requirements not specifically foreseen. The latter costs are estimated as a percentage of the sum of direct costs and construction management costs.

Training and Testing will begin prior to the completion of facility construction to ensure that the MRS facility and operations staff will be prepared to perform their intended functions safely and within quality requirements by the time the facility becomes operational. The training and certification

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(a) See Section E.1.5 for reasons why the licensing and permitting fees are not estimated.

(b) Note that the Design and Construction elements in this costing framework refer to all costs during the design and construction phases, including both capital-funded and operating expense funded costs. In the conceptual design report (Ralph M. Parsons Company 1985), the architect-engineer used the term "construction" to cover the capital-funded portion of the combined design and construction costs. The reconciliation of the difference between these two cost estimates for the combined design and construction categories for the preferred site-design case is explained in Section E.2.1 (Construction). This distinction between the term "construction" used in this appendix and that in the conceptual design report should be kept in mind throughout this appendix as well as the Program Plan.

programs will cover safety and radiological monitoring groups, operations and maintenance crews, and emergency response teams. Training and operations testing will sequence through the mockup facility in the site services building, the cold tests in the R&H building (full complement of equipment installed in the hot cells without using actual spent fuel assemblies), and the hot test in the R&H building (using actual spent fuel assemblies). Also included in the estimates for this program element are costs for fire protection and security training, and for preparing the necessary training documentation as well as a 20% contingency allowance.

Operation costs include salaries and benefits for operating and maintenance personnel and were estimated for activities associated with receiving, consolidating, packaging, shipping offsite, or temporarily storing and then shipping offsite, spent nuclear fuel and the associated waste from handling and consolidating the spent fuel. The costs were developed from the Ralph M. Parsons Company estimates of the numbers of operating and maintenance personnel required for operating and maintaining the R&H building, CHTRU facility, storage facility and support facilities plus administrative and support staff, together with the costs of materials. Additional costs are included in this program element for continuing environmental monitoring during the operational period of the facility, and for operations management and support. Costs for facility improvement and modifications and for storage casks and canisters are also included.

The costs incurred during facility operation include both capital-funded and operating expense-funded expenditures. Capital-funded expenditures include costs for the sealed storage casks and facility improvements. Operating expense-funded expenditures include the following general categories: 1) labor--determined by a composite annual wage rate that includes all labor costs and the number of staff persons; 2) consumables--items used during operation and maintenance of the facility, such as canisters, drums, filters, and miscellaneous items; 3) maintenance, supplies and contract labor--paid to suppliers for parts, supplies, and labor used for facility maintenance and operation; and 4) utilities, including fuel oil/diesel and gasoline. A 20% contingency allowance was made to cover the normal uncertainty in cost estimate at this stage of design.

Decommissioning costs begin to be incurred approximately four years before the end of operations when the decommissioning plan is prepared and the storage casks are unloaded and decontaminated in preparation for decommissioning. The major part of decommissioning costs associated with decommissioning the R&H building, CHTRU facility, and the storage and support facilities will not begin until the last of the consolidated spent fuel has been shipped to the repository. Costs for site improvements or reclamation are included. This cost category also includes a 20% contingency allowance.

Institutional Interactions costs are incurred 1) to provide timely and full information exchange and appropriate participation between and among the DOE, the public, the State, and local officials regarding the development, deployment, operation, and decommissioning of the MRS facility; and 2) to ensure that the State and local governments receive fair and reasonable financial assistance for the effects of construction and operation of the MRS facility. In this analysis, only costs associated with public information programs are estimated, because the other cost elements are still under discussion.[a]

Program Management costs cover the period from congressional approval through operational demonstrations of the MRS facility. Services provided include 1) system engineering and configuration management, 2) project planning and control for a major systems acquisition, 3) management of subcontracts, 4) management services such as procurement, financial services and program office staff, and 5) quality assurance. These costs were based on estimates of the annual level of effort required. During facility operation, all program management costs are estimated under the Operation program element. During the period when the facility is being decommissioned, costs of program management are estimated separately.

Economic Assumptions

Unless otherwise noted, costs included in this appendix are specified in terms of 1986 constant dollars, and thus do not include the effect of general inflation. When making comparisons of cost estimates in future years, it would be necessary to convert the cost estimates in this appendix to the dollar terms of the year in which the new cost estimates are being specified.

E.1.2 Site and Design Combinations

Section 141(b)(4) of the NWPA requires that the MRS proposal include at least three alternative sites and at least five alternative combinations of such proposed sites and facility designs. The DOE has chosen the sealed storage cask as the primary storage method for the proposed MRS facility. The field drywell was selected as the alternative storage method. The DOE has selected the former Clinch River Breeder Reactor site in the State of Tennessee as the preferred site for locating the MRS facility. Two alternative sites were also identified for evaluation: the DOE Reservation at Oak Ridge, Tennessee, and the former Hartsville nuclear plant site near Nashville, Tennessee. Six site-design combinations were evaluated: one preferred and five alternative cases. Cost estimates have been prepared for all six cases.

(a) Refer to the MRS proposal (Volume 1) for a description of the DOE's proposed program.

E.1.3 Waste Logistics

The waste logistics used in this analysis are based on the schedule for waste acceptance, storage, and shipment from the MRS facility to the first repository, shown in Table F-1 of the Draft Mission Plan Amendment, Illustrative Waste Acceptance Schedule (DOE 1987a). This schedule indicates a maximum required receipt and shipping rate of 2,650 MTU, total throughput of 59,760 MTU, and expected onsite maximum inventory of 14,700 MTU. The MRS facility will initiate limited receipt of spent fuel from reactors following completion of cold systems testing and will continue to receive spent fuel for 26 years thereafter. The MRS facility will ship spent fuel to the first repository from 2003 to 2027. Defense waste will be sent directly to the first repository and the second repository will operate independently of the MRS facility.

E.1.4 Facility Design

The conceptual design for the MRS facility has a design receipt rate of 3,600 MTU/year and onsite storage capacity of 15,000 MTU. Plans for facility operations are based on a five-day, 3 shifts/day mode (with a standby mode on the weekends) to accommodate an operating receipt/ship rate of as much as 3,000 MTU per year. A total plant operating staff of about 600 employees would be required at these throughput rates during steady-state operation. For the first few years of operation of the MRS facility, the consolidated spent fuel would be placed into temporary storage. Shipment of spent fuel to the repository would begin in 2003. In subsequent years, the facility would serve primarily as a receiving and packaging facility for the first repository. The major elements of the MRS facility are the R&H building, the CHTRU facility, the support facilities and the storage facility.

E.1.5 Costs Not Included

Certain items are not included in the cost estimates presented in the next sections. These are discussed below.[a]

As discussed in the MRS proposal (Volume 1), it is recommended that financial assistance be made available to local units of government affected by MRS deployment upon congressional approval. When agreements are reached and the costs can be estimated, they will be included in MRS life-cycle cost estimates.

The DOE is recommending that Congress direct that revenues equivalent to taxes be provided to the State of Tennessee and affected units of local government for the MRS facility. This will provide revenues to the State and localities equivalent to those which would be received if a commercial facility were built on the site. When costs have been identified, they will also be included in MRS life-cycle cost estimates.

Pursuant to Section 117(b) and (c) of the NWPA, binding Consultation and Cooperation Agreements will be sought with Tennessee within 60 days after congressional approval of the MRS Program. Since these agreements have not been negotiated, there are no cost estimates available at this time.

The DOE could provide preliminary estimates for the 3 items listed above. However, because these costs will ultimately be determined through negotiations, it is not appropriate to include them at this time.

Also not included in the cost estimates are licensing and permitting costs associated with other federal, state and local entities. At this time, there is no clear indication whether the federal entities will make these costs part of their request for congressional budget appropriations or whether they may directly charge the Waste Fund under Title 10 Code of Federal Regulations,

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(a) The cost of transporting spent nuclear fuel within the federal waste management system is a major component of the total system life-cycle costs of the federal waste management system. (For the improved-performance system, the other three major components are development and evaluation (D&E) costs, repository costs, and MRS costs.) Hence, any changes in total system costs attributable to the transportation component are being estimated separately, instead of being included in the MRS facility costs. In other words, the impacts on transportation cost of incorporating an MRS facility into the federal waste management system is a valid consideration, but it is more properly evaluated from a total system perspective and is not included as part of the life-cycle cost estimate for the MRS facility per se.

Part 170--Fees for Facilities and Materials Licenses and other Regulatory Services under the Atomic Energy Act of 1954, as Amended. Currently, Part 170 does not discuss MRS. State and local permitting fees have not been identified at this time.

The sales tax on materials purchased for construction and operation has not been included. Site acquisition costs also have not been included in the estimates at this time. The mechanism for transfer of proprietorship or compensation for use of the land may have to be negotiated for one of the sites. For reference purposes, current land value estimates for 1350 acres in the State of Tennessee (at comparable locations) would be approximately $2.0 million.

E.2 COST ESTIMATE FOR THE PREFERRED SITE-DESIGN CASE

The preferred site-design case cost estimate is the life-cycle cost of developing, constructing, operating, and decommissioning an MRS facility using the sealed storage cask concept at the Clinch River Breeder Reactor (CRBR) site in Tennessee. This section presents the details of this cost estimate by first explaining individual cost components and then discussing the total facility life-cycle costs. Major uncertainties concerning the cost estimates are then explored. Unless otherwise noted, all cost estimates are expressed in constant 1986 dollars.

E.2.1 Cost Categories

This section presents the details of the preferred site-design case cost estimate by cost category. The nine cost categories were defined in Subsection E.1.1. Due to the need to consider funding categories in the later analysis, whether or not a cost category includes capital-funded or operating expense-funded items is indicated in the following discussion.

Environmental Evaluations

The costs for Environmental Evaluations activities, such as environmental data confirmation and verification and preparation of the ER, are estimated to be $5.3 million. All environmental data collection and documentation will need to follow strict quality assurance (QA) requirements. For example, all existing environmental documentation will be verified by onsite sampling and inspection to comply with QA requirements for an NRC license application. The environmental data collection, confirmation and verification activity accounts for $3 million. Preparation of the ER and public interactions will require that another $2 million and $0.3 million is reserved for responding to questions following submittal of the ER. Costs for this element are expense-funded.

Design

The costs associated with the Design element of the MRS Program are estimated to be about \$98.8 million, including 20% contingency allowance. The major cost components are as follows:

Cost Item	Millions of Constant 1986 Dollars[a]
R&H building	\$48.1
CHTRU facility	0.2
Support facilities	10.8
Storage facility	2.8
Site design data	5.6
Site improvements	1.5
Utilities	2.6
Design verification	17.3
Design management support	9.8
Total Design	\$98.8

These cost estimates are based on estimates of the number of drawings required and the assumption that 160 hours of labor is required per drawing. The hourly charge to produce drawings is assumed to be \$50 dollars per hour. In addition, cost incurred by the design contractor for design verification (\$1 million) and for licensing support (\$4 million) during the license application period are included. These latter cost items are distributed 90% to the R&H building and 10% to the storage facility. The engineering design cost of \$66 million for the design phase is capital-funded. All other costs, i.e., for site design data, design verification, as well as design management support, are operating expense-funded.

