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Comparison of Cask and Drywell Storage Concepts for a Monitored Retrievable Storage/ Interim Storage System

D. E. Rasmussen
Program Manager

December 1982

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
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Richland, Washington 99352

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Technical Contributors/Editors

T. A. Evans - AGNS*
J. F. Fletcher
J. T. Ganley - GA**
W. L. Godfrey - AGNS
G. M. Holter
K. D. Hayden - WHC***
W. S. Kelly
W. Knox - AGNS
R. P. Morissette - GA
J. F. Nesbitt
K. J. Schneider
R. I. Smith

Formal Editing

J. A. Powell
R. I. Smith

Word Processing

S. C. Cozad
H. K. Mills
J. A. Smith

Duplicating

E. Anderson, et al.

Coordination and Secretarial

P. N. McDuffie
C. A. Jones

* Allied-General Nuclear Services, Barnwell, South Carolina
** General Atomic Company, San Diego, California
*** Westinghouse Hanford Company, Richland, Washington

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1.0 EXECUTIVE SUMMARY

Changes in recent years in federal policies regarding spent nuclear reactor fuel reprocessing and/or disposal have produced delays in completing the construction and startup of commercial fuel reprocessing plants, and in the development and deployment of waste disposal facilities. As a result, some nuclear power plants are running out of spent fuel storage capacity. Start of reprocessing would improve spent fuel storage capacity. However, the sizeable quantities of waste produced in reprocessing would need to be stored until a repository is available. Legislative initiatives are under way in Congress to provide storage and disposal capabilities responsive to this situation.

The Department of Energy (DOE), through its Richland Operations Office is evaluating the feasibility, timing, and cost of providing a federal capability for storing the spent fuel, high-level wastes (HLW), and transuranic (TRU) wastes that DOE may be obligated by law to manage until permanent waste disposal facilities are available. Three concepts utilizing a monitored retrievable storage/interim storage (MRS/IS) facility have been developed and analyzed. The first concept, co-location with a reprocessing plant, has been developed by staff of Allied General Nuclear Services. The second concept, a stand-alone facility, has been developed by staff of the General Atomic Company. The third concept, co-location with a deep geologic repository, has been developed by the Pacific Northwest Laboratory with the assistance of the Westinghouse Hanford Company and Kaiser Engineers. This report summarizes the results of those studies.

The MRS/IS facility co-located with a fuel reprocessing plant utilizes the water pool receiving, inspection, and handling facilities and other support facilities already present on the site as part of the reprocessing plant. Spent fuel and solidified HLW are stored either in large metal dry storage casks or in subsurface drywells in built-up berms. Remote-handled TRU (RHTRU) wastes are stored in metal drywells in built-up berms. Contact-handled TRU (CHTRU) wastes are stored in cargo containers that are covered by a berm to protect against tornado damage.

The MRS/IS stand-alone facility, located separately from other nuclear fuel cycle facilities, utilizes a water pool receiving station and dry, shielded cells for inspection, handling, and packaging as needed. Spent fuel and solidified HLW are stored either in large metal dry storage casks or in subsurface drywells. RHTRU wastes are stored either in a shielded storage building or in subsurface drywells in a built-up berm, depending on the surface radiation dose rates of the containers. CHTRU wastes are stored in a conventional surface warehouse structure.

The MRS/IS facility co-located with a repository utilizes a dry receiving station for inspection, handling, and packaging as needed. Spent fuel and HLW are stored either in large metal dry storage casks or in subsurface drywells. RHTRU wastes are stored in concrete storage casks. CHTRU wastes are stored in a conventional surface warehouse structure.

The objectives of this study are: 1) to develop preconceptual designs for MRS/IS facilities, 2) to examine various issues such as transportation of wastes, licensing of the facilities, and environmental concerns associated with operation of such facilities, and 3) to estimate the life-cycle costs of the facilities when operated in response to a set of scenarios that define the quantities and types of waste requiring storage in specific time periods, generally spanning the years 1989 to 2037.

Three scenarios are examined to develop estimates of life-cycle costs for the MRS/IS facilities. In the first scenario, the reprocessing plant is placed in service in 1989 and HLW canisters are stored until a repository is opened in the year 1998. Additional reprocessing plants and repositories are placed in service at intervals as needed to meet the demand. In the second scenario, the reprocessing plants are delayed in starting operations by 10 years, but the repositories open on schedule. In the third scenario, the repositories are delayed 10 years, but the reprocessing plants open on schedule.

The inventories of spent fuel and HLW requiring storage in an MRS/IS facility are shown in Figure 1.1 as a function of time for each of the three scenarios. The life-cycle costs estimated in this study include: the capital

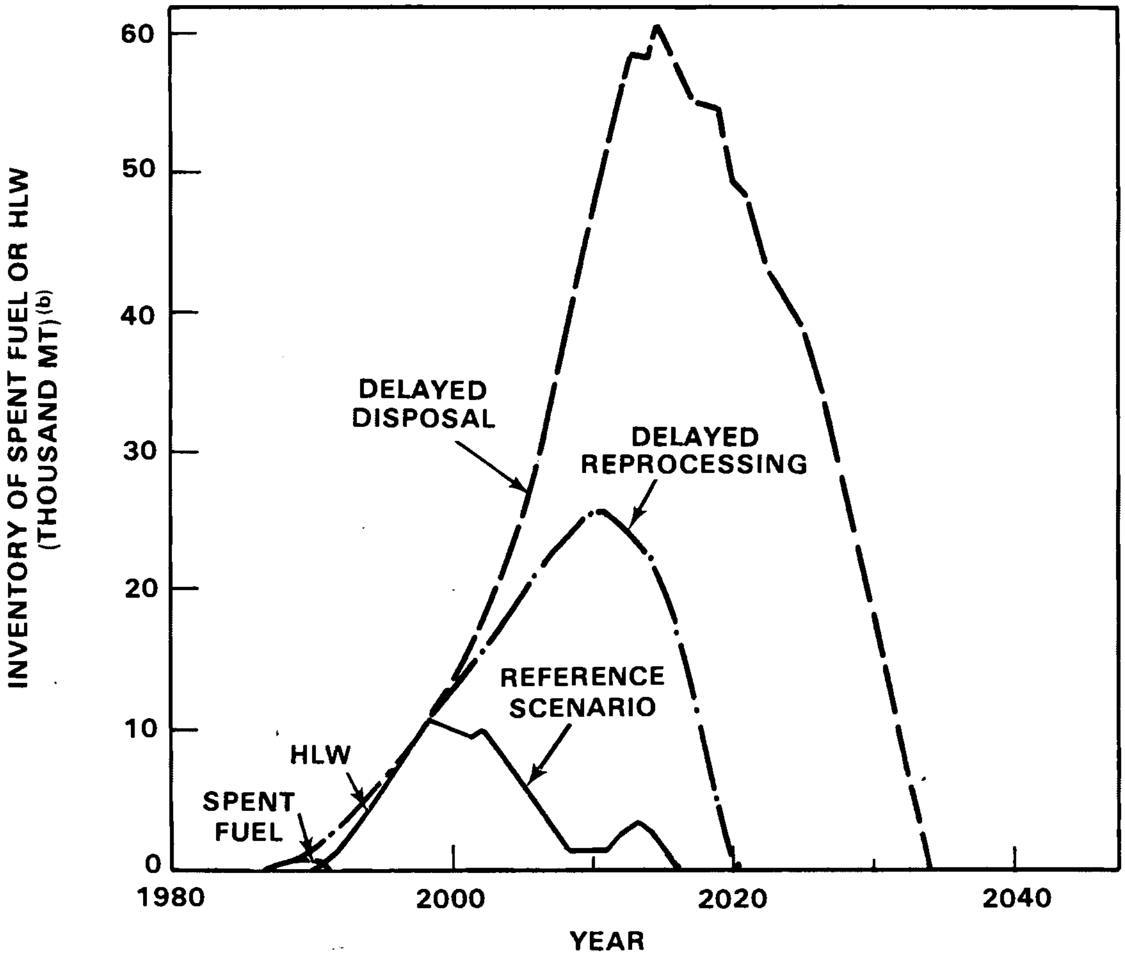


FIGURE 1.1. Inventories of Spent Fuel and HLW Requiring Storage[a]

(a) These scenarios represent maximum capacities and do not include any moderating effects of extended burnup operation, rod consolidation, or private AFRs.
(b) To convert from MTHM to fuel assemblies or HLW canisters, divide the MTHM values by 0.18 MTHM/BWR, 0.42 MTHM/PWR, 2.143 MTHM/canister.

expenditures for structures, casks and/or drywells, storage areas and pads, and transfer equipment; the cost of staff labor, supplies, and services; and the incremental cost of transporting the waste materials from the site of origin to the MRS/IS facility (costs in excess of the normal reactor-to-reprocessing plant-to-repository transport costs).

The estimated life-cycle costs (undiscounted) for each of the conceptual facilities, in each of the three fuel cycle scenarios, utilizing metal casks or drywells for storage of spent fuel and HLW, are summarized in Table 1.1.

TABLE 1.1. Estimated Life-Cycle Costs for Conceptual MRS/IS Facilities (millions of mid-1982 dollars, undiscounted)

	Location of the Storage Facility					
	Reprocessing Plant		Stand-Alone		Repository	
Scenario	Cask	Drywell	Cask	Drywell	Cask	Drywell
Reference	379	277	1340	1124	731	518
Delayed Reprocessing	839	340	1722	1513	2257	1973
Delayed Disposal	2224	1713	4376	2989	2487	1235

From the results of this study it is concluded that:

- The use of a modular dry storage system utilizing large metal casks and/or drywells is feasible. Such a system could be developed and deployed to meet the projected storage needs.
- Storage in drywells is less expensive than storage in large metal casks.
- Co-location with a reprocessing plant is somewhat less expensive than the other alternatives, due principally to the use of available handling facilities at the reprocessing plant.
- Consolidation of spent fuel assemblies at the reactor sites and shipment in transportable large metal storage casks would significantly reduce overall waste management system costs.
- Storage in large metal casks would be more cost-effective if the stored materials could be also shipped to the storage site in sealed storage casks, thus eliminating the need for a transfer facility.

The principal advantages/disadvantages of each MRS/IS concept evaluated in this report are described below:

MRS/IS/Reprocessing Plant. Co-location with a reprocessing plant reduces the capital cost of the MRS/IS facility since the receiving and handling station and other supporting facilities at the reprocessing plant can also serve the storage facility.

Since the site is already approved for nuclear applications, the time required to obtain the necessary permits and licenses should be reduced, as compared with a new site. Thus, authorization, construction and utilization of the storage facility could be accomplished at an earlier date.

The incremental transportation links for this concept (transport in addition to the normal reactor-to-reprocessor-to-repository links) are zero. Thus waste management transportation costs are minimized.

Storage at the reprocessing plant may be publicly perceived as likely to become permanent disposal, a perception that might lead to public opposition to siting of the storage facility.

MRS/IS/Stand-Alone. The stand-alone facility can be sited in many places, since the location does not have to be suitable for either a reprocessing plant or a geologic repository. Thus, selection of a site and the obtaining of necessary permits and licenses might be accomplished more quickly, compared with a repository-based site.

The incremental transportation links for this concept are longer than for the repository concept except with the delayed reprocessing scenario.

Storage at the stand-alone facility may be publicly perceived as likely to become permanent disposal, a perception that might lead to public opposition to siting of the storage facility.

MRS/IS/Repository. Co-location with a geologic repository reduces the overall capital investment in the waste management system since the waste handling facility and its supporting facilities become the surface installations for the repository. Using these facilities over the life span of the repository approximately doubles the useful life of the structures and permits amortization of the capital costs over a longer time period.

Except for the delayed reprocessing scenario, the incremental transportation links are zero, thus minimizing waste management transportation costs.

The stored materials are transferred directly from storage to the repository without leaving the site, thereby minimizing the potential for transportation accidents and the possible exposure of the public that could otherwise result from such accidents.

2.0 INTRODUCTION

Until 1975, commercial nuclear power generating plant owners had planned to store spent fuel at the reactor for only a short period prior to shipment to a reprocessing plant. Reactors built in that era initially had storage space for only one or two batch discharges of spent fuel in addition to a full core discharge capability. While installation of larger capacity storage racks has alleviated the situation temporarily, changes in federal policies in the late seventies have delayed completion and startup of commercial fuel reprocessing plants, and some nuclear power generating plants are faced with the possibility of shutdown due to lack of spent fuel storage capacity.

Similarly, delay in selecting waste disposal methods and sites has delayed the projected completion date of waste repositories. This delay has raised the question of where will spent fuel not suited to reprocessing and wastes from a reprocessing plant be stored and/or disposed of.

In recognition of this situation, legislative initiatives are under way in Congress to provide appropriate storage and disposal facilities. In response to these legislative initiatives, the Department of Energy (DOE), through its Richland Operations Office, is evaluating the feasibility and cost of storing spent nuclear fuel, solidified high-level wastes (HLW), and transuranic (TRU) wastes in government facilities until a reprocessing plant and/or appropriate waste disposal facilities are available. Three conceptual government-owned monitored retrievable storage/interim storage (MRS/IS) facilities for wastes that the government may become obligated to manage are the subject of this report.

Three MRS/IS siting alternatives were studied. Two storage methods for spent fuel and high-level waste were evaluated for each site. Systems for handling both remote-handled and contact-handled transuranic waste were also evaluated for each site. The use of dry passive storage was assumed in these studies. The three siting alternatives studied were:

- located on a reprocessing site
- strategically located stand-alone site
- located at a future geologic repository site.

The storage methods evaluated for spent fuel and HLW were:

- large metal casks
- drywells.

Study of each alternative site was assigned to a study team. Each team independently developed the storage concept most appropriate to the specific site and responsive to previously established common criteria, guidelines, and storage methods. The study team assignments were:

- co-located with a reprocessing plant site - Allied-General Nuclear Services
- stand-alone site - General Atomic
- co-located with a repository site - Pacific Northwest Laboratory, with assistance from Westinghouse Hanford Company and Kaiser Engineers.

Each study team completed its study assignment and prepared a final (draft) report. This report is a summary of the information, results, and conclusions presented in those reports. Each study team participated in preparation of this summary report.

This report has six sections and appendices. Section 1 contains the executive summary, and Section 2 contains the introduction. Conceptual design guidelines, including legislative guidance, functional criteria for the MRS/IS facility, and planning assumptions are presented in Section 3, and conclusions and recommendations are presented in Section 4. The siting alternatives and facility concepts are summarized in Section 5. Concept evaluations are compared in Section 6, including the technical and economic merits and the specific attributes of each concept. Detailed information on economic comparisons is provided in Appendix A. The data bases and evaluation guidelines are given in Appendix B.

3.0 CONCEPTUAL DESIGN GUIDELINES

To ensure valid and equitable comparisons of the various conceptual designs for monitored retrievable storage/interim storage (MRS/IS) facilities, PNL provided specific guidelines for the preparation of critical sections of the studies. The legislative guidance that provides the bases for the MRS/IS concept is discussed in Section 3.1. The functional criteria for an MRS/IS facility, used to develop the conceptual designs, are presented in Section 3.2. The study bases used in evaluating the conceptual designs are described in Section 3.3. Additional details are presented in Appendix B.

3.1 LEGISLATIVE GUIDANCE

Several bills presently under consideration by Congress deal with interim storage of commercial spent nuclear fuel; monitored retrievable storage of spent fuel, solidified high-level wastes, and transuranic wastes; and permanent disposal of these nuclear wastes in deep geologic repositories. Each bill under consideration provides for establishment of repositories, mechanisms to ensure full recovery of the costs of storage and disposal operations from the waste generators, and procedures to ensure that interested states and Indian tribes can be involved in the siting process. Several of the proposed bills differ regarding who has title to the radioactive material while in storage prior to final disposal in a repository.

Specific provisions of the pending legislation that are unique to interim storage, monitored retrievable storage, and transuranic waste storage are discussed in the following subsections. It should be noted that many of the subjects addressed in pending legislation are still being debated, including monitored retrievable storage. At the time of this writing, the final form of the legislation is not known.

3.1.1 Emergency Storage of Spent Fuel

The bills contain language that would make licensing of additional spent fuel storage capacity at existing reactor sites easier by eliminating some of the issues that would otherwise have to be considered (availability or desirability of alternatives, the need for power from the reactor, any issues relating to reactor operation, etc.).

In addition, use of federally-owned away-from-reactor facilities for emergency storage is proposed. The facilities would be limited in capacity [1700 (H.R.3809) or 2800 (S.1662) metric tons], would be exempt from licensing if located at an existing federal site (H.R.3809), and would not be a major federal action as defined in the National Environmental Policy Act (NEPA) (H.R.3809). The operation of an emergency storage facility is limited to 5 to 7 years (President Reagan's letter to T. P. O'Neill dated April 28, 1982), or 8 to 12 years (S.1662).

The emergency storage provisions are intended to provide a way to avoid shutdown of operating power reactors if full core discharge capability is lost as the quantities of stored fuel approach the pool's capacity. This type of storage is intended as a very limited effort, of relatively short duration. Longer-term storage of radioactive materials such as spent fuel, solidified high-level waste, and transuranic waste would be provided for by monitored retrievable storage facilities, which are discussed in the next subsection.

3.1.2 Monitored Retrievable Storage

In pending legislation, the DOE is directed to submit to Congress within 1 year of passage of the enabling legislation a proposal to develop one or more MRS facilities. This proposal is to include: 1) the federal program for developing, siting, building, and operating licensed storage facilities for spent fuel and HLW; 2) site-specific designs, specifications, and cost estimates suitable for construction authorization; and 3) a plan for integration of the MRS facility into the federal nuclear waste management program, especially in terms of away-from-reactor storage and of the deep geologic disposal repositories also mandated by the legislation.

In all cases, an environmental assessment (EA) is required at the time the proposal is submitted, with an environmental impact statement (EIS) to be issued before construction is initiated. The MRS facility must be licensed by the NRC. During the NEPA and licensing processes, some issues normally considered, such as the need for the facility, alternative sites, and alternative designs, need not be considered.

Both S.1662 and H.R.3809 treat the MRS facility as a complement to a repository program. Both the MRS facility and the repositories are to be paid for by a nuclear waste management fund financed by a 1-mill/kWh fee paid by users of electricity from nuclear power generating plants.

No specific instructions are given in the various House bills regarding the capacity of an MRS facility. However, in the Senate bill (S.1662), until a second repository is in operation, a limit of 70,000 metric tons of spent fuel is placed on the combined capacity of an MRS facility and the first repository when located within 50 miles of each other.

Similarly, no clearly defined limit is proposed for the duration of MRS operations, when the MRS facility is to be built or when MRS waste must be transferred to a repository. Instead, the MRS facilities are simply to remain in service until geologic repositories are available.

The House bills exclude military waste from licensed nuclear waste management facilities; S.1662 requires military waste to be included in such facilities.

3.1.3 Storage of Transuranic Wastes

The bill also defines high-level radioactive waste, in part, as any solid material derived from liquid waste produced directly in reprocessing, that contains fission products and transuranic waste in sufficient concentrations. Those TRU wastes which result from reprocessing are considered in this study.

In addressing storage and disposal of transuranic (TRU) wastes, House bill 7187 specifically states that TRU wastes, regardless of concentration, from decommissioning and decontamination of civilian nuclear facilities (except utilization facilities) and from civilian fuel R&D program can be stored in facilities owned by the government at the time the act is enacted. TRU waste from those sources are not considered in this study.

3.2 FUNCTIONAL CRITERIA

The following functional criteria were used as the basis for development of the three conceptual studies.

- The MRS/IS system shall have the capability to receive, inspect, repackage where necessary, and store and retrieve for subsequent shipment spent fuel, solidified HLW and TRU waste.
- The MRS/IS system shall be capable of containing radioactive material within the storage package during the entire storage period.
- The MRS/IS system shall have a monitoring system capable of detecting any releases of radioactive material.
- The MRS/IS system shall be capable of protecting the stored material against any likely natural or man-created events, excluding acts of war.
- The MRS/IS system shall be capable of passively removing the heat generated from decay of radioactive materials that have been discharged from a reactor at least 10 years.
- The MRS/IS system shall be capable of adequately protecting operating personnel and the public from the radiation emitted from stored materials.
- The MRS/IS system shall be capable of interfacing with all systems within the total waste management system, including the reprocessing and disposal systems.
- The MRS/IS system shall be capable of accounting for the quantity, type, and history of the material stored in the facility.
- Security, surveillance, and physical protection shall be provided for the facility, with additional safeguards provided to vital areas, in accordance with federal regulations.
- The MRS/IS facility shall be designed to preclude any criticality events.

- The MRS/IS facility shall be of modular design and capable of incrementally increasing or decreasing its processing rate and storage capacity to accommodate different circumstances.
- The MRS/IS facility shall be capable of handling existing rail and truck shipping casks.

3.3 STUDY BASES

The study bases serve as guidelines in the evaluation of the conceptual designs for an MRS/IS facility. The facility and operating cost bases, presented in Section 3.3.1, ensure that all costs are calculated in equivalent dollars and that present worth values are calculated using the same discount factors, so that the relative costs of the various concepts are directly comparable. Guidelines provided for transportation unit costs, reference shipping distances, and transport modes are discussed in Section 3.3.2. The reference and alternative fuel cycle waste scenarios, briefly described in Section 3.3.3, ensure that the analyses are all based on the same quantities and mixes of wastes to be handled.

3.3.1 MRS/IS Facility and Operating Cost Bases

It is assumed that an MRS/IS facility will be government-owned and financed. To establish a common cost basis and thus facilitate evaluation of the relative costs of each concept, all costs are based on mid-1982 dollars. It is assumed that the government's cost of money is 2 percent over inflation. Thus all costs are estimated without inflation or escalation beyond mid-1982, and a discount rate of 2 percent is used to obtain the present worth of future year expenditures.

All costs from the present through the final year of decommissioning are entered into a calendarized (yearly) cash flow table in mid-1982 dollars. The present worth of expenditures in each year is calculated using the discount factors provided. The annual costs are summed for all years to provide undiscounted program costs and the present worth costs at a 2 percent discount. The present worth costs (discounted) are used for comparing the options.

To ensure equitable and valid cost comparisons of the three concepts, the details of component costs, background, and cost bases are presented in support of the costs given in the cash flow table.

3.3.2 MRS/IS Transportation Guidelines

Truck and rail transportation systems are specified for spent fuel, solidified HLW, canistered RHTRU wastes, RHTRU wastes <5 R/hr, RHTRU wastes >5 R/hr and CHTRU wastes. All truck shipping systems are legal weight systems, i.e., 80,000 pounds maximum gross vehicle weight. There is no intent to endorse or reject any particular shipping system. Where possible, the systems selected are existing and licensed. Where no such system exists, those postulated for use are well along in the design stage and are expected to eventually meet the packaging regulations in 00 CFR 70. Reference canister sizes, compatible with the reference shipping casks, are specified for shipping HLW and TRU wastes.

Reference one-way shipping distances selected are 500 miles and 2500 miles. The 500-mile distance approximates a typical distance between eastern power reactors and the Barnwell Nuclear Fuel Plant (BNFP), a reprocessing plant. The 2500-mile distance approximates a typical distance between either an eastern power reactor or the BNFP and a repository located in the western United States. The stand-alone facility is assumed to be located 500 miles from reactors and the BNFP, and 2500 miles from the repository. Only the incremental shipping distances, beyond those that would be encountered without introduction of an MRS/IS facility, are used in calculating the transportation costs in this study.

It is assumed that 50 percent by volume of the spent fuel and of each of the waste types transported to and from the MRS/IS facility is shipped by truck and 50 percent by rail. Each transport mode has its own advantages and disadvantages, and the reference split reflects no bias toward either mode.

To establish a basis for cost comparisons among the various MRS/IS concepts, a common set of unit transportation costs is used. Mid-year 0982 dollars are used for calculating transportation unit costs. Transport costs are calculated based on the use of private industry carriers and shipping containers. Total transportation costs include round-trip shipping charges, special equipment/security costs, shipping container leasing fees and demurrage fees. Transportation unit costs for both truck and rail modes are calculated in dollars per shipment for each type of waste and its reference shipping system.

3.3.3 Fuel Cycle and Waste Scenarios

Three spent fuel and waste handling scenarios are developed as baselines for evaluation of the three MRS/IS facility concepts. Each of these, the reference scenario, the delayed reprocessing scenario, and the delayed disposal scenario are addressed in each evaluation.

The reference scenario defines the number of metric tons of spent fuel or metric tons equivalent of HLW (the quantity of HLW resulting from reprocessing a metric ton of spent fuel) to be considered in facility designs. To convert from MTHM to fuel assemblies or HLW canisters, divide the MTHM values by 0.18 MTHM/BWR, 0.42 MTHM/PWR, 2.143 MTHM/canister. Annual quantities are projected for up to 50 years covering:

- spent fuel discharged per year
- spent fuel storage inventories at-reactor, at MRS/IS facilities, shipped to disposal, and in inventory in repositories
- reprocessing rate
- HLW inventories at reprocessing plant(s), stored at MRS/IS facilities, shipped to disposal, and in inventory in repositories
- TRU waste generated by the reprocessing and fuel fabrication plant(s).

The other scenarios project the annual quantities expected if reprocessing is delayed or repository start-up is delayed. In the reference scenario, HLW canisters are stored until the repository is assumed to be opened in the year 1998. Additional reprocessing plants and repositories are placed in service at intervals as needed to meet the demand. In the delayed reprocessing scenario, the reprocessing plants are delayed in starting operations by 10 years, but the repositories open on schedule. In the delayed disposal scenario, the repositories are delayed 10 years, but the reprocessing plants open on schedule. Since the storage facilities are postulated to begin operation in 1990, all spent fuel in excess of existing storage capacity through 1990 is assumed to be stored either in metal casks at reactor sites or in government-owned emergency storage. Detailed discussions of these scenarios are given in Appendix B.

4.0 CONCLUSIONS

The studies on which this report is based were performed under a well-defined set of criteria and for sites characterized in relation to other facilities associated with the nuclear fuel cycle. Within those limits and based on the specific drywell and metal storage cask concepts used in the studies, the study team made the following conclusions:

- The use of drywells of the type studied herein for monitored retrievable storage of either high-level waste or spent fuel is less costly than the use of large metal storage casks of the type studied herein.
- Large metal storage casks would be more cost-competitive if they were licensed for shipping. The savings involve reduced capital and operating cost for receiving and transfer facilities. Licensing would also reduce the cost of transport in the overall fuel cycle. See next item.
- Transport of spent fuel and nuclear wastes represents a major cost in the fuel cycle. Most of the transport is required with or without an MRS/IS facility, and only the transportation cost increases (or increment) due to use of a storage facility are included in this report. For the reference scenario, neither the facility co-located with a repository nor the facility co-located with a reprocessing plant incurs any incremental transportation costs. The stand-alone MRS/IS facility has incremental transportation costs in all scenarios.
- Based on the concepts studied herein, no large differences in total cost exist between the facility co-located with a repository and the facility co-located with a reprocessing plant because each shares facilities and infra-structure with the co-located facility. The stand-alone facility is more expensive since it must provide its own support facilities with no opportunity for cost sharing.
- There are no technological breakthroughs needed to successfully deploy an MRS/IS system using either cask or drywell storage.

Technology development is needed to firmly establish design criteria and to provide information for license applications.

- The MRS/IS concepts, in the reference and delayed disposal scenarios, are principally waste (high-level and transuranic) storage facilities. Only in the delayed reprocessing scenario is the capability to store large quantities of spent fuel required.
- In the delayed reprocessing scenario, the facility co-located with a reprocessing plant is apparently the least costly. This occurs because one round trip between the storage facility and the reprocessing plant is required for any other location. Note: If the reprocessing plant were late, much of the spent fuel sent to the MRS/IS facility might go directly to disposal when the repository opened. The reprocessing plant could be supplied with all the spent fuel needed for full-time operation directly from reactor storage without drawing any from the MRS/IS facility.
- The handling and storage of TRU waste is a very significant part of the overall facility requirements. The volume of material is large, exceeding the volume of solidified high-level waste resulting from the same fuel.
- Development of the technology needed to support licensing (e.g., experiments and analysis of solidified HLW canisters stored in drywells) should proceed.
- Development of <u>standardized</u> waste packages and transportation containers should be undertaken. This includes solidified HLW canisters, TRU waste containers, and transportation containers for both.
- A more thorough understanding of the interfaces between an MRS/IS facility and the other waste management system components should be developed, including:
    1. common use of facilities
    2. usefulness of lag storage to reprocessing and/or repository
    3. canisters and container configurations.

5.0 SUMMARY OF SITE AND CONCEPT ALTERNATIVES

This report covers MRS/IS facilities that would be co-located with specific plants that provide another part of fuel cycle processing as well as one that would be a stand-alone or generic site. These sites are identified in Section 5.1. Generic aspects of the storage concepts that may be applicable to any one or all of the sites are noted in Section 5.2. The processing and storage concepts considered are identified and described in Sections 5.3, 5.4, and 5.5.

5.1 SITE ALTERNATIVES

The MRS/IS facility sites examined in this study are: 1) a facility co-located with a reprocessing plant, 2) a facility located separate from any other fuel cycle facility, and 3) a facility co-located with a geologic repository. These sites are identified and discussed in this section.

5.1.1 Site Location and Description for a Facility Co-located with Reprocessing Plant

The assumed location for the MRS/IS facility co-located with a reprocessing plant is at the Barnwell Nuclear Fuel Processing (BNFP) plant. The BNFP is located about 7 miles west of the City of Barnwell on a site of over 1700 acres of land, in a predominantly rural area in Barnwell County, South Carolina. The location of the BNFP Site is shown in Figure 5.1.

5.1.1.1 Site Description and Arrangement

The BNFP is located on the eastern edge of the Aiken Plateau portion of the Atlantic Coastal Plain physiographic province. The landform of the area is a gently sloping, gently rolling smooth plain.

The BNFP Site is largely forest land, with a small number of abandoned farm fields undergoing secondary succession, and several Carolina Bays. There are no natural streams on the BNFP Site.

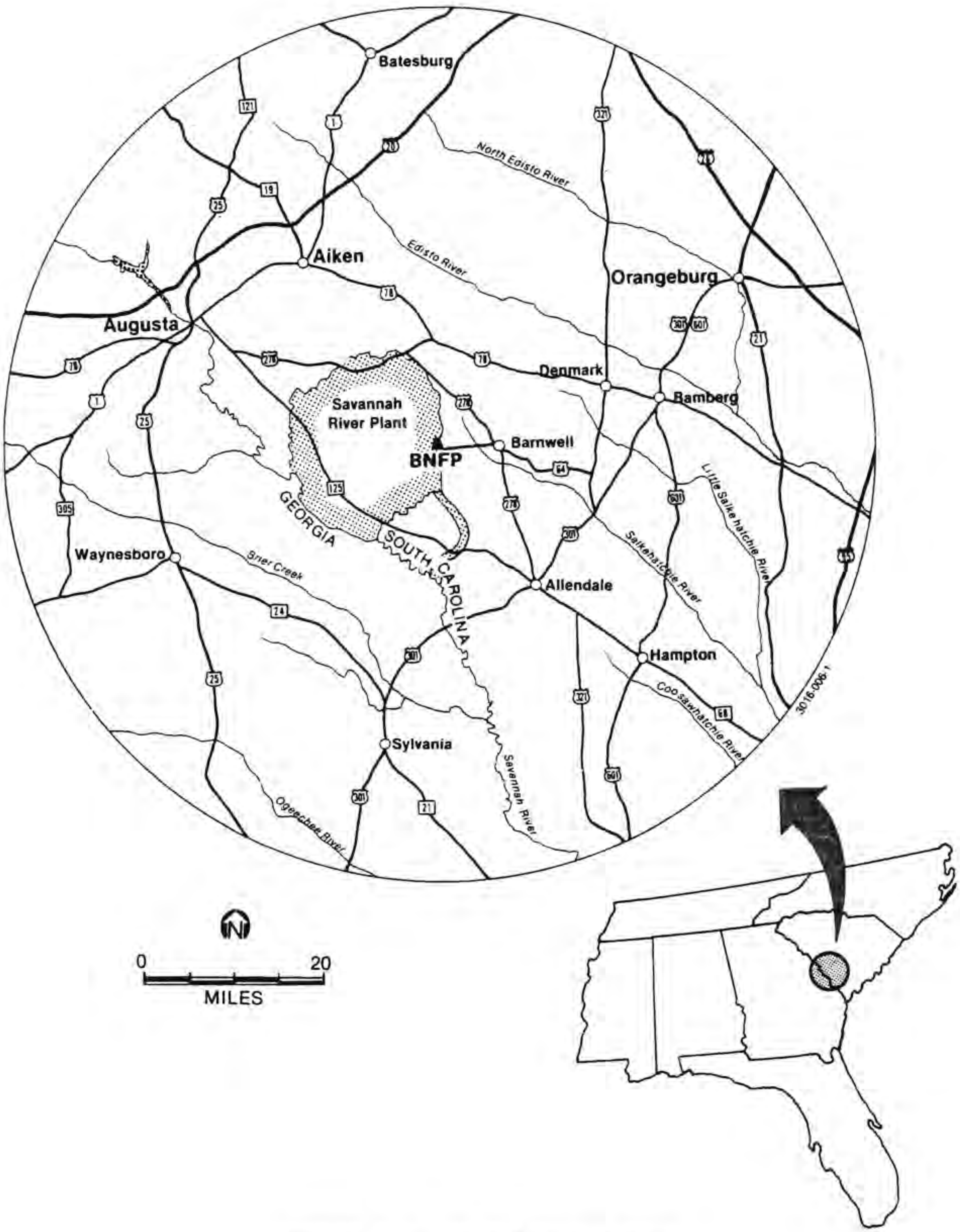


FIGURE 5.1. BNFP Site Location

The plant site is wholly-owned private property. A right-of-way for the principal access road to the site has been granted to the State of South Carolina. An easement for the power transmission lines that supply the BNFP has been granted to South Carolina Electric and Gas Company. The railroad spur serving the BNFP is a wholly-owned plant property within the site boundary.

5.1.1.2 Site Parameters

The conditions at the BNFP Site, including meteorology, hydrology, geology, and seismic information, are discussed in the following paragraphs. There are no hills or valleys in the vicinity of the BNFP Site that tend to channel airflow or create mechanical air turbulence. There are no bodies of water in the area large enough to create atmospheric diffusion problems associated with a water/land transition zone.

The BNFP Site is in the northeasterly portion of the watershed of Lower Three Runs Creek (LTRC), a tributary of the Savannah River. The site is in the interfluvial area between LTRC and the Salkehatchie River and lies completely within the LTRC drainage area. There are no surface streams on the site and, for all practical purposes, there are no surface runoff features. Except for unusually heavy precipitation, rainfall is held in local surface depressions, and is dissipated by evaporation, by transpiration and, in part, by infiltration into the groundwater table. In general, the BNFP Site is considerably higher than any reasonably expected flood stage of LTRC. The outfall structure through which Beacon Pond discharges into LTRC appears to be the only component of the plant area that may be subject to flooding. The ground-surface elevations of area features important to the BNFP are listed in Table 5.1.

TABLE 5.1. Elevations of Significant Local Features (feet, MSL)

Par Pond water surface	200
LTRC bed (just below Par Pond Dam)	140
Beacon Pond water surface	241
BNFP Facilities area ground surface	250

The surface runoff from the site is not materially affected by the BNFP facility or operations therein.

The BNFP Site is underlain by about 1000 ft of unconsolidated and occasionally cemented sediments of Quaternary, Tertiary, and Cretaceous ages. The base rock is mostly Triassic basalt and Precambrian schist.

The surface soils are generally dry and firm. These soils consist of loose-to-medium-density fine Quaternary sands extending from 2 to 7 ft below the ground surface. The average thickness is about 4 ft.

A seismic reflection survey was conducted at the site in 1968 to provide subsurface data that would complement information obtained during drilling and sampling operations for foundation investigations and for hydrologic programs. The seismic work consisted of seismic refraction surveys and seismic cross-hole surveys to determine compressional (P) and shear (S) wave velocities in the subsurface geologic strata for assessing elastic properties of subsurface soils, which bear on the evaluation of dynamic response characteristics of foundations and structures during seismic excitations.

There are historic records for more than 400 earthquakes with epicenters at Summerville (near Charleston), which was the epicenter of the Charleston earthquake of 1886. This earthquake and its aftershocks have dominated the seismic record of the southeast. The Charleston area is located about 80 miles east of the BNFP Site and has been described as having the highest concentration of epicenters and as having experienced the largest single earthquake in the southeastern United States.

There are no known capable faults within a 100-mile radius of the BNFP. In the Valley and Ridge and in the Blue Ridge-Piedmont provinces, there is no known correlation between earthquakes and tectonic structures. Earthquakes in the Charleston seismic zone are considered to be associated with a tectonic structure buried under more than 3000 ft of sediments of the Coastal Plain physiographic province.

In summary, extensive field investigations, laboratory tests, and engineering analyses have shown conclusively that the seismic design criteria used for BNFP facilities accord with all accepted safety standards.

5.1.2 Siting of Stand-Alone MRS/IS Facility

This section describes the natural features desired for an MRS/IS site and delineates locations having these features.

The stand-alone MRS/IS facility could be located in most states of the U.S. because it does not use the geologic features of the site as one of the radionuclide containment boundaries. In reality, however, the characteristics of a particular site will have an impact on the design of the MRS/IS facility. In addition, the licensing of a particular site for storage of radioactive material may be more or less difficult, depending upon the seismic or meteorological conditions of the site.

5.1.2.1 Site Location and Arrangement

A study to identify suitable locations for MRS/IS facilities was conducted by Woodward and Clyde (1981). A set of judgment standards and screening specifications was applied to data on the 48 contiguous states. The screening process was divided into two phases, national and regional. The first phase applied specifications that were uniform for the entire U.S., and the second phase applied specifications on a regional or state-by-state basis. The screening process, which was intended to be conservative and to focus attention on areas containing many suitable sites, did not consider engineering measures that would alleviate minor problems nor take into account additional information that would indicate a site's suitability for a surface MRS/IS facility.

The national screening for surface drywell facilities identified large potential areas in 40 states; the regional screening reduced this to 36. The results of the national screening, shown in Figures 5.2 and 5.3, indicate that there are many potential sites for a surface MRS/IS facility in both the eastern and western U.S. Although Figure 5.3 does not include the Hanford Site or the Nevada Test Site, these areas are also considered suitable sites. They are excluded from the study described because they were already considered suitable and are discussed under separate reports. Also not included on Figure 5.2 is the BNFP Site, excluded by Woodward and Clyde because of water table limitations. However, drywell designs for the BNFP Site are of the berm type, which makes that site suitable.

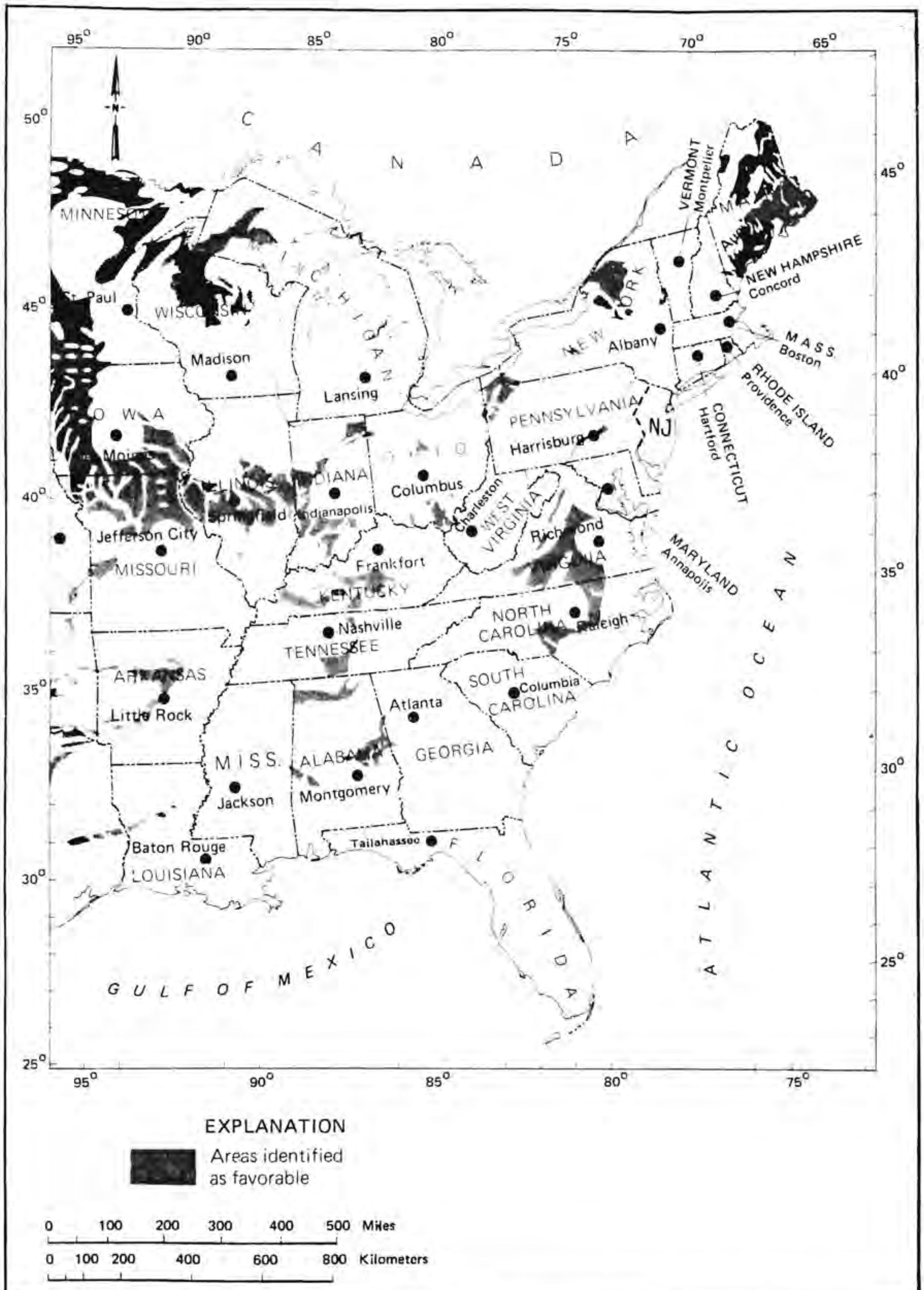


FIGURE 5.2. National Screening Results for a Stand-Alone MRS/IS Facility in the Eastern U.S.

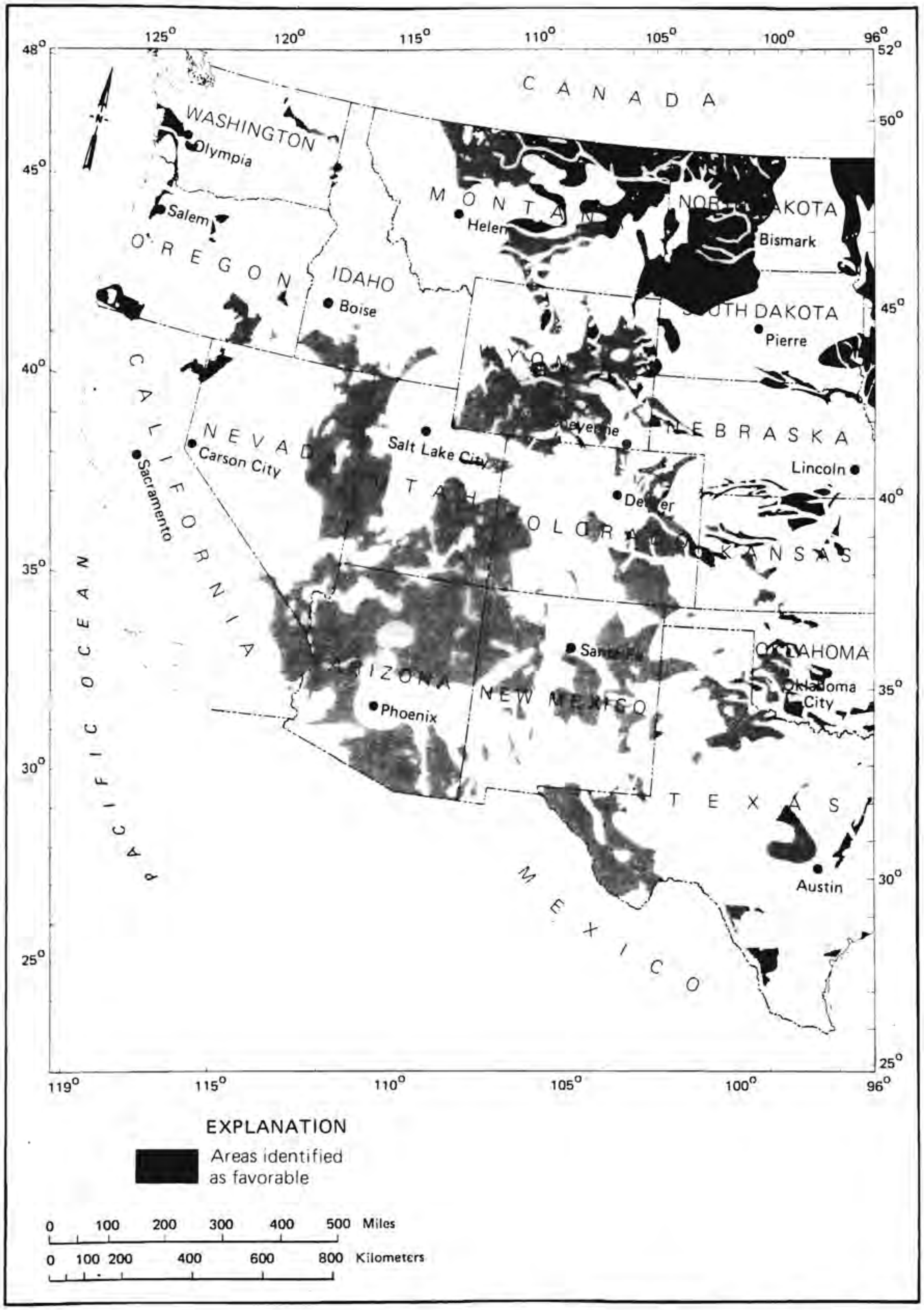


FIGURE 5.3. National Screening Results for a Stand-Alone MRS/IS Facility in the Western U.S.

Thus, as indicated in Figures 5.2 and 5.3, there are numerous locations in the continental U.S. that would be adequate for the site of an MRS/IS facility from the aspect of natural features. No specific area is assumed as the hypothetical site for the stand-alone MRS/IS facility in this study. However, the receiving, handling, storage, and service facilities as identified or described in Sections 5.3, 5.4, and 5.5 are generic in nature and compatible with any site that may be selected within the continental U.S.

5.1.2.2 Site Parameters

The desirable natural features of a surface MRS/IS facility are given below. Although some of the MRS/IS concepts examined in this study use drywells or other below-grade storage, the depths are no greater than 14 ft. Therefore, consideration of a surface facility is appropriate.

The major considerations affecting the construction and operation of a surface MRS/IS facility, as well as the containment and retrieval of the spent fuel or waste, are: 1) surface and groundwater system characteristics; 2) karst topography; 3) tectonics; 4) meteorology; 5) the possibility of human intrusion; and 6) the impact of handling and storage operations on population centers and the environment.

The natural features for the site are as follows:

1. Good drainage and a low water table. The site should be away from rivers, lakes, playas, or floodplains. Excessive moisture could accelerate degradation of the container and provide a pathway for release if the containment failed. The groundwater level should be below the base of the drywells to provide a buffer zone.

2. Satisfactory karst conditions such that no ground or rock dissolves or subsides. This will prevent ground collapse, which could open paths for groundwater flow.

3. Good thermal conductivity of the rock or soil. This is important for drywell design.

4. Adequate surface area. To minimize grading and excavation costs during construction, the site should be relatively flat or gently sloping.

5. Suitable tectonics. The site should not be located where there is any significant probability of fault rupture, ground motion, or volcanic activity that could degrade the performance of the system below acceptable levels.

6. Low probability of inadvertent human intrusion. The site should be located away from exploitable natural resources (e.g., oil, gas, coal, geothermal resources, mineral deposits) or any natural attractions.

7. Avoidance of existing hazardous operations. The site should be located away from major industrial and transportation installations.

8. Low density of nearby population centers. The facility should be located to minimize potential risk to and conflict with nearby population centers.

9. Adequate environmental protection. Numerous federal and state laws require that site location not adversely affect the environment. The site should be outside national parks, wildlife refuges, and wilderness preserves.

10. Satisfactory meteorological conditions. Areas of high tornado or windstorm activity, for example, should be avoided.

11. Easy access to rail lines and interstate highways. This will reduce the additional costs of constructing extensive rail lines or highways.

5.1.3 Site Location and Description for a Facility Co-Located with Repository

Likely locations for an MRS/IS facility co-located with a repository in the western U.S. all have rather similar characteristics. For purposes of this analysis, a location within the boundaries of the Hanford Site in the semi-arid southeastern portion of Washington State is assumed. The general geographic location of the site is illustrated in Figure 5.4.

5.1.3.1 Site Location and Arrangement

A hypothetical site for the MRS/IS facility is postulated to be located west of the 200 West Area within the Hanford Site above the Cold Creek Syncline. The facility site arrangement is compatible with the constraints of the hypothetical site and should also satisfy the requirement of the follow-on

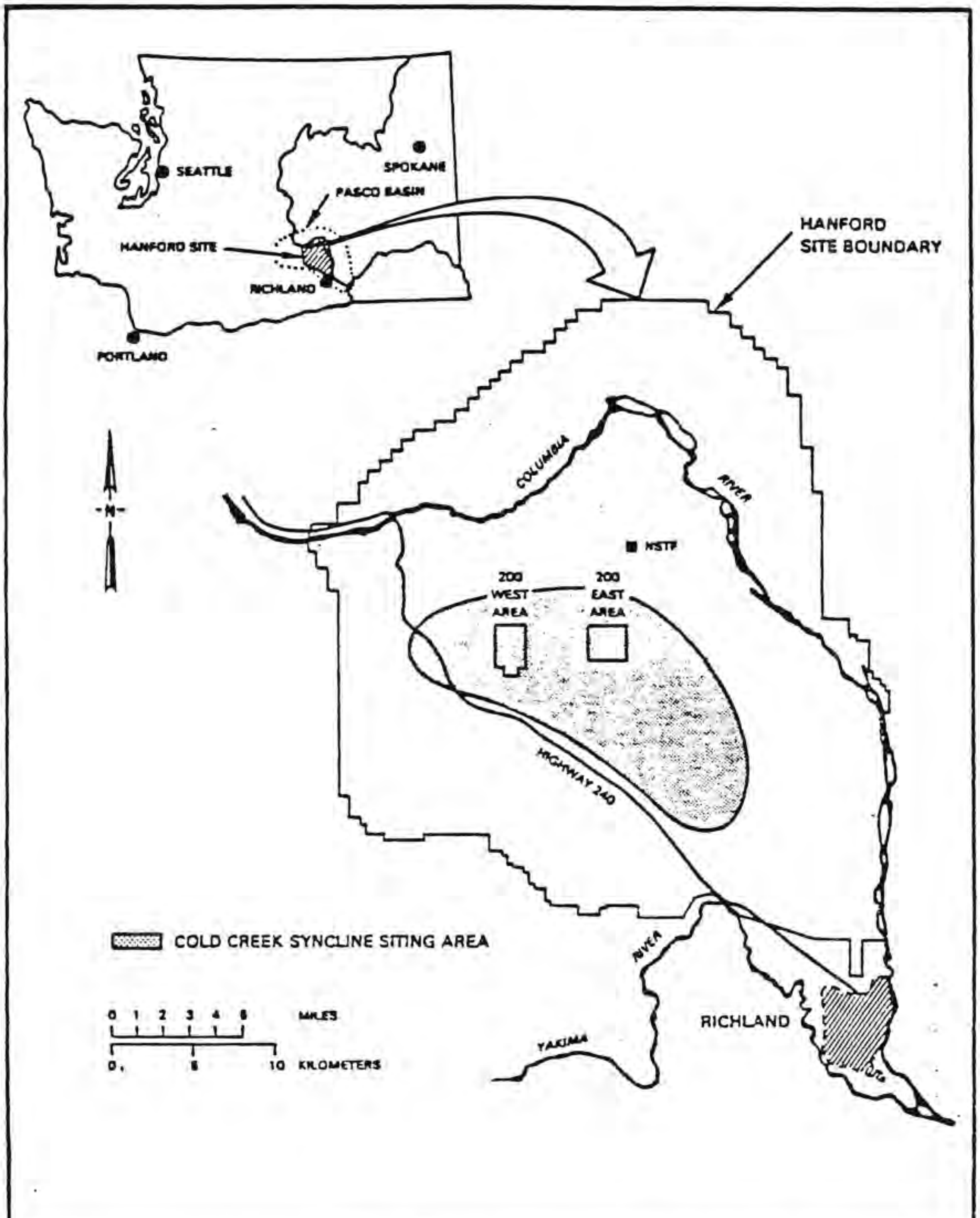


FIGURE 5.4. Location Map - Hanford Site

repository and its operation. Approximately 250 acres will be required for the initial facility. To cover the interim storage requirements for the various scenarios, up to 400 acres may be required. The 400 acres are part of the total approximately 550 acres projected to be required at the surface to supply and support an underground respository of up to 2000 acres.

The initial area will be developed by the required site preparation, roads, fences, walkways, and rail systems with due consideration and provisions for the additional areas and facilities that may be required later.

5.1.3.2 Site Parameters

Conditions of this hypothetical site are assumed to be similar to typical conditions found at Hanford. These assumed conditions are discussed in this subsection.

The Hanford climate is generally mild and dry, with occasional periods of high winds and with hot summers and mild winters. Average annual precipitation is 6.25 inches (15.9 cm). Average monthly wind speeds range from 5 mph (2.3 m/s) to 9 mph (4.1 m/s) with the prevailing wind direction from the northwest, although the strongest winds are from the southwest.

The number of thunderstorm days at Hanford gives an estimated annual lightning-strike frequency of 0.022 for a building 30 feet (9 m) high. This frequency corresponds to about one strike per 45 years.

Tornadoes are infrequent in the region; they tend to be small and cause little damage when they do occur. Data have been analyzed to determine the probability of a tornado hitting a particular Hanford facility. During any year, it is estimated that the probability is six chances in a million or less than once in 100,000 years.

The Hanford Site lies on the low-lying, partly dissected and modified alluvial plain of the Columbia River within the central part of the Pasco Basin. The MRS/IS facility site is underlain by 1000 feet (300 m) of sands, silts, and clays laying on a basalt lava accumulation estimated to be 10,000 feet (3000 m) thick. The soil type which makes up the site consists of Rupert Sand, which is mostly composed of granitic, quartzitic, and basaltic sand.

The Hanford Site is described as a "shrub-steppe" zone characterized by low precipitation and wide daily and annual temperature ranges. The vegetation consists primarily of eight major kinds of shrub-steppe communities.

The MRS/IS facility site is to be incorporated into an environment already slightly altered from its original state due to 1) livestock grazing and 2) the activities associated with Hanford projects since the early 1940s. Land within a 50-mile (80 km) radius is used primarily for grazing, growing wheat, and irrigated farm crops. The nearest military facility is the U.S. Army Yakima Firing Range located ~30 miles (48 km) to the northwest. There are no recreational facilities within a 5-mile radius of the proposed site. The closest public highways are State Highways 12, 240 and 24.

The Hanford Site lies in a region characterized by few earthquakes of damaging intensity, with no clear-cut relationships of epicenters to specific surface faulting or specific geologic structures. To date, no intensities greater than four on the Modified Mercalli Scale (MM-IV) with a gravitational ground acceleration of 0.01 g have occurred in the immediate Hanford Site area, although intensities as high as MM-V or MM-VI have been observed in surrounding areas.

The hydrology of the Hanford Site consists of both surface and subsurface flow systems. The Columbia and Yakima Rivers form the principal surface water drainage of the area. The groundwater flow systems consist of unconfined and numerous confined aquifers. Hydrologic knowledge of aquifer properties is quite extensive for the unconfined system. An extensive field testing program is under way to acquire a solid understanding of all confined aquifers that may be important in designing and siting an underground repository.

The proposed facility site is not located in a floodplain as defined by 10 CFR 122. The estimated 100-year maximum Columbia River flood of 444,000 cfs would result in a river elevation of 356 ±2 feet mean sea level (MSL), based on U.S. Corps of Engineers projections. The probable maximum flood (PMF) would result in a Columbia River elevation of 382 ±4 feet with an occurrence rate of once every several thousand years. The hypothetical site for the MRS/IS facility is at an elevation of ~600 feet MSL; therefore, it is concluded that the site would not be subject to inundation by any flood having a volume equal to or less than the PMF.

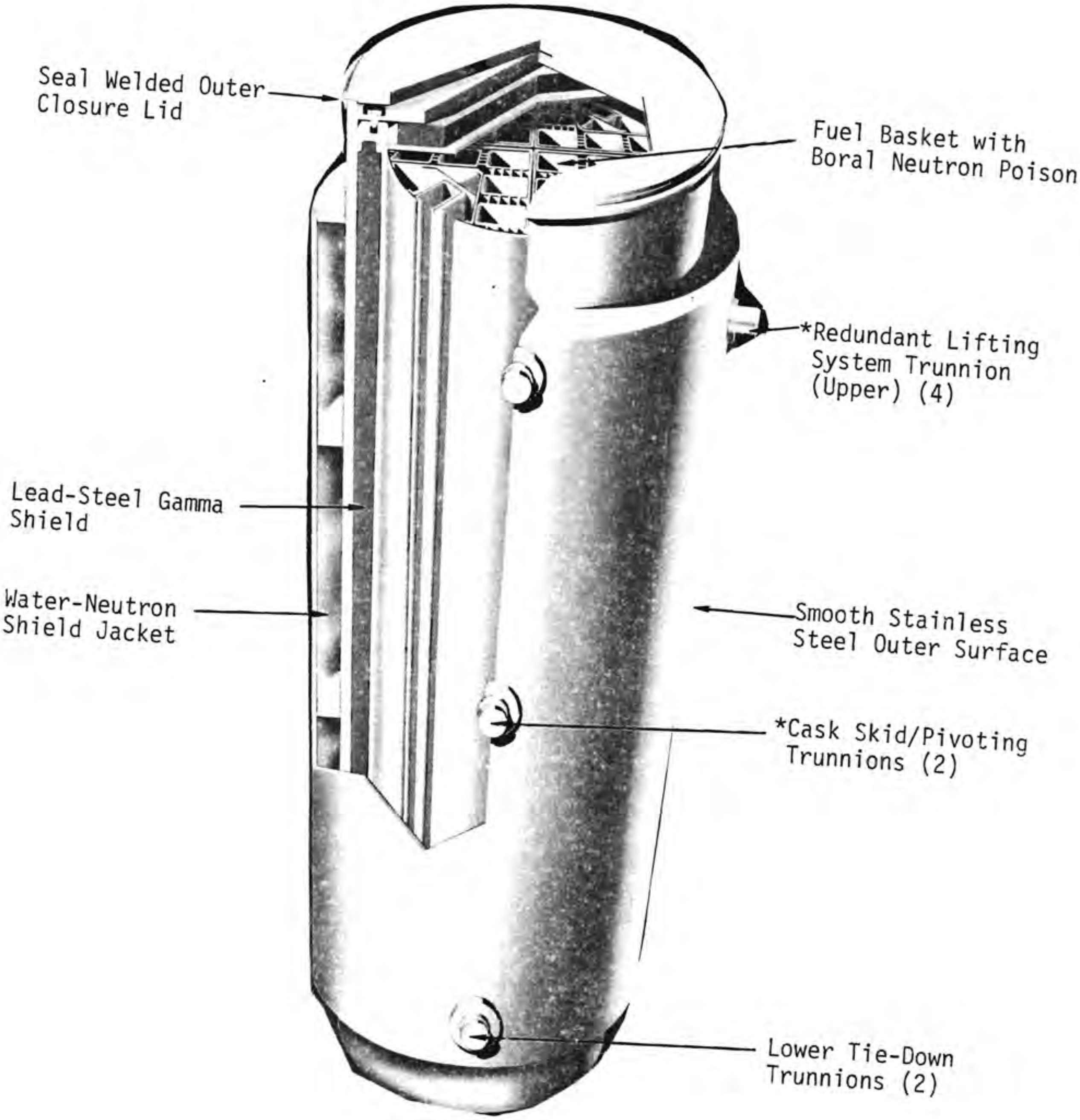
5.2 GENERIC STORAGE CASK AND DRYWELL DESIGNS

All siting concepts utilize the same large metal dry storage cask design, and two of the three siting concepts utilize the same drywell design. These generic designs are described in this section.

5.2.1 Reference Metal Cask

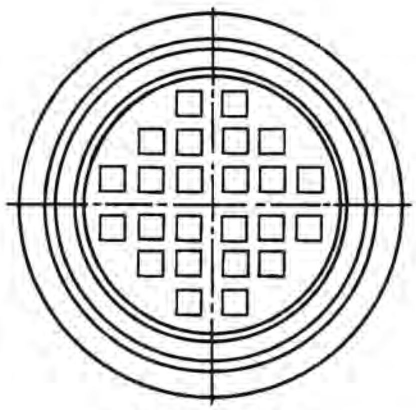
All MRS/IS concepts in this study utilize the same metal cask design, the REA 2023 cask, being designed by Ridihalgh-Eggers Associates (REA) of Columbus, Ohio, and fabricated by Brooks and Perkins (Livonia, Michigan) for the DOE. The PWR fuel version has a cavity 66 in. in diameter by 167 in. in length and would be suitable for consolidated fuel, or with a special basket, for solidified HLW storage. The design of the cask body closely follows the proven construction concepts of the NL 10/24 cask, which was domestically licensed in 1976 for shipment of spent fuel. The construction is a stainless steel composite with a poured lead gamma shield and a water jacket (for neutron shielding). The primary containment meets the requirements of the ASME Boiler and Pressure Code. The shield wall thickness and thermal capability are based on fuel aged at least 5+ years. The neutron poison in the basket is Boral (a borated aluminum composite), which has been used extensively for high-density spent fuel racks. Boral (a Brooks and Perkins product) has been extensively evaluated for corrosion, irradiation stability, heat transfer, and nuclear criticality prevention over a 20-year period and has been approved by the NRC for a number of applications.

The cask design is illustrated in Figures 5.5 and 5.6. The cask capacity for spent fuel storage is listed in Table 5.2. As noted previously, the cask has a smooth-walled stainless steel exterior and is passively cooled. The design is based on nominal nuclear and thermal characteristics given in Table 5.3. Aging fuel beyond 5 years (particularly for high-burnup fuel) could be required to reduce the decay heat output and to lower the neutron and gamma source strength.

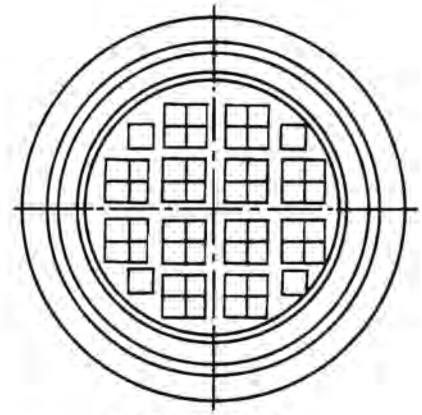


*Trunnions are removable.

FIGURE 5.5. REA 2023 Storage Cask

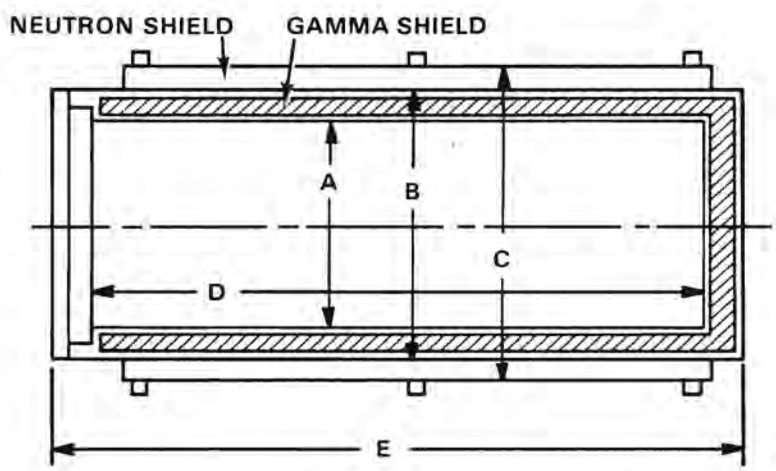


PWR BASKET



BWR BASKET

STORAGE QUANTITY				
FUEL TYPE	INTACT		CONSOLIDATED	
	QTY.	MTU's	QTY.	MTU's
BWR ELEMENTS	52	10	104	20
PWR ELEMENTS	24	11.5	48	23



FUEL TYPE	A IN	B IN	C IN	D IN	E IN	WT T	NEUTRON SHIELD	GAMMA* SHIELD
PWR	66	80.5	93	166.7	182	97	6 in.	4.5 in.
BWR	61	75	87.5	177.3	192.6	95	6 in.	4.3 in.

* LEAD ONLY

FIGURE 5.6. REA Cask Dimensional Data

TABLE 5.2. REA 2023 Storage Capacity

	Units	MTU or Equivalent	Maximum Thermal Load, kW	Total Material Weight, lb
BWR Fuel				
(a) Intact - uncanned	52	9.4	21 (5 yr)	32,500
(b) Intact - canned	52	9.4	21 (5 yr)	44,200
(c) Consolidated	104	18.8	21 (8.5 yr)	81,000
PWR Fuel				
(a) Intact - uncanned	24	10.1	24 (5 yr)	34,800
(b) Intact - canned	24	10.1	24 (5 yr)	48,000
(c) Consolidated	48	20.2	24 (10.5 yr)	84,000
HLW canister	14	30.0	33 (10.5 yr)	32,400

TABLE 5.3. Nominal Nuclear and Thermal Characteristics of Spent Fuel Storage in the Reference Metal Cask

	BWR	PWR
Fuel Data		
Enrichment	3.5% ^{235}U	3.5% ^{235}U
Age-out-of-reactor	5 yr	5 yr
Maximum width, intact-in.	5.75	8.75
Maximum length, intact-in.	176	165.5
Shielding Data		
Gamma source, photons/sec-cask	9.0×10^{16}	9.5×10^{16}
Neutron source, neutrons/sec-cask	3.9×10^{9}	3.3×10^{9}
Surface dose rate, mrem/hr	20	20
Thermal Data		
Decay heat, kW/assy	0.4	1.0
Maximum fuel clad temperature	250°C	250°C

Separate designs for PWR and BWR fuel are offered primarily to accommodate the additional length of BWR fuel assemblies. The inner cavity coolant is air, initially at ambient temperature and pressure. Two bolted closure heads are employed. The outer closure provides for seal-welding the flange before storage, thus ensuring a leak-tight container. Literature on the REA cask indicates that continuous monitoring of the primary containment (inner cavity) and secondary containment (space between the closure heads) is possible.

The cask body is designed to accommodate a variety of handling alternatives. It has a total of eight trunnions--all removable--with the following functions:

- Upper (lifting) trunnions (4) - To accommodate redundant lifting system and mate with tiedown system.
- Mid-body (pivoting) trunnions (2) - Pivoting operation minimizes required handling space and permits horizontal lift of cask skid.
- Lower (tiedown) trunnions (2) - Mates with rear tiedown on the skid.

A key design feature is the incorporation of the handling/storage skid with the tiedowns. This permits a direct movement between a storage pad and a rail car. The only additional equipment required for shipping is the upper and lower impact limiters and the rail car.

5.2.2 Reference Drywell

The same drywell reference design is used in the stand-alone MRS/IS facility and in the facility co-located with the repository. This design is described herein. The drywell used in the facility co-located with a reprocessing plant, is of a different design and is described in Section 5.3.3.2.

A typical drywell loaded with a spent fuel assembly or HLW canister is shown in Figure 5.7.