Regulatory Compliance

The costs for complying with regulatory requirements include those incurred for 1) preparing a license application to the NRC including guidance to and review of designs, 2) obtaining various permits from the State and other entities, and 3) preparing license review supplements prior to construction. Also included in this cost category are the costs incurred for 4) preparing and

(a) All costs greater than \$0.1 million were utilized in the estimates in this appendix. When summed, the totals may therefore give an appearance of greater precision than actually exists. Moreover, the last digits may not add due to rounding.

submitting license amendments during construction, 5) conducting license-related activities during operation, and 6) submitting a decommissioning amendment. The total cost of Regulatory Compliance is estimated to be $28.4 million and is expense-funded. The major cost components are shown below:

Cost Item	Millions of Constant 1986 Dollars
NRC license application	$4.3
Permits	0.6
License review and amendments	2.7
License amendments during construction	4.0
Operation reporting	12.6
Decommissioning amendment	4.2
Total Regulatory Compliance	$28.4

Construction

Total cost in the construction phase is estimated to be $655.0 million, including 22% contingency allowance.[a] The details of this estimate are as follows:

Cost Item	Millions of Constant 1986 Dollars
R&H building	$427.0
CHTRU facility	1.3
Support facilities	39.3
Storage facility	31.8
Site improvements	59.1
Utilities	5.0
Construction management & support	91.4
Total Construction Phase	$655.0

Excluding construction management and support, the others are construction contracts totaling about $564 million. Construction management and support costs include $53 million for construction management, $28 million for field engineering, inspection and review of vendor submittals, and $10 million for

(a) The specific contingency allowances used, by building, are as follows:

R&H Building	25%
CHTRU	10
Site improvements and utilities	10
Storage facility	15
Support facilities	10
Weighted average	22% (Ralph M. Parsons Company 1985)

operational support to construction. Except for the $10 million for operational support to construction, all costs during the construction phase are capital-funded.

Total cost of combined design and construction phases of the MRS Program is $753.7 million, of which $710.8 million is capital-funded and $42.9 million is expense-funded.[a] This is composed of the following:

Cost Item	Millions of Constant 1986 Dollars
Design and license support	$ 66.0
Field engineering and vendor submittal review	28.4
Construction management	52.8
Construction contracts	563.5
Subtotal Design & Construction (Capital-Funded)	$710.8
Site design data	$ 5.6
Design verification	17.3
Design management support	9.8
Operational support	10.2
Subtotal Design & Construction (Expense-Funded)	$42.9
Total Design & Construction (Capital- and Expense-Funded)	$753.7

Training and Testing

Total training and testing costs are estimated to be $62.8 million, including 20% contingency allowance. This total includes costs for developing the operating procedures, training the operators, testing equipment, conducting preoperational testing of the facility and equipment, and training for fire protection and security. All the costs are expense-funded. The details of this cost category follow:

(a) This is the "construction" cost estimate included in the design report (Ralph M. Parsons Company 1985) noted earlier in Section E.1.1.

Cost Item	Millions of Constant 1986 Dollars
Operating procedure & training	$35.8
Preoperational testing	22.3
Fire protection and security training	4.7
Total Training and Testing	$62.8

Operation

Total operation cost until all stored spent fuel is retrieved and shipped to the repository is estimated to amount to $2218 million, including 20% contingency allowance. This total includes costs for procurement of the storage casks, capital additions and modifications, operating staff salary and benefits, canisters, other consumables such as drums and filters, and utilities including electricity and fuel oil. These are shown below:

Cost Item	Millions of Constant 1986 Dollars
Casks and capital additions	$612.6
Staff	766.7
Canisters	490.6
Other consumables	147.9
Utilities	200.5
Total Operation	$2218.2

According to the items included in the costing framework in Subsection E.1.1, total operating costs can also be disaggregated as follows:

Cost Item	Millions of Constant 1986 Dollars
R&H building	$1174.8
CHTRU facility	1.0
Support facilities	320.6
Storage facility	20.1
Environmental surveillance	20.7
Operations management and support	68.4
Capital modifications/additions	612.6
Total Operation	$2218.2

Costs incurred during the operation phase are both capital- and operation expense-funded. A total of $612 million will be capital-funded, including $357 million for storage casks and $255 million for capital additions or modifications.

Decommissioning

Decommissioning costs are assumed to be 12% of facility construction cost and 5% of the cost of all sealed storage casks produced. These assumptions are based on experience and engineering judgment (Engineering News Report 1984). Of the total cost incurred during the construction phase of $655 million, $91 million is for construction management and support, not directly related to physical facilities at the MRS site. Hence, these are excluded in computing the facilities-related decommissioning cost. Moreover, approximately $23 million of the remaining $563 million of construction costs is for excavation and other earth work and is not used in computing the decommissioning cost for capital facilities. Hence, the total construction cost used for computing decommissioning costs is only $540 million. Total decommissioning cost is estimated to be $83 million and is expense-funded. Since the construction cost used for computing decommissioning cost includes a 22% (weighted average) contingency allowance, the decommissioning cost can be viewed as containing the same 22% contingency allowance. The detailed breakout is shown below:

Cost Item	Millions of Constant 1986 Dollars
R&H building	$51.2
CHTRU facility	0.2
Support facilities	4.7
Storage facility (incl. casks)	20.4
Site improvements (incl. utilities)	6.5
Total Decommissioning	$83.0

Institutional Interactions

As discussed in Subsection E.1.5, the total costs for institutional interactions will include financial assistance to state and local entities, which is still under discussion. However, the cost of public information programs is estimated to be $2.2 million for the period 1986 through 1991. This cost category is expense-funded.

Program Management

Program management costs include those costs associated with system engineering and configuration management, institutional relations, project planning and control, subcontract management, management services, and quality assurance. Annual program management costs are estimated for three periods: 1) preoperation until the start of full-scale operation, 2) operation, and 3) postoperation. The latter period contains only quality assurance costs. During the operation years, all program management costs, including QA costs, are included in the cost estimate for operations. During the postoperational period, program management costs other than QA costs are included in the decommissioning costs. This cost category is expense-funded. The cost components are shown below:

Cost Item	Millions of Constant 1986 Dollars
System engineering & configuration management	$17.3
Institutional relations	3.8
Project planning and control	20.0
Subcontract management	6.6
Management service	10.3
Quality assurance	12.9
Total Program Management	$70.8

E.2.2 Total MRS Facility Life-Cycle Cost of the Preferred Site-Design Case

Table E.1 presents the preferred site-design case cost estimates for the MRS facility using the 12-inch-diameter current design storage canister as the basis for costing. Total life-cycle cost for the MRS facility is estimated to be $3224 million. Among the nine cost categories, operations accounts for the largest share, about 69%. Construction is second with 20%. Preconstruction activities of environmental evaluation, design, and regulatory compliance combined account for 4%. Training and testing accounts for 2%. Decommissioning and program management account for 3% and 2%, respectively. It should be noted that among the nine cost categories, contingency allowances of 20% were explicitly incorporated into the categories of design, construction, training and testing, operation, and decommissioning. The other four categories do not include such allowances.

Table E.2 presents the annual costs by cost category for the preferred site-design case. Annual expenditures are highest during the construction period and initial facility operation years, ranging from $50 million to $190 million per year. When the MRS facility is in steady-state operation, the annual cost is estimated to be about $71 million per year. The estimated staffing requirement for operation during this period is 601 people.

The cost of the MRS facility, as an integral part of the waste management system, has also been presented in the document, Analysis of the Total System

TABLE E.1. Life-Cycle Cost Estimate for the Preferred Site-Design Case (MRS Facility at the Clinch River, Tennessee, Site Using the Sealed Storage Cask)

Cost Element	Constant 1986 Dollars (Millions)	(%)
Environmental Evaluations	5.5	0.2
Design	98.8	3.1
Regulatory Compliance	28.4	0.9
Construction	655.0	20.3
Training and Testing	62.8	1.9
Operation	2218.1	68.8
Decommissioning	83.0	2.9
Institutional Interactions	2.2	0.1
Program Management	70.8	2.2
Total MRS Facility	3224.5	100.0

Life Cycle Cost (TSLCC) for the Civilian Radioactive Waste Management System (DOE 1987b), for each combination of MRS facility and first repository site. These estimates are $2713 million for Tuff, $2725 million for Basalt, and $2735 million for Salt. The differences between these estimates and the $3224 million presented above is attributable to two factors. First, the TSLCC includes $86 million of MRS facility development and evaluation (D&E) costs in a separate D&E category. Second, the TSLCC analysis assumes less expensive repository site-specific canisters are used at the MRS facility for preparation of spent fuel, which accounts for the remaining cost differences.

Disaggregation of Costs By Function

The MRS facility life-cycle cost estimates shown in Tables E.1 and E.2 can also be disaggregated by function of the MRS operation. The MRS performs functions such as spent fuel consolidation, storage, and related support functions. The spent fuel consolidation function is performed within the R&H building. Viewed in this manner, the estimate of total facility cost can be disaggregated into the following components by function:

Function	Millions of Constant 1986 Dollars
R&H operation	$1906.8
Storage	461.9
Support	855.8
TOTAL	$3224.5

TABLE E.2. Annual Cost Estimate for the MRS Facility, by Cost Category (millions of constant 1986 dollars)

Design: Sealed Storage Cask   Site: Clinch River, Tennessee

Year	Environmental Evaluations	Design	Regulatory Compliance	Construction	Training and Testing	Operation	Decommissioning	Institutional Interaction	Program Management	Total Program
1	3.5	8.8	2.0	0.0	0.0	0.0	0.0	0.5	9.2	24.0
2	1.2	24.6	1.5	0.0	0.0	0.0	0.0	0.4	8.4	36.1
3	0.4	29.9	1.5	0.0	0.0	0.0	0.0	0.4	8.7	40.9
4	0.3	24.1	1.5	1.5	0.4	0.0	0.0	0.4	6.9	35.1
5	0.0	6.6	1.2	37.9	0.7	0.0	0.0	0.4	6.5	53.3
6	0.0	4.6	0.8	144.4	1.4	0.0	0.0	0.0	6.8	158.0
7	0.0	0.1	0.8	176.5	2.6	0.0	0.0	0.0	6.4	186.4
8	0.0	0.0	0.8	176.5	5.4	0.0	0.0	0.0	6.7	189.4
9	0.0	0.1	0.8	111.8	12.3	9.1	0.0	0.0	4.9	139.0
10	0.0	0.0	0.4	6.4	15.5	11.6	0.0	0.0	2.3	36.3
11	0.0	0.0	0.4	0.0	24.4	83.5	0.0	0.0	0.0	108.3
12	0.0	0.0	0.4	0.0	0.0	89.3	0.0	0.0	0.0	89.7
13	0.0	0.0	0.4	0.0	0.0	110.9	0.0	0.0	0.0	111.3
14	0.0	0.0	0.4	0.0	0.0	99.1	0.0	0.0	0.0	99.5
15	0.0	0.0	0.4	0.0	0.0	110.8	0.0	0.0	0.0	111.2
16	0.0	0.0	0.4	0.0	0.0	119.1	0.0	0.0	0.0	119.5
17	0.0	0.0	0.4	0.0	0.0	98.8	0.0	0.0	0.0	99.2
18	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
19	0.0	0.0	0.4	0.0	0.0	72.9	0.0	0.0	0.0	73.4
20	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
21	0.0	0.0	0.4	0.0	0.0	72.9	0.0	0.0	0.0	73.3
22	0.0	0.0	0.4	0.0	0.0	73.0	0.0	0.0	0.0	73.4
23	0.0	0.0	0.4	0.0	0.0	73.0	0.0	0.0	0.0	73.4
24	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
25	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
26	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
27	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
28	0.0	0.0	0.4	0.0	0.0	72.9	0.0	0.0	0.0	73.3
29	0.0	0.0	0.4	0.0	0.0	73.0	0.0	0.0	0.0	73.4
30	0.0	0.0	0.4	0.0	0.0	72.9	0.0	0.0	0.0	73.3
31	0.0	0.0	0.4	0.0	0.0	73.0	0.0	0.0	0.0	73.4
32	0.0	0.0	0.4	0.0	0.0	72.8	0.0	0.0	0.0	73.3
33	0.0	0.0	0.4	0.0	0.0	72.8	0.0	0.0	0.0	73.2
34	0.0	0.0	0.4	0.0	0.0	72.8	0.0	0.0	0.0	73.2
35	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
36	0.0	0.0	0.4	0.0	0.0	62.5	0.0	0.0	0.0	62.9
37	0.0	0.0	0.4	0.0	0.0	25.0	0.4	0.0	0.0	25.8
38	0.0	0.0	0.4	0.0	0.0	25.0	0.4	0.0	0.0	25.8
39	0.0	0.0	0.4	0.0	0.0	25.0	0.4	0.0	0.0	25.8
40	0.0	0.0	0.4	0.0	0.0	25.0	1.5	0.0	0.0	26.9
41	0.0	0.0	0.9	0.0	0.0	9.8	17.0	0.0	0.5	28.2
42	0.0	0.0	0.9	0.0	0.0	0.0	20.1	0.0	1.0	22.0
43	0.0	0.0	0.9	0.0	0.0	0.0	18.8	0.0	1.0	20.7
44	0.0	0.0	0.9	0.0	0.0	0.0	13.0	0.0	1.0	14.9
45	0.0	0.0	0.9	0.0	0.0	0.0	11.4	0.0	0.5	12.8
TOTAL	5.5	98.8	28.4	655.0	62.8	2218.1	83.0	2.2	70.8	3224.5

E.3 COST ESTIMATES FOR ALTERNATIVE CASES

In addition to the cost estimates for the preferred site-design case explained above, cost estimates are also developed for the five alternative cases. Alternative cases involving the sealed storage cask design at the alternative sites of Hartsville and Oak Ridge, Tennessee, are considered first. The cases involving the alternative storage design (field drywell) at the three alternative sites are then presented. All cost estimates are based on a 12-inch-diameter current design storage canister, which is not specific to the geologic medium of the first repository.

E.3.1 Sealed Storage Cask at Alternative Sites

Table E.3 presents the life-cycle cost estimates for an MRS facility using a sealed storage cask design for all three sites. The difference in cost for these two alternative cases from the preferred site-design case result from the differences in the site preparation required during construction. The life-cycle cost for the Oak Ridge site is estimated to be about $11 million lower, and that for the Hartsville site is about $7 million higher, than the preferred site-design case.

E.3.2 Field Drywell at the Preferred and Alternative Sites

Table E.4 presents the cost estimates for the MRS facility using the field drywell design at the preferred (Clinch River) site and two alternative sites. The differences in costs, compared to the sealed storage cask design, occur mainly in the cost categories of construction and operation. There are also smaller differences in costs for decommissioning. There are no differences in the cost estimate for the other six cost categories.[a] Table E.5 presents the specific differences using the preferred Clinch River, Tennessee, site as an example. Total facility life-cycle cost for an MRS facility using the drywell concept is estimated to be $162 million, or about 5% less than the cost estimate for one using the sealed storage cask design. The field drywell design has higher construction costs, yet lower operation and decommissioning costs, than the sealed storage cask design.

E.4 COST SENSITIVITIES AND OTHER FACTORS

While the cost estimates presented above are based upon the best information presently available, actual technical, economic, and institutional factors

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(a) Because the required size of the site for the MRS facility is different for the two designs, the acquisition costs, if any, are also likely to be different. However, the cost estimates presented do not include such cost items.

TABLE E.3. Life-Cycle Cost Estimates for the MRS Facility at the Preferred and Alternative Sites for the Sealed Storage Cask Design

Cost Categories	Millions of Constant 1986 Dollars		
	Clinch River	Hartsville	Oak Ridge
Environmental Evaluations[a]	$5.5	$5.5	$5.5
Design	98.8	98.8	98.8
Regulatory Compliance	28.4	28.4	28.4
Construction	655.0	662.0	643.5
Training and Testing	62.8	62.8	62.8
Operation	2218.1	2218.1	2218.1
Decommissioning	83.0	83.0	83.0
Institutional Interactions	2.2	2.2	2.2
Program Management	70.8	70.8	70.8
Total MRS Facility	$3224.5	$3231.5	$3213.0

(a) The $5.5 million cost is the best estimate at this time for the Clinch River site. Since more data are available for the Clinch River site than the other two sites, costs can be expected to be somewhat higher for the Hartsville and Oak Ridge sites. However, separate estimates have not been made for the other sites.

might deviate from those incorporated into the assumptions used for deriving the cost estimates. The impact of some of these factors can be analyzed through sensitivity testing, while impacts of other factors can only be discussed qualitatively. The sensitivities of the life-cycle cost estimates to changes in the assumptions concerning the staffing requirements during operations, unit labor cost, and real escalation in labor cost are examined first. Other factors affecting cost estimates are then discussed qualitatively.

E.4.1 Sensitivity to Operations Staffing Requirements

The equilibrium production operation of the MRS facility is based on 2650 MTU throughput per year. Actual storage conditions at the reactors may dictate either a higher or lower production rate. This could lead to some adjustments in the staffing requirements during operations. If the operation manpower requirement over the operating life of the facility is either 10% higher (or lower) than that of the preferred site-design case, total facility life-cycle cost would be 2.8%, or $90 million, higher (or lower) than the preferred site-design case (see Table E.13, Section E.6).

TABLE E.4. Life-Cycle Cost Estimates for the MRS Facility with the Field Drywell Design, by Potential Site

Cost Categories	Millions of Constant 1986 Dollars		
	Clinch River	Hartsville	Oak Ridge
Environmental Evaluations[a]	$ 5.5	$ 5.5	$ 5.5
Design	98.8	98.8	98.8
Regulatory Compliance	28.4	28.4	28.4
Construction	751.2	727.2	736.5
Training and Testing	62.8	62.8	62.8
Operation	1959.5	1959.5	1959.5
Decommissioning	83.0	83.0	83.0
Institutional Interactions	2.2	2.2	2.2
Program Management	70.8	70.8	70.8
Total MRS Facility	$3061.9	$3038.0	$3047.2

(a) The $5.5 million cost is the best estimate at this time for the Clinch River site. Since more data are available for the Clinch River site than the other two sites, costs can be expected to be somewhat higher for the Hartsville and Oak Ridge sites. However, separate estimates have not been made for the other sites.

TABLE E.5. Cost Differentials Due to Difference in Storage Design at the Clinch River Site

Cost Category	Millions of Constant 1986 Dollars		
	Sealed Storage Cask (SSC)	Field Drywell (FD)	Differences (SSC-FD)
Construction	$655.0	$751.2	-$96.2
Operation	2218.1	1959.5	258.6
Decommissioning	83.0	82.9	0.1
Subtotal	$2956.1	$2793.6	$162.5
All other costs	268.5	268.5	
Total Life Cycle	$3224.5	$3061.9	$162.5

E.4.2 Sensitivity to Unit Labor Cost

The cost estimate for the preferred site-design case is based on the assumption that unit labor cost stays constant in real terms over the entire program period. The cost estimate would change if either the per person annual wage cost used were changed or if some real wage escalation were assumed. For example, if the unit labor cost for operations over the operating life of the facility is 20% higher (or lower) than that used for the preferred site-design case, the MRS life-cycle cost estimate will be 5.6%, or $180 million, higher (or lower). Similarly, if unit labor cost is assumed to be escalating at a 1% real rate during operation instead of the 0% real escalation in the preferred site-design case, then the life-cycle cost of the MRS facility can be expected to be 7.9% higher (see Table E.14, Section E.6).

E.4.3 Other Factors Affecting Cost Estimates

Other factors that could potentially affect the cost estimates for the preferred site-design case include the geological medium of the first repository, the timing of congressional approval of the MRS Program, and delays in construction for any reason. The following provides brief qualitative discussions on each of these items.

First, it is useful to note that, among the nine cost categories included in the preferred site-design case cost estimate, the five categories of design, construction, training and testing, operation, and decommissioning, which account for about 96% of total life-cycle costs, have explicitly incorporated a contingency allowance of about 20% to take care of normally unexpected occurrences in the required activities in each of the five elements (see Sections E.1 and E.2).

At this time, three potential geological media are under consideration for the first repository: basalt, salt, and tuff. The requirements for canistering consolidated waste materials at the MRS facility could differ according to the geological medium of the repository. If the waste disposal is to be in either a basalt or a salt repository, packaging the waste canisters into another container might be required. In contrast, the waste might be consolidated and placed into a single container for disposal in a tuff repository. The costs of canisters would differ, depending on the repository geological medium, as would the life-cycle cost estimates for the facility.

The designs for repository-specific canisters are larger than the current-design MRS canisters and thus each can contain larger numbers of consolidated fuel per canister. Therefore, although the cost per repository-specific canister may be higher, total canister costs are lower than that incorporated into the preferred site-design case using the current design canister, because of the reduced number of canisters needed. At this time, the current design (12-inch-diameter) canister has been used in the preferred site-design case. Relative to this item, the cost estimate can be viewed as conservative.

The preferred site-design case cost estimate assumes congressional approval for the construction of the MRS facility in 1987 and the start of operations in 1998. The timing of the congressional decision would potentially impact the schedule for deployment of the MRS facility. If the schedule is compressed and overtime is required for construction, then construction cost may be raised. Similarly, substantial delays in construction due to labor- and weather-related work stoppages beyond those covered by the contingency allowances would also add to costs.

E.5 FUNDING

Section 141(b)(2)(B) of the NWPA requires that a funding plan be developed to finance the deployment, operation, and decommissioning of an MRS facility and Section 302 of the NWPA authorizes use of the Nuclear Waste Fund for all MRS activities. Other provisions of the NWPA preclude using appropriated funds from the DOE's regular budget to fund the MRS facility.

This section describes analyses of alternative funding approaches, the rationale for selecting the proposed approach, and the proposed plan to fund the MRS Program. The impact on the total waste management system life-cycle cost is discussed and the annual and cumulative funding requirements for the MRS Program are provided.

E.5.1 Analysis of Alternative Funding Approaches

In this section, the possible alternative approaches for funding the MRS Program are first reduced to those successfully meeting the initial screening criteria. A second set of evaluation criteria are then explained and applied to those alternatives satisfying the initial screening criteria to select the proposed funding approach.