Each drywell consists of a cylindrical carbon steel encasement vessel buried vertically in the ground. The encasement may be surrounded by concrete

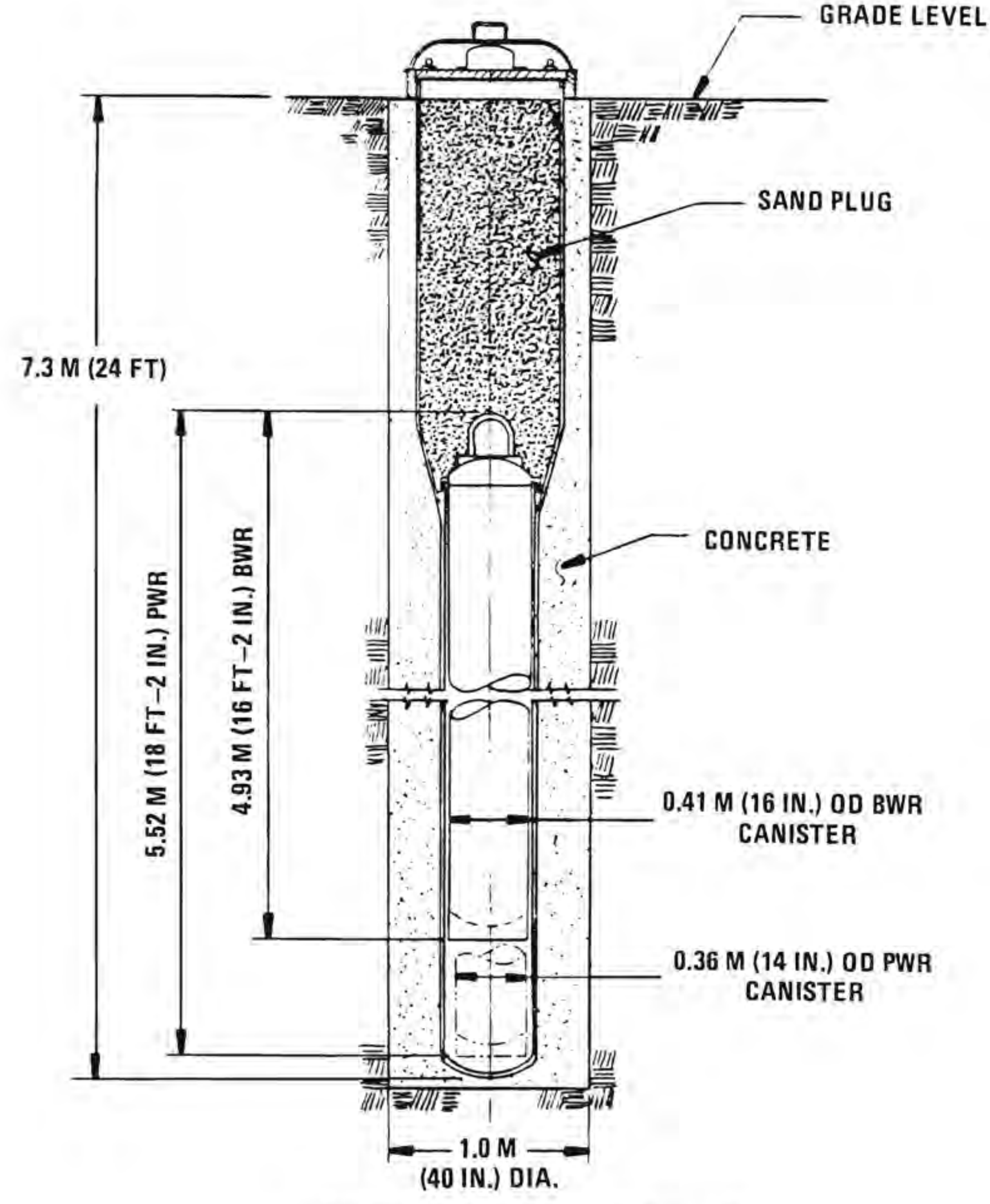


FIGURE 5.7. Typical Drywell

or sand, depending on the thermal criteria to be established on heat output and temperature limits. The encasement vessel is designed, fabricated, and tested in accordance with the current ASME Boiler and Pressure Vessel Code, Section VIII, Division 2. The encasement vessels are shop-fabricated of standard pipe sections. The closure plate on top of the encasement vessel is field-welded to the encasement to complete the containment after a waste package canister and radiation shield plug are placed.

The canister is suspended in the drywell by a dish-shaped steel support ring welded to the pipe reducer section of the encasement. A similar dish-shaped ring is welded to the upper portion of the package canister during fabrication of the canister. As received HLW canisters do not include this ring; therefore, the ring is welded on the canister while in the receiving and packaging facility. In addition to supporting the package, the dish-shaped rings seal the sand shield plug in the upper compartment of the encasement vessel. The ring configuration also centers the package in the drywell during placement.

A loose sand fill placed in the compartment space above the canister in each drywell encasement creates a radiation shield plug. A stainless steel tube through the sand shield plug permits the drywell interior to be sampled for airborne activity.

Each drywell encasement vessel has a steel cover plate that is field-welded to the top of the drywell after a canister and the shield sand are placed. The closure plate has lifting lugs and a sample valve assembly. The sample valve is protected by a detachable weather cover. A nameplate atop the closure plate identifies the steel canister. A reusable metal cover protects empty drywells from the weather prior to canister placement.

A stainless steel thermowell attached to the exterior of the drywell encasement protects a thermocouple used to periodically measure the exterior surface temperature of the drywell encasement, to detect any abnormal thermal conditions.

5.3 MRS/IS FACILITY CO-LOCATED WITH A REPROCESSING PLANT

One option being studied is to construct the MRS facility adjacent to a reprocessing plant. This approach differs from other options in that the delayed repository case results in multiple MRSs--one at each reprocessing plant. The system described relies on the existing capabilities of the associated reprocessing plant(s) for shipping and receiving waste or spent fuel. A modular approach to constructing the storage areas allows the facilities to be built in annual increments. Contact-handled TRU (CHTRU) is stored in standard cargo containers, while remote-handled TRU (RHTRU) is stored in drywells constructed in engineered berms. Spent fuel or solidified high-level waste (HLW) is stored either in the same type drywell or in metal storage casks arranged in a parking-lot configuration.[a] These storage concepts are discussed in the following sections.

5.3.1 Receiving and Handling Facility

For the reference and delayed disposal scenarios where the wastes from reprocessing are stored in the MRS/IS facility, shipment comprises an onsite waste transfer. For the delayed reprocessing scenario where spent fuel is stored in the MRS/IS facility, the reprocessing plant's existing cask handling facilities are utilized to receive fuel for transfer to either storage casks or drywells. Thus, in either case no special receiving or handling facility is required.

5.3.2 Contact-Handled TRU Storage

The criteria for selecting a storage system for contact-handled transuranic wastes (CHTRU) include modular construction, protection from design-basis natural disasters, maintenance of double confinement for plutonium-bearing materials, low cost, and ease of decommissioning.

The concept used in this analysis is illustrated in Figures 5.8 and 5.9.

(a) The drywell and cargo container concepts presented are identical, except for dimensions, to detailed designs (Title II) which exist for the BNFP solid waste storage area (SWA). The SWA has already been the subject of NRC licensing action, and additional design details are available.

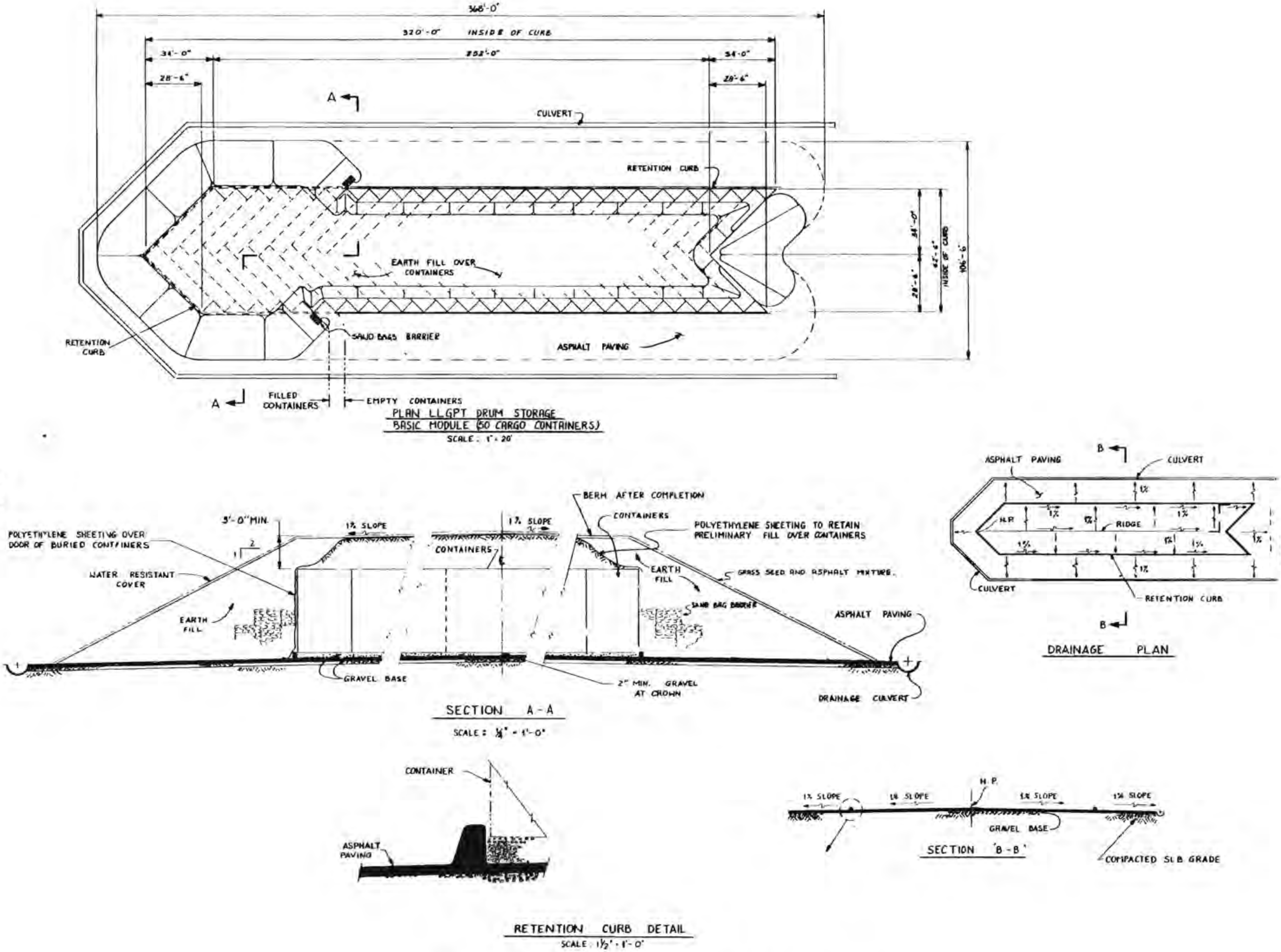


FIGURE 5.8. Bermed Storage of CHTRU Drums

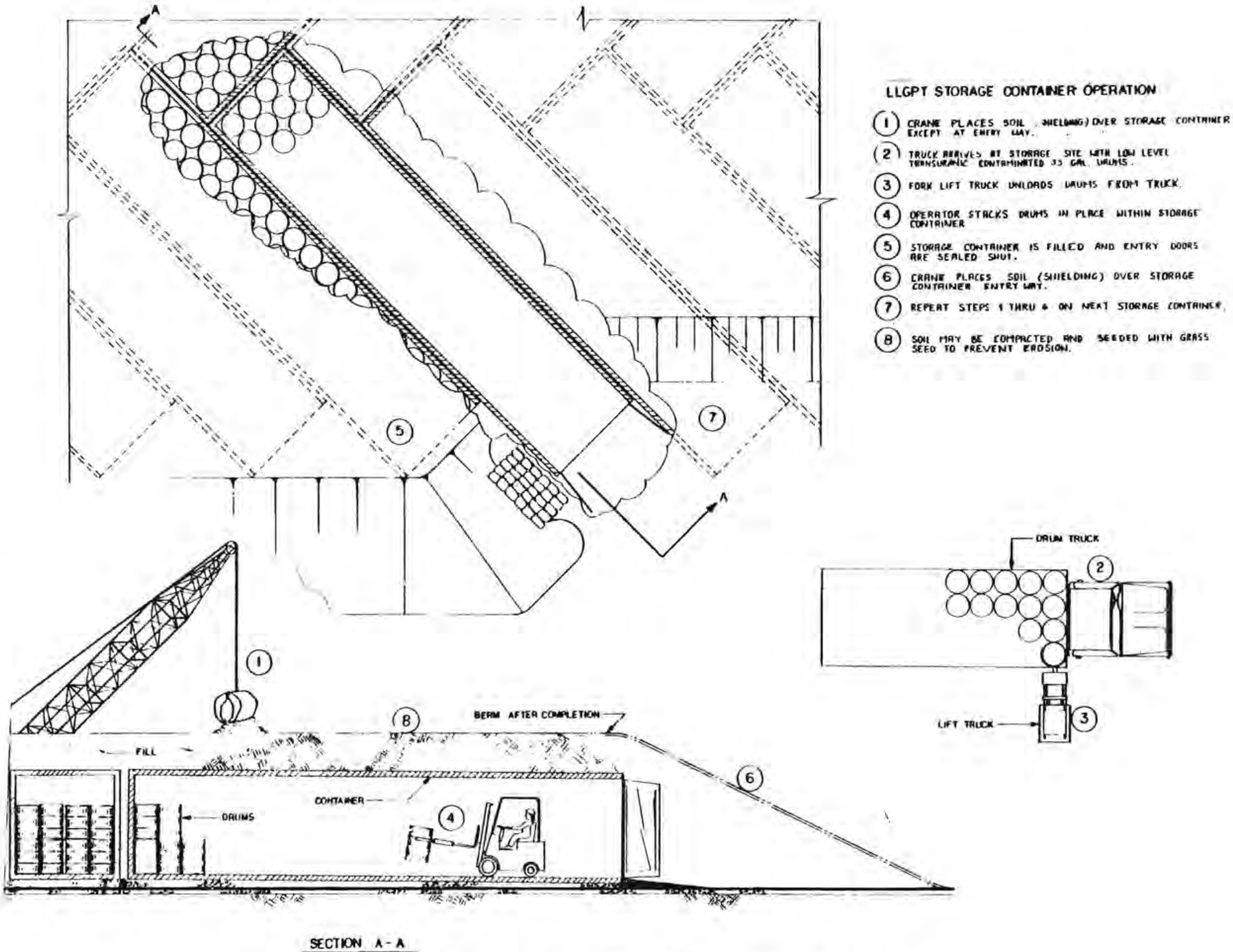


FIGURE 5.9. CHTRU Storage Container Operation

Standard cargo containers are utilized, being readily available, sealable, and able to support an earthen cover for tornado protection. A herringbone pattern is used to allow placement of earthen cover over a full container without interfering with loading operations in an adjacent unit.

Expansion of storage capacity is accomplished by adding modules on roughly an annual basis.

5.3.3 Remote-Handled Waste Storage

Spent fuel and solidified HLW are stored in either storage casks or drywells. Remote-handled TRU waste is stored in drywells installed in an engineered berm having properties specifically designed for this application.

Each of these storage concepts is discussed in subsequent paragraphs.

5.3.3.1 Metal Casks

The casks and related equipment being considered for use in the MRS/IS system are discussed in this subsection. The REA 2023 cask is used as the basis for this study while the GNS-Castor cask is also described in detail as a possible backup.

The casks most nearly ready for either storage or dual-purpose use in the U.S. are the REA 2023 and the GNS Castor casks. Both of these casks are in active design/construction phases. Full-scale testing of both casks is planned for late 1982-1983 at the BNFP for uncontaminated-checkout purposes, and at the TVA-Browns Ferry Plant for "warm" checkout.

Cask Description. The REA 2023 cask is described as the design basis cask for this study in Section 5.2.7. A brief description of an alternative cask is provided since both are being evaluated for possible application.

The Gesellschaft für Nuklear Service (GNS) cask is based on shipping casks currently being used in Europe. The 1C model is a nominal 80-ton cask with a 28-in. square cavity cross-section (see Figure 5.10). The 1C design is representative of the entire series from a construction/handling viewpoint.

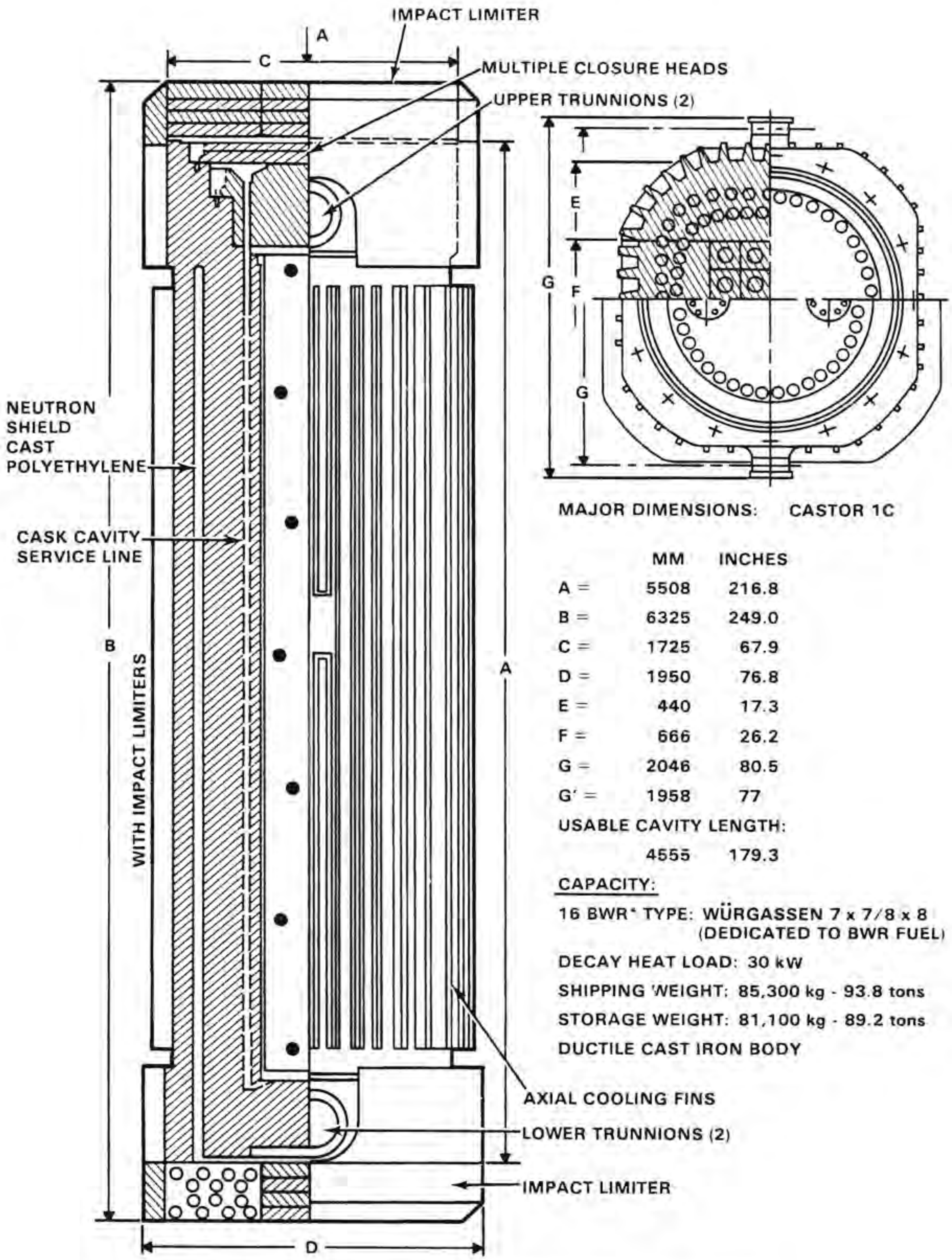


FIGURE 5.10. GNS 1C Storage/Shipping Cask

The GNS-Castor cask body construction is unique and represents a potential breakthrough in cost (and possibly fabrication time). The body is a massive iron casting (not a fabricated steel or steel-lead structure). Tests performed in Europe have demonstrated the strength of this cask under simulated drop- and fire-accident conditions. The lack of U.S. experience with this type of construction could have a major impact on licensing. The cast-iron body has integral fins on the cask exterior for heat rejection. The cask outer surface is epoxy, painted over the cast iron. To date, European experience with decontamination after pool immersion has been good. Neutron shielding is provided by a double row of long cylindrical, borated polyethylene channels cast into the body of the cask.

The GNS-Castor cask uses as many as four bolted closure heads for storage purposes (with 11 gasketed/sealed surfaces). The space between each of the closure heads can be monitored for leakage. The internal cavity is filled with helium at 0.6 atmospheres (absolute) pressure. The space between the closure heads is filled with pressurized nitrogen. For storage purposes, air may be used in the internal cavity (particularly if fuel temperatures less than 250°C can be ensured). The cask is designed for transporting one-year-old fuel. Further design of the castor-cask series for storage would probably focus on fuel cooled for 5 or more years, thus allowing an increase in storage capacity per cask.

The basic cask storage modules are shown in Figure 5.11 for spent fuel storage, and in Figure 5.12 for storage of canisters of solidified high-level waste. Multiples of these basic modules, as required for the three fuel cycle scenarios, are shown in Figures 5.13, 5.14 and 5.15.

The handling methods for unloading fuel from truck/rail casks and reloading the fuel into REA casks for on-site storage are depicted in Figure 5.16. The unloading/loading operations are performed underwater in the Cask Unloading Pools (CUP) located in the Fuel Receiving and Storage Station (FRSS). No additional equipment is required for this operation beyond the existing FRSS systems and equipment.

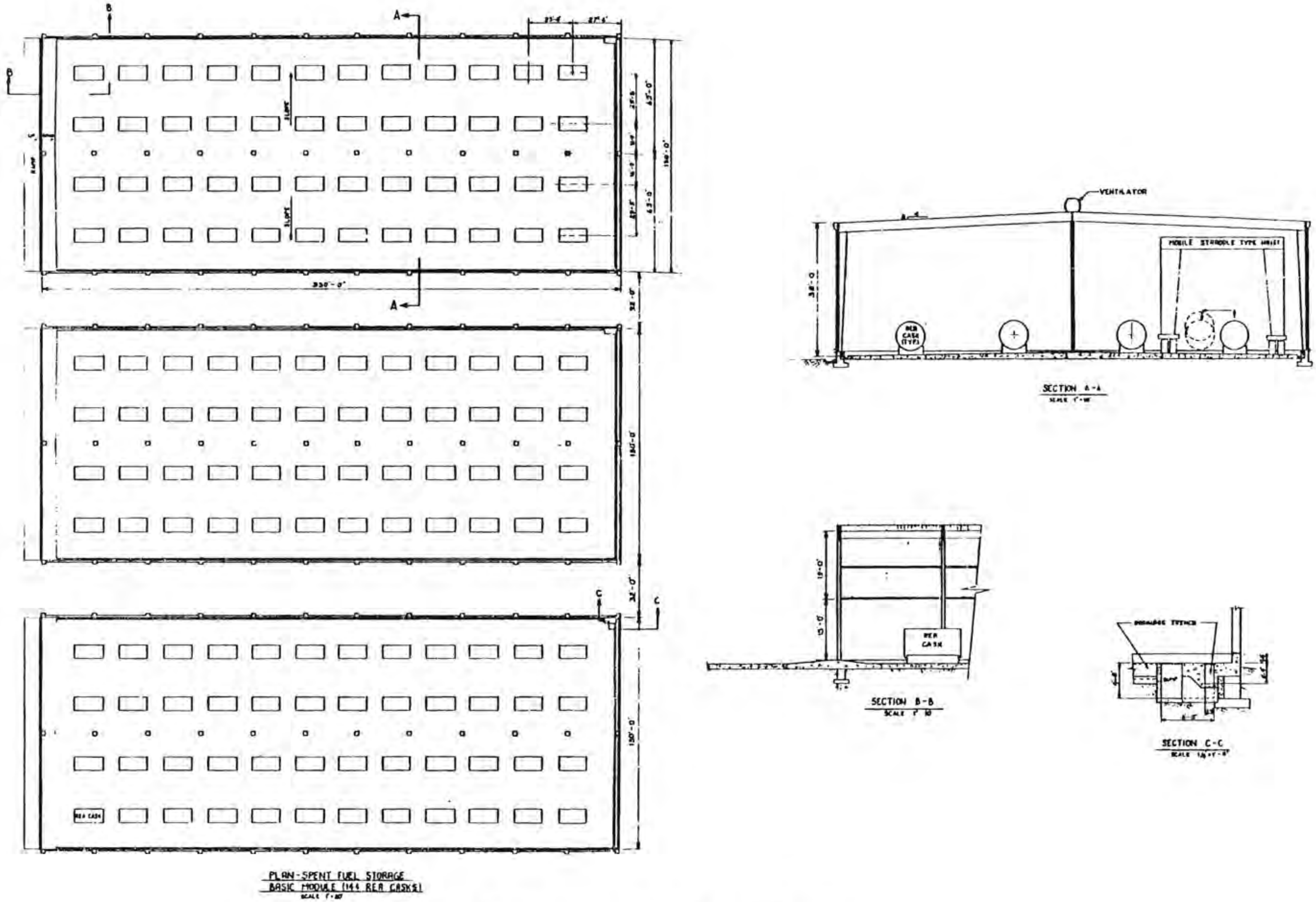


FIGURE 5.11. Spent Fuel Storage Module

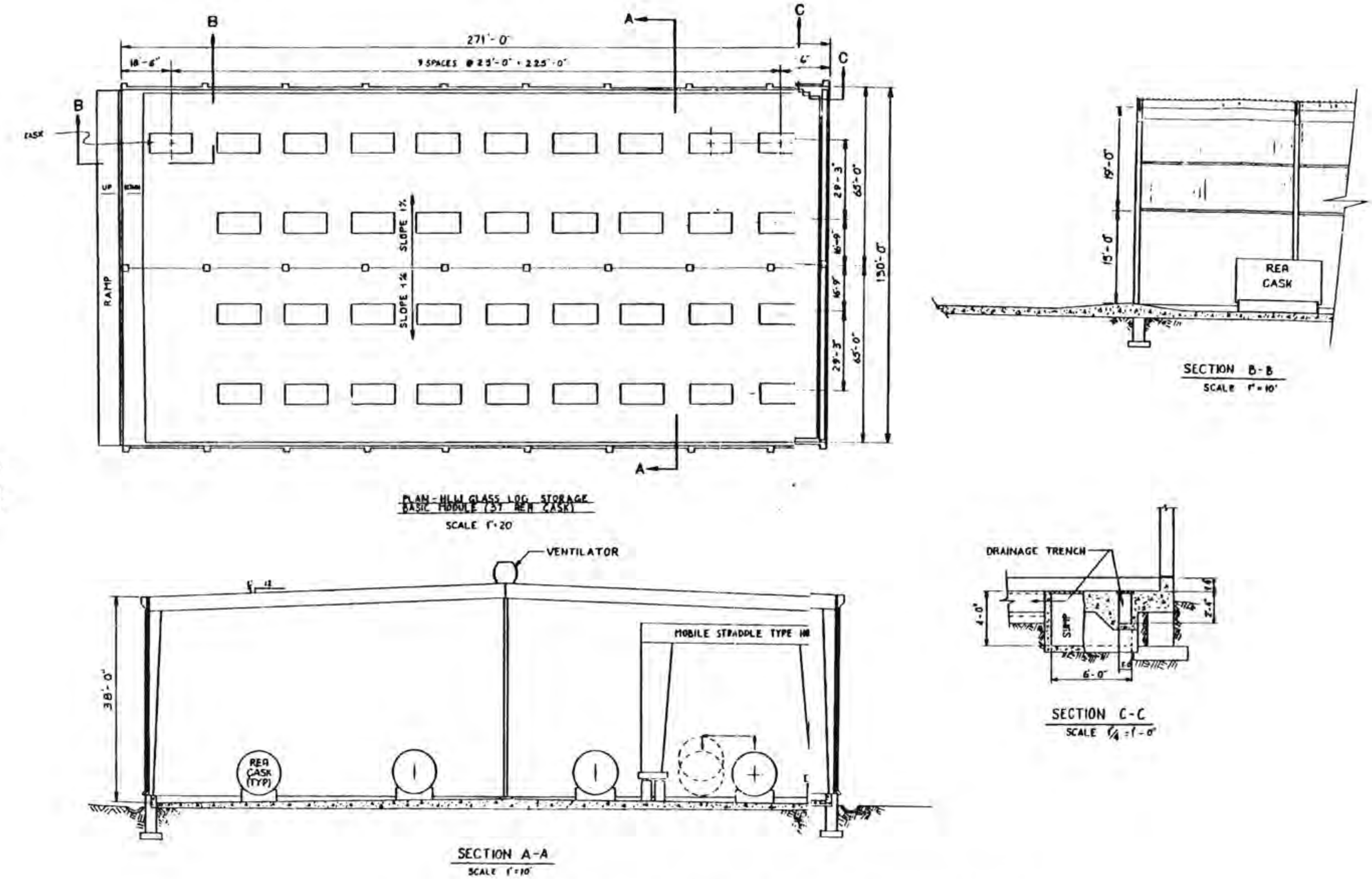


FIGURE 5.12. Solidified HLW Canister Storage Module

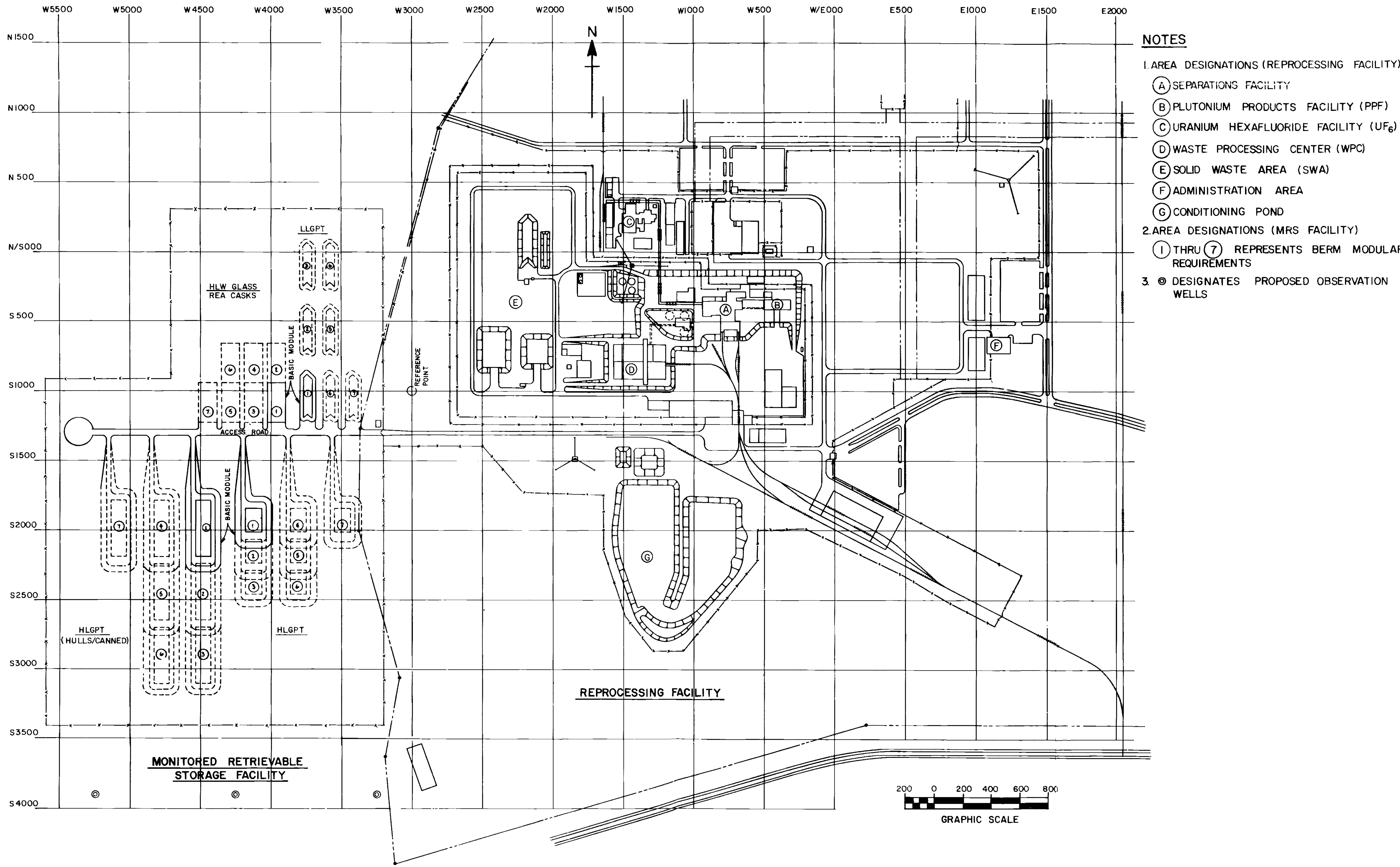


FIGURE 5.13. MRS/IS Facility Co-located with a Reprocessing Plant, Reference Scenario

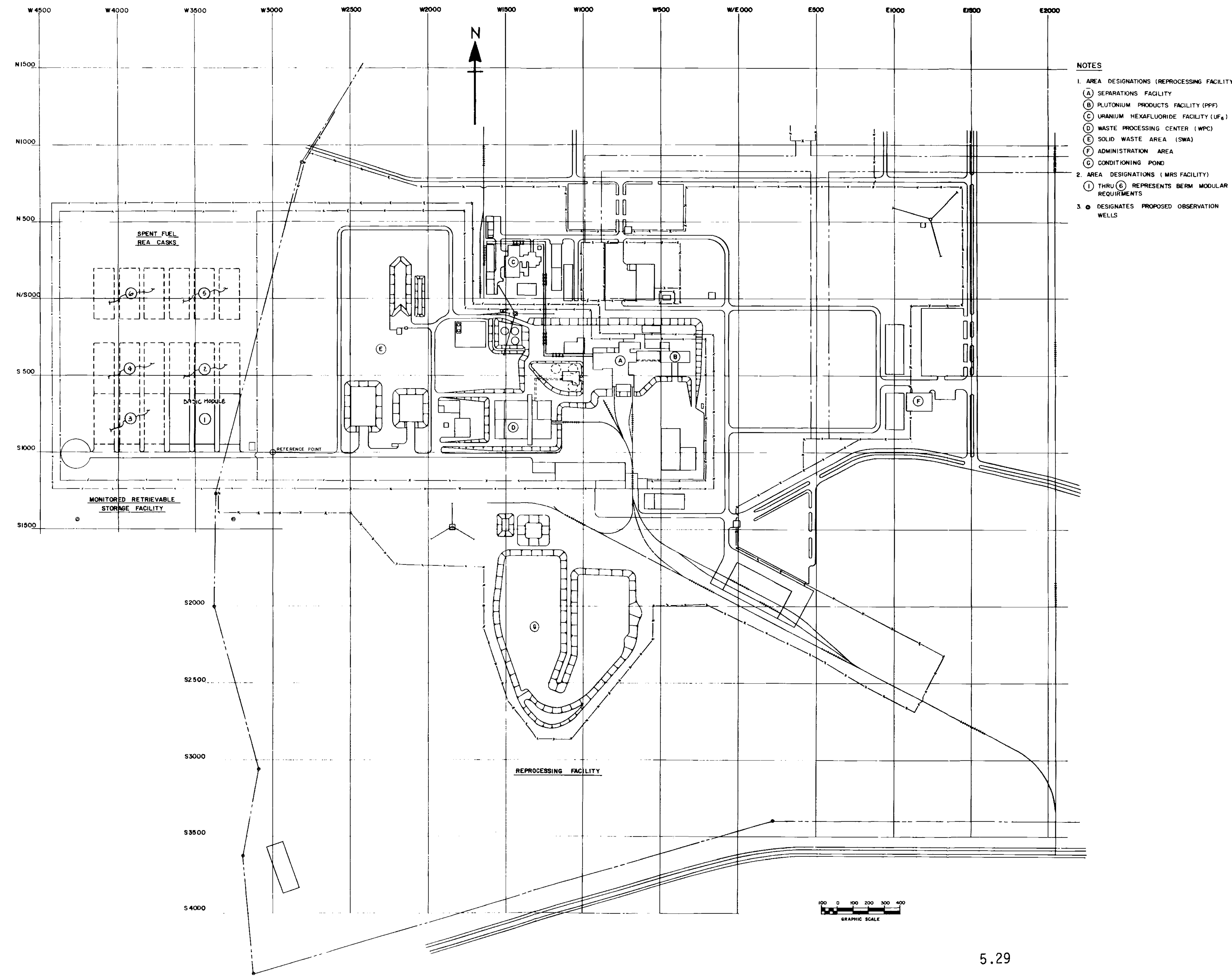


FIGURE 5.14. MRS/IS Facility Co-located with a Reprocessing Plant, Delayed Reprocessing Scenario

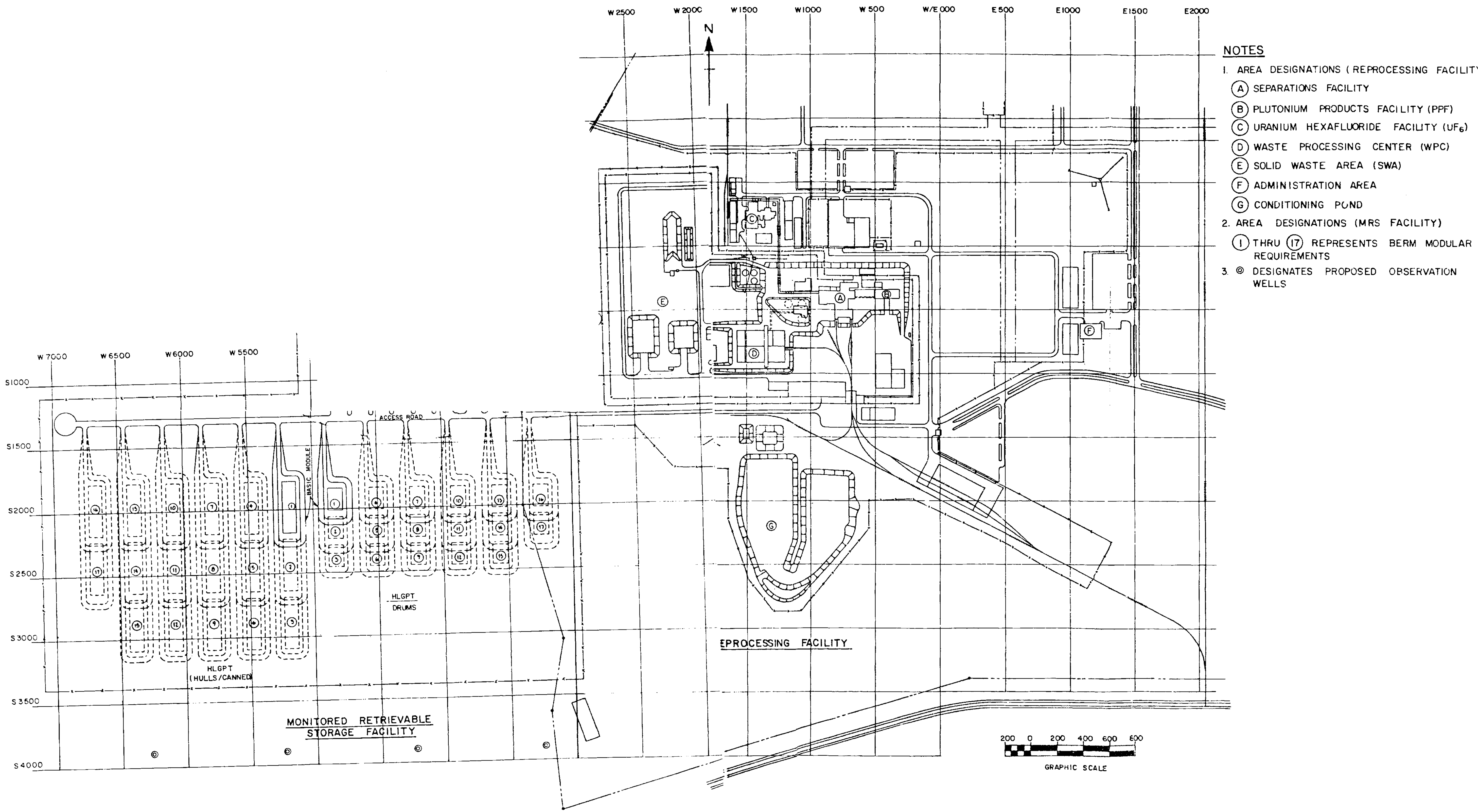


FIGURE 5.15. MRS/IS Facility Co-located with a Reprocessing Plant, Delayed Disposal Scenario

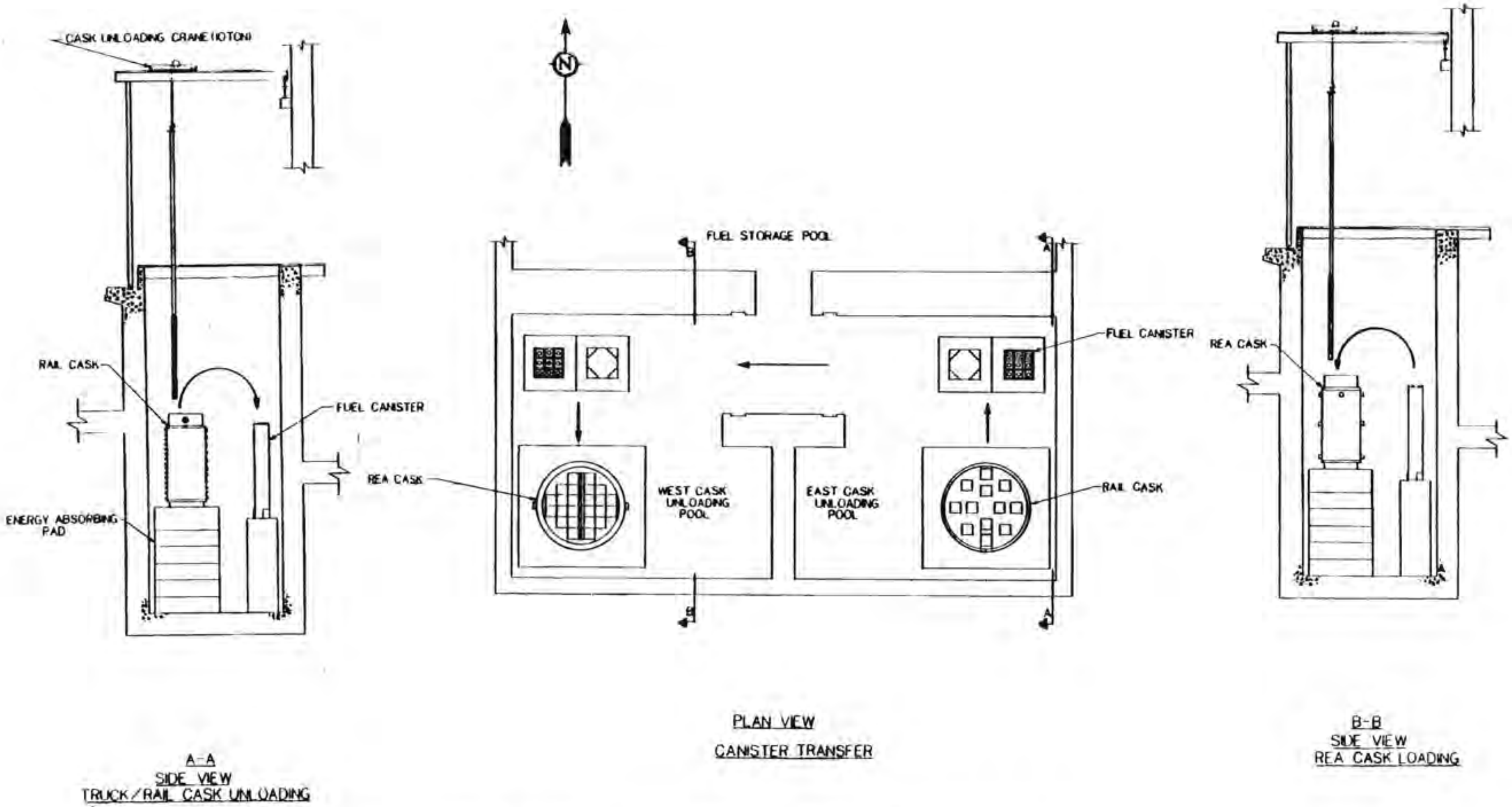


FIGURE 5.16. Cask Unloading/Loading Operation

5.3.3.2 Drywells

The drywells utilized in this concept are installed in a built-up berm. The berm concept provides for modular construction as capacity is needed, and ensures that the "environment" would remain inviolate even in the unlikely event of a package system failure. The confinement barrier philosophy is found in AEC Regulatory Guide 3.18, "Confinement Barriers and Systems for Fuel Reprocessing Plants."

Berm Description. As shown on Figure 5.17, a clay pad is laid at the existing grade level and is covered with a layer of relatively large aggregate (sand). The purpose of the clay and sand layers is to break the capillary communication between the unsaturated soil and the berm. The sand layer is then covered with another clay layer to provide the maximum capillary contrast. The remainder of the berm is constructed of a homogeneous sandy clay fill having known ion exchange properties and a pore structure which is more open and free draining than the clay pads.

In this fill, above the clay pads, is laid a horizontal network of monitoring pipes which can be made of any appropriate material, including possibly PVC or polymer glass.

The berm is capped with concrete. The toe of the berm is open, in the manner of an earth-fill dam, to provide an escape route for water which may pass through any breach in the cap. A monitorable surface drainage system is provided for surface runoff from the berm.

Holes are excavated in the berm, and corrugated drywells with solid bottoms are set with aggregate uniform sand, separating the metallic drywell (galvanized steel) from the soil. The purpose of the uniform sand in this case is to 1) break the capillary communication between the drywell casing itself and the soil and 2) insulate the metal from the acidic soil. The drywell may be equipped with a dip-leg for monitoring purposes, which is in turn equipped with a valve and a pressure gauge. An accumulation of water or change in activity level inside the drywell can be detected via this route. Beside each storage drywell is a monitoring drywell which, coupled with the underlying pipe network, gives a three-dimensional "fix" on any leaked radioactivity.

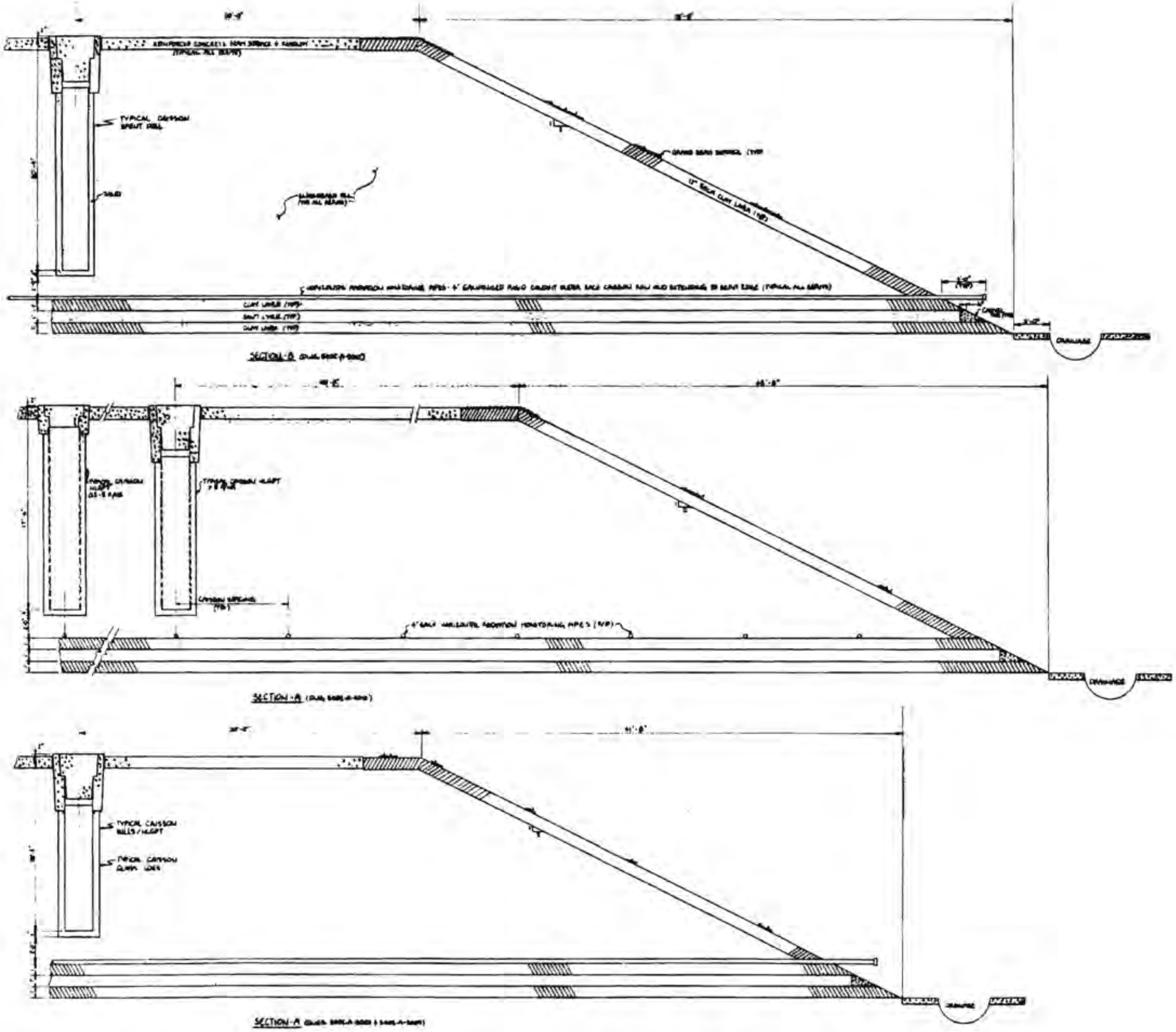


FIGURE 5.17. Cross-Sections of a Typical Berm Module

Even if an unidentified series of events did result in nuclides reaching the outside of the drywell and enough water were available around the drywell, the worst case movement of water and representative nuclides would not provide any immediate or nonmonitored detrimental consequences. The berm as designed isolates any contaminants from man while allowing detection through the three-dimensional drywell monitoring network. The minimum time for water leaving the drywell to reach the surface outflow system is 145 days. During that time, the event is monitorable by via neutron sondes in the three-dimensional drywell network. A drywell leak of at least 3490 gal is required, which is a depth in the drywell of about 198 in. The mean annual rainfall at the BNFP is 55 in. per year, and the maximum intensity is 11 in. per hour for a 5-minute expected duration. Even if a drywell remained uncovered during the probable maximum rainfall, the volume of water required would not be available.

Estimates of the time required for cesium and plutonium to first appear in the surface drainage system are 113 and 2820 years, respectively. Such times indicate the berm structure's effectiveness in localizing any sorbable nuclides.

Drywell Storage

Several options are presented for sizing the storage areas and drywells. One canister per drywell (with one PWR/two BWR spent fuel assemblies = 0.38 to 0.46 MTU/hole) is the most conservative choice. It offers the most conservative design from a thermal standpoint and simultaneously offers the reprocessing plant operator the greatest flexibility in selection of fuel assemblies for reprocessing. It is also probably the most costly since it results in the greatest number of holes.

At the opposite end of the loading spectrum is a 3/7 spent fuel canister (three PWR/seven BWR assemblies = 1.33 MTU/hole). This larger canister is the recommended approach since it is anticipated that the actual age of the spent fuel will be significantly older than 10 years. Criticality concerns can be overcome by either poisoning the can (i.e., use of Boral or similar neutron poison used as a fuel divider in the can) or taking credit for fuel burnup.

The latter approach has been approved for reactor high-density spent fuel racks. Preliminary calculations indicate that the proposed 250°C limit for fuel cladding temperature will not be exceeded using a 3/7 canister, even assuming a worst-case, 10-year-old fuel with 35,000 to 40,000 MWd/MTU burnup.

The holes drilled for the drywells are positioned on a square pitch to enable the placement of aisles for facility handling operations. A minimum of 10 ft is assumed to permit movement of the cask transport vehicle and to preclude exceeding soil loading limitations.

Similar berms are utilized for solidified HLW and remote-handled TRU wastes. The modular berm sizes and shapes for storage of spent fuel, HLW, and RHTRU are illustrated in Figures 5.18, 5.19, and 5.20.

5.3.4 Service Facilities

Most of the necessary service facilities to support the MRS at BNFP are currently available as part of the reprocessing facility. These services include utilities (steam, electricity, water, etc.), connecting highway and railroad lines, administration buildings, a security and safeguards system, health physics and environmental monitoring, an analytical laboratory area, a maintenance and machine shop area with supporting warehouse, and a completed fuel receiving and storage area. At this time, however, neither a cask fleet servicing facility for the transportation vehicles (a conceptual design of such a facility has been completed) nor hot laundry facilities are available on the site.

5.4 MRS/IS STAND-ALONE FACILITY

The MRS/IS facility described in this section is a stand-alone facility capable of receiving and storing PWR and BWR spent fuel assemblies, canisters containing solidified HLW, and various forms of TRU waste contained in drums, canisters, and boxes. The facility is divided into three principal areas: the first handles and stores the spent fuel and solidified HLW; the second handles and stores all the TRU waste including canistered hulls; and the third is the support facilities.

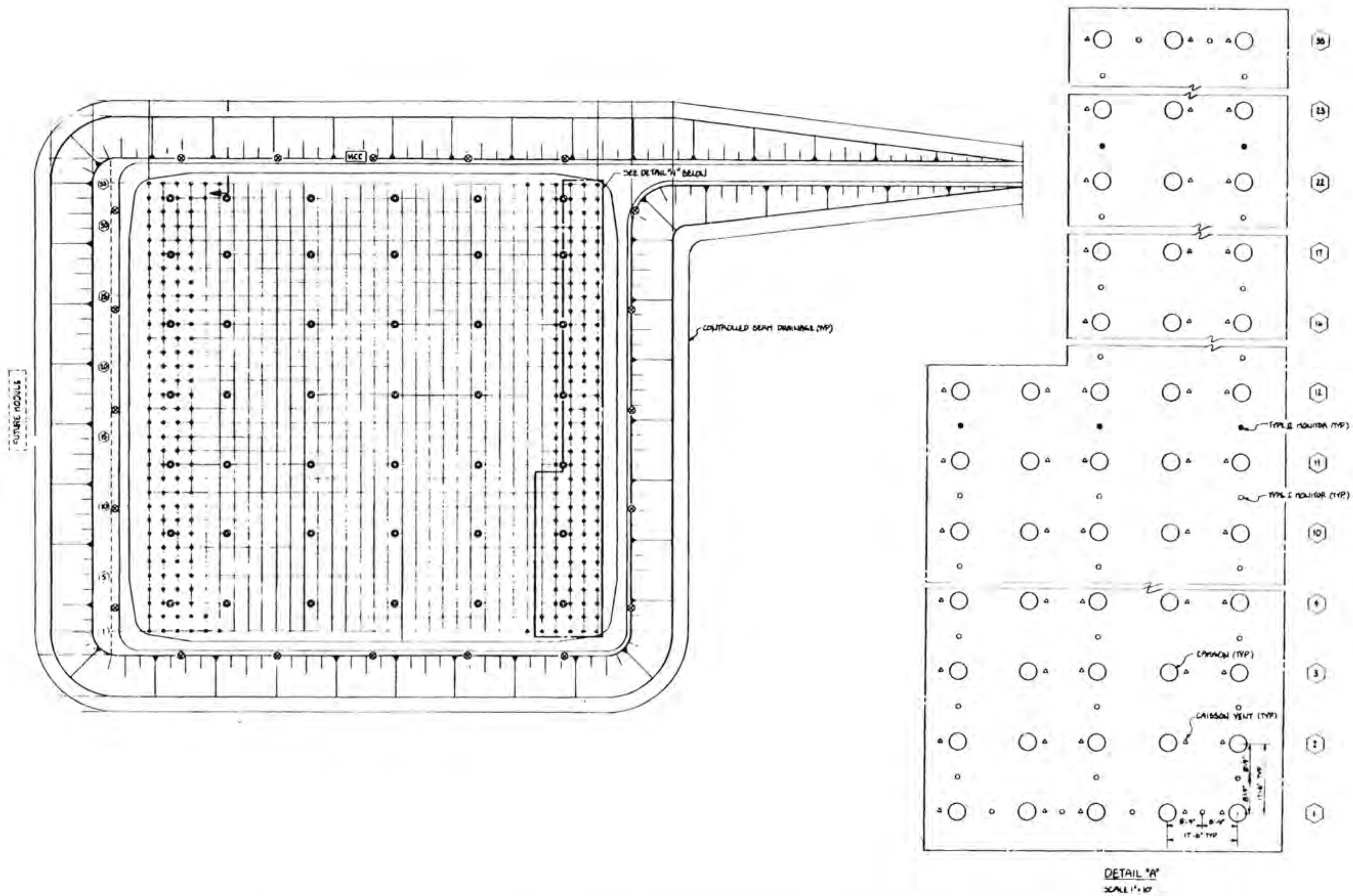


FIGURE 5.18. Typical Berm Module for Drywell Storage of Spent Fuel

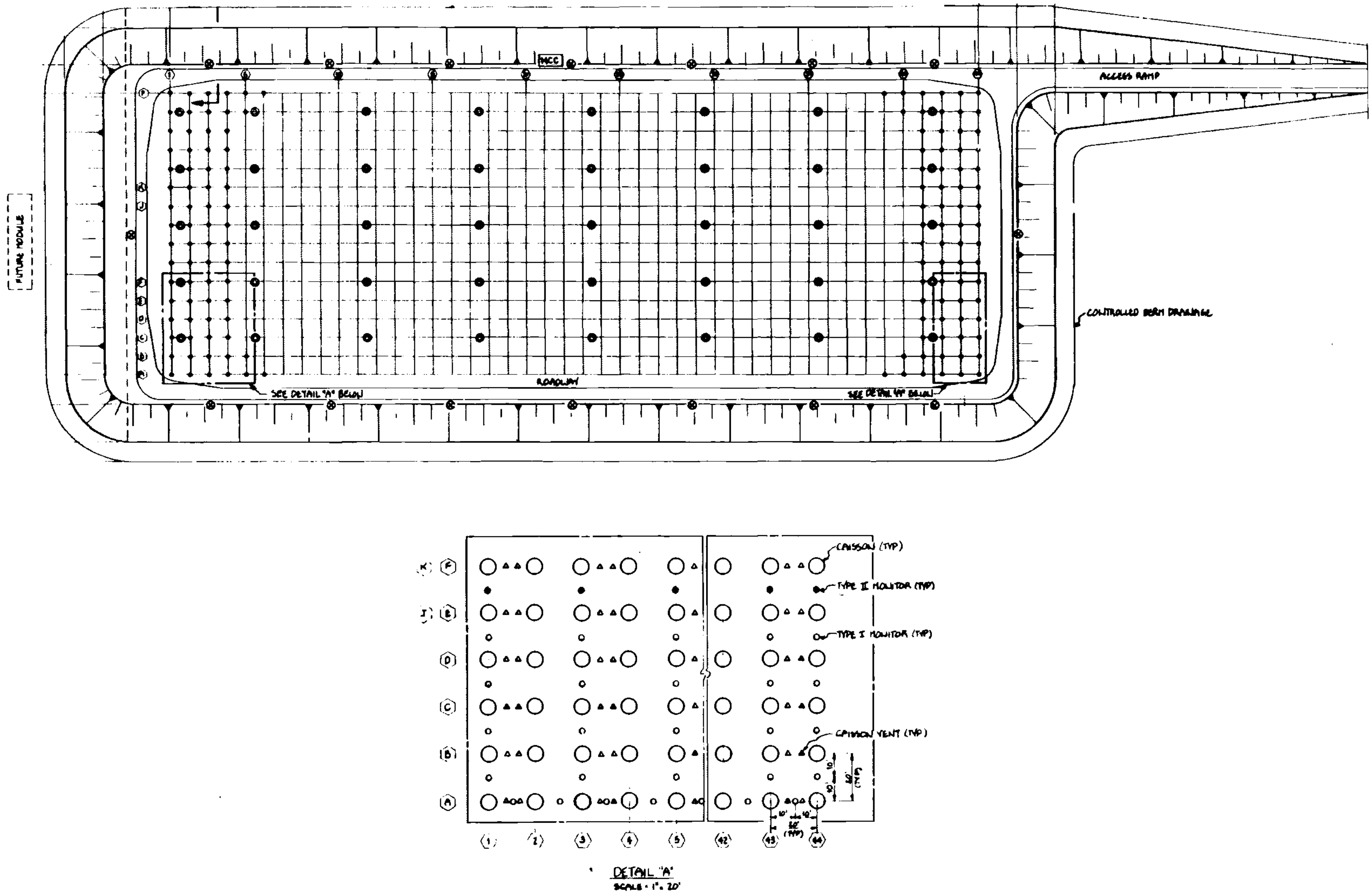


FIGURE 5.19. Typical Berm Module for Drywell Storage of HLW

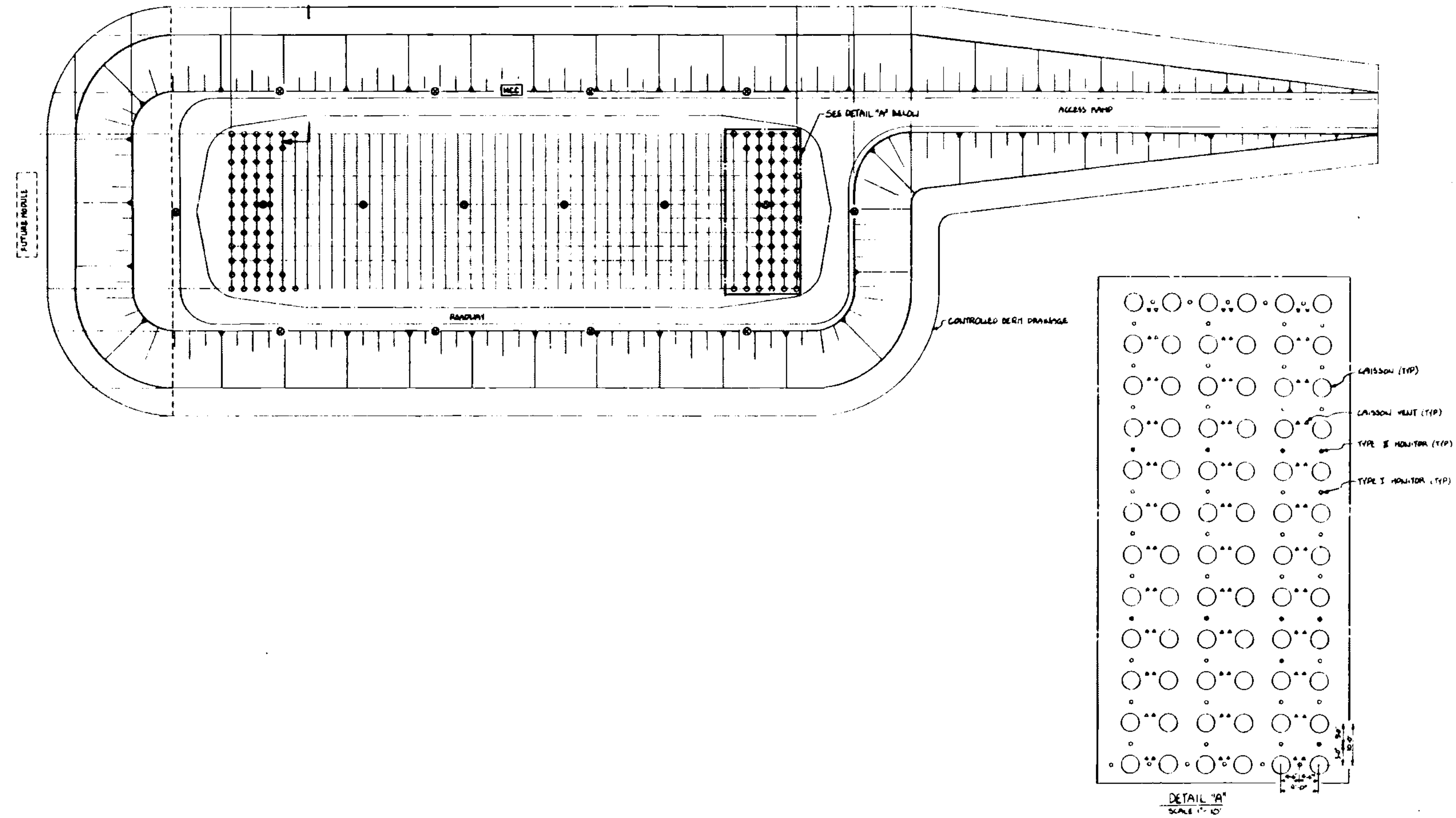


FIGURE 5.20. Typical Berm Module for Drywell Storage of RHTRU Wastes

Two concepts for the spent fuel and HLW storage area are considered. The first concept uses metal storage casks, and the second uses surface drywells. It is assumed that the casks are not transportable, although, in the future, they may be made transportable with the addition of certain safety equipment. The drywell considered is the reference design identified in Section 5.2.2. Both storage concepts require an onsite receiving and shipping facility. The facility accommodates both rail and truck shipments and uses a wet handling system to unload the spent fuel or HLW from the shipping casks.

The second storage area (TRU waste) of the facility is divided into three sections. The first receives contact-handled TRU waste (CHTRU) and stores it in prefabricated buildings. Because the radiation and decay heat levels are low, the construction of the building is relatively light. The second section stores remote-handled TRU waste (RHTRU) in heavier concrete vaults. These vaults provide greater radiological protection than the buildings in the first section but do not require any special features for heat removal. The third section handles hulls and hardware in canisters. This waste requires substantial radiological protection and heat removal capability and is placed in drywells located in earthen berms.

The support facilities include all the buildings, structures, and systems needed to maintain operation of the MRS/IS facility, including the administration building, the process steam plant, and the emergency vehicle/fire truck station.

The designs of the spent fuel/HLW and TRU waste areas are modular. This allows for incremental expansion of the handling facilities and storage areas to accommodate the three scenarios (reference, delayed reprocessing, delayed disposal).

5.4.1 Receiving and Handling Facility

The stand-alone MRS/IS concept requires the construction of receiving and handling facilities for spent fuel/HLW and TRU wastes. The spent fuel/HLW receiving and handling facilities are very similar no matter which storage concept is being used. The major differences are related to packaging and interfacing with different transfer systems. The same facilities for receiving and handling TRU wastes are utilized with either a cask or drywell storage concept.

5.4.1.1 Cask MRS/IS Spent Fuel/HLW Receiving and Handling

The receiving and handling system for the cask version of the MRS/IS facility has three principal functions. In the case where spent fuel or solidified HLW enters the MRS/IS facility, the functions are:

1. To accept (receive and inspect) rail and truck casks containing spent fuel or solidified HLW.
2. To transfer spent fuel or solidified HLW from the rail or truck transport casks into storage casks.
3. To deliver loaded storage casks to the transfer system for transport to the cask storage area.

When spent fuel or solidified HLW is retrieved from the storage area for shipment to a reprocessing plant or repository, the facility functions are:

1. To accept loaded storage casks from the transfer system.
2. To unload spent fuel or solidified HLW from the storage cask into a rail or truck transport cask.
3. To prepare loaded rail and truck casks for shipment.

Functional flow diagrams which provide detailed breakdowns of the principal facility functions are given in Figures 5.21 and 5.22.