Description and Initial Screening of Alternative Approaches

Two criteria were used for initial screening of potential approaches to funding the MRS Program. First, given the cost burden requirement of the NWPA, any potential funding approach not meeting such requirement need not be considered further. Thus, any approach to finance the MRS Program from the general revenues of the federal government through the regular DOE budget is excluded. Second, the MRS facility is an integral part of the federal waste management system. From this perspective, an approach that imposes a surcharge on only the generators and owners of spent fuel that passes through the MRS facility would be inconsistent with the integral nature of the MRS facility. The decision of which fuel will pass through the MRS facility rests on overall system considerations and not on the preferences of individual utilities. Hence, this approach is not considered further.

Given the above criteria considerations, there are only two potential alternative approaches to funding the MRS Program:

1. Waste Fund Approach: With this approach all MRS Program costs would be financed by the Nuclear Waste Fund, established under Section 302(c) of the NWPA to cover the cost of the federal waste management system. The current Nuclear Waste Fund fee is being assessed at 1 mill/kWh of electricity generated from all nuclear power plants. If a required annual review of the fee adequacy were to conclude that the 1 mill/kWh fee would not ensure full cost recovery, then an adjustment to the fee could be requested.

2. Overall Surcharge Approach: With this alternative a separate surcharge would be assessed on all generators and owners of HLW and SNF in order to set up a separate MRS fund to finance the MRS Program.

Evaluation Criteria

Four criteria were used to evaluate these two funding approaches:

1. Cost of Administration: To the extent that alternative approaches achieve the same overall objective, the ones that are easier and less costly to administer and implement would be preferred.

2. Flexibility in Response to Changing Situations: Due to potentially changing economic and operational situations, the charge for waste disposal may need to be adjusted. The approaches that are more flexible from a system standpoint would be preferable to those that are less flexible.

3. Regulatory Acceptance: Nuclear utilities are subject to state and federal regulation through approval of costs and ratesetting. Approaches that require setting up additional reserves for paying waste disposal fees in the future are more likely to run into difficulties in securing regulatory acceptance, particularly in determining the appropriate size of the reserve account.

4. Incentive for Cost-Effective Management of the System: Since the waste management system is complex, costly and has a long planning

horizon, it is necessary to have some built-in mechanism which encourages efficient management so that the cost to ratepayers can be kept at the lowest possible level consistent with meeting the overall objective of the waste management system.

Discussion

With the Waste Fund approach, there would be no need, except for accounting purposes, to distinguish between funds used to finance MRS activities and funds used to finance other waste management system activities. With the overall surcharge approach, a separate MRS fund would need to be established and the surcharge amount would be determined separately from the waste fee to ensure that the separate MRS fund would be adequate to finance MRS activities. This additional step would tend to raise the cost of administering the total waste management system. Hence, from the perspective of cost and ease of administration, the Waste Fund approach is preferable to the overall surcharge approach.

Both the Waste Fund and overall surcharge approaches have about the same flexibility to respond to changing economic and waste management system situations. The 1 mill/kWh fee would probably gain wider regulatory acceptance more easily than the overall surcharge approach because it is clearly mandated by Congress in the NWPA, has been in practice since April 1983, and the 1 mill/kWh charge appears relatively fixed and easily understood. In contrast, to determine the amount of separate charge, precise cost estimates of the MRS facility and how the charge would be allocated among utilities would need to be determined. To the extent the cost estimates and utility charges may be contested in regulatory proceedings, there is more uncertainty in the overall surcharge approach concerning regulatory acceptance than the Waste Fund approach.

It could be argued that because the overall surcharge approach would cover only the MRS Program activities whereas the Waste Fund approach covers the overall waste management system, the overall surcharge approach might be more conducive to cost-effective management and control of the MRS activities than the Waste Fund approach. Nevertheless, it should be possible to closely monitor and control the cost of MRS activities under the Waste Fund approach and to achieve the same cost-effective management of the MRS activities as could be achieved under the overall surcharge approach.

The Waste Fund approach is consistent with both the philosophy and the provisions of the NWPA. Section 302(d) of the NWPA provides that expenditures can be made from the Waste Fund only for purposes of radioactive waste disposal activities under Title I and II of the NWPA, including the following (emphasis added):

"(1) the identification, development, licensing, construction, operation, decommissioning, and post-decommissioning maintenance and monitoring of any repository, monitored, retrievable storage facility or test and evaluation facility constructed under this Act;

(2) the conducting of nongeneric research, development, and demonstration activities under this Act;

(3) the administrative cost of the radioactive waste disposal program;

(4) any costs that may be incurred by the Secretary in connection with the transportation, treating, or packaging of spent nuclear fuel or high-level radioactive waste to be disposed of in a repository, to be stored in a monitored, retrievable storage site or to be used in a test and evaluation facility;

(5) the costs associated with acquisition, design, modification, replacement, operation, and construction of facilities at a repository site, a monitored, retrievable storage site or a test and evaluation facility site and necessary or incident to such repository, monitored retrievable storage facility or test and evaluation facility; and

(6) the provision of assistance to States, units of general local government, and Indian tribes under sections 116, 118, and 219."

This statutory language clearly envisions the use of the Waste Fund for MRS-related activities. Funding MRS directly through the Waste Fund rather than through a separate fund via the surcharge approach is more appropriate in that the MRS facility confers benefits directly and indirectly to all contributors to the Waste Fund through improvements in the waste management system, including better integration and performance, and provision of a cost-effective capability to accommodate potential repository schedule changes. Based upon the above considerations, the DOE is confident that financing the MRS Program through the Nuclear Waste Fund is fully justified under the provisions of the NWPA and recommends that the MRS Program be funded through the Waste Fund.

E.5.2 Funding Plan

Based upon the above considerations, the DOE's plan for funding the MRS Program is as follows:

1. The MRS Program will be financed through the Nuclear Waste Fund.

2. Although the federal waste management system is self-financing, the amount of money allowed to be spent from the Nuclear Waste Fund is governed through the federal budget process. The NWPA requires that a budget be submitted for the NWF and provides that appropriations be subject to triennial authorization. The Fund Management Plan (DOE

1984) has been developed for implementation. The budgeting and financial management of the MRS Program will be in accordance with the DOE Fund Management Plan.

3. Each year, the annual costs from the most recent update of the MRS facility cost estimates will be converted into a budget request and incorporated into the overall Nuclear Waste Fund budget request. This budget request will go through the federal budgeting process and would be subject to congressional authorization and appropriation.

4. Disbursement of authorized and appropriated funds for the MRS Program will be controlled and reported according to DOE Order 2200, "Financial Management of Civilian Nuclear Waste Activities."

5. The DOE will continue to conduct an annual review of the 1 mill per kWh fee for waste disposal to determine whether the revenues would be sufficient to finance the total costs of the federal waste management system, including the cost of the MRS facility. If it is determined that the fee is inadequate to assure full cost recovery, an adjustment to the 1 mill/kWh fee will be proposed.

E.5.3 Nuclear Waste Fund

This section briefly explains the revenue sources and temporary financing mechanisms of the Nuclear Waste Fund. The primary source of revenues to the Waste Fund is the fee collected from the owners and generators of HLW and SNF. A secondary source of revenue is the interest income derived from investing any positive balance of the Fund. In the event that there are revenue shortfalls, temporary financing mechanisms are available in the form of congressional appropriations and borrowings from the Treasury.

The NWPA authorizes collection of a fee of 1 mill per kWh on net generation of electricity from nuclear power plants on or after April 6, 1983, and a one-time fee on SNF and HLW discharged by April 6, 1983, as well as in-core spent fuel or spent fuel planned to be reinserted into the core as of April 6, 1983 [NWPA, Section 302(a)(2) and (3)]. The NWPA also requires the DOE to annually review the adequacy of the fees collected in funding the waste management activities and to propose adjustment to the unit disposal fee to ensure that the Waste Fund will achieve full cost recovery.

For the fees on net generation, payments by utilities will be based on actual generation that occurred during a quarter. According to the contractual arrangement, individual utilities must report quarterly on the amount they owe to the Waste Fund, and payments must be made within thirty days after the end of the quarter. Late payments would be assessed with interest charges (10 CFR 961). For long-term planning purposes, the DOE is relying on the Energy Information Administration's mid-growth forecast of electricity generation.

It is estimated that the one-time fee for all accumulated SNF and HLW, in-core spent fuel, or spent fuel planned to be reinserted into the core as of April 6, 1983, for all operating reactors totaled about $2.3 billion. Utilities have three payment options: 1) a single payment by June 30, 1985, 2) payments in 40 quarterly installments, and 3) payments at time of delivery of waste to the federal system. Whereas the 1985 single-payment option is interest free, the delayed-payment options would incur interest charges based on the U.S. Treasury rate from 1983 until payments are made. As of July 1, 1985, the amount paid into the Waste Fund via the single-payment option was $1.4 billion (Engel 1986).

The President has authorized that defense high-level waste be disposed at the repository. Therefore, the federal government would be paying into the Waste Fund according to a fee schedule to be determined through a ratemaking process that is presently under way. This fee payment by the federal government would become a source of revenue to the Waste Fund.

During the early period of the waste management program, revenues to the Waste Fund could exceed the expenses. In that event, the temporary excess funds are to be invested, and the interest income realized will become a supplemental source for funding the waste management activities in later years [NWPA, Section 302(e)(3)].

Likewise, during the beginning years and prior to substantial payments by utilities, the current expenses could exceed the revenues. The NWPA authorizes congressional appropriations to fund the initial program start-up activities [NWPA, Section 302(c)(2) and (d)]. The Waste Fund can also borrow from the Treasury to meet cash flow requirements [NWPA, Section 302(e)(5)]. However, both the separate appropriations and borrowing from the Treasury will need to be repaid with interest [NWPA, Section 302(e)(6)].

E.5.4 Impact on Total Waste Management System Life-Cycle Costs

The life-cycle costs of deploying, operating, and decommissioning an MRS facility employing the sealed storage cask design at the Clinch River site in Tennessee are estimated in the DOE total system life-cycle cost (TSLCC) estimates (DOE 1987b), which are updated annually. The TSLCC analysis estimates the cost of the total waste management system including development and evaluation costs, first repository costs, second repository costs, and MRS costs applied to a variety of combinations of repository sites. These cost estimates are used to evaluate the adequacy of the waste fund fee that finances the waste program. From the federal waste system perspective, the total system life-cycle cost is composed of four major components: development and evaluation (D&E), repositories, MRS, and transportation. As the federal waste management system is changed from one without an MRS facility to the improved-performance system with an integral MRS facility, the four cost components change as follows:

1) Based on the TSLCC estimates in preparation, the D&E cost component is not expected to be significantly affected because most of the D&E costs associated with the MRS facility have been included in the MRS life-cycle cost estimate.

2) The costs of surface facilities at the first repository will be reduced because of the transfer of much of the spent fuel handling, consolidation, and associated support functions from the repository to the MRS facility.

3) The MRS cost component increases from zero to the facility life-cycle cost estimate.

4) The transportation system cost may also change because of the changes in routing and modal characteristics of spent fuel shipments.

The D&E cost component includes program costs that support, but are not directly attributable to, the program facility cost categories of design, construction, operation and decommissioning. Typical D&E cost components include:

- DOE program management costs associated with the facility or system components
- system engineering costs
- design verification costs
- environmental documentation costs
- regulatory compliance costs
- training and testing costs
- impact payments, grants, etc. to affected state/local agencies.