The following description of the receiving and handling system is for material entering the MRS/IS facility. As shown in Figure 5.22, the system operation is almost reversed when material is retrieved and shipped out of the facility. The receiving and handling system is made up of the following subsystems or areas:

- receiving/inspection area
- carrier preparation/wash-down area
- carrier wash-down/cask unloading area
- cask wash-down/cooling pit

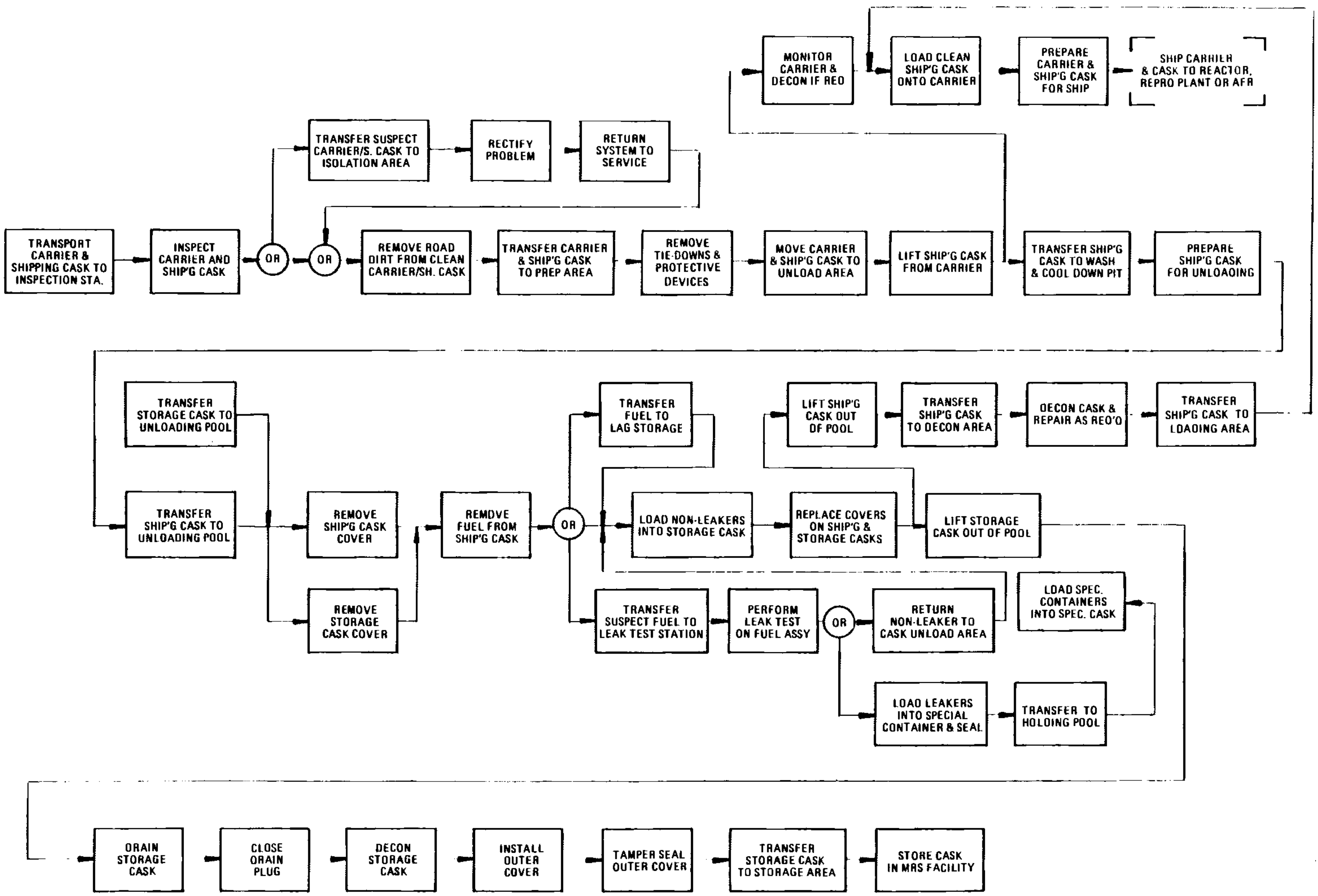


FIGURE 5.21. Spent Fuel/HLW Receiving and Storage Flow Diagram

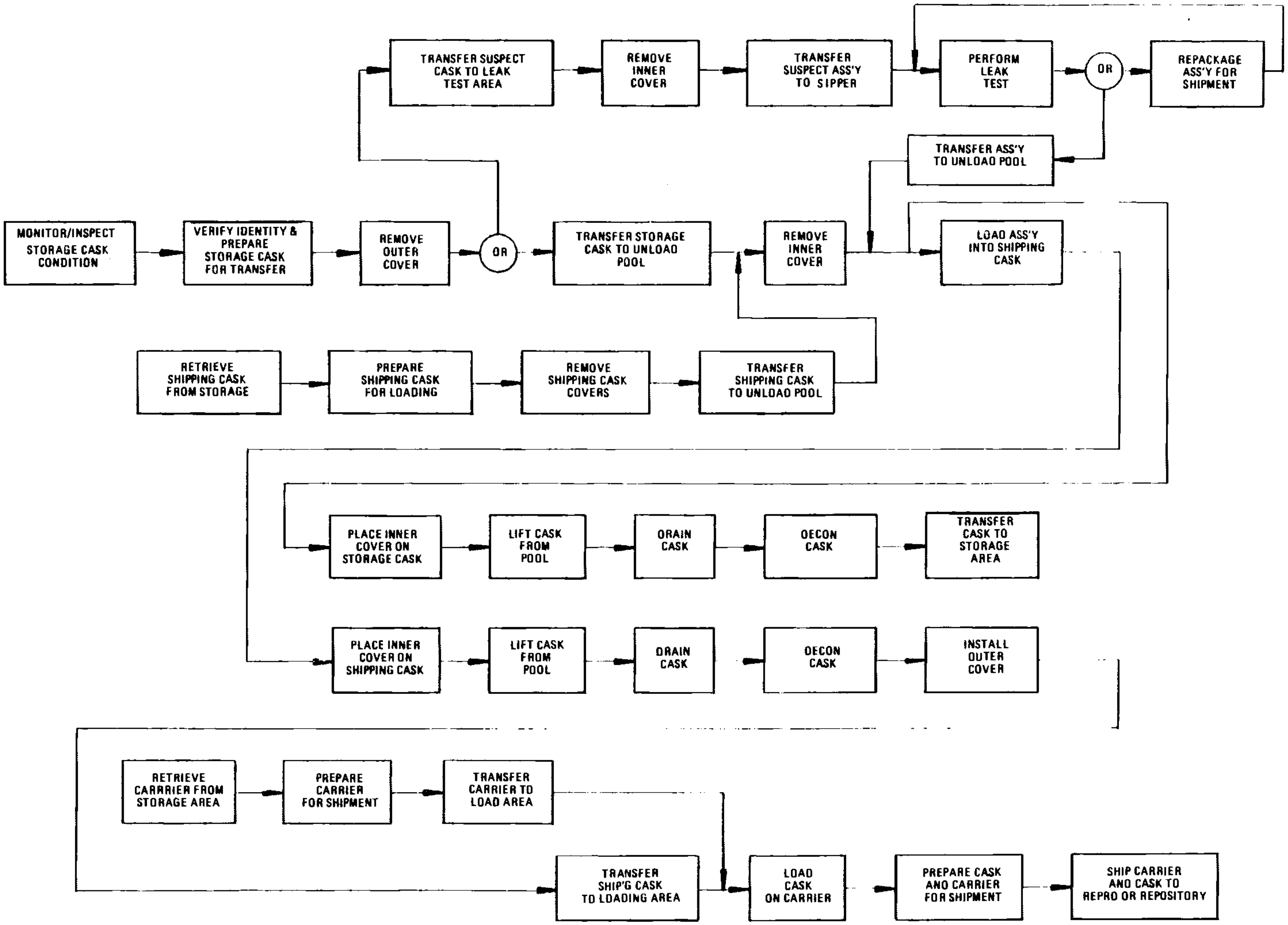


FIGURE 5.22. Retrieval from Storage and Shipment to Repository or Reprocessing Plant

- spent fuel/solidified HLW unloading/transfer pool
- transport cask decontamination pit
- hot cell/lag storage area
- support areas and systems.

One module in the receiving and handling building contains two truck bays, one rail bay, a fuel/HLW unloading/transfer pool, the cooling and decontamination pits, and a cask storage area. The receiving/inspection area is located at the site boundary. The area is paved to facilitate access for the carriers. Lighting is provided for night operation and sheds for protection of personnel against inclement weather. Rail and truck carriers are stationed in this area while awaiting document processing and are then inspected for contamination and damage. Any carriers suspected of having excessive damage or sabotage are immediately moved to the suspect truck and rail car storage area. After the receiving inspection is complete, carriers are moved to the spent fuel and solidified HLW receiving facility or to the rail car or truck parking areas.

Figure 5.23 is a plan view of the spent fuel and HLW handling facility. This building is approximately 450 x 430 ft and contains the remainder of the receiving and handling system.

After the receiving inspection is complete, the cask and carrier are moved into the carrier preparation/wash-down area, where road dirt is removed from the cask and carrier and tie-downs and other protective devices are taken away. The area is an enclosed space approximately 105 ft wide, 56 ft long, and 42 ft high. It is equipped with sealable doors at the entrance for air control. The facility is made up of modules, with each module having two truck bays and one rail bay. The rail bay can accommodate a truck if necessary. Each bay is equipped with a 10-ton crane and has storage space for the cask accessories and peripheral equipment and the lifting yokes and accessories.

Next, the cask and carrier are moved to the carrier wash-down cask unloading area, where the cask is lifted from the carrier. Each module is equipped with a 125-ton bridge crane which lifts the cask from the carrier and transfers it to the cask wash-down/cooling pit.

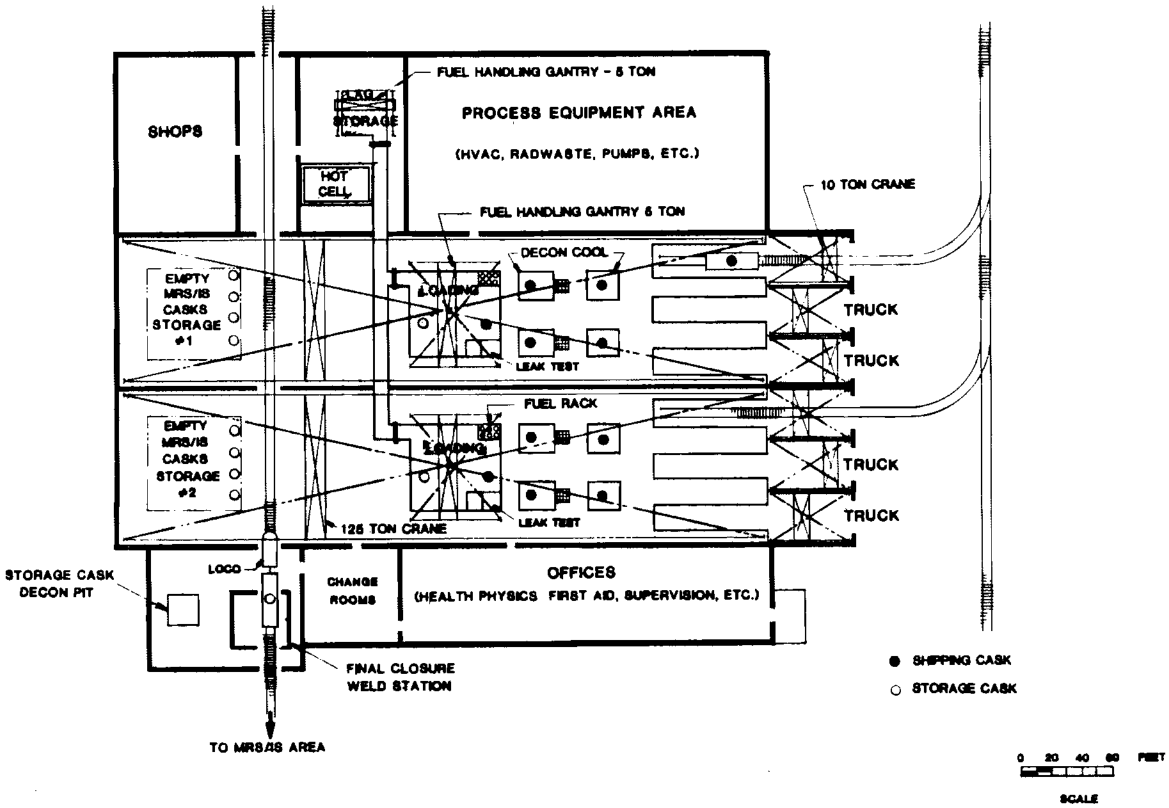


FIGURE 5.23. MRS/IS Facility Spent Fuel and High-Level Waste Handling Building Plan

In the cask wash-down/cooling pit, the external surface of the cask is cleaned, the cask interior is vented to the off-gas system, and the cask is cooled using first steam and then water. During this cooldown, the cask temperatures and contamination levels are periodically monitored. When cooldown is complete, the outer cask cover is removed and the cask transferred (by crane) to the loading/unloading pool.

The wash-down/cooling pit is made of reinforced concrete and is 20-ft square and 25-ft deep. Each module has two pits. Each pit is equipped with flexible couplings for venting the gas inside a cask to the off-gas system, is seismically qualified, and can withstand the loads caused by accidental dropping of a rail or truck transport cask into the pit.

In the fuel loading/unloading pool, the transport cask is lowered into the water, the inner cover is removed, the cask is lowered further down into the water, and the spent fuel assemblies or waste canisters are unloaded and placed into the storage cask. Fuel unloading continues in this manner until the storage cask is full.

Each module has one loading/unloading pool. It is made of reinforced concrete and is approximately 60-ft long by 57-ft wide by 50-ft deep at the deepest point. Storage and transport casks are loaded into the pool by the traveling 125-ton overhead bridge crane. The cask grappling system is equipped with redundant yokes to ensure that a cask cannot be dropped while it is being transported. Transfer of fuel assemblies or waste canisters is handled by a 5-ton overhead gantry crane.

The pool is designed with storage shelves for cask hardware (including the inner cover) and has a leak test (sipping) system. A rack for temporary storage of fuel assemblies or canisters is also included. The shelves, racks, and bottom of the pool are fitted with energy-absorbing pads or grills. The pool is designed so that 10 ft of water cover the assembly or canister being handled at all times. A pool water clean-up system maintains the water radioactivity at acceptable levels.

To complement the handling system, an underwater television camera is provided. This permits easy identification and inspection of received material. An underwater vacuum system is also provided to collect any loose debris or scale that may fall from the cask or its contents. Positive means (e.g., locks or stops) are provided to prevent fuel assemblies or canisters from being placed in critical configurations and to prevent movement of casks above fuel assemblies or canisters.

The transport cask is placed in the decontamination pit prior to being reloaded onto a carrier for return to the reactor or reprocessing plant. The cask interior and exterior are washed with decontaminating solutions, and the cask covers are replaced.

The decontamination pit is approximately 23-ft square and is built of reinforced concrete. It is equipped with high-pressure hoses for spraying detergent and rinsing radiation monitoring instrumentation, a cleaning solution drain and disposal system, and instrumentation for leak-checking the assembled cask. The bottom of the pit has an energy-absorbing pad, and air and helium supply lines are available for drying and leak testing. Each module has two decontamination pits.

Loading of clean casks onto a carrier is performed in the cask loading bay using the 125-ton bridge crane.

The hot cell is designed to accommodate radioactive equipment requiring maintenance or repair and to encapsulate leaking spent fuel assemblies or solidified HLW canisters. Although the MRS/IS facility will not, as a general rule, accept leaking assemblies, some fuel or canisters may be damaged in transit, during handling, or in storage, and a facility (hot cell) for repair or recanistering must be available.

The hot cell is constructed of reinforced concrete and is approximately 20 ft wide, 40 ft long, and 25 ft high. The walls are 36- to 48-in. thick, and all windows are fitted with leaded, oil-filled glass. The hot cell contains two remote control manipulators, a 5-ton crane, television cameras, and various jigs and fixtures required for repair or recanistering.

Fuel assemblies are transported to the hot cell from the pool by a transfer buggy that runs the length of the canal from the lag storage pool to the loading/unloading pools. Spent fuel assemblies or HLW canisters enter the hot cell through an air lock in the floor of the cell. The assembly or canister is surrounded by a shield sleeve which is lowered into the canal. The floor port is opened, the assembly or canister drawn up into the cell, and the port closed.

The lag storage pool is made of reinforced concrete and is 30-ft square and 25-ft deep. It provides temporary storage for BWR assemblies, PWR assemblies, or solidified HLW canisters. Storage for about 10 weeks worth of HLW canisters handling at the peak facility handling rate is provided.

The support areas and systems portion of the receiving and handling facility consist of the following subsystems:

- HVAC
- electrical power and lighting system
- fire protection system

- radiation monitoring system
- radwaste system
- decontamination system
- utility piping system
- process instrumentation system
- control room area
- storage cask receiving and storage areas
- maintenance shops
- health physics areas
- administration/employee service area.

The receiving and handling facility accommodates the three fuel cycle scenarios by varying the number of modules and/or the number of shifts of workers to achieve the desired capacity. The plant handling rates for spent fuel are given in Table 5.4, and the rates for solidified HLW are given in Table 5.5. As indicated in the tables, the same handling rate is available using fewer modules and more shifts. Because of the high capital cost of the modules, use of more shifts is felt to be the more economical option for attaining the desired handling rate.

TABLE 5.4. Receiving and Handling Facility Handling Rates for Spent Fuel (MTU/yr)

	No. of Shifts		
No. of Modules	1	2	3
1	170	339	508
2	339	678	1016
3	508	1016	1524

TABLE 5.5. Receiving and Handling Facility Handling Rates for Solidified HLW (MTU_e/yr)

	No. of Shifts		
No. of Modules	1	2	3
1	764	1529	2293
2	1529	3057	4586

5.4.1.2 Drywell MRS/IS Spent Fuel/HLW Receiving, Handling and Packaging

The facilities for receiving and handling spent fuel and HLW at the drywell MRS/IS are essentially the same as those described in 5.4.1.1. The hot cell described in 5.4.1.1 is also used for welding the support ring on the HLW canisters. This ring supports the canister in the drywell encasement.

In addition, the drywell MRS/IS facilities for the delayed reprocessing scenario are capable of packaging spent fuel into sealed metal canisters. This is accomplished in the weld and test cell, which is sized to accommodate the packaging and testing functions for a 2.1 MTHM/day throughput on a 5-day week single shift basis. Shifts and cells are added as required to meet the anticipated flow of spent fuel. An operating gallery, located parallel and adjacent to the weld and test cell extends the length and height of the cell to allow direct viewing (via shield windows) for manipulator handling of assemblies and HLW canisters and for performing maintenance operations. Space is provided for personnel and auxiliary equipment in support of the handling and packaging operations. There is a package loadout room at grade level into which transport vehicles will enter to receive packages.

5.4.1.3 TRU Waste Receiving and Handling.

At the MRS/IS stand-alone site, all incoming TRU waste is routed through the TRU waste receiving facility. The receiving facility is divided into the CHTRU and RHTRU receiving facility and the spent fuel residue receiving facility. A further division is made according to mode of transportation, i.e.. rail car or truck. Waste containers arriving by rail are transferred at the receiving facility to site transporters.

A plan view of the proposed TRU waste receiving facility is shown in Figure 5.24. The major portion of the facility is devoted to receiving and transfer of the fuel residue canisters. This part of the facility contains the receiving bays, the unloading and transfer pool, and the load-out station, together with the associated process, radwaste, and hot-cell facilities. The whole area is serviced by a 100-ton bridge crane. A 5-ton gantry crane is provided at the pool for handling fuel residue canisters.

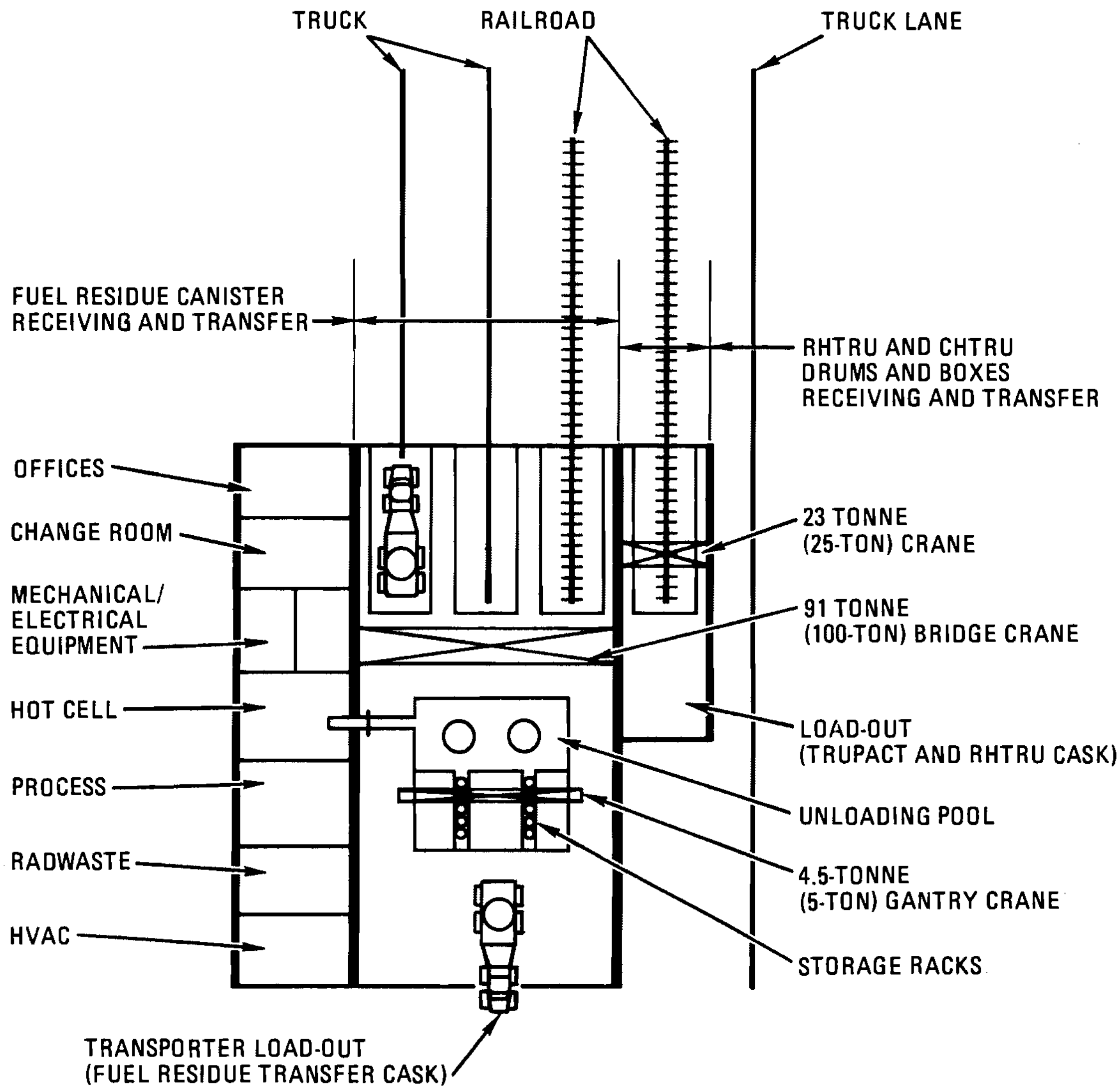


FIGURE 5.24. TRU Waste Receiving and Transfer Facility

An adjoining building houses the receiving and transfer area for RHTRU and CHTRU drums and boxes. A 25-ton crane is provided for transfer of RHTRU multidrum shipping casks and CHTRU TRUPACT shipping containers from incoming rail cars to site truck transporters for delivery to their storage building.

The required handling rate varies considerably, depending on the particular timetable for availability of reprocessing and disposal facilities. The handling capacity of the receiving facility is adequately sized for the initial waste storage requirements by operating on a single work shift basis and can be increased to the peak handling requirements by operating with second and third shifts.

5.4.2 Contact-Handled Waste Storage

Indoor interim storage of CHTRU waste is a simple concept. A traditional warehouse is sufficient to meet storage needs, and because the shielding requirements are so low, there is no need for special handling equipment.

Variations in the concept are mostly in the choice of structural materials. A precast concrete indoor storage facility has been selected as the reference concept. This comprises a modular, thin-slab, precast, reinforced-concrete structure designed to store CHTRU waste in 208-liter (55-gal) carbon steel drums and 4 x 6 x 6 ft steel boxes. The structure is divided into storage cells. Each cell is 40 ft wide by 70 ft long and has the capacity to store 4200 drums.

Figure 5.25 illustrates the facility expanded to include 10 storage cells, for a capacity of 42,000 drums. The cells are constructed on both sides of a central corridor and have large sliding doors for access. Forced-air ventilation is not required for the stored waste; natural air circulation is provided by roof vents and cell wall openings. Monitoring systems are installed to sample the air within the cells.

Transportation of CHTRU waste to the MRS/IS site is anticipated to be by TRUPACT containers. TRUPACT containers arriving by rail are transferred at the TRU waste receiving area to a site transporter (low-boy truck) for delivery to the storage building. Truck-borne TRUPACT containers are routed directly to the storage building. Transfer of the waste drums and boxes to the storage cells is made by forklift truck.

5.4.3 Remote-Handled Waste Storage

The stand-alone MRS/IS facility stores a variety of remote-handled wastes, which include:

- spent fuel
- solidified HLW
- RHTRU waste drums
- RHTRU and fuel residue canisters.

Two methods of storage for spent fuel and HLW are considered, large metal casks and subsurface drywells. Two methods of storage for RHTRU are also

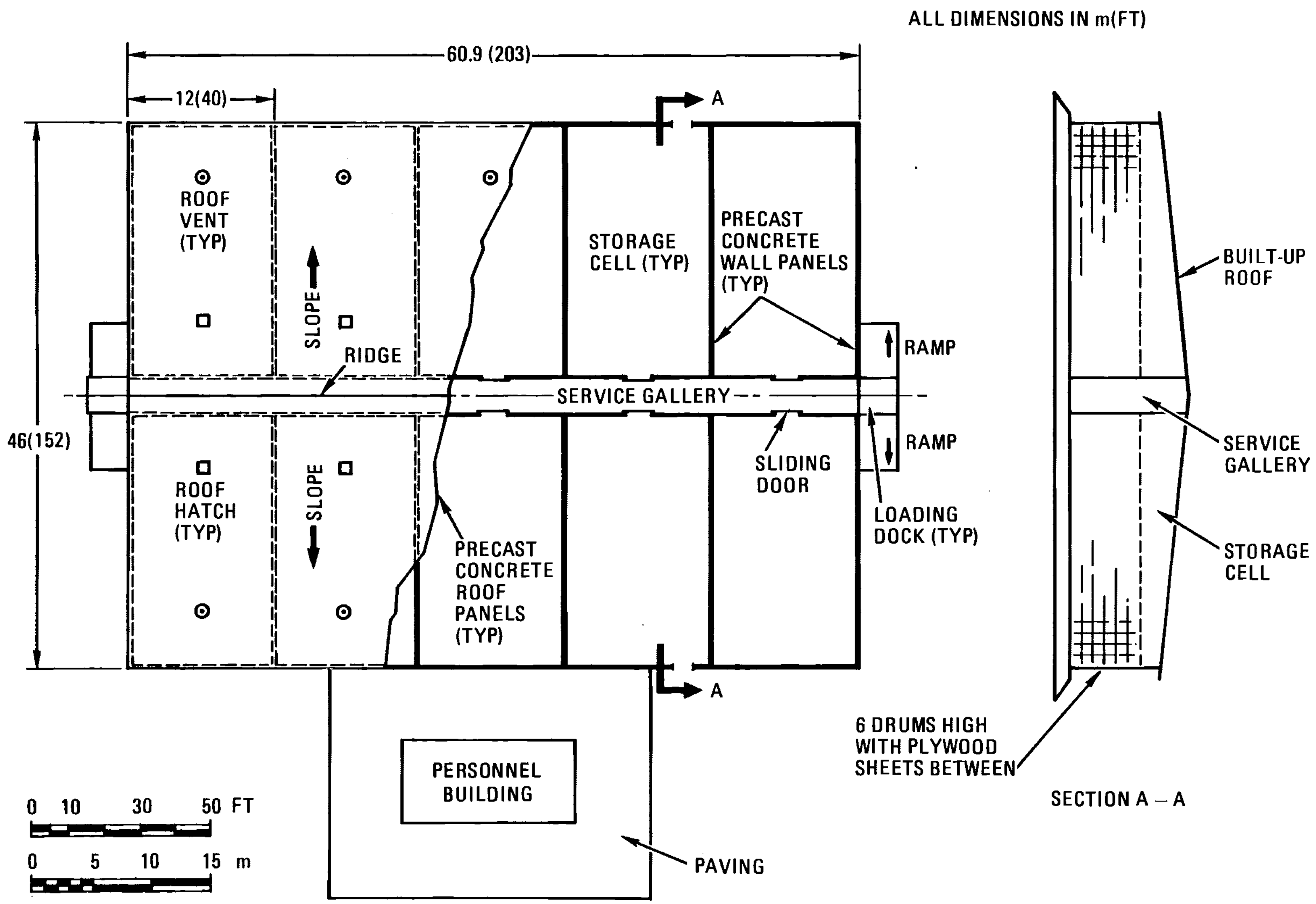


FIGURE 5.25. Indoor Storage Facility for CHTRU Waste

considered, a shielded vault for drum storage and caissons in a built-up berm for canisters. Each of these methods is described in a succeeding subsection.

5.4.3.1 Metal Casks

Spent fuel and HLW is stored in large metal casks which are described in Section 5.2.1. In the storage area, the casks are stored upright on large concrete pads, which provide for maximum heat transfer. The dimensions of the pad and the spacing of the casks on the pad are shown in Figure 5.26. Each pad has a rail line to accommodate the rail car. Because the spent fuel assemblies are placed intact in the storage casks and the fuel will be at least 10-yr old, calculations performed by REA indicate that the peak fuel cladding temperatures will be below 250°C (485°F). In the case of solidified HLW, the thermal load in the cask is approximately 30 kW. Detailed heat transfer calculations need to be performed to demonstrate that the temperature limits on the glass and canister wall can be met.

Each pad holds 204 casks. The numbers of casks and pads required for the three scenarios are given in Table 5.6. In all cases, the first pad is set in place during initial construction of the receiving and handling facility. In the reference case, the second pad is needed on line in 1995; the delayed reprocessing scenario requires additional pads in 1993, 1995, and 1997. The most severe pad construction schedule is required by the delayed disposal scenario, in which new pads are needed in 1995, 1999, 2002, 2004, 2006, 2007, 2009, 2010, and 2011.

The casks are positioned on the pads using the cask transfer system. The function of the transfer system is to transport storage casks between the receiving and handling facility and the storage area. To accomplish this, a system with a rail transport car and a mobile crane is used. Fully loaded storage casks are removed from the loading pool, drained, and dried. The cask is then placed on a low-bed rail car, which is pulled by a small locomotive to the final closure weld station. Following welding, the cask is tamper-sealed, identified, and transported to the storage area. The time to transport the cask from the weld station to the MRS/IS area is estimated to be less than 20 minutes. At the storage area, the cask is lifted from the rail car using a 125-ton-capacity mobile crane and is placed on the concrete storage pad.

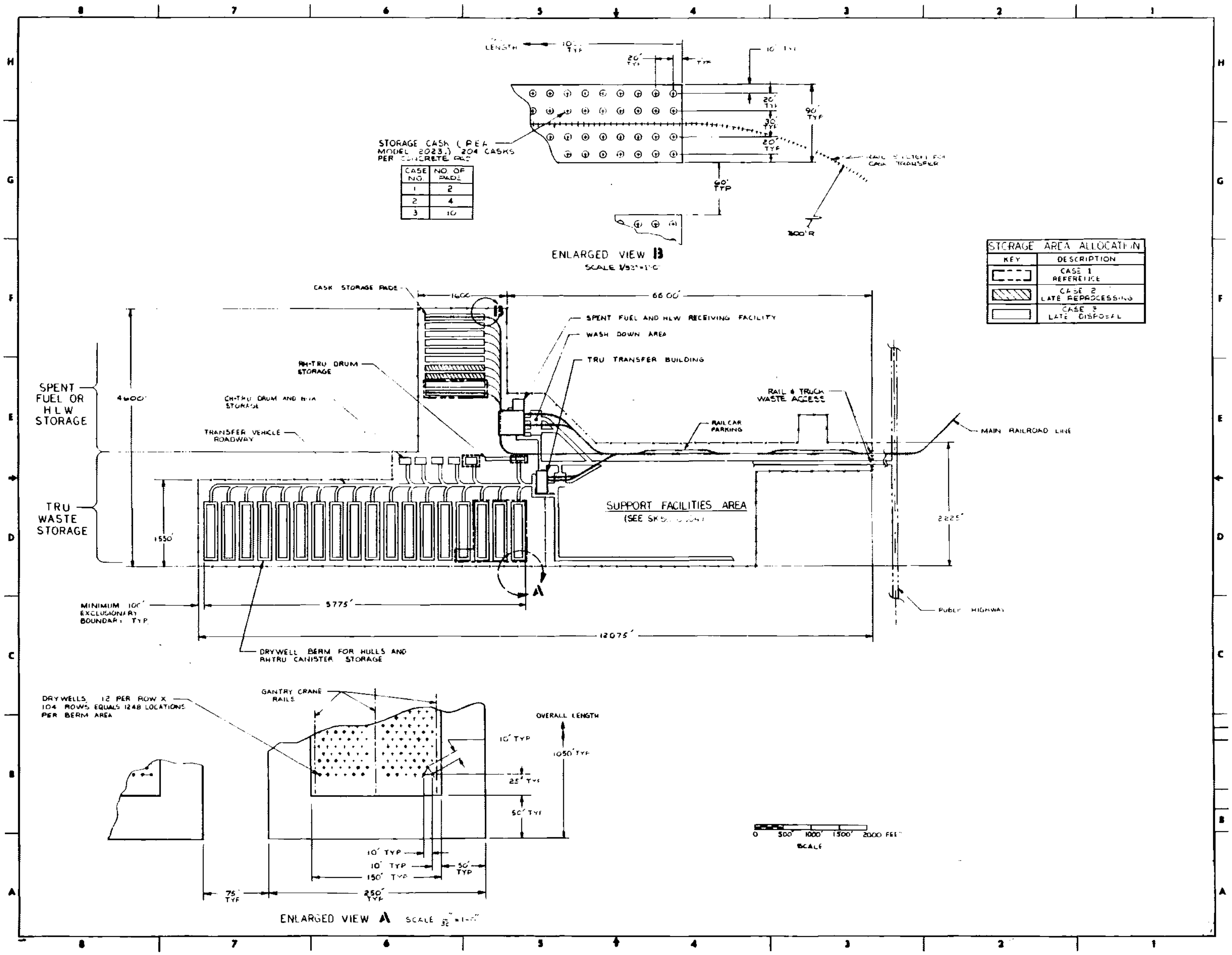


FIGURE 5.26. MRS/IS Stand-Alone Facility Cask Storage Site Plan

TABLE 5.6. Number of Casks and Pads Required for Study Scenarios

Scenario	No. Casks	No. Pads
Reference	350	2
Delayed reprocessing	769	4
Delayed disposal	2112	10

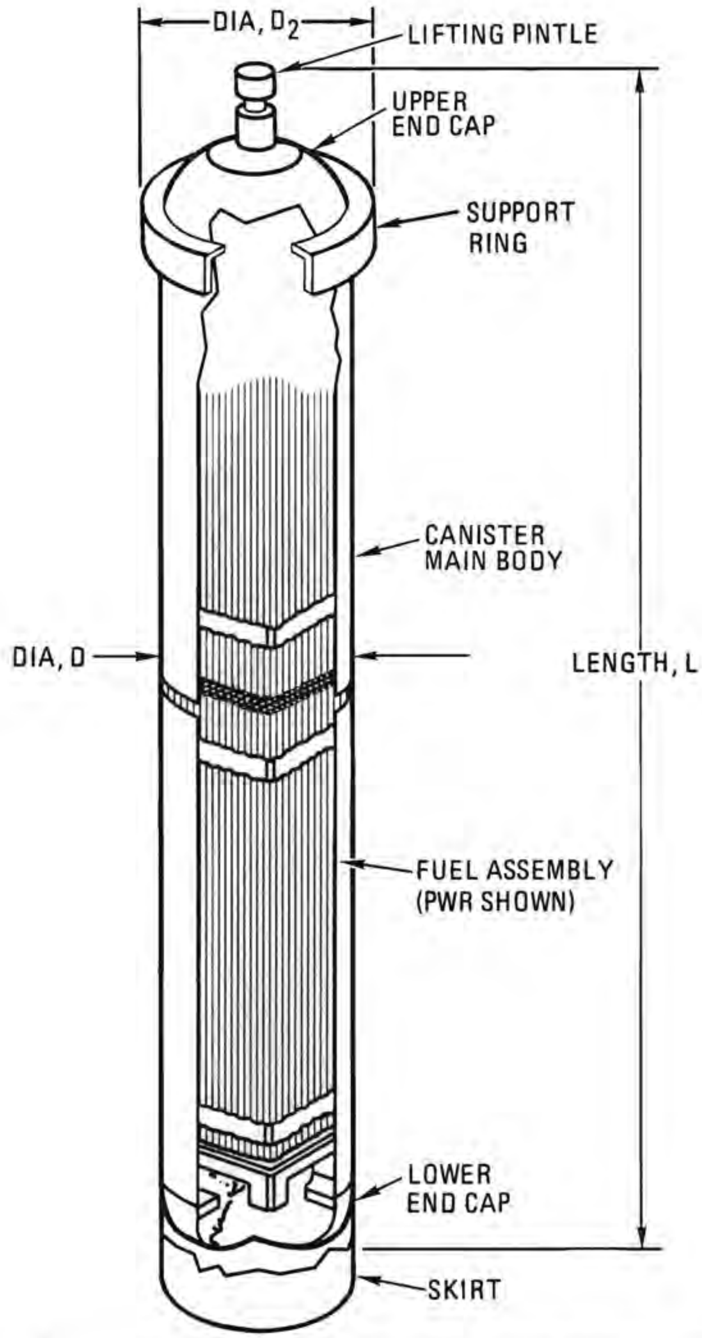
The cask is tied down, and initial measurements of temperature and radioactivity levels are made. The rail car is returned to the handling facility for another cask.

5.4.3.2 Drywells

An alternative system for storing spent fuel and HLW is in drywells which are described in Section 5.2.2. The primary function of the storage system is to provide shielded, passively cooled, below-ground storage for spent fuel and solidified HLW packages. The storage system consists of the canistered spent fuel or solidified HLW and the drywell storage field.

Spent LWR fuel is stored in canisters sized for either one PWR or three BWR fuel assemblies. Because the fuel cladding is considered the primary containment for the spent fuel, the canister provides an additional barrier as well as a means of handling the fuel assemblies in and out of the drywells. Solidified HLW in the form of borosilicate glass arrives at the facility already in a canister and therefore does not require packaging. The conceptual design for the canister package is shown in Figure 5.27.

The drywell storage field consists of vertical steel encasements with a 305-mm (12-in.) blanket of concrete buried in the ground in a rectangular array. The center-to-center spacing of the drywells is determined by the heat output of the waste package, the maximum allowable waste temperature, and the heat transfer properties of the soil. A conceptual site plan for an open-field drywell storage facility is shown in Figure 5.28. It is sized for solidified HLW packages with a 3-kW heat output, with drywell spacing suitable for dry, low-thermal-conductivity soil. Similar spacing is assumed to be required to maintain spent fuel cladding temperatures at or below 250°C (482°F) for 10-year-old fuel.



CANISTER TYPE	LENGTH, L	DIAMETER D	DIAMETER, D_2
PWR	5.53 M (18 FT 2 IN.)	0.36 M (14 IN.)	49 CM (19-1/4 IN.)
BWR	4.92 M (16 FT 2 IN.)	0.41 M (16 IN.)	49 CM (19-1/4 IN.)
HLW	4.83 M (15 FT 10 IN.)	0.36 M (14 IN.)	49 CM (19-1/4 IN.)

FIGURE 5.27. Spent Fuel Canister for Open-Field Dry Well Storage

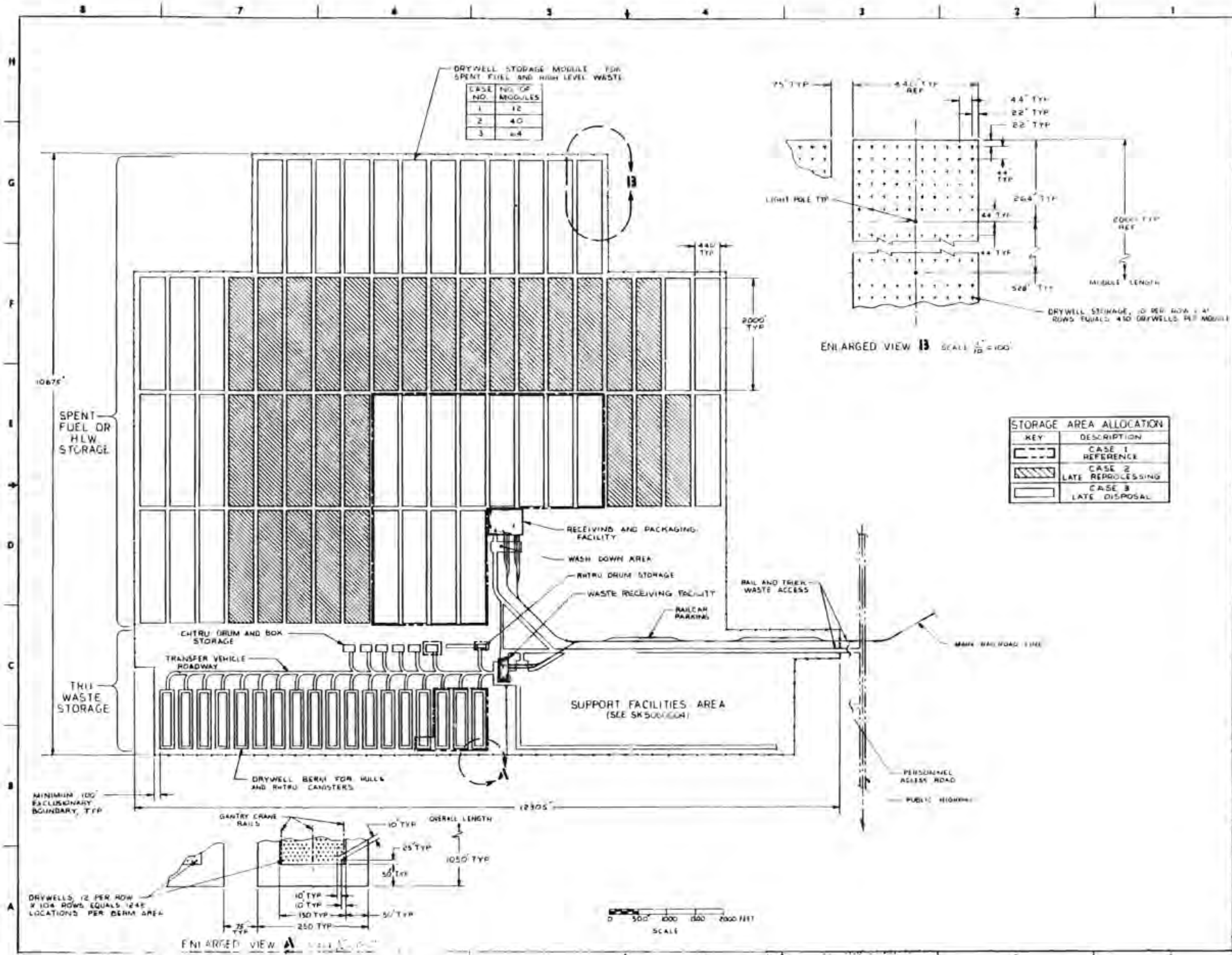


FIGURE 5.28. MRS/IS Stand-Alone Facility Drywell Storage Site Plan

The waste canisters are transferred to and loaded into the drywells using the transfer system, which consists of a transporter cask attached to a transporter vehicle. The primary functions of the transfer system for the drywell storage concept are to collect waste packages of spent fuel or HLW from the receiving and packaging facility load-out station, transport them to the storage field, position the transfer cask over the drywell, and place the canisters in the drywell encasement.

The transporter cask contains the waste package while providing continuous cooling and shielding during the transfer operation. The package is shielded by a vertical, cylindrical, bottom-loading cask complete with a hoisting mechanism and a grapple device to permit vertical loading and retrieval of the canister. The cask bottom section, including a cask closure gate and a retractable radiation shield sleeve, interfaces with the drywell for transfer of the package into the drywell. The cask and the shield sleeve will limit the radiation dose rate to no greater than 0.25 mrem/h at a distance of 6 m (20 ft) for the entire transfer operation. The bottom of the cask has a sealing device (such as an inflatable seal) to provide complete containment of the package during placement by direct contact with the drywell closure flange. Closed-circuit television cameras and monitors and other viewing devices inside the cask will verify package identity and control package placement and retrieval.

The transporter vehicle transports waste packages from the receiving and packaging building load-out station and places them in drywells at a specified rate per single-shift day. The 150-ton vehicle operates on engineered roadways in the drywell storage areas on large earthmover pneumatic tires at approximately 16 km/h (10 miles/h).

Positioning mechanisms adjust the cask vertically, horizontally, and angularly to align with the drywell centerline. A sand placement and removal system deposits and removes sand, which provides vertical shielding. The package and sand shielding material is transported to the storage area. The canister is placed in three steps:

1. Drywell preparation is accomplished by removing the temporary cover and inspecting, cleaning, and removing the closure plate.

2. Package placement occurs by aligning the transporter cask with the drywell center line and lowering the cask and seal to the drywell. The cask bottom gate is opened and the radiation shield lowered into the drywell. The canister is lowered into the drywell, and sand is discharged into the space above the canister.

3. Placement is completed when the sand fill is completed, the radiation sleeve retracted, the cask bottom gate closed, and the cask raised from the drywell. The top of the drywell is cleaned, and the top closure is placed and welded. Instrument installation is completed, and the sample valve is secured.

The packages may be retrieved anytime during the storage period. Package retrieval is generally the reverse of storage, using the same transporter vehicle.

5.4.3.3 Storage Vaults

Indoor shielded storage of RHTRU waste drums calls for construction of heavily shielded storage vaults. Because of the possibility of high dose rates, the concept requires remote operation for handling and placement of the RHTRU waste. The indoor storage vault is designed for RHTRU packaged in drums. The relatively few RHTRU canisters would be stored in the same facility as the spent fuel residue canister.

The basic storage module for indoor storage of RHTRU waste is a structure which has a capacity of 5000 drums (10 cells, 500 drums per cell). The general arrangement and section views of the storage building expanded to a capacity of 20,000 drums (40 cells) are shown in Figure 5.29.

The module has two main operating areas: 1) the service area, which comprises the cask receiving room, control room, and offices, and 2) the storage area, which comprises a series of adjacent twin cells separated by structural partitions. The storage portion of each cell is 20 ft square and 17 ft high. An additional 12 ft above the cells is needed for crane operation.

The RHTRU drum cask is delivered into the cask receiving room on a low-boy truck or tractor-trailer. Unloading, moving, and stacking of the RHTRU waste drums are accomplished with a remotely operated bridge crane.

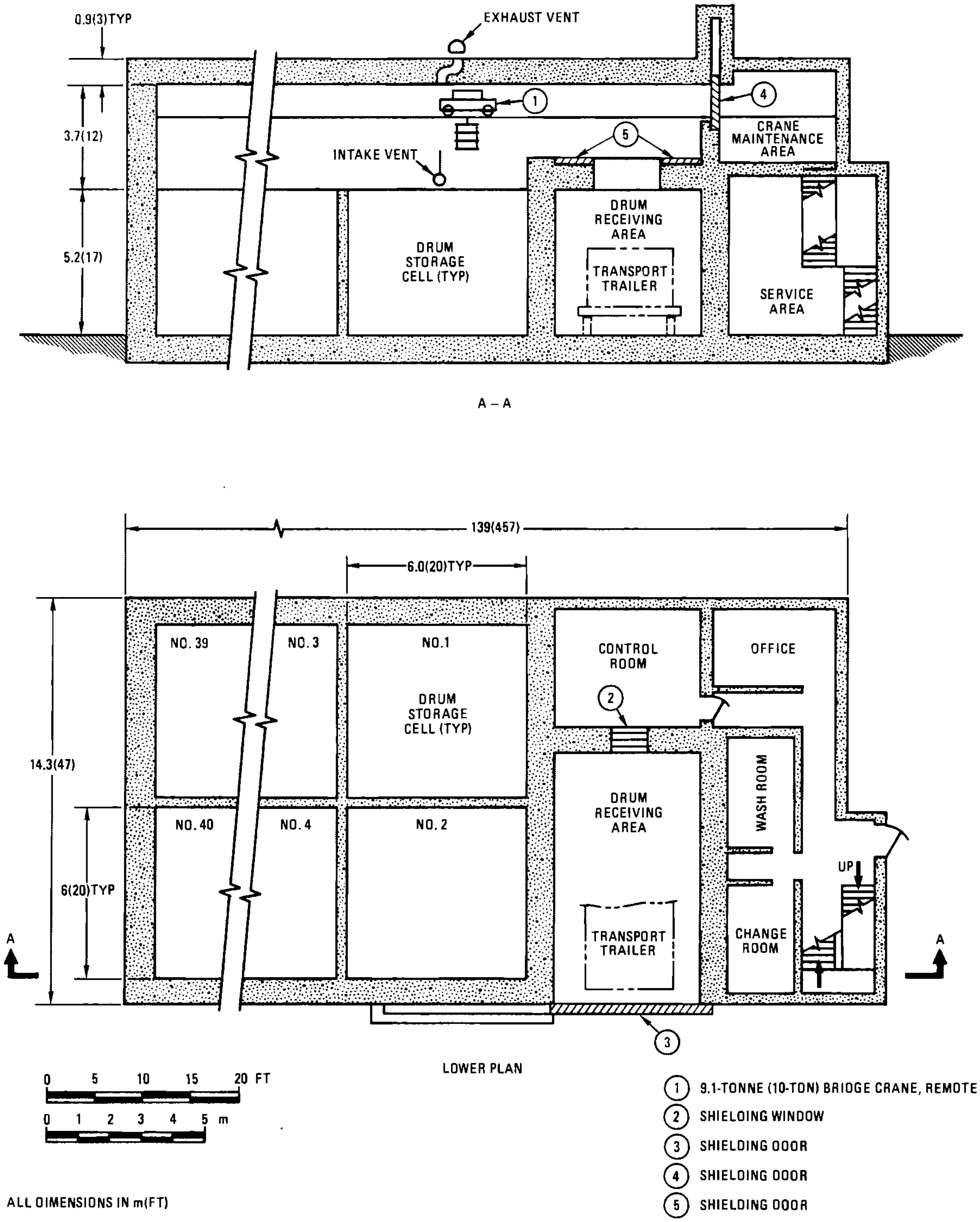


FIGURE 5.29. Indoor Storage Facility for RHTRU Waste

To permit quick unloading, a drum surge area is provided at the upper level, directly above the control room, so that about 90 drums may accumulate. The 10-ton bridge crane is remotely operated from the control room, which contains television monitors. The crane runs over the entire length of the storage area and transports the drums using a vacuum-operated lifting device. Positioning, viewing, and unloading of drums is aided by two television cameras carried by the crane at bridge level and by spotlights that illuminate the entire work area. When the crane requires maintenance, it can be moved to the crane maintenance area, which is separated from the storage area by a guillotine-type shielding door. Air circulation through the storage area is provided by ventilation openings located in the roof and walls of each cell. Monitoring systems are installed to sample the air within the cells.

Shipping casks containing drums of RHTRU waste drums and arriving by rail are transferred at the TRU waste receiving facility to a site transporter for delivery to the RHTRU storage building. Truck-borne shipping casks are routed directly. The storage facility provides equipment for the remote transfer of the RHTRU waste drums from their shielded shipping casks to their shielded storage cells.

5.4.3.4 Storage Berms

The RHTRU and fuel residue canisters are stored in drywells similar to those described in Section 5.2.2 or in drywells located in berms as described in Section 5.3.3.2. The choice is dependent on site conditions. Berm storage of the RHTRU and fuel residue canisters is assumed for the stand-alone MRS/IS facility.

The site transfer cask provides continuous shielding of the fuel residue canister during transfer from the TRU waste receiving facility to the storage berm. The transfer cask is transported by a site tractor-trailer combination and comprises a heavily shielded bottom-loading cask equipped with isolation valve and internal hoist and grapple mechanisms.

5.4.4 Service Facilities

The MRS/IS support facilities include all buildings, structures, and utility and other systems required to support the spent fuel/HLW and TRU waste handling and storage areas. The location of the support facilities is shown in Figures 5.26 and 5.28. A plot plan of the building arrangement within the support facilities area is shown in Figure 5.30. The support facilities area, including vehicular and rail access routes, is placed so as to maintain the operation of the adjoining spent fuel/HLW and TRU waste areas and to maximize site security and safety under emergency situations.

The buildings and structures in the MRS/IS support facilities area are:

- administration, industrial relations, and cafeteria building
- security and gatehouse building
- firehouse, clinic, and emergency vehicle building
- visitor center
- environment and instrument laboratory building
- laundry
- warehouse
- general maintenance building
- locomotive maintenance building
- truck and rail car inspection area
- standby power building and electric substation
- compressor and chiller building
- cooling tower
- steam plant building
- coal thawing and unloading building
- coal storage building.

The design requirements for these buildings, systems, and the projected staffing levels are presented in Sections 2.1.1 through 2.1.16 of Reference 1.

The utility and service support systems required for the MRS/IS facility are:

- electric power system, including the primary, standby, and uninterruptible supplies
- water supply system, including yard piping, pumps, and water treatment system
- sewage treatment system

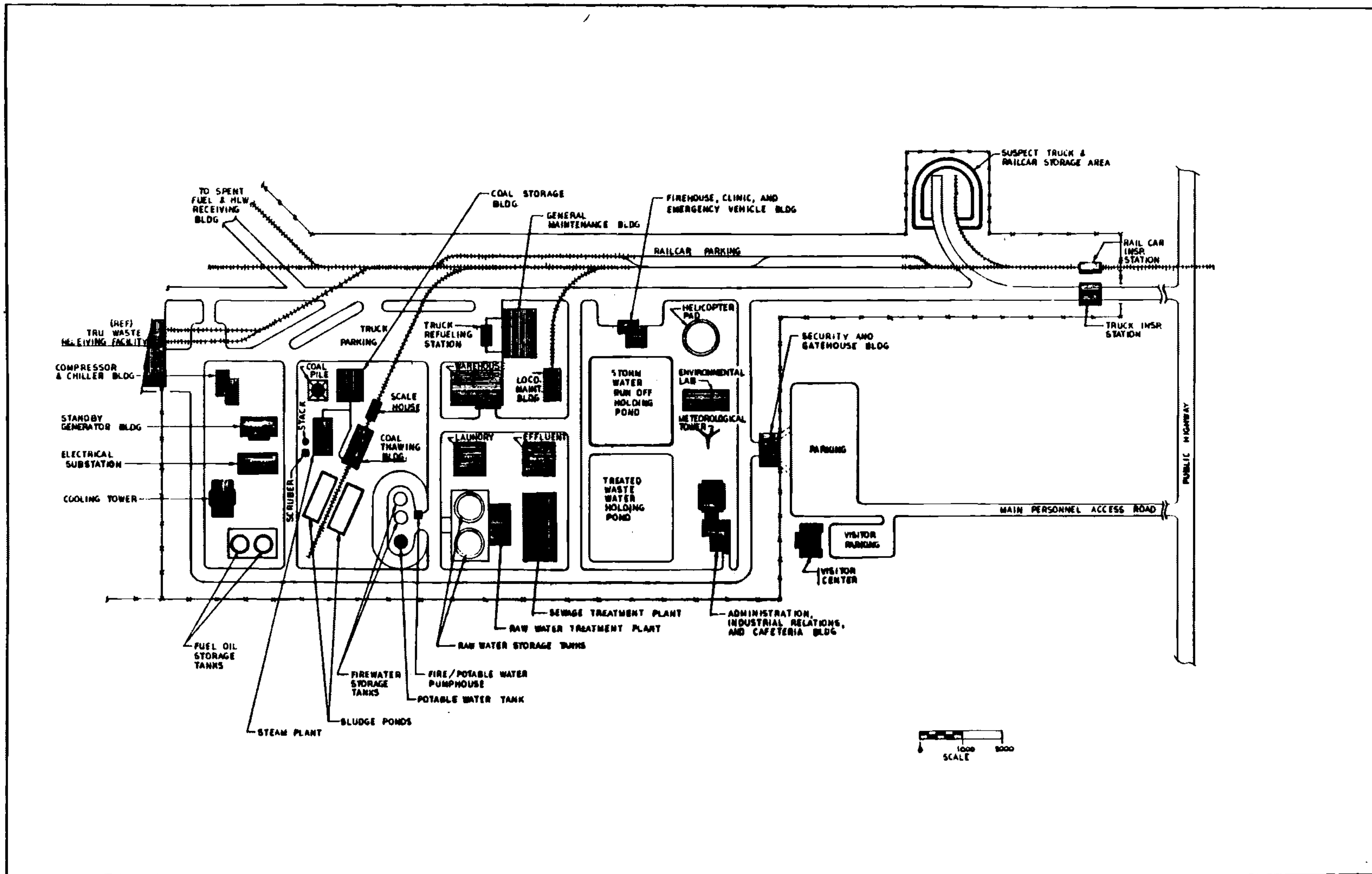


FIGURE 5.30. Support Facilities Area Site Plan

- compressed air distribution system
- chilled water distribution system
- steam distribution system
- fire water/potable water system.

5.5 MRS/IS FACILITY CO-LOCATED WITH A REPOSITORY

The MRS/IS facility described in this section comprises a waste handling facility where the incoming waste shipments are received and the individual fuel assemblies/HLW canisters/TRU containers are examined and decontaminated and/or repackaged as appropriate before transfer to the storage areas. The MRS/IS facility also contains storage areas where the spent fuel assemblies and HLW canisters are stored in either large metal storage casks standing on support pads or in subsurface drywells with the surrounding soil providing shielding. Remote-handled TRU wastes (RHTRU) are stored in concrete casks standing on support pads in the storage areas, and contact-handled TRU wastes (CHTRU) are stored in a surface warehouse. Transfer of the stored wastes from the storage areas to the repository is accomplished after the repository is opened.

5.5.1 Receiving and Handling Facility

The waste handling facility (WHF), illustrated in Figure 5.31, is used to receive, examine, and prepare for storage both remote-handled and contact-handled waste. It provides space and systems so the process functions can be accomplished effectively and safely as well as providing the necessary support activities and functions. Its requirements are basically independent of the storage concept used (i.e., surface casks or subsurface drywells). However, requirements and/or size or capacity will vary with the various fuel cycle and transportation scenarios. Also, if the drywell storage concept is adopted, additional provisions and capabilities will be required to overpack all fuel elements on a production basis in the WHF. The building is the sealed-confinement type with ventilation systems adequate to prevent exposure of the public to radiation doses in excess of allowable limits.

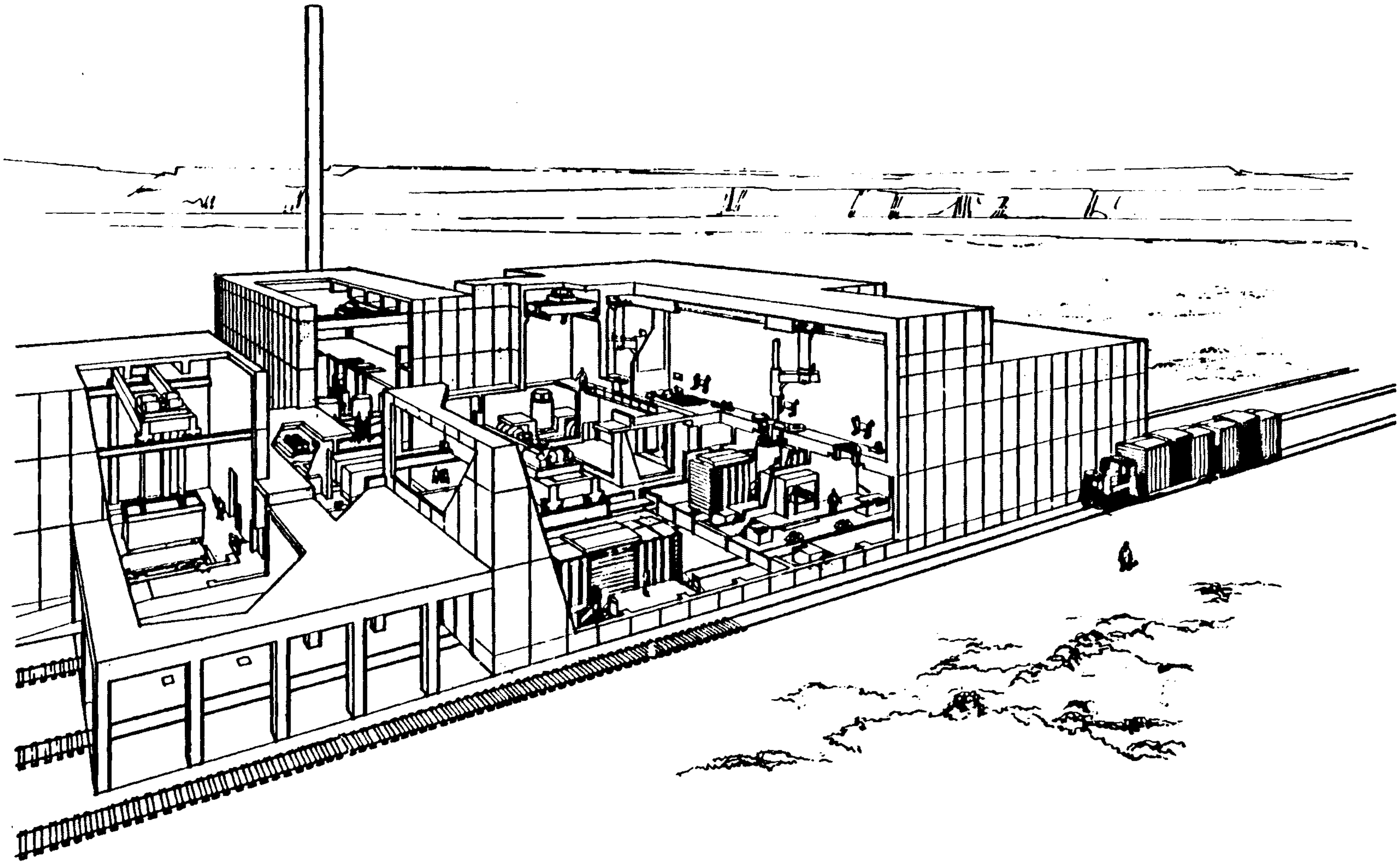


FIGURE 5.31. Waste Handling Facility

The core of the WHF (Figures 5.32, 5.33 and 5.34) is designed for the handling and transfer of waste packages that require remote handling. This is done in a series of hot cells located on an upper level and flanked by operating and service galleries. On the ground floor, beneath this group, the shipping cask unloading area provides a space in which the incoming cask is upended and connected to the shielding sleeve from the primary hot cell, thus providing a confined route for transfer of fuel, canisters or drums from the cask to the primary hot cell. Below the secondary cell is another transfer corridor for loading the casks to be transferred to storage.

The second waste handling area in the facility is for waste packages that can be contact-handled. After preliminary inspection and washdown, the drums or containers are removed from the carriers; inspected for damage, radiation and surface contamination; decontaminated or modified if necessary; and placed on pallets as appropriate for transfer to storage.

The building support areas include radwaste treatment facilities, ventilation and filter rooms, mechanical and electrical rooms, service areas, and administrative areas.

Two separate ventilating systems are furnished in the building: the confinement system for the waste handling areas, and a standard ventilating system for support and administrative areas. The confinement system supplies fresh air to the negative pressure zones of the waste handling areas and exhausts it through a filter system (which includes HEPA filters) to the stack.

The cask receiving and shipping portion of the facility can accommodate at least two rail cars or trucks at any given time. Shipping casks transported either by rail or by truck are inspected, cooled and, they and their contents are transported to the transfer or packaging portion of the facility. This portion of the facility consists of two basic areas: 1) cask carrier preparation and 2) cask and material transfers or unloading. The preparation activities are carried out in enclosed spaces that also serve as air locks for truck and rail car entry into the transfer area. This portion of the facility has the process functions shown in Figure 5.35.