The MRS facility costs presented in this program plan contain estimates for cost components equivalent to six of the seven D&E categories itemized above (refer to Section E.1.1). No estimates were included, however, for permitting or NRC licensing of the MRS facility (the federal fee bases have not yet been promulgated) or for state grants and impact payments, which are subject to negotiation under the consultation and cooperation agreements specified in the NWPA.

For the various combinations considered by the TSLCC analysis, the inclusion of an MRS facility in the waste management system reduced the first repository costs by approximately $0.9 to $1.4 billion depending on the specific repository site. Transportation costs for these scenarios ranged from a reduction of $0.3 billion to an increase of $0.1 billion. For the combinations analyzed, the costs for MRS resulted in a net increase in system costs from $1.5 to $1.6 billion or, translated to percentages, a 4% to 5% increase in total system costs.

Based on results of the 1986 fee adequacy review (Engel 1986), and the DOE's assessment of the projected growth of the U.S. nuclear economy, the NWF generated at the current 1 mill/kWh fee level would be adequate for funding the improved-performance waste management system (including an integral MRS facility). Consistent with the MRS funding plan described above and with past practice, the annual review of fee adequacy for FY-1987 is currently being conducted, using updated waste management system cost estimates and revenue projections. If this review should indicate that the 1 mill/kWh fee would not generate sufficient revenue to assure full cost recovery for the approved program, an adjustment to the fee would be submitted for congressional approval.

E.5.5 Cost by Funding Category

Table E.6 provides a summary of cost estimates by funding classification for the preferred site-design case, separating the capital-funded from the operating expense-funded items. Total capital-funded items are estimated to be about $1323 million, including about $710 million for facility design and construction, about $253 million for facility improvements, and about $359 million for the production of the sealed storage casks. The majority ($1605 million) of the operating expense-funded items of $1901 million goes to facility operation. The other operating expense-funded items are preoperational support (about $105 million), decommissioning ($83 million), and other support (about $107 million). (Note that all cost estimates cited in this discussion are in terms of constant 1986 dollars.)

It is useful to illustrate the relationship between the funding categories shown in Table E.6 and the cost categories shown in Table E.1. Among the nine

TABLE E.6. Summary of Estimated Costs by Funding Category for the MRS Program for the Preferred Site-Design Case

Item	Millions of Constant 1986 Dollars	
Capital-Funded		
Facility Construction		$710.8
Design-Construction		
Design Phase	$66.0	
Construction Phase	81.3	
Construction Contractors	563.5	
Capital Improvement		252.8
Casks		359.8
Total Capital-Funded		$1323.4
Operating Expense-Funded		
Preoperational Support		$ 105.7
Design Verification	$17.3	
Site Design Data	5.6	
Design Management Support	9.8	
Operational Support Cost During Construction Phase	10.2	
Training and Testing	62.8	
Facility Operation		1605.6
Staff	766.7	
Consumable	638.4	
Utilities	200.5	
Decommissioning		83.0
Other Support		106.9
Environmental Evaluation	5.5	
Regulatory Compliance	28.4	
Institutional Interactions	2.2	
Program Management	70.8	
Total Operating Expense-Funded		$1901.3
TOTAL MRS FACILITY		$3224.5

cost categories shown in Table E.1 (and explained in Sections E.1 and E.2), six categories are treated as totally operating expense-funded: Environmental Evaluations, Regulatory Compliance, Institutional Interactions, Program Management, Training and Testing, and Decommissioning. Except for the two cost categories of Training and Testing and Decommissioning, the other four of the six are grouped under the "Other Support" item in Table E.6.

The cost categories of Design, Construction, and Operation have both capital-funded and operating expense-funded components. For example, the total estimated cost for the Design phase, $98.7 million, is composed of $66 million capital-funded for the design and $32.7 million operating expense-funded. This is shown below:

	Millions of Constant 1986 Dollars		
Design Phase	Capital-Funded	Operating Expense-Funded	Total
Design	$66.0		$66.0
Design Verification		$17.3	17.3
Site Design Data		5.6	5.6
Design Management Support		9.8	9.8
Total Design Phase	$66.0	$32.7	$98.8

Similarly, the total Construction cost of $655 million is composed of $644.8 million capital-funded and $10.2 million operating expense-funded, as shown below:

	Millions of Constant 1986 Dollars		
Construction Phase	Capital-Funded	Operating Expense-Funded	Total
Design-Construction Management	$81.3		$81.3
Construction Contractors	563.5		563.5
Operational Support		$10.2	10.2
Total Construction Phase	$644.8	$10.2	$655.0

As shown below, the total Operation cost of $2218 million includes capital-funded items of capital improvements and casks:

Operation Phase	Millions of Constant 1986 Dollars Capital-Funded	Operating Expense-Funded	Total
Facility Operation		$1605.6	$1605.6
Capital Improvements	$252.8		252.8
Casks	359.8		359.8
Total Operation Phase	$612.6	$1605.6	$2218.2

Table E.7 illustrates the annual and total costs by funding category for the life-cycle of the MRS facility for the preferred site-design case. Table E.15 provides a further breakdown of these annual costs. The cost of the program from the time of congressional approval until the facility becomes operational, plus decommissioning, will be approximately $990 million. Of this total, approximately $710 million of capital funds will be used for facility design and construction.

Annual costs for the MRS Program will be heaviest during construction and initial operation years. They will range from about $53 million to about $190 million. During steady-state operation, annual spending is estimated to be $73 million per year. The funding requirement for facility decommissioning is $83 million.

E.6 DETAILED COST AND DATA TABLES

Tables E.8 through E.12 present the detailed annual cost estimates for the alternative site-design combinations. Table E.13 presents the sensitivity cases for changes in staffing requirements during operation. Table E.14 presents the sensitivity cases for changes in unit labor costs. Table E.15 provides additional details on the estimated annual costs by funding category shown in Table E.7.

TABLE E.7. Estimated Annual Costs for the Preferred Site-Design Case by Funding Category (millions of constant 1986 dollars)

Year	Capital-Funded	Expense-Funded	Total Project
1	2.0	21.9	24.0
2	17.3	18.9	36.2
3	25.4	16.0	41.4
4	20.3	15.1	35.4
5	37.9	16.1	54.0
6	142.6	16.6	159.2
7	174.5	14.7	189.2
8	174.5	21.8	196.3
9	119.6	22.7	142.3
10	17.5	27.6	45.1
11	46.6	37.3	83.9
12	53.3	36.4	89.7
13	75.0	36.3	111.3
14	62.8	36.7	99.5
15	75.0	36.3	111.2
16	62.8	56.7	119.5
17	35.4	63.8	99.2
18	9.5	63.9	73.5
19	9.5	63.8	73.4
20	9.5	64.0	73.5
21	9.5	63.8	73.3
22	9.5	63.9	73.4
23	9.5	63.9	73.4
24	9.5	63.9	73.4
25	9.5	63.9	73.4
26	9.5	64.0	73.5
27	9.5	64.0	73.5
28	9.5	63.8	73.3
29	9.5	63.9	73.4
30	9.5	63.8	73.3
31	9.5	63.8	73.3
32	9.5	63.7	73.2
33	9.5	63.7	73.2
34	9.5	63.7	73.2
35	9.5	64.0	73.5
36	9.5	53.3	62.8
37	0.0	25.8	25.8
38	0.0	25.8	25.8
39	0.0	25.8	25.8
40	0.0	26.9	26.9
41	0.0	28.2	28.2
42	0.0	22.0	22.0
43	0.0	20.7	20.7
44	0.0	14.9	14.9
45	0.0	12.8	12.8
Total	1323	1901	3224

TABLE E.8. Annual Cost Estimate for the MRS Facility, by Cost Category (millions of constant 1986 dollars)

Design: Sealed Storage Cask Site: Hartsville, Tennessee

Year	Environmental Evaluations	Design	Regulatory Compliance	Construction	Training and Testing	Operation	Decom-missioning	Institutional Interaction	Program Management	Total Program
1	3.5	8.8	2.0	0.0	0.0	0.0	0.0	0.5	9.2	24.0
2	1.2	24.6	1.5	0.0	0.0	0.0	0.0	0.4	8.4	36.1
3	0.4	29.9	1.5	0.0	0.0	0.0	0.0	0.4	8.7	40.9
4	0.3	24.1	1.5	1.5	0.4	0.0	0.0	0.4	6.9	35.1
5	0.0	6.6	1.2	38.3	0.7	0.0	0.0	0.4	6.5	53.7
6	0.0	4.6	0.8	146.0	1.4	0.0	0.0	0.0	6.8	159.6
7	0.0	0.1	0.8	178.4	2.6	0.0	0.0	0.0	6.4	188.3
8	0.0	0.0	0.8	178.4	5.4	0.0	0.0	0.0	6.7	191.3
9	0.0	0.1	0.8	112.9	12.3	9.1	0.0	0.0	4.9	140.1
10	0.0	0.0	0.4	6.4	15.6	11.6	0.0	0.0	2.3	36.3
11	0.0	0.0	0.4	0.0	24.4	83.5	0.0	0.0	0.0	108.3
12	0.0	0.0	0.4	0.0	0.0	89.3	0.0	0.0	0.0	89.7
13	0.0	0.0	0.4	0.0	0.0	110.9	0.0	0.0	0.0	111.3
14	0.0	0.0	0.4	0.0	0.0	99.1	0.0	0.0	0.0	99.5
15	0.0	0.0	0.4	0.0	0.0	110.8	0.0	0.0	0.0	111.2
16	0.0	0.0	0.4	0.0	0.0	119.1	0.0	0.0	0.0	119.5
17	0.0	0.0	0.4	0.0	0.0	98.8	0.0	0.0	0.0	99.2
18	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
19	0.0	0.0	0.4	0.0	0.0	72.9	0.0	0.0	0.0	73.4
20	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
21	0.0	0.0	0.4	0.0	0.0	72.9	0.0	0.0	0.0	73.3
22	0.0	0.0	0.4	0.0	0.0	73.0	0.0	0.0	0.0	73.4
23	0.0	0.0	0.4	0.0	0.0	73.0	0.0	0.0	0.0	73.4
24	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
25	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
26	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
27	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
28	0.0	0.0	0.4	0.0	0.0	72.9	0.0	0.0	0.0	73.3
29	0.0	0.0	0.4	0.0	0.0	73.0	0.0	0.0	0.0	73.4
30	0.0	0.0	0.4	0.0	0.0	72.9	0.0	0.0	0.0	73.3
31	0.0	0.0	0.4	0.0	0.0	73.0	0.0	0.0	0.0	73.4
32	0.0	0.0	0.4	0.0	0.0	72.8	0.0	0.0	0.0	73.3
33	0.0	0.0	0.4	0.0	0.0	72.8	0.0	0.0	0.0	73.2
34	0.0	0.0	0.4	0.0	0.0	72.8	0.0	0.0	0.0	73.2
35	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
36	0.0	0.0	0.4	0.0	0.0	62.5	0.0	0.0	0.0	62.9
37	0.0	0.0	0.4	0.0	0.0	25.0	0.4	0.0	0.0	25.8
38	0.0	0.0	0.4	0.0	0.0	25.0	0.4	0.0	0.0	25.8
39	0.0	0.0	0.4	0.0	0.0	25.0	0.4	0.0	0.0	25.8
40	0.0	0.0	0.4	0.0	0.0	25.0	1.5	0.0	0.0	26.9
41	0.0	0.0	0.9	0.0	0.0	9.8	17.0	0.0	0.5	28.2
42	0.0	0.0	0.9	0.0	0.0	0.0	20.1	0.0	1.0	22.0
43	0.0	0.0	0.9	0.0	0.0	0.0	18.8	0.0	1.0	20.7
44	0.0	0.0	0.9	0.0	0.0	0.0	13.0	0.0	1.0	14.9
45	0.0	0.0	0.9	0.0	0.0	0.0	11.4	0.0	0.5	12.8
TOTAL	5.5	98.8	28.4	662.0	62.8	2218.1	83.0	2.2	70.8	3231.5