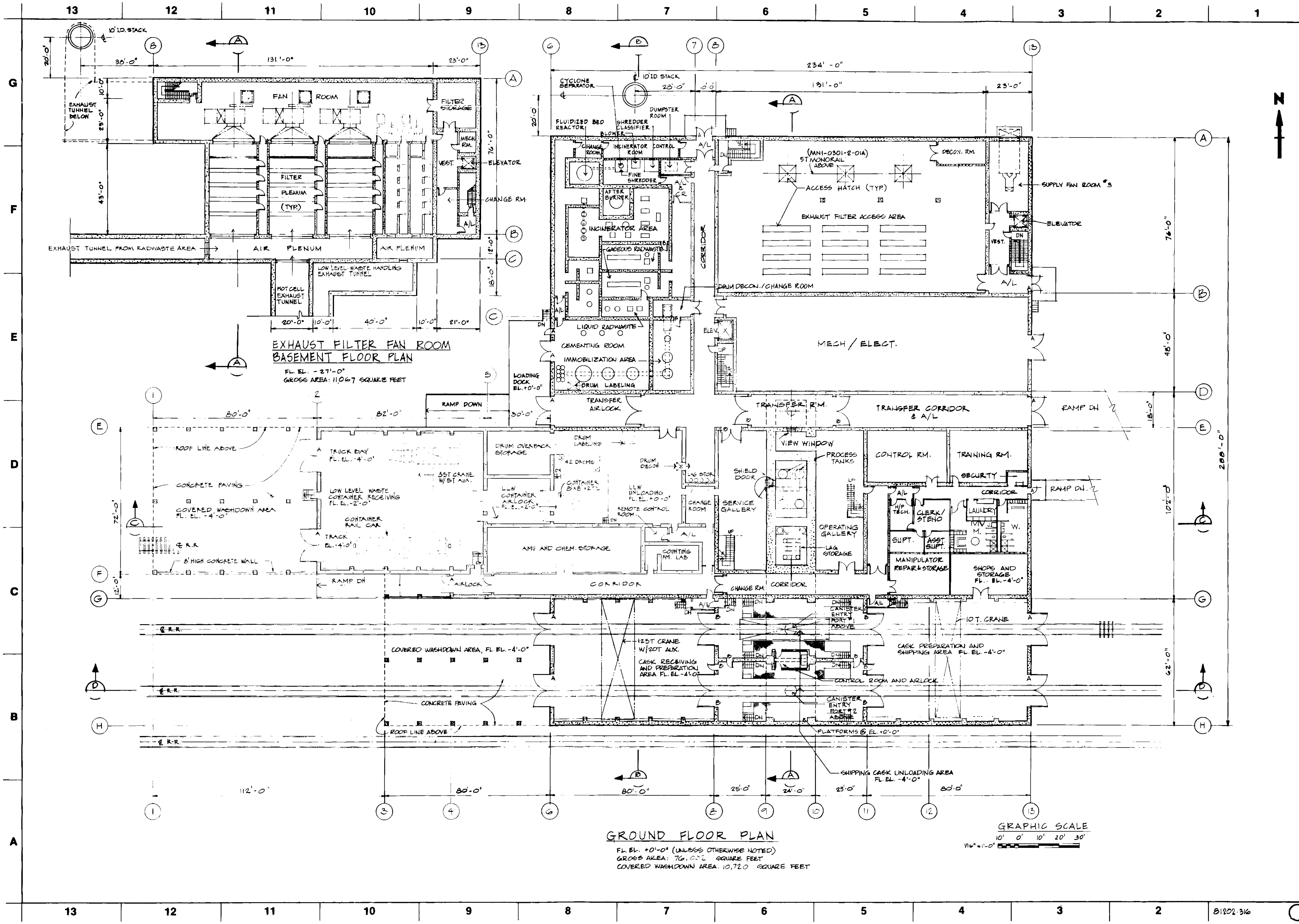


FIGURE 5.32. Waste Handling Facility - Ground Floor Plan

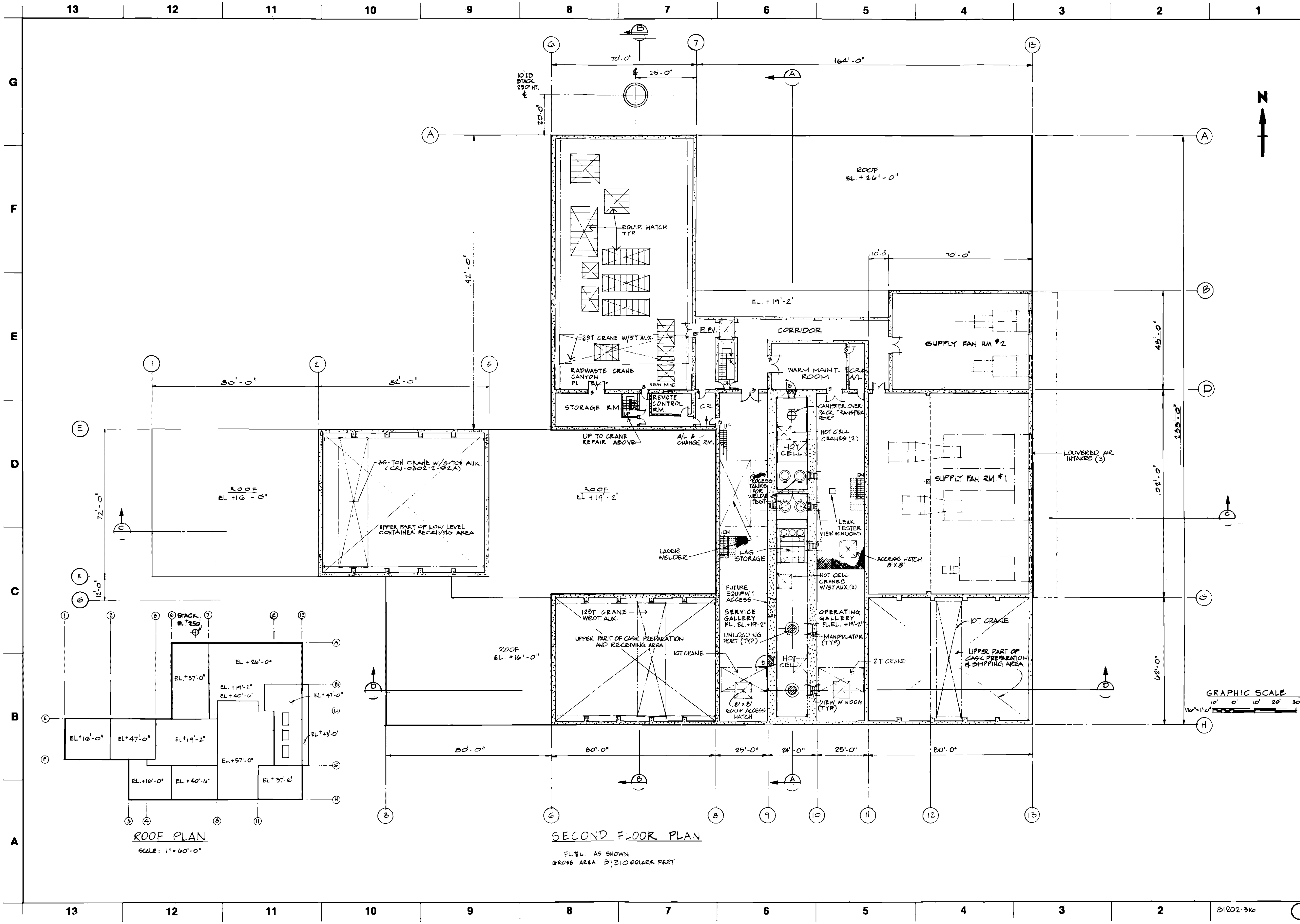


FIGURE 5.33. Waste Handling Facility - Upper Levels

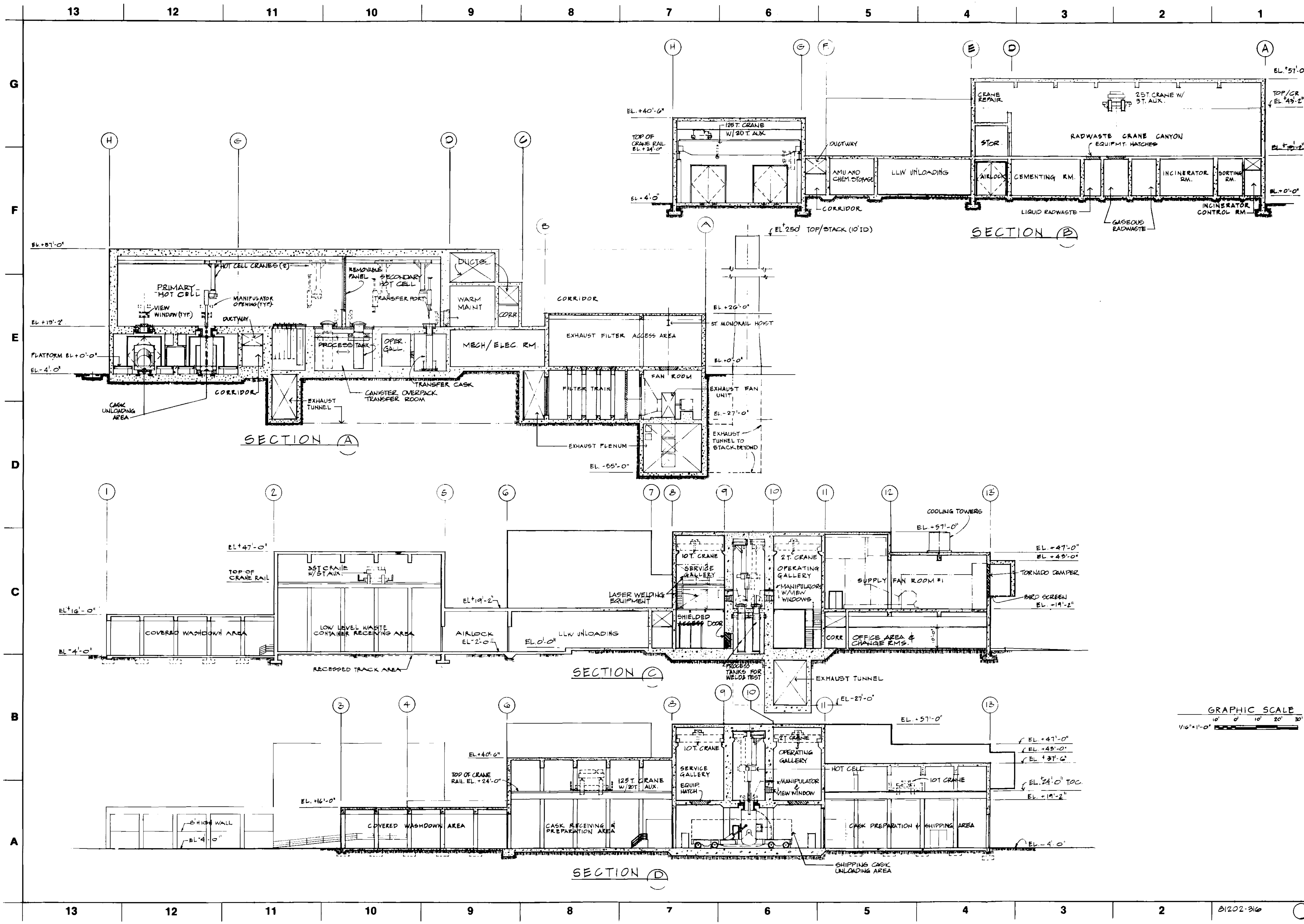


FIGURE 5.34. Waste Handling Facility - Sections and Elevations

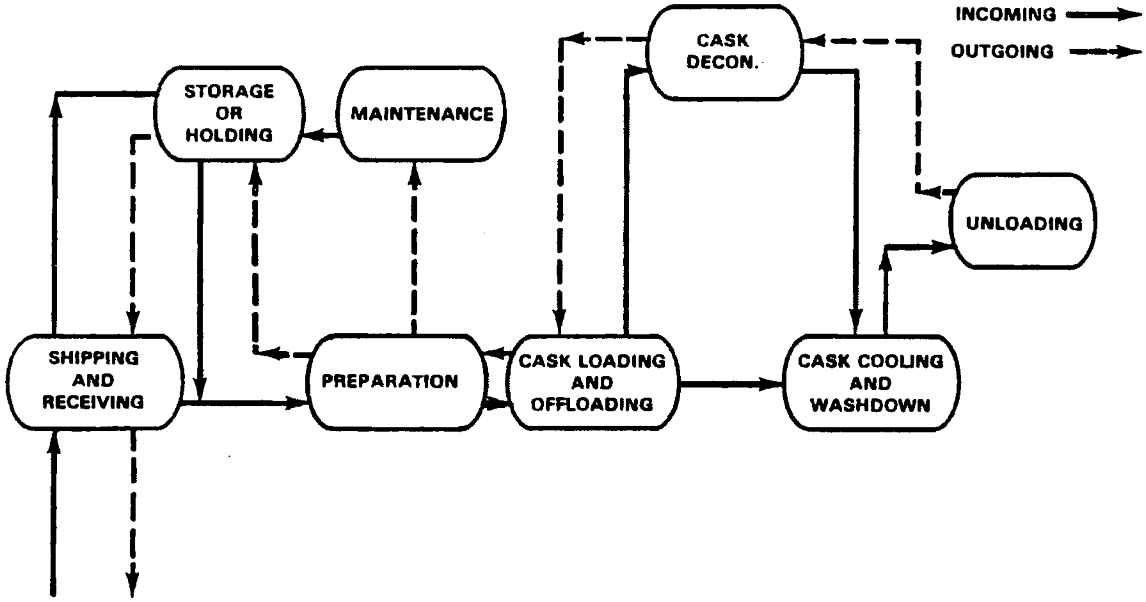


FIGURE 5.35. Cask Receiving and Handling

If the cask is shipped in a horizontal position it is raised to vertical position on the transporter or set in a vertical position on a special car. Then it is moved beneath the primary hot cell and mated with a shielded collar lowered from the cell. After removal of the shielding plugs from the hot cell and the cask, each canister or fuel bundle is raised up into the hot cell. After the fuel bundle or waste canister is checked as necessary, it is stored temporarily in a lag storage location or is placed in one of the process tank areas or cells. These areas have the capability of enclosing fuel bundles or canisters in an overpack, inspecting spent fuel or completed waste packages (both helium-leak and ultrasonically tested for structural soundness), and decontaminating if necessary. Clean canisters and packages are transferred from the primary process cells to the secondary (and clean) hot cell. From there the completed waste package is lowered through shielding collars into a storage cask, which can be sealed and made ready for transfer to storage area.

Remotely operated cranes, manipulators or devices are used to perform the following functions in the transfer and packaging hot cells:

- remove and replace shielding plugs for cell ports
- unlock/lock and remove/replace cask shield plugs

- extract material packages from shipping cask, move them to and through the hot cells, place them in transfer or storage casks; also the reverse of the above sequence

5.5.2 Transfer and Storage of Contact-Handled Waste - TRUSS Facility

The Transuranic Surface Storage (TRUSS) facility, shown in Figure 5.36, is an above-ground, warehouse-type building designed to optimize life cycle costs for CHTRU drum and steel box storage while maintaining safety, security, and storage environment requirements. The facility provides indoor container storage in clean, dry conditions. State-of-the-art handling and storage methods permit efficient operation with forklifts and a minimum of operating personnel. Containers on pallets are transported to the TRUSS facility by forklift, truck or rail. The necessary segregation of TRU waste types is accomplished within the facility by zoning with interior walls and aisles, or by covering arrays of similar containers with fire-retardant covers. The facility is sized to accommodate primarily the drummed and boxed CHTRU waste generated between start-up of the reprocessing plant and start-up of the co-located repository, Table 5.7.

A precast concrete building is used for the TRUSS facility to meet requirements of containment and protection. A fairly tight building with an inward-directed air flow provides reasonable assurance of meeting this objective. This type structure also provides ample protection from plausible natural events. Floor and loading bay areas are designed to accommodate the handling equipment and containers.

Deliveries to the TRUSS facility are normally made by truck from the WHF and are received in an enclosed loading bay which fully contains the delivery trucks or trailers. The loading docks in these bays match the height of truck or trailer beds to permit forklift unloading and storage operations. Fifty-five-gallon drums are handled by forklifts equipped with drum handling tongs, and stacked in rectangular modules in designated areas in the building. Drums are stacked no more than 5 layers high, but the storage arrays may be any convenient length or width. Forklifts configured with regular tines handle TRU boxes and preassembled 6- or 12-packs of 55-gallon drums.

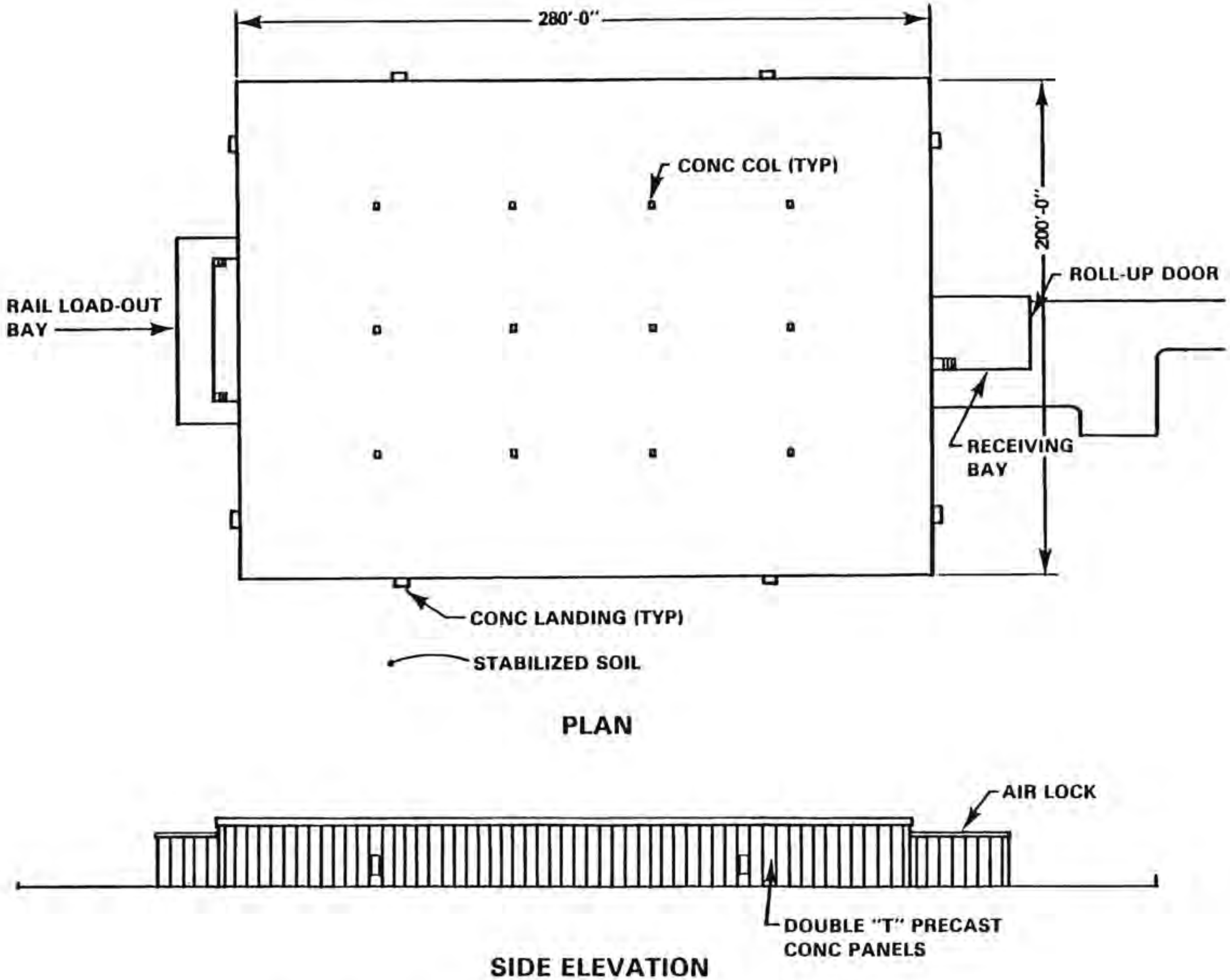


FIGURE 5.36. Transuranic Surface Storage Facility

TABLE 5.7. MRS/IS Reference Scenario Storage Requirements

	MTHM	Containers	Casks Required	Comments
HLW-1 ft dia. x 10 ft	10,500	4,900	350	REA-2023 cask, 14 canisters per cask
RHTRU-2 ft dia. x 10 ft		3,845	1,282	Concrete cask, average 3 containers per cask
RHTRU-55 gal		4,486	408	Concrete cask, 12 drums per cask
CHTRU-55 gal[(a)]		34,076		
CHTRU-4 ft x 6 ft x 6 ft[(b)]		286		

(a) Stacked four high, ~35,000 ft^2 required.
(b) Stacked two high, ~3,500 ft^2 required.

The relative humidity inside the TRUSS facility is below critical levels for the vast majority of the storage periods, even without mechanical dehumidification equipment or heating.

Radiation monitoring and alarm systems are provided in the TRUSS building, in the ventilation stack, and exterior to the building, to detect any inadvertent releases.

5.5.3 Transfer and Storage of Remote-Handled Wastes - Casks

Two different types of storage casks are used. The REA is the reference cask for fuel and HLW storage. This cask is compatible with loading and unloading procedures which are common to reactor and reprocessing plants. The cask can be handled and stored in either a horizontal or vertical attitude. The cask design permits continuous monitoring of both primary and secondary containment.

For storage of RHTRU, concrete casks, as shown in Figure 5.37, are used. The concrete casks are up to 9 ft in diameter by 16 ft long and weigh up to 90 tons. Different bore sizes and shielding thicknesses are used to accommodate different cask payloads, which vary from one 2-ft diameter by 10-ft long RHTRU canister to twelve 55-gallon drums.

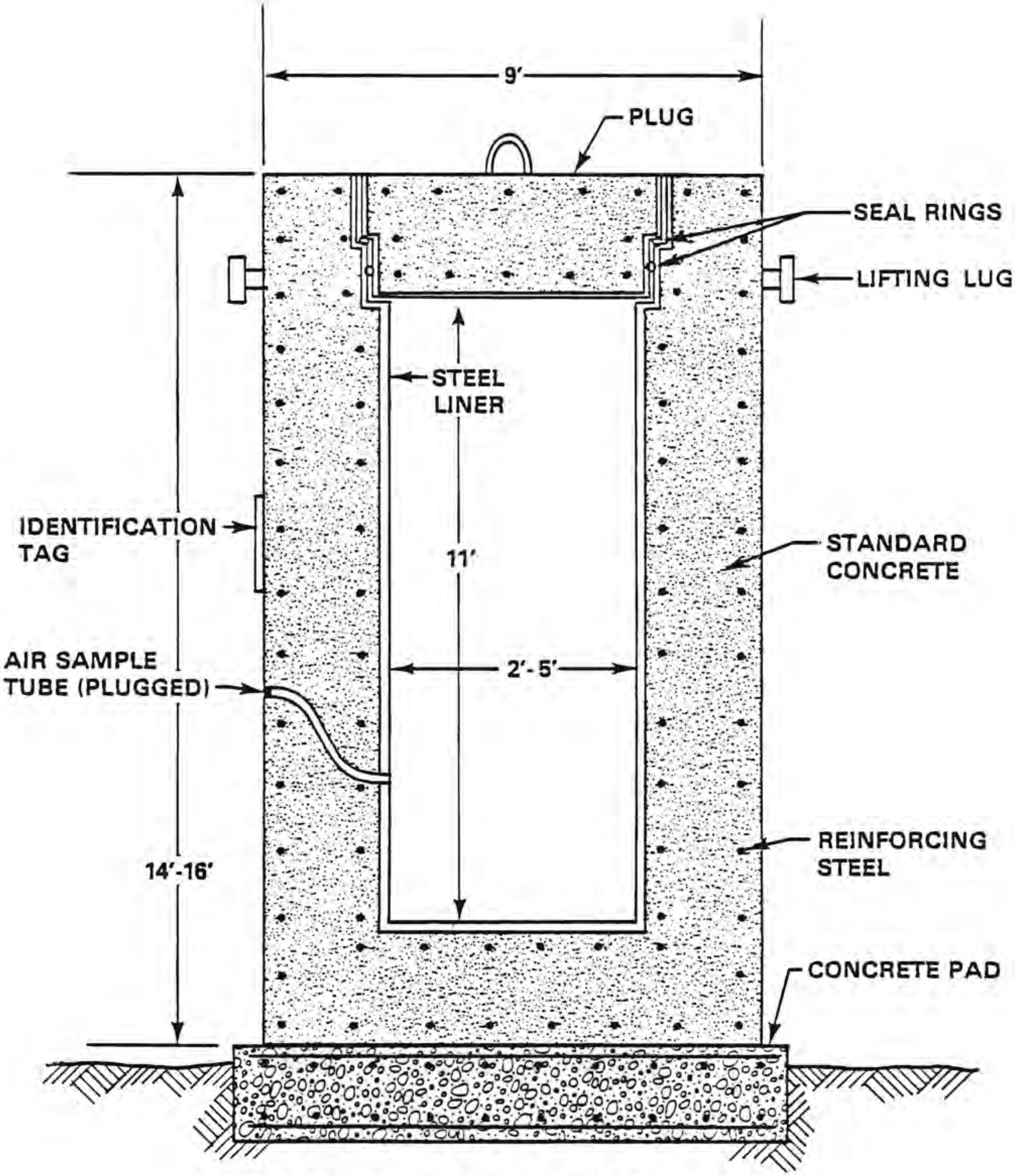


FIGURE 5.37. Concrete Cask for RHTRU Waste Storage

The same handling, unloading and storage system is used for all casks. This system uses above-ground storage on reinforced concrete pads. A typical storage yard is 200 ft by 1850 feet and accommodates about 1000 casks on a nominal 20-ft spacing.

5.5.3.1 Surface Cask Storage

After a cask storage unit is filled in the WHF, it is loaded onto a pneumatic-tired transport trailer and towed into the cask storage area by a wheel tractor. The storage area is served by a mobile yard gantry crane, which spans two rows of storage units with an aisle between the rows for transport trailer access. This allows the gantry crane to unload a storage unit on either side of the transport trailer, as shown in Figure 5.38. In the storage area, the transport trailer meets the yard gantry crane at the placement site. The gantry crane attaches to the storage unit by means of a cab-controlled power-operated load grab, lifts the cask unit clear of the trailer bed and places the unit in final position on its preconstructed concrete foundation pad. While performing the unloading operation, the gantry crane stands on power-operated stabilizing jacks and operates as a fixed gantry.

The transport and yard gantry crane system can retrieve any storage unit from any position in the storage area by reversing the procedure of the normal delivery. The storage area aisles provide unlimited access to any single storage unit, and retrieval cycle time is comparable to the delivery-placement cycle time.

For the waste casks, the storage area is subdivided into lots of ~1000 storage units. The array spacing within each lot, to provide 400 ft^2 for each storage unit in conformance with design limitations for handling operations is as follows (center-to-center of storage units):

- parallel to travel of transport trailer and yard gantry crane - spacing alternately 21 ft to 27 ft.
- transverse to travel of transport trailer and yard gantry crane - spacing nominally 16 ft 8 in.

The above arrangement and spacings are based on the reference 8 to 9 ft diameter casks, but they can be modified to accommodate casks of different

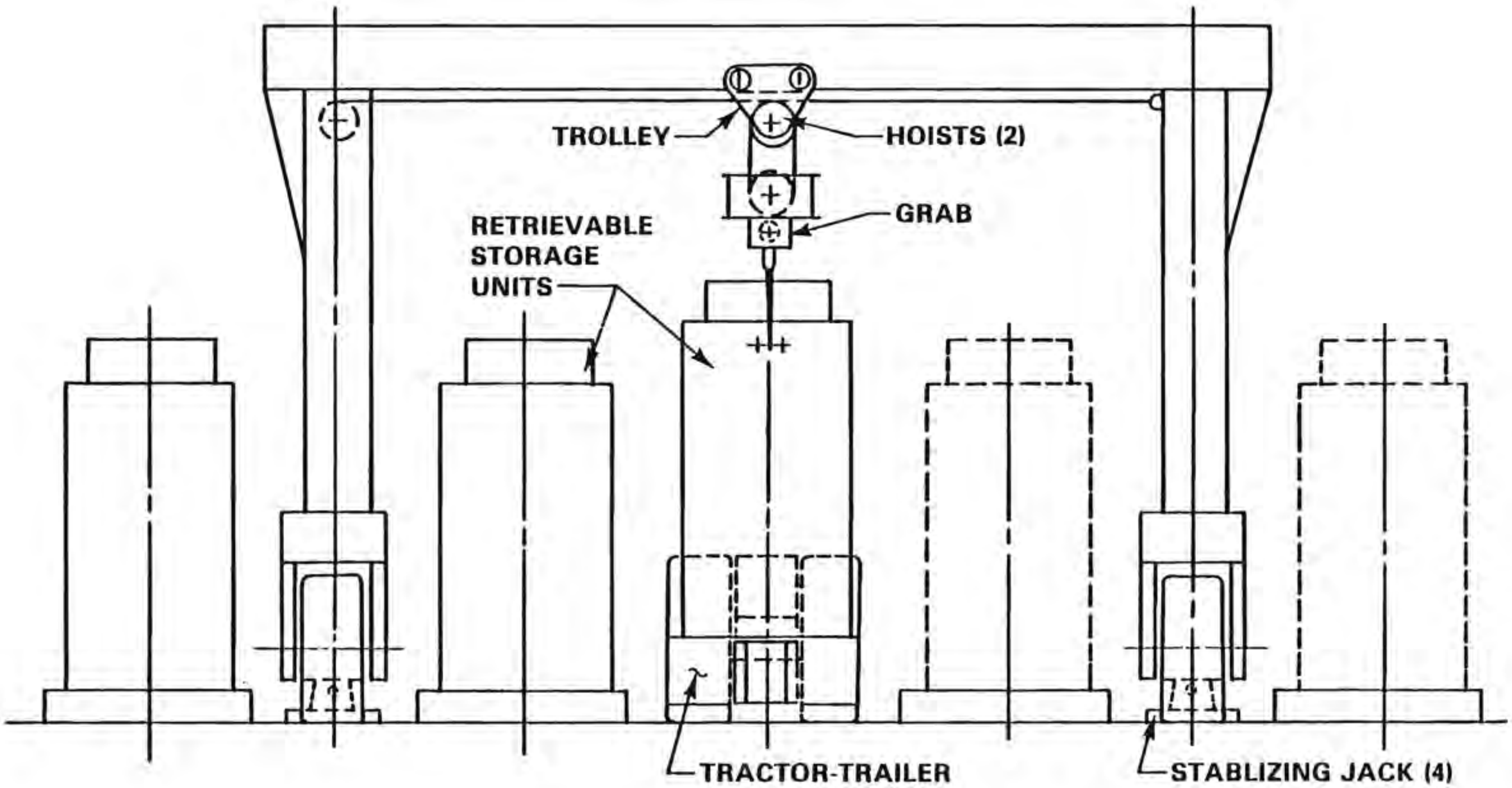


FIGURE 5.38. Yard Gantry Crane

sizes (within reasonable limits). Different cask sizes would only change the internal array arrangement and not the land usage of the storage system.

The initial storage area fence will enclose an area capable of storing waste through the year 1995. Initial construction will consist of about 100 foundation pads, which is the number required for the first 5 years of facility operation for the reference scenario.

Foundation pads for support of the waste storage units are poured in place. The pads are octagonal, circular or three smaller square reinforced concrete slabs on grade, approximately 18 inches thick. After construction of the initial 100 pads, they will be built in quantities dictated by the placement schedule.

The area between storage pads, and the lightly traveled portions of the wide aisles between lots, are treated with defoliant, graded, and surfaced with 8 inches of crushed rock. This surface is considered adequate for travel by the transport equipment and yard gantry crane equipped with wide base earthmover-type pneumatic tires, and for use by surveillance and maintenance vehicles. The main roadway portions of aisles, where repeated and heavy traffic is expected, and feeder and collector roadways traveled by the transport equipment are 10 inches of compacted aggregate over a prepared and compacted subgrade.

The transport trailer is a 110-ton capacity, low-bed, four-wheel trailer, running on wide base earthmover-type pneumatic tires. The tractor for the transport trailer is a four wheel, pneumatic-tired, diesel-engined unit which has electric power and lighting to allow night operation in the storage area. The mobile yard gantry crane is a self-contained, self-propelled, straddle-type lifting system, with rated lifting capacity of 110 tons when stationary on stabilizing jacks. Initial equipment complement is one tractor, trailer and mobile yard crane.

5.5.4 Transfer and Storage of Remote-Handled Wastes - Drywells

Below-grade drywells could be used for the interim storage of waste requiring major shielding and isolation. If RHTRU waste packages of a configuration not compatible with drywell dimensional limits are received, they could be stored in concrete casks as previously discussed.

Dry well passive storage consists of the reference drywell (described in Section 5.2.2) extending about 24 ft into the ground. The ground provides shielding from radiation and permits dry heat dispersion by conduction through the surrounding soil to the atmosphere. The bottom of the pipe is sealed by welding and the top of the drywell is sealed by gasketing or welding. A small sealed tube is provided for periodic sampling of the drywell interior for airborne activity.

After a drywell package, which would typically contain three BWR fuel elements, one PWR fuel element or one HLW canister, is either prepared or checked out in the WHF, it and sand shielding material are transported to the storage area in a shielded cask transporter vehicle.

The transporter is supported by and travels on large earthmover-type pneumatic tires. The fuel and HLW canisters are shielded by a vertical, cylindrical bottom-loading cask mounted on the transporter. The cask is complete with a hoisting mechanism and a grapple device to permit vertical loading and retrieval of the canister. The transporter is equipped with positioning mechanisms for vertical, horizontal, and angular adjustment of the cask for alignment with the drywell centerline, and is capable of handling a package with maximum dimensions of about 18 ft 6 inches in length and 16 inches in diameter. The heaviest package weight is ~3850 pounds. The sequence of the canister placement, as illustrated in Figure 5.39, is accomplished in three major steps: drywell preparation, package placement, and drywell closure.

The storage area consists of a rectangular array of the reference drywells buried in the ground, with a uniform 17-ft center-to-center spacing for spent fuel assemblies and a 44-ft spacing for HLW canisters. The initial storage field for fuel contains about 1110 drywells, with primary and secondary road systems for package transport, support equipment, and security vehicles.

The storage area is expandable by modular construction of drywells to ensure a minimum availability of 1 year of storage capacity in advance of ongoing storage operations. It is assumed that the soil will effectively transfer 1 kW/hr of thermal decay heat from the spent fuel packages to the

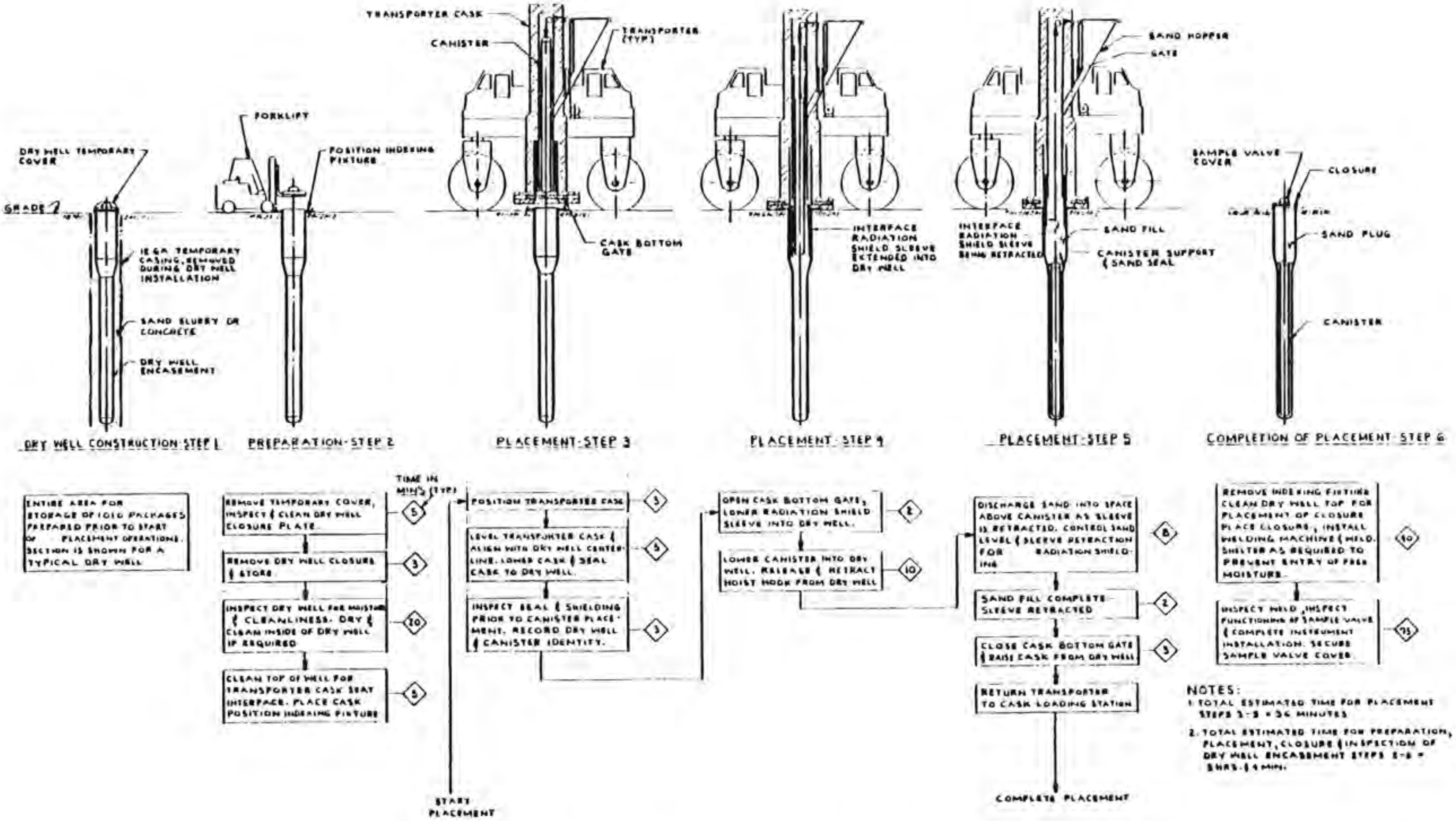


FIGURE 5.39. Drywell Canister Unloading Sequence

atmosphere on a 17-ft spacing. However, to facilitate the transfer of the 2.3 kW/hr decay heat from the HLW packages, an 11- to 12-inch blanket of a more highly conductive material (e.g., concrete) is placed around the drywell encasements that are on 44-ft spacings.

5.5.5 Service Facilities

In addition to the WHF and the storage areas, other support and servicing buildings and facilities as shown in Figure 5.40 are provided for the efficient and safe operation of the MRS/IS facility, first in its role as interim storage and later as the basic surface facility for the co-located repository. Because of the existence and close proximity to various site services such as fire and emergency vehicles, no site-specific facilities are provided for these. The major facilities provided are:

Administration Building. A one-story building of 6000 to 8000 ft^2 provides office and storage space for the onsite administration, quality assurance, safety, and engineering personnel. Overall administrative functions are conducted in other existing site buildings.

Maintenance Building. A one-story building of about 15,000 ft^2 provides the supporting shops and associated shop storage for the MRS/IS operation.

Material Warehouse Building. The material warehouse, a building of varying heights, consists of two functional portions: a high bay building of about 50 ft high and a low bay for administrative and small equipment storage. The total building has an area of about 20,000 ft^2. The high bay portion of the building has a bridge crane for handling operating supplies and spare equipment for the WHF and other support buildings. Forklift truck access is provided for stacked pallet racks and floor storage areas. Also, areas are provided for outdoor storage of large equipment items.

Gate Houses. There are two, one-story gate house buildings for the area. The first provides a security check area for entering employees and visitors and the second is for rail car and truck shipments. Truck inspection and rail car inspection pits are provided adjacent to the second guard station.