TABLE E.9. Annual Cost Estimate for the MRS Facility, by Cost Category (millions of constant 1986 dollars)

Design: Sealed Storage Cask   Site: Oak Ridge, Tennessee

Year	Environmental Evaluations	Design	Regulatory Compliance	Construction	Training and Testing	Operation	Decom-missioning	Institutional Interaction	Program Management	Total Program
1	3.5	8.8	2.0	0.0	0.0	0.0	0.0	0.5	9.2	24.0
2	1.2	24.6	1.5	0.0	0.0	0.0	0.0	0.4	8.4	36.1
3	0.4	29.9	1.5	0.0	0.0	0.0	0.0	0.4	8.7	40.9
4	0.3	24.1	1.5	1.5	0.4	0.0	0.0	0.4	6.9	35.1
5	0.0	6.6	1.2	37.4	0.7	0.0	0.0	0.4	6.5	52.8
6	0.0	4.6	0.8	141.8	1.4	0.0	0.0	0.0	6.8	155.4
7	0.0	0.1	0.8	173.3	2.6	0.0	0.0	0.0	6.4	183.2
8	0.0	0.0	0.8	173.3	5.4	0.0	0.0	0.0	6.7	186.2
9	0.0	0.1	0.8	109.8	12.3	9.1	0.0	0.0	4.9	137.0
10	0.0	0.0	0.4	6.4	15.6	11.6	0.0	0.0	2.3	36.3
11	0.0	0.0	0.4	0.0	24.4	83.5	0.0	0.0	0.0	108.3
12	0.0	0.0	0.4	0.0	0.0	89.3	0.0	0.0	0.0	89.7
13	0.0	0.0	0.4	0.0	0.0	110.9	0.0	0.0	0.0	111.3
14	0.0	0.0	0.4	0.0	0.0	99.1	0.0	0.0	0.0	99.5
15	0.0	0.0	0.4	0.0	0.0	110.8	0.0	0.0	0.0	111.2
16	0.0	0.0	0.4	0.0	0.0	119.1	0.0	0.0	0.0	119.5
17	0.0	0.0	0.4	0.0	0.0	98.8	0.0	0.0	0.0	99.2
18	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
19	0.0	0.0	0.4	0.0	0.0	72.9	0.0	0.0	0.0	73.4
20	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
21	0.0	0.0	0.4	0.0	0.0	72.9	0.0	0.0	0.0	73.3
22	0.0	0.0	0.4	0.0	0.0	73.0	0.0	0.0	0.0	73.4
23	0.0	0.0	0.4	0.0	0.0	73.0	0.0	0.0	0.0	73.4
24	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
25	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
26	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
27	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
28	0.0	0.0	0.4	0.0	0.0	72.9	0.0	0.0	0.0	73.3
29	0.0	0.0	0.4	0.0	0.0	73.0	0.0	0.0	0.0	73.4
30	0.0	0.0	0.4	0.0	0.0	72.9	0.0	0.0	0.0	73.3
31	0.0	0.0	0.4	0.0	0.0	73.0	0.0	0.0	0.0	73.4
32	0.0	0.0	0.4	0.0	0.0	72.8	0.0	0.0	0.0	73.3
33	0.0	0.0	0.4	0.0	0.0	72.8	0.0	0.0	0.0	73.2
34	0.0	0.0	0.4	0.0	0.0	72.8	0.0	0.0	0.0	73.2
35	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
36	0.0	0.0	0.4	0.0	0.0	62.5	0.0	0.0	0.0	62.9
37	0.0	0.0	0.4	0.0	0.0	25.0	0.4	0.0	0.0	25.8
38	0.0	0.0	0.4	0.0	0.0	25.0	0.4	0.0	0.0	25.8
39	0.0	0.0	0.4	0.0	0.0	25.0	0.4	0.0	0.0	25.8
40	0.0	0.0	0.4	0.0	0.0	25.0	1.5	0.0	0.0	26.9
41	0.0	0.0	0.9	0.0	0.0	9.8	17.0	0.0	0.5	28.2
42	0.0	0.0	0.9	0.0	0.0	0.0	20.1	0.0	1.0	22.0
43	0.0	0.0	0.9	0.0	0.0	0.0	18.8	0.0	1.0	20.7
44	0.0	0.0	0.9	0.0	0.0	0.0	13.0	0.0	1.0	14.9
45	0.0	0.0	0.9	0.0	0.0	0.0	11.4	0.0	0.5	12.8
TOTAL	5.5	98.8	28.4	643.5	62.8	2218.1	83.0	2.2	70.8	3213.0

TABLE E.10. Annual Cost Estimate for the MRS Facility, by Cost Category (millions of constant 1986 dollars)

Design: Field Drywells Site: Clinch River, Tennessee

Year	Environmental Evaluations	Design	Regulatory Compliance	Construction	Training and Testing	Operation	Decom-missioning	Institutional Interaction	Program Management	Total Program
1	3.5	8.8	2.0	0.0	0.0	0.0	0.0	0.5	9.2	24.0
2	1.2	24.6	1.5	0.0	0.0	0.0	0.0	0.4	8.4	36.1
3	0.4	29.9	1.5	0.0	0.0	0.0	0.0	0.4	8.7	40.9
4	0.3	24.1	1.5	1.5	0.4	0.0	0.0	0.4	6.9	35.1
5	0.0	6.6	1.2	42.6	0.7	0.0	0.0	0.4	6.5	57.8
6	0.0	4.6	0.8	166.2	1.4	0.0	0.0	0.0	6.8	179.8
7	0.0	0.1	0.8	203.2	2.6	0.0	0.0	0.0	6.4	213.1
8	0.0	0.0	0.8	203.2	5.4	0.0	0.0	0.0	6.7	216.1
9	0.0	0.1	0.8	128.0	12.3	0.0	0.0	0.0	4.9	146.1
10	0.0	0.0	0.4	6.4	15.6	0.0	0.0	0.0	2.3	24.7
11	0.0	0.0	0.4	0.0	24.4	36.8	0.0	0.0	0.8	62.0
12	0.0	0.0	0.4	0.0	0.0	67.4	0.0	0.0	0.0	67.8
13	0.0	0.0	0.4	0.0	0.0	76.8	0.0	0.0	0.0	77.4
14	0.0	0.0	0.4	0.0	0.0	77.2	0.0	0.0	0.0	77.6
15	0.0	0.0	0.4	0.0	0.0	76.7	0.0	0.0	0.0	77.1
16	0.0	0.0	0.4	0.0	0.0	65.8	0.0	0.0	0.0	66.2
17	0.0	0.0	0.4	0.0	0.0	72.9	0.0	0.0	0.0	73.3
18	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
19	0.0	0.0	0.4	0.0	0.0	72.8	0.0	0.0	0.0	73.4
20	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
21	0.0	0.0	0.4	0.0	0.0	72.9	0.0	0.0	0.0	73.3
22	0.0	0.0	0.4	0.0	0.0	73.0	0.0	0.0	0.0	73.4
23	0.0	0.0	0.4	0.0	0.0	73.0	0.0	0.0	0.0	73.4
24	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
25	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
26	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
27	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
28	0.0	0.0	0.4	0.0	0.0	72.9	0.0	0.0	0.0	73.3
29	0.0	0.0	0.4	0.0	0.0	73.0	0.0	0.0	0.0	73.4
30	0.0	0.0	0.4	0.0	0.0	72.9	0.0	0.0	0.0	73.3
31	0.0	0.0	0.4	0.0	0.0	73.0	0.0	0.0	0.0	73.4
32	0.0	0.0	0.4	0.0	0.0	72.8	0.0	0.0	0.0	73.3
33	0.0	0.0	0.4	0.0	0.0	72.8	0.0	0.0	0.0	73.2
34	0.0	0.0	0.4	0.0	0.0	72.8	0.0	0.0	0.0	73.2
35	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
36	0.0	0.0	0.4	0.0	0.0	62.5	0.0	0.0	0.0	62.9
37	0.0	0.0	0.4	0.0	0.0	25.0	0.4	0.0	0.0	25.8
38	0.0	0.0	0.4	0.0	0.0	25.0	0.4	0.0	0.0	25.8
39	0.0	0.0	0.4	0.0	0.0	25.0	0.4	0.0	0.0	25.8
40	0.0	0.0	0.4	0.0	0.0	25.0	1.5	0.0	0.0	26.9
41	0.0	0.0	0.9	0.0	0.0	9.8	17.0	0.0	0.5	28.2
42	0.0	0.0	0.9	0.0	0.0	0.0	20.0	0.0	1.0	22.0
43	0.0	0.0	0.9	0.0	0.0	0.0	18.8	0.0	1.0	20.7
44	0.0	0.0	0.9	0.0	0.0	0.0	13.0	0.0	1.0	14.9
45	0.0	0.0	0.9	0.0	0.0	0.0	11.4	0.0	0.5	12.7
TOTAL	5.5	98.8	28.4	751.2	62.8	1959.5	82.9	2.2	70.8	3061.9

TABLE E.11. Annual Cost Estimate for the MRS Facility, by Cost Category (millions of constant 1986 dollars)