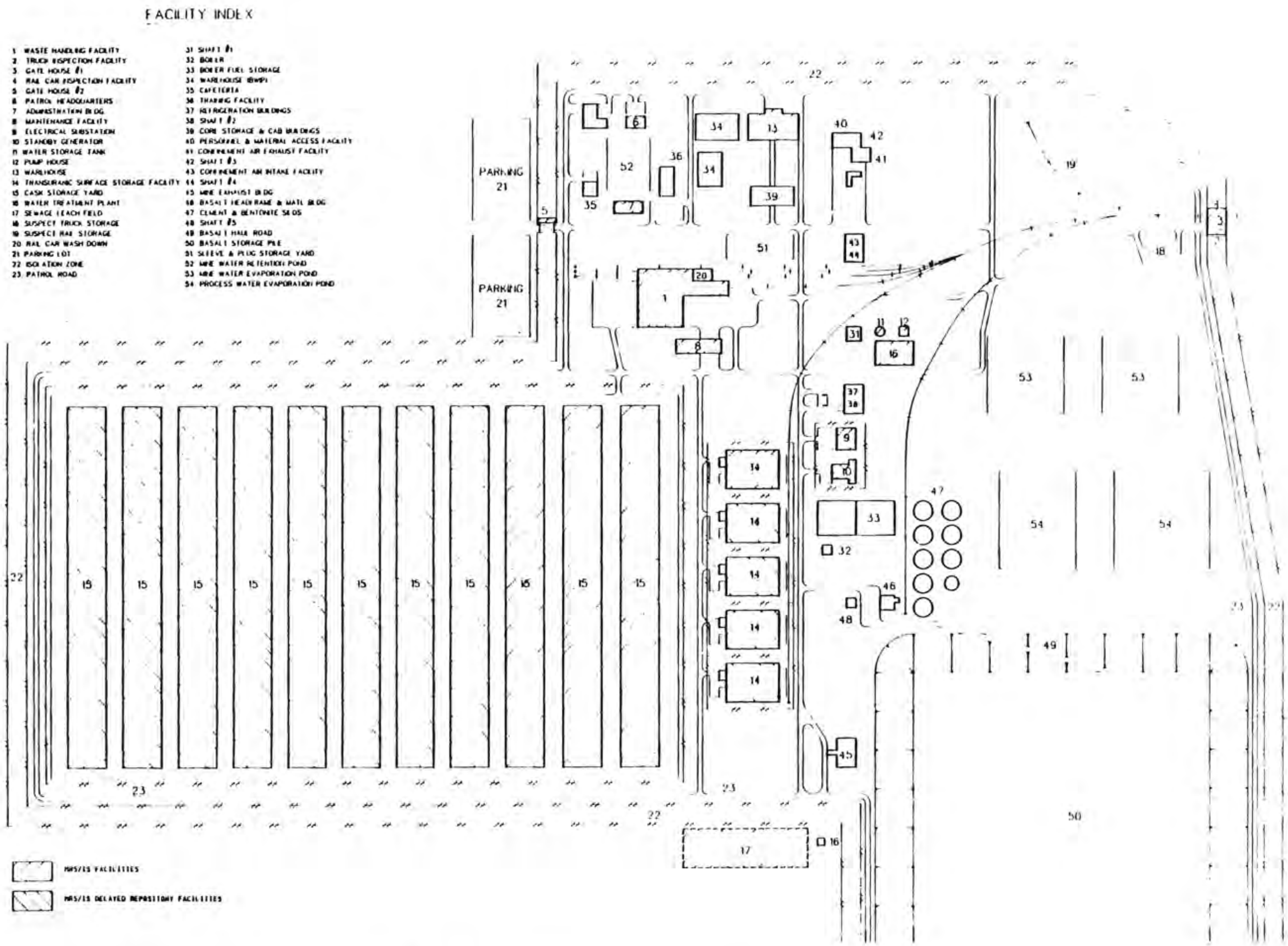


FIGURE 5.40. MRS/IS/Repository Arrangement

5.5.6 Service Utilities and Systems

Water, electrical power, roads and railways to the MRS/IS facility are assumed to be available from sources on the site. Descriptions of these utility systems plus several in-area systems are given below.

Water Supply. Water will be supplied from an existing export line pumping station. This water supply delivers water to the required in-plant systems; these include the raw water system, water treatment, water storage, water distribution and the fire protection system. A water treatment plant is provided for a sanitary water supply. Distribution pumps will maintain a 100 psig normal distribution network for sanitary and process use. The fire protection system will include a 250,000-gallon water tank and two fire pumps discharging into the facility water distribution network supplying fire hydrants, sprinkler systems and fire hoses. One pump will be electric-motor-driven and one will be diesel-engine-driven.

Electrical Power Systems. Normal and emergency standby power systems will be provided. Offsite power will be obtained at 115 or 230 kV and will be brought to a new substation that will reduce the voltage to 13.8 kV. Dual electrical feed systems to the substation are planned for maximum reliability. From the main substation the power will be distributed to the various building and centers via 13.8 kV direct burial cables.

Emergency standby power will be provided to vital systems by means of a turbine generator set. An essential function of this system is to restore power to those essential loads which must maintain safety functions but can accept short duration interruption in power. Uninterruptable power will be supplied by batteries to those systems that cannot accept short duration interruptions.

Sanitary Waste Disposal System. A sanitary waste disposal system is provided to collect, treat, and dispose of a maximum flow of 10,000 gallons/day of sanitary waste generated at the proposed facility. Sewage collection is through an underground gravity pipe system. The sewer pipe is laid under 4-1/2 feet of earth cover for frost protection. Sewage is treated in a prepacked, extended aeration, biological treatment plant which meets all local, state and federal effluent discharge standards. Effluents from the treatment plant are discharged to an offsite subsurface tile drainage field. Wastes from potentially radioactively contaminated sources are not discharged to the sanitary waste disposal system, but are treated within the facility waste treatment system.

Communications and Fire Alarm System. Communication systems for the facility include a PA system, a plant intercom system, and telephone systems for both inside and outside calls. Security communications are handled primarily by the site radio system. Evacuation, radiation alert, and fire alarm systems also are provided.

Radiation Monitoring and Surveillance. Radiation monitoring is conducted both inside and outside the buildings and in the storage yards to assure that radiation levels and airborne particulate levels on or about the facility or area do not exceed preset limits. Monitors located in areas frequented by onsite personnel have local alarm capability. Other monitors and monitoring devices are under continuous surveillance at the environmental console or are periodically checked by health physics personnel.

Area and perimeter monitoring are accomplished with continuous air monitors (CAMs) and ion-chamber-type dosimeters strategically placed around the outside boundary of the site to provide continuous monitoring of the immobilized spent fuel and remote handled wastes. The heaviest concentration of units is located downwind from the facility. The CAMs are of the fixed-filter type and designed to withstand exposure to adverse elements of the environment.

Radiation monitors are placed strategically around the outside boundary of the site. The heaviest concentration of units is located downwind of the prevailing winds. Three types of monitors are used: area gamma monitors, beta-gamma particulate monitors, and thermoluminescent dosimeters.

REFERENCE

1. GA-1981. Monitored Retrievable Storage Tunnel Rack Concept, Volume 3: Support Facilities, DOE Report GA-A106370, General Atomic Company, August 1981.

6.0 STUDY RESULTS

The results of the studies made on conceptual MRS/IS facilities that are located at each of three sites and that handle the quantities of radioactive waste identified in the three principal fuel cycle scenarios are presented in this section. The life-cycle cost for each of the three concepts and the advantages and disadvantages of each concept are summarized in Section 6.1. A number of more generic topics are discussed in Section 6.2; including licensing and safety, environment, transportation, and socioeconomic considerations, relations to other facilities, advantages/disadvantages of utilizing an existing federal site, and the technical status of postulated system components and projected research and development needs.

6.1 COMPARISON OF THE THREE MRS/IS FACILITY CONCEPTS

The construction and operating schedules for the MRS/IS facilities, a summary of the cost assumptions used in the study, and a comparison of the total system costs, and cash flows for the three types of facilities considered in this study are presented in this section. Also presented are discussions of the advantages and disadvantages of each concept.

6.1.1 Construction and Operating Schedules

Construction schedules for the three MRS/IS facilities are shown in Figure 6.1. The schedules for the stand-alone version and the version co-located with a repository are similar--the total time from receipt of funding authorization to start-up is 6 and 5 1/2 years, respectively. In the case of an MRS/IS facility co-located with a reprocessing plant the total time span is considerably shorter (about 3 1/2 years). It has been assumed that the first reprocessing plant will be licensed to start operation in 1989 and that the MRS/IS facility will share much of the handling equipment with the reprocessing plant.

The construction schedules given above indicate that an MRS/IS could be operational about 1988-1990. However, these construction schedules, developed by the study contractors, do not include the additional time needed for such things as: 1) selection and qualification of a site, 2) the conceptual design

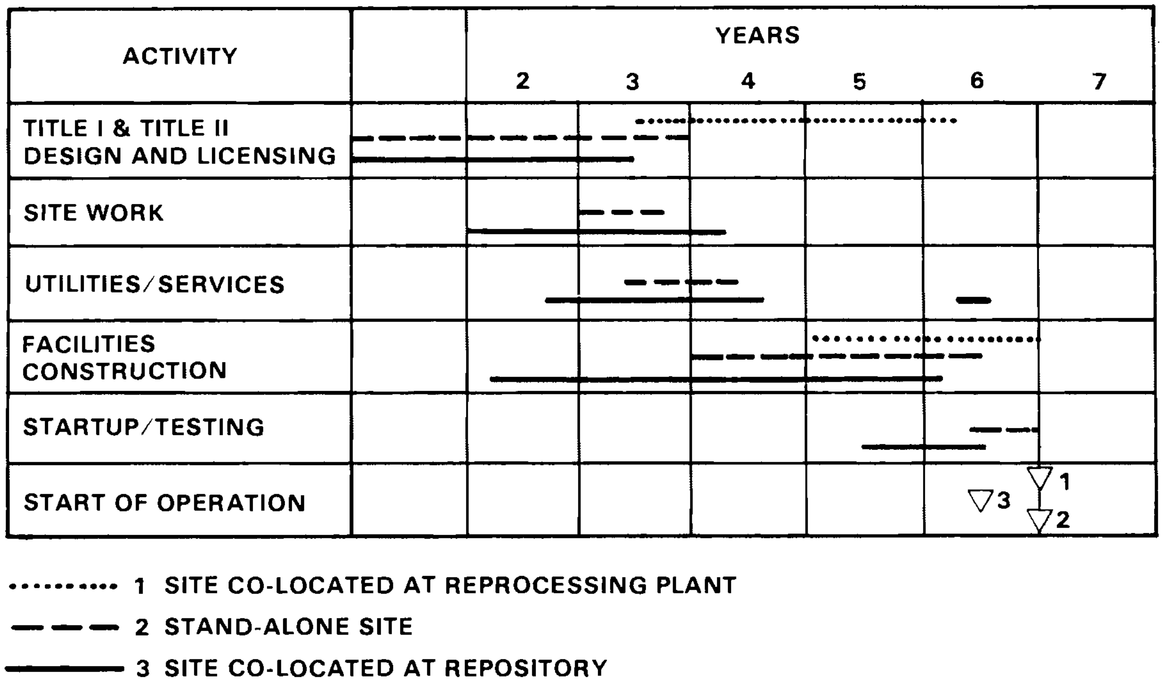


FIGURE 6.1. MRS/IS Facilities Construction Schedule Comparisons

for concept selection, 3) Congressional funding authorization, and 4) qualification and selection of an architect engineer for the detailed design. Inclusion of these factors will add approximately 5 years to the schedule, resulting in an earlier startup date for an MRS/IS of 1994 or 1995. Since these factors could vary with the site, they were eliminated from the study and a startup date of 1990 selected for all versions of the MRS/IS facility.

Figures 6.2, 6.3, and 6.4 contain the life cycles (timeline schedules for construction, operation, and decommissioning) of MRS/IS facility concepts for this reference scenario, the delayed reprocessing scenario, and the delayed disposal scenario, respectively. The inventories of spent fuel and HLW requiring storage in an MRS/IS facility are illustrated in Figure 6.5 as a function of time, for each of the three scenarios.

The MRS/IS facility co-located at a reprocessing plant shares much of its handling and support equipment with the reprocessing plant. Thus its capital costs are mainly those of storage equipment, and its construction period is appreciably shorter than for the other concepts. Similarly, the cost and time for decommissioning are shorter than for the stand-alone concept.

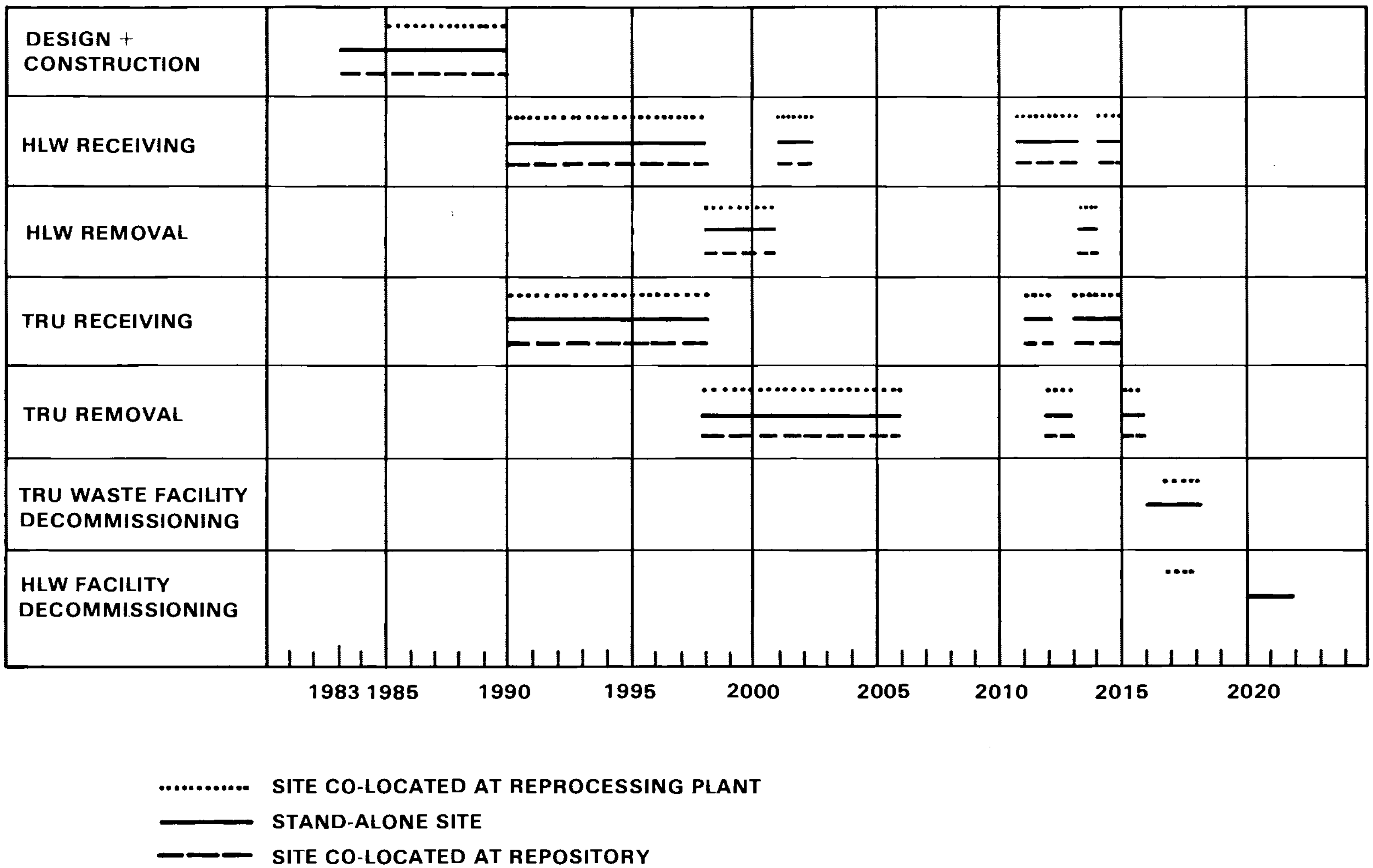


FIGURE 6.2. MRS/IS Life Cycles for Reference Scenario

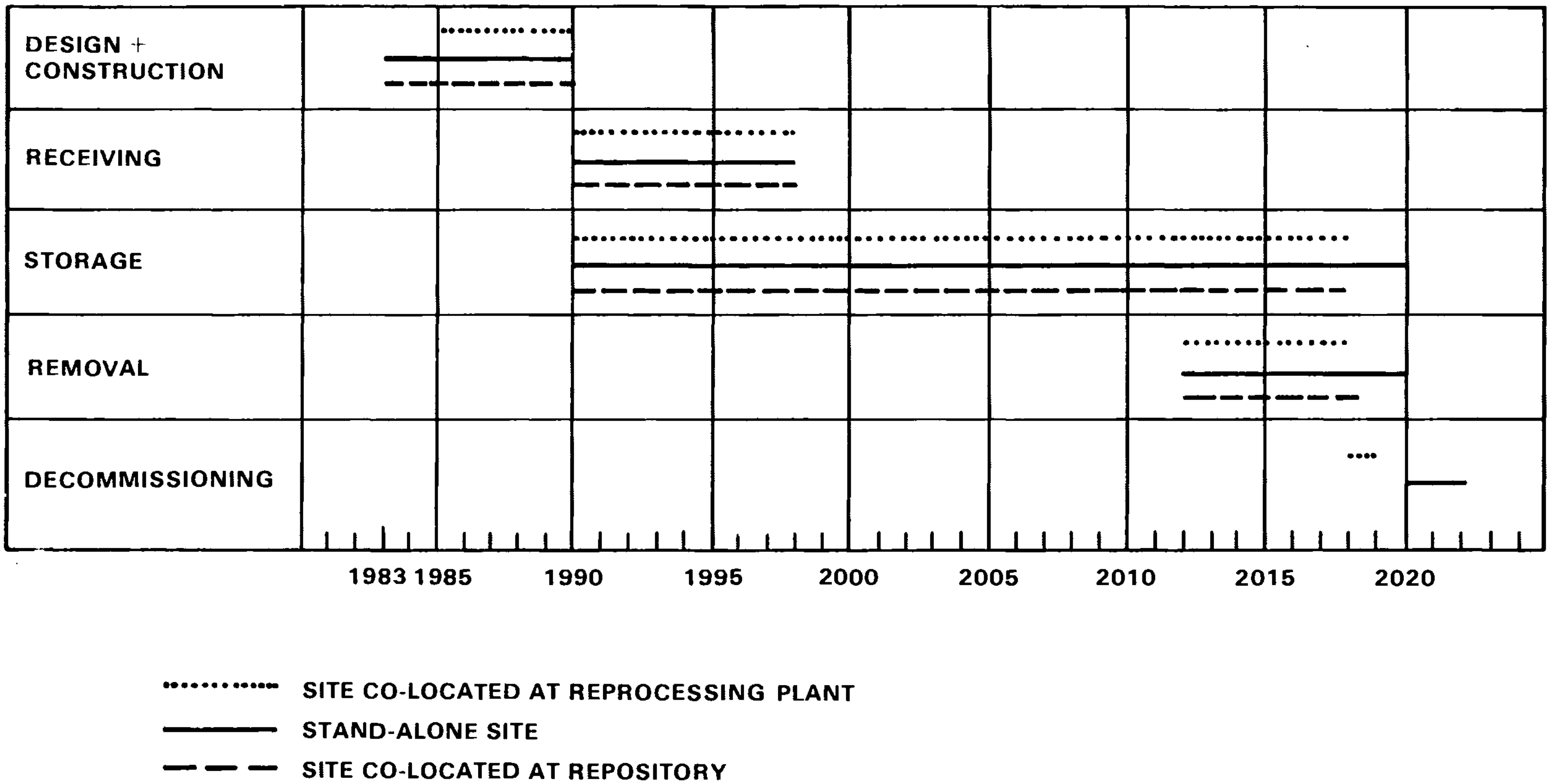


FIGURE 6.3. MRS/IS Life Cycles for Delayed Reprocessing Scenario

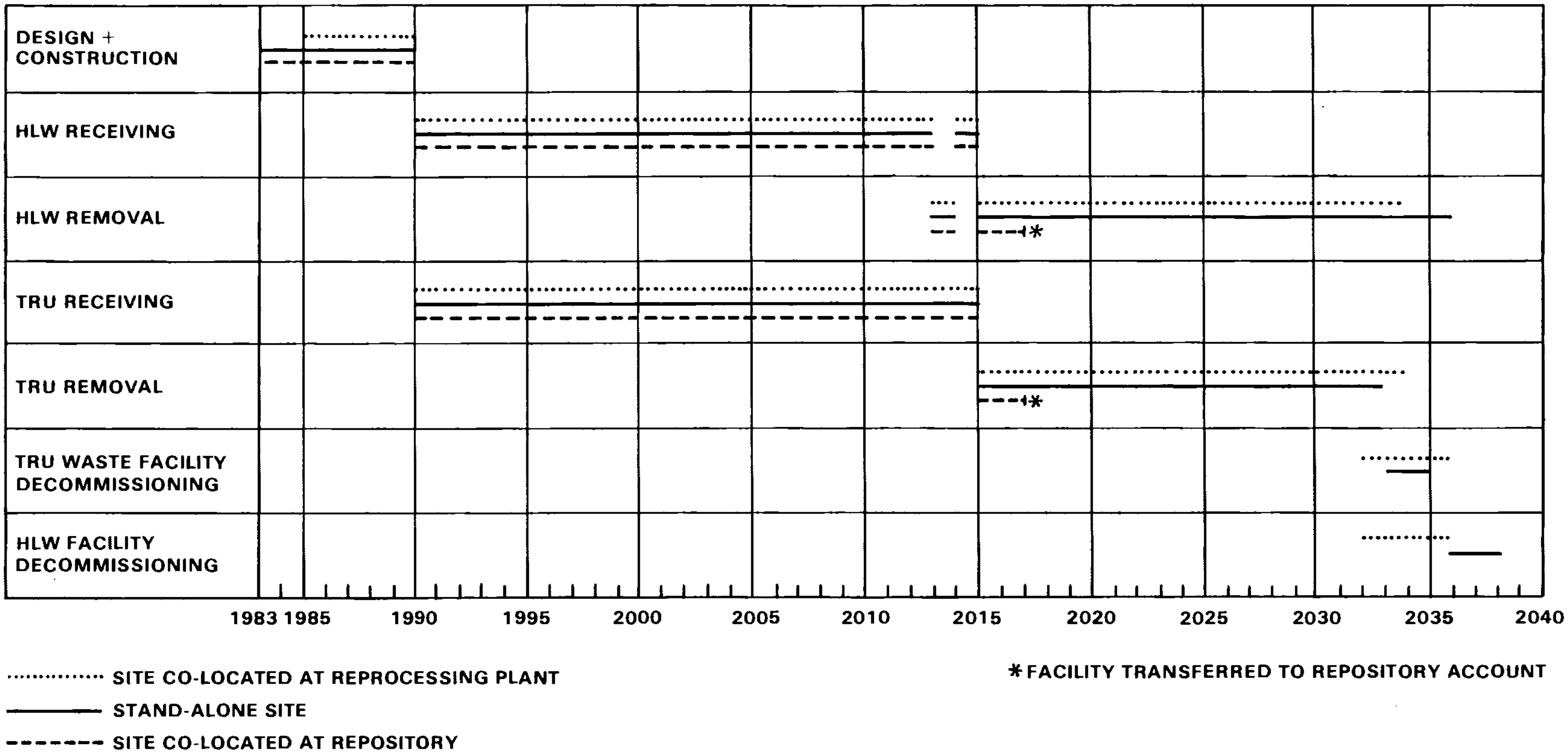


FIGURE 6.4. MRS/IS Life Cycles for Delayed Disposal Scenario

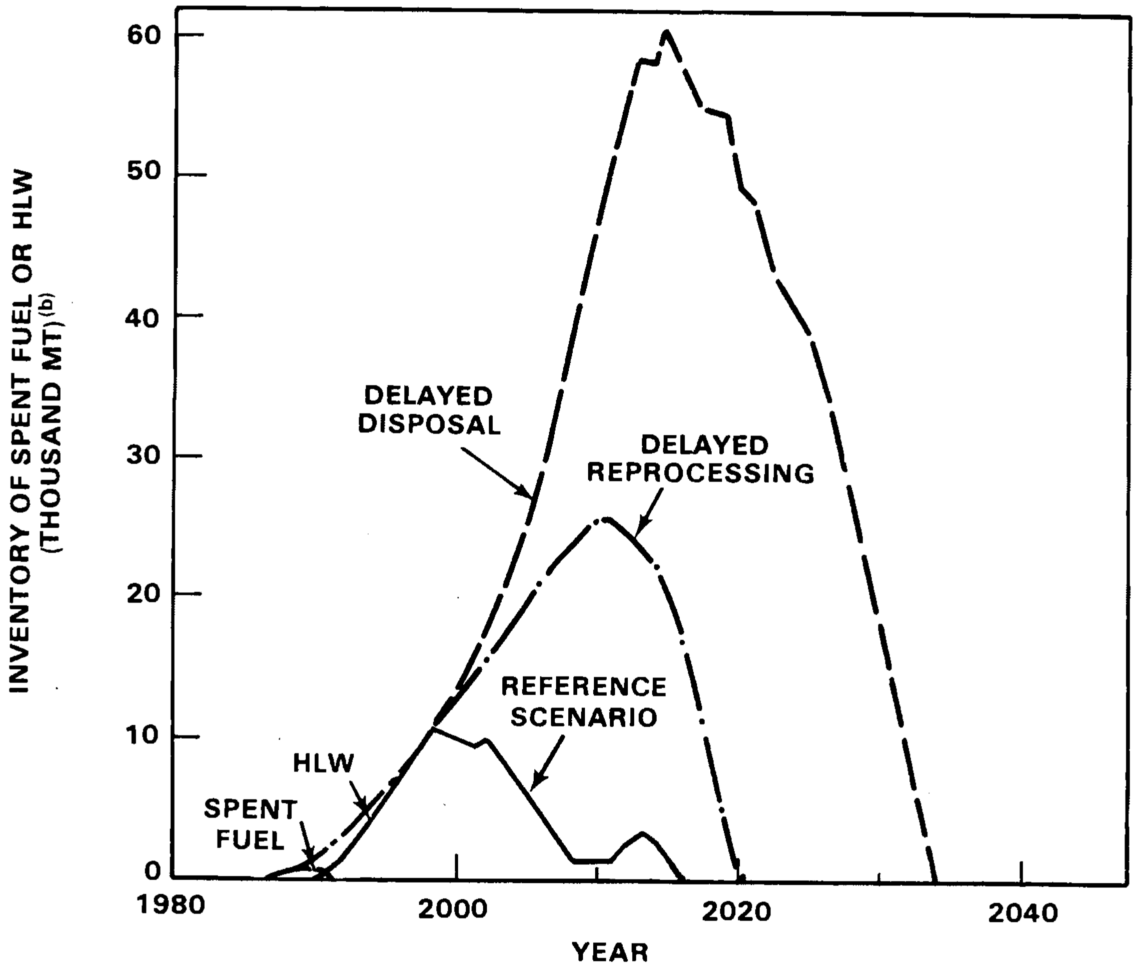


FIGURE 6.5. Inventories of Spent Fuel and HLW Requiring Storage[(a)]

(a) These scenarios represent maximum capacities and do not include any moderating effects of extended burnup operation, rod consolidation, or private AFRs.
(b) To convert from MTHM to fuel assemblies or HLW canisters, divide the MTHM values by 0.18 MTHM/BWR, 0.42 MTHM//PWR, 2.143 MTHM/canister.

The stand-alone facility has no opportunity for sharing of facilities; hence the capital and operating costs tend to be higher, and both the construction and decommissioning periods are longer than for the two co-located concepts. To compensate for the tendency to higher costs, a somewhat lower fuel/waste handling capacity is assumed for the stand-alone facility than for the other concepts. The lower handling capacity does not affect the rate of loading wastes and spent fuel into the storage facility, but does result in some "stretch out" of the unloading period, with consequent lengthening of the effective life of the facility.

The MRS/IS facility co-located with a repository is constructed as a complete, independent fuel/waste handling and storage facility. However, the handling equipment is designed to be compatible with use as the surface handling facility for the repository, and the MRS/IS support facilities are shared with the repository after the repository is opened. Thus, when the effective life of the storage facility is over, the handling equipment is transferred to the repository account and is not subject to decommissioning until the repository is closed. The storage facilities may either be continued in service as "lag storage" for the repository, or decommissioned with salvage value of the casks compensating for decommissioning costs.

The life cycles for the three MRS/IS facility concepts have been developed from the data in Appendix B.1. Because of the "rules" used in the computer program that generated the MRS/IS mass flow rates some small anomalies appear in the operating schedules. For example, in the reference scenario the MRS/IS plant is, as a general rule, being emptied in the years 2013 through 2020. However, as shown in Figure 6.2, the MRS/IS facility has a net receipt of HLW in the year 2014 followed in 2015 by more removal of HLW from storage. It is expected that arrangements would be made to continue unloading the storage facility once it has begun so as to minimize transfers of material between the MRS/IS facility, the reprocessing plant, and the repository.

It must also be noted that since the facilities commence operation in 1990, no spent fuel enters the MRS/IS facility in the reference or delayed disposal scenarios. In the delayed reprocessing scenario, the peak MRS/IS spent fuel inventory shown in Table B.5 (Appendix B) is reduced to 7547 MTHM. It is assumed that spent fuel would be stored at reactor sites (in metal casks, for example) or at an emergency storage site during the period 1985 through 1989.

6.1.2 Total System Costs

A comparison of the total system costs for three MRS/IS facility concepts considered in this study is presented in Table 6.1. The costs for both cask and dry-well versions of the facilities are included and the costs are separated into capital costs, operating costs and incremental transportation costs (see Section 6.2.3 for a discussion of transportation costs).

The capital costs which include the costs of all structures and the storage system (casks or drywells and their associated equipment) is highest for the stand-alone facility. This is due to the fact that both co-located facilities share handling and support facilities with the reprocessing plant or repository. The facility co-located with a reprocessing plant, in particular, shares existing facilities with the Barnwell reprocessing plant, and it is assumed that the same cost division could be used for future reprocessing plants with MRS/IS facilities. The differences between the stand-alone and repository-co-located concepts are smaller (about 25 percent), apparently due to differences in the level of support facilities, the fact that 7-day/24-hour operation is assumed for the repository concept versus 5-day/24-hour operation for the stand-alone version, and in the base cost estimates for the handling and receiving building. In the repository-co-located concept it is assumed that the entire handling facility is constructed prior to startup of the MRS/IS facility and would be large enough to satisfy both the storage facility and repository handling rate requirements. After the storage facility ceases operation the handling facility is devoted exclusively to repository handling.

In all concepts, the facilities with drywells have lower capital costs than those with casks. This is due to the difference in cost between casks and drywells and can be seen in Table 6.1.

In general, the capital costs for the delayed disposal scenario are larger than those for the delayed reprocessing scenario which in turn are larger than those for the reference scenario. The exception is the drywell MRS/IS facility co-located with the reprocessing plant. The increased costs are due to both the increasing size of the storage facilities required for the

TABLE 6.1. Total System Costs for MRS/IS Facilities (millions of mid-82 dollars)

Scenario	MRS/IS Concept	Capital Facility	Capital Storage	Operating	Incremental Transportation	Total System Costs	Discounted Total
Reference	Co-located Reprocessing						
	Cask	6	320	53	--	379	300
	Drywell	11	184	82	--	277	213
	Stand-Alone						
	Cask	318	396	466	160	1340	1026
	Drywell	322	140	502	160	1124	846
	Co-located Repository						
	Cask	178	353	200	--	731	578
	Drywell	180	138	200	--	518	412
Delayed Reprocessing	Co-located Reprocessing						
	Cask	3	783	53	--	839	654
	Drywell	7	137	196	--	340	257
	Stand-Alone						
	Cask	460	650	417	195	1722	1335
	Drywell	527	198	593	195	1513	1151
	Co-located Repository						
	Cask	176	676	212	1193	2257	1592
	Drywell	176	302	302	1193	1973	1376
Delayed Disposal	Co-located Reprocessing						
	Cask	38	1919	268	--	2224	1425
	Drywell	66	1103	545	--	1713	1032
	Stand-Alone						
	Cask	411	2225	1044	696	4376	2834
	Drywell	415	763	1116	696	2989	1994
	Co-located Repository						
	Cask	188	2037	262	--	2487	1660
	Drywell	190	784	262	--	1235	868

delayed scenarios and the additional handling facilities required at the reprocessing-co-located and stand-alone facilities (the repository-co-located version uses the same handling facility for all three cases). The cost reduction for the reprocessing plant drywell MRS/IS facility is due to the larger capacity drywell assumed for that concept, which is assumed to hold three PWR elements or seven BWR elements as opposed to the one PWR/three BWR element-capacity drywells used in the other two concepts.

The reprocessing plant-co-located MRS/IS facility also exhibits lower operating costs than the other two versions for the reference and the delayed reprocessing scenarios. In the delayed disposal scenario, the repository-co-located MRS/IS facility has the lowest operating costs although they are approximately the same as the reprocessing-co-located concept costs. The stand-alone concept has appreciably higher operating costs in all three scenarios.

These differences in operating costs are due to the assumptions made with respect to sharing of costs with the reprocessing plant or repository. In the former concept it is assumed that MRS/IS facility operating costs are with the reprocessing plant from the startup of the storage MRS/IS facility. In the repository-co-located concept it is assumed that the full operating costs are borne by the storage facility until the repository comes on line. Between that date and 2016, the storage facility would bear about one-half of the operating cost (the other half being charged to the repository). After 2016, it is assumed that all operating costs would be charged to the repository operations.

The stand-alone concept incurs 100 percent of the operating cost throughout its lifetime. The differences between it and the other two concepts are particularly marked in the delayed disposal scenario where the MRS/IS is operating for a period of 46 years. The stand-alone facility operating costs also include the full decommissioning costs (10 percent of the total capital costs, less casks is assumed). The repository-co-located facility decommissioning costs are assumed to be zero (the repository bears the full cost of the eventual decommissioning). The reprocessing-co-located facility decommissioning costs are lower than those for the stand-alone facility because of the lower capital costs (essentially only the storage facilities are decommissioned).

In all studies it is assumed that the scrap value of the casks is at least equal to the decommissioning cost.

The storage facility co-located with the reprocessing