Design: Field Drywells Site: Hartsville, Tennessee

Year	Environmental Evaluations	Design	Regulatory Compliance	Construction	Training and Testing	Operation	Decom-missioning	Institutional Interaction	Program Management	Total Program
1	3.5	8.8	2.0	0.0	0.0	0.0	0.0	0.5	9.2	24.0
2	1.2	24.6	1.5	0.0	0.0	0.0	0.0	0.4	8.4	36.1
3	0.4	29.9	1.5	0.0	0.0	0.0	0.0	0.4	8.7	40.9
4	0.3	24.1	1.5	1.5	0.4	0.0	0.0	0.4	6.9	35.1
5	0.0	6.6	1.2	41.4	0.7	0.0	0.0	0.4	6.5	56.8
6	0.0	4.6	0.8	160.8	1.4	0.0	0.0	0.0	6.8	174.4
7	0.0	0.1	0.8	196.6	2.6	0.0	0.0	0.0	6.4	206.5
8	0.0	0.0	0.8	196.6	5.4	0.0	0.0	0.0	6.7	209.5
9	0.0	0.1	0.8	124.0	12.3	0.0	0.0	0.0	4.8	142.1
10	0.0	0.0	0.4	6.4	15.6	0.0	0.0	0.0	2.3	24.7
11	0.0	0.0	0.4	0.0	24.4	36.8	0.0	0.0	0.0	61.6
12	0.0	0.0	0.4	0.0	0.0	67.4	0.0	0.0	0.0	67.8
13	0.0	0.0	0.4	0.0	0.0	76.8	0.0	0.0	0.0	77.2
14	0.0	0.0	0.4	0.0	0.0	77.2	0.0	0.0	0.0	77.6
15	0.0	0.0	0.4	0.0	0.0	76.7	0.0	0.0	0.0	77.1
16	0.0	0.0	0.4	0.0	0.0	65.8	0.0	0.0	0.0	66.2
17	0.0	0.0	0.4	0.0	0.0	72.9	0.0	0.0	0.0	73.3
18	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
19	0.0	0.0	0.4	0.0	0.0	72.9	0.0	0.0	0.0	73.4
20	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
21	0.0	0.0	0.4	0.0	0.0	72.9	0.0	0.0	0.0	73.3
22	0.0	0.0	0.4	0.0	0.0	73.0	0.0	0.0	0.0	73.4
23	0.0	0.0	0.4	0.0	0.0	73.0	0.0	0.0	0.0	73.4
24	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
25	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
26	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
27	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
28	0.0	0.0	0.4	0.0	0.0	72.9	0.0	0.0	0.0	73.3
29	0.0	0.0	0.4	0.0	0.0	73.0	0.0	0.0	0.0	73.4
30	0.0	0.0	0.4	0.0	0.0	72.9	0.0	0.0	0.0	73.3
31	0.0	0.0	0.4	0.0	0.0	73.0	0.0	0.0	0.0	73.4
32	0.0	0.0	0.4	0.0	0.0	72.8	0.0	0.0	0.0	73.3
33	0.0	0.0	0.4	0.0	0.0	72.8	0.0	0.0	0.0	73.2
34	0.0	0.0	0.4	0.0	0.0	72.8	0.0	0.0	0.0	73.2
35	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
36	0.0	0.0	0.4	0.0	0.0	62.5	0.0	0.0	0.0	62.9
37	0.0	0.0	0.4	0.0	0.0	25.1	0.4	0.0	0.0	25.8
38	0.0	0.0	0.4	0.0	0.0	25.0	0.4	0.0	0.0	25.8
39	0.0	0.0	0.4	0.0	0.0	25.0	0.4	0.0	0.0	25.8
40	0.0	0.0	0.4	0.0	0.0	25.0	1.5	0.0	0.0	26.9
41	0.0	0.0	0.9	0.0	0.0	9.8	17.0	0.0	0.5	28.2
42	0.0	0.0	0.9	0.0	0.0	0.0	20.0	0.0	1.0	22.0
43	0.0	0.0	0.9	0.0	0.0	0.0	18.8	0.0	1.0	20.7
44	0.0	0.0	0.9	0.0	0.0	0.0	13.0	0.0	1.0	14.9
45	0.0	0.0	0.9	0.0	0.0	0.0	11.4	0.0	0.5	12.7
TOTAL	5.5	98.8	28.4	727.2	62.8	1959.5	83.0	2.2	70.0	3038.0

TABLE E.12. Annual Cost Estimate for the MRS Facility, by Cost Category (millions of constant 1986 dollars)

Design: Field Drywells Site: Oak Ridge, Tennessee

Year	Environmental Evaluations	Design	Regulatory Compliance	Construction	Training and Testing	Operation	Decom-missioning	Institutional Interaction	Program Management	Total Program
1	3.5	8.8	2.0	0.0	0.0	0.0	0.0	0.5	9.2	24.0
2	1.2	24.6	1.5	0.0	0.0	0.0	0.0	0.4	8.4	36.1
3	0.4	29.9	1.5	0.0	0.0	0.0	0.0	0.4	8.7	40.9
4	0.3	24.1	1.5	1.5	0.4	0.0	0.0	0.4	6.9	35.1
5	0.0	6.6	1.2	41.9	0.7	0.0	0.0	0.4	6.5	57.3
6	0.0	4.6	0.8	162.9	1.4	0.0	0.0	0.0	6.8	176.5
7	0.0	0.1	0.8	199.2	2.6	0.0	0.0	0.0	6.4	209.1
8	0.0	0.0	0.8	199.2	5.4	0.0	0.0	0.0	6.7	212.1
9	0.0	0.1	0.8	125.5	12.3	0.0	0.0	0.0	4.9	143.6
10	0.0	0.0	0.4	6.4	15.6	0.0	0.0	0.0	2.3	24.7
11	0.0	0.0	0.4	0.0	24.4	36.8	0.0	0.0	0.0	61.6
12	0.0	0.0	0.4	0.0	0.0	67.4	0.0	0.0	0.0	67.0
13	0.0	0.0	0.4	0.0	0.0	76.8	0.0	0.0	0.0	77.2
14	0.0	0.0	0.4	0.0	0.0	77.2	0.0	0.0	0.0	77.6
15	0.0	0.0	0.4	0.0	0.0	76.7	0.0	0.0	0.0	77.1
16	0.0	0.0	0.4	0.0	0.0	65.8	0.0	0.0	0.0	66.2
17	0.0	0.0	0.4	0.0	0.0	72.9	0.0	0.0	0.0	73.3
18	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
19	0.0	0.0	0.4	0.0	0.0	72.9	0.0	0.0	0.0	73.4
20	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
21	0.0	0.0	0.4	0.0	0.0	72.9	0.0	0.0	0.0	73.3
22	0.0	0.0	0.4	0.0	0.0	73.0	0.0	0.0	0.0	73.4
23	0.0	0.0	0.4	0.0	0.0	73.0	0.0	0.0	0.0	73.4
24	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
25	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
26	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
27	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
28	0.0	0.0	0.4	0.0	0.0	72.9	0.0	0.0	0.0	73.3
29	0.0	0.0	0.4	0.0	0.0	73.0	0.0	0.0	0.0	73.4
30	0.0	0.0	0.4	0.0	0.0	72.9	0.0	0.0	0.0	73.3
31	0.0	0.0	0.4	0.0	0.0	73.0	0.0	0.0	0.0	73.4
32	0.0	0.0	0.4	0.0	0.0	72.8	0.0	0.0	0.0	73.3
33	0.0	0.0	0.4	0.0	0.0	72.8	0.0	0.0	0.0	73.2
34	0.0	0.0	0.4	0.0	0.0	72.8	0.0	0.0	0.0	73.2
35	0.0	0.0	0.4	0.0	0.0	73.1	0.0	0.0	0.0	73.5
36	0.0	0.0	0.4	0.0	0.0	62.5	0.0	0.0	0.0	62.9
37	0.0	0.0	0.4	0.0	0.0	25.0	0.4	0.0	0.0	25.8
38	0.0	0.0	0.4	0.0	0.0	25.0	0.4	0.0	0.0	25.8
39	0.0	0.0	0.4	0.0	0.0	25.0	0.4	0.0	0.0	25.8
40	0.0	0.0	0.4	0.0	0.0	25.0	1.5	0.0	0.0	26.9
41	0.0	0.0	0.9	0.0	0.0	9.8	17.0	0.0	0.5	28.2
42	0.0	0.0	0.9	0.0	0.0	0.0	20.0	0.0	1.0	22.0
43	0.0	0.0	0.9	0.0	0.0	0.0	18.8	0.0	1.0	20.7
44	0.0	0.0	0.9	0.0	0.0	0.0	13.0	0.0	1.0	14.9
45	0.0	0.0	0.9	0.0	0.0	0.0	11.4	0.0	0.5	12.7
TOTAL	5.5	98.8	28.4	736.5	62.8	1959.5	83.0	2.2	70.8	3047.2

TABLE E.13. Sensitivities of Preferred Site-Design Case Cost Estimate to Changes in Staffing Requirements During Facility Operation (millions of constant 1986 dollars)

Design: Sealed Storage Casks Site: Clinch River, Tennessee

Year	(1) Total MRS Program	(2) Labor Cost During Operation	(3) Change in Labor Cost due to 10% Change in Staffing Requirements (SR)	(4) Total MRS Program Costs With the Changes In SR: 10% Higher	(5) Total MRS Program Costs With the Changes In SR: 10% Lower	(6) Deviations From Column (1): 10% Higher	(7) Deviations From Column (1): 10% Lower
1	24.0	0.0	0.0	24.0	24.0	0.0	0.0
2	36.2	0.0	0.0	36.2	36.2	0.0	0.0
3	41.0	0.0	0.0	41.0	41.0	0.0	0.0
4	35.2	0.4	0.0	35.2	35.1	0.1	-0.1
5	53.4	0.7	0.1	53.4	53.3	0.1	-0.1
6	158.0	1.4	0.1	158.1	157.8	0.1	-0.1
7	186.4	2.5	0.3	186.7	186.2	0.1	-0.1
8	189.4	4.9	0.5	189.9	188.9	0.3	-0.3
9	139.0	9.6	1.0	139.9	138.0	0.7	-0.7
10	36.3	12.1	1.2	37.5	35.1	3.3	-3.3
11	108.3	37.2	3.7	112.0	104.6	3.4	-3.4
12	89.7	17.3	1.7	91.5	88.0	1.9	-1.9
13	111.3	17.3	1.7	113.0	109.6	1.6	-1.6
14	99.5	17.3	1.7	101.2	97.8	1.7	-1.7
15	111.2	17.3	1.7	113.0	109.5	1.6	-1.6
16	119.5	25.0	2.5	122.0	117.0	2.1	-2.1
17	99.2	28.7	2.9	102.1	96.3	2.9	-2.9
18	73.5	28.7	2.9	76.3	70.6	3.9	-3.9
19	73.4	28.7	2.9	76.2	70.5	3.9	-3.9
20	73.5	28.7	2.9	76.4	70.6	3.9	-3.9
21	73.3	28.7	2.9	76.2	70.4	3.9	-3.9
22	73.4	28.7	2.9	76.3	70.5	3.9	-3.9
23	73.4	28.7	2.9	76.3	70.6	3.9	-3.9
24	73.5	28.7	2.9	76.3	70.6	3.9	-3.9
25	73.5	28.7	2.9	76.3	70.6	3.9	-3.9
26	73.5	28.7	2.9	76.4	70.6	3.9	-3.9
27	73.5	28.7	2.9	76.4	70.7	3.9	-3.9
28	73.3	28.7	2.9	76.2	70.5	3.9	-3.9
29	73.4	28.7	2.9	76.3	70.5	3.9	-3.9
30	73.3	28.7	2.9	76.2	70.5	3.9	-3.9
31	73.4	28.7	2.9	76.2	70.5	3.9	-3.9
32	73.3	28.7	2.9	76.1	70.4	3.9	-3.9
33	73.2	28.7	2.9	76.1	70.3	3.9	-3.9
34	73.2	28.7	2.9	76.1	70.4	3.9	-3.9
35	73.5	28.7	2.9	76.4	70.6	3.9	-3.9
36	62.9	28.7	2.9	65.7	60.0	4.6	-4.6
37	25.8	18.6	1.9	27.7	24.0	7.2	-7.2
38	25.8	18.6	1.9	27.7	24.0	7.2	-7.2
39	25.8	18.6	1.9	27.7	24.0	7.2	-7.2
40	26.9	18.6	1.9	28.7	25.0	6.9	-6.9
41	28.2	6.2	0.6	28.9	27.6	2.2	-2.2
42	22.0	0.0	0.0	22.0	22.0	0.0	0.0
43	20.7	0.0	0.0	20.7	20.7	0.0	0.0
44	14.9	0.0	0.0	14.9	14.9	0.0	0.0
45	12.8	0.0	0.0	12.8	12.8	0.0	0.0
TOTAL	3.224.5	818.1	81.8	3.306.3	3.142.7	2.8	-2.8

Sources and Notes: Col. (1): from Table E.2; Col. (2): derived from R. M. Parsons 1986; Col. (3): (0.1) x Col. (2); Col. (4): Col. (1) + Col. (3); Col. (5): Col. (1) - Col. (3); Col. (6): [Col. (4)/Col. (1) - 1.0] x 100%; Col. (7): [Col. (5)/Col. (1) - 1.0] x 100%.

TABLE E.14. Sensitivities of Preferred Case Cost Estimate to Changes in Unit Wage Cost During Facility Operation (millions of constant 1986 dollars)

Design: Sealed Storage Cask   Site: Clinch River, Tennessee

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
					Total MRS Cost With Changes			% Deviations from Column (2)		
Year	Adjustment Factor for 1% Escalation	Total MRS Program	Labor Cost During Operation	Changes in Labor Cost With 20% Change in Unit Labor Cost	Labor Cost 20% Higher	Labor Cost 20% Lower	1% Real Escalation	Labor Cost 20% Higher	Labor Cost 20% Lower	1% Real Escalation
1	0.0000	24.0	0.0	0.0	24.0	24.0	24.0	0.01	0.01	0.0
2	0.0000	36.2	0.0	0.0	36.2	36.2	36.2	0.01	0.01	0.0
3	1.0000	41.0	0.0	0.0	41.0	41.0	41.0	0.01	0.01	0.0
4	1.0100	35.2	0.4	0.1	35.3	35.1	35.2	0.21	-0.21	0.0
5	1.0201	53.4	0.7	0.1	53.5	53.2	53.4	0.31	-0.31	0.0
6	1.0303	158.6	1.4	0.3	158.3	157.7	158.0	0.21	-0.21	0.0
7	1.0406	186.4	2.5	0.5	186.9	185.9	186.5	0.31	-0.31	0.1
8	1.0510	189.4	4.9	1.0	190.4	188.4	189.5	0.51	-0.51	0.1
9	1.0615	139.0	9.6	1.9	140.9	137.1	139.6	1.41	-1.41	0.4
10	1.0721	36.3	12.5	2.4	38.8	33.9	37.2	6.71	-6.72	2.4
11	1.0829	106.3	37.2	7.4	115.7	100.9	111.4	6.92	-6.92	2.8
12	1.0937	89.7	17.3	3.5	93.2	86.3	91.4	3.91	-3.92	1.8
13	1.1046	111.3	17.3	3.5	114.8	107.8	113.1	3.12	-3.12	1.6
14	1.1157	99.5	17.3	3.5	103.0	96.0	101.5	3.51	-3.52	2.0
15	1.1268	111.2	17.3	3.5	114.7	107.8	113.4	3.11	-3.12	2.0
16	1.1381	119.5	25.0	5.0	124.5	114.5	123.0	4.23	-4.22	2.9
17	1.1495	99.2	28.7	5.7	105.0	93.5	103.5	5.81	-5.82	4.3
18	1.1610	73.5	28.7	5.7	79.2	67.7	78.1	7.81	-7.81	6.3
19	1.1726	73.4	28.7	5.7	79.1	67.6	78.3	7.81	-7.81	6.8
20	1.1843	73.5	28.7	5.7	79.3	67.8	78.8	7.81	-7.81	7.2
21	1.1961	73.3	28.7	5.7	79.0	67.5	78.9	7.81	-7.81	7.7
22	1.2081	73.4	28.7	5.7	79.2	67.7	79.4	7.81	-7.81	8.1
23	1.2202	73.4	28.7	5.7	79.2	67.7	79.8	7.81	-7.81	8.6
24	1.2324	73.5	28.7	5.7	79.2	67.7	80.1	7.81	-7.81	9.1
25	1.2447	73.5	28.7	5.7	79.2	67.7	80.5	7.81	-7.81	9.6
26	1.2572	73.5	28.7	5.7	79.2	67.8	80.9	7.81	-7.81	10.0
27	1.2697	73.5	28.7	5.7	79.3	67.8	81.3	7.81	-7.81	10.5
28	1.2824	73.3	28.7	5.7	79.1	67.6	81.4	7.81	-7.81	11.1
29	1.2953	73.4	28.7	5.7	79.1	67.7	81.9	7.81	-7.81	11.5
30	1.3082	73.3	28.7	5.7	79.1	67.6	82.2	7.81	-7.81	12.1
31	1.3213	73.4	28.7	5.7	79.1	67.6	82.6	7.81	-7.81	12.6
32	1.3345	73.3	28.7	5.7	79.0	67.5	82.9	7.81	-7.81	13.1
33	1.3478	73.2	28.7	5.7	78.9	67.4	83.2	7.81	-7.81	13.6
34	1.3653	73.2	28.7	5.7	79.0	67.5	83.6	7.81	-7.81	14.2
35	1.3749	73.5	28.7	5.7	79.2	67.8	84.3	7.81	-7.81	14.6
36	1.3887	62.9	28.7	5.7	68.6	57.1	74.0	9.11	-9.11	17.8
37	1.4026	25.8	18.6	3.7	29.5	22.1	33.3	14.41	-14.41	29.0
38	1.4166	25.8	18.6	3.7	29.5	22.1	33.6	14.42	-14.41	30.0
39	1.4308	25.8	18.6	3.7	29.5	22.1	33.8	14.42	-14.41	31.1
40	1.4451	26.9	18.6	3.7	30.6	23.1	35.2	13.91	-13.91	30.9
41	1.4595	28.2	6.2	1.2	29.5	23.0	31.1	4.41	-4.41	10.1
42	1.4741	22.0	0.0	0.0	22.0	22.0	22.0	0.02	0.02	0.00
43	1.4897	20.7	0.0	0.0	20.7	20.1	20.7	0.01	0.01	0.00
44	1.5039	14.9	0.0	0.0	14.9	14.9	14.9	0.02	0.02	0.00
45	1.5188	12.8	0.0	0.0	12.8	12.8	12.8	0.01	0.01	0.00
TOTAL		3224.5	818.1	163.6	3388.1	3060.8	3421.1	5.61	-5.61	7.9

Sources and Notes: Col. (1): $(1.01)^{t-3}$ where t is year from year 3 on. For year 1 and year 2, the adjustment factor is assigned 1.0. Col. (2): from Table E.2; Col. (3): Derived from R. M. Parsons, 1986; Col. (4): (0.2) x Col. (3); (Col. (5): Col. (2) + Col. (4); Col. (6): Col. (2) - Col. (4); Col. (7): Col. (2) + [Col. (1) - 1.0] x Col. (3). Col. (8): [Col. (5)/Col. (2) - 1.0] x 100; Col. (9): [Col. (6)/Col. (2) - 1.0] x 100; Col. (10): [Col. (7)/Col. (2) - 1.0] x 100.

TABLE E.15. Detailed Cost Schedules by Funding Category (millions of constant 1986 dollars)

	Capital-Funded			Operating Expense-Funded				
Year	Facility Construction	Facility Modification	Casks	Preoperation Support[a]	Facility Operation	Decommissioning	Other Project Support[b]	Total Project
1	0.0	0.0	0.0	6.8	0.0	0.0	15.1	24.0
2	2.0	0.0	0.0	7.3	0.0	0.0	11.6	36.2
3	17.3	0.0	0.0	4.9	0.0	0.0	11.1	41.4
4	25.4	0.0	0.0	6.0	0.0	0.0	9.2	35.5
5	20.3	0.0	0.0	8.0	0.0	0.0	8.1	54.1
6	37.9	0.0	0.0	9.0	0.0	0.0	7.6	159.2
7	142.6	0.0	0.0	7.5	0.0	0.0	7.2	189.2
8	174.5	0.0	0.0	14.3	0.0	0.0	7.5	196.3
9	174.5	0.0	9.1	16.9	0.0	0.0	5.8	142.3
10	110.5	0.0	11.6	24.9	0.0	0.0	2.7	45.1
11	5.9	0.0	46.6	0.0	36.8	0.0	0.4	83.9
12	0.0	0.0	53.3	0.0	36.0	0.0	0.4	89.7
13	0.0	21.7	53.3	0.0	35.9	0.0	0.4	111.3
14	0.0	9.5	53.3	0.0	36.3	0.0	0.4	99.5
15	0.0	21.7	53.3	0.0	35.8	0.0	0.4	111.2
16	0.0	9.5	53.3	0.0	56.3	0.0	0.4	119.5
17	0.0	9.5	25.9	0.0	63.4	0.0	0.4	99.2
18	0.0	9.5	0.0	0.0	63.5	0.0	0.4	73.5
19	0.0	9.5	0.0	0.0	63.4	0.0	0.4	73.4
20	0.0	9.5	0.0	0.0	63.6	0.0	0.4	73.5
21	0.0	9.5	0.0	0.0	63.4	0.0	0.4	73.3
22	0.0	9.5	0.0	0.0	63.5	0.0	0.4	73.4
23	0.0	9.5	0.0	0.0	63.5	0.0	0.4	73.4
24	0.0	9.5	0.0	0.0	63.5	0.0	0.4	73.5
25	0.0	9.5	0.0	0.0	63.5	0.0	0.4	73.5
26	0.0	9.5	0.0	0.0	63.6	0.0	0.4	73.5
27	0.0	9.5	0.0	0.0	63.6	0.0	0.4	73.5
28	0.0	9.5	0.0	0.0	63.4	0.0	0.4	73.3
29	0.0	9.5	0.0	0.0	63.5	0.0	0.4	73.4
30	0.0	9.5	0.0	0.0	63.4	0.0	0.4	73.3
31	0.0	9.5	0.0	0.0	63.4	0.0	0.4	73.4
32	0.0	9.5	0.0	0.0	63.4	0.0	0.4	73.3
33	0.0	9.5	0.0	0.0	63.3	0.0	0.4	73.2
34	0.0	9.5	0.0	0.0	63.3	0.0	0.4	73.2
35	0.0	9.5	0.0	0.0	63.6	0.0	0.4	73.5
36	0.0	9.5	0.0	0.0	52.9	0.0	0.4	62.9
37	0.0	0.0	0.0	0.0	25.0	0.4	0.4	25.8
38	0.0	0.0	0.0	0.0	25.0	0.4	0.4	25.8
39	0.0	0.0	0.0	0.0	25.0	0.4	0.4	25.8
40	0.0	0.0	0.0	0.0	25.0	1.5	1.5	26.9
41	0.0	0.0	0.0	0.0	9.8	17.0	1.4	28.2
42	0.0	0.0	0.0	0.0	0.0	20.1	1.9	22.0
43	0.0	0.0	0.0	0.0	0.0	18.8	1.9	20.7
44	0.0	0.0	0.0	0.0	0.0	13.0	1.9	14.9
45	0.0	0.0	0.0	0.0	0.0	11.4	1.4	12.8
TOTAL	710.9	252.9	359.8	105.7	1505.5	83.0	106.7	3224.4

(a) Preoperation support includes costs of design verification, collection of design-related site data, operation contractor support to design ($9.2M) and construction ($10M), and training and testing ($62M).
(b) Other project support includes costs for four categories: Environmental Evaluations, Regulatory Compliance, Institutional Interactions, and Program Management.

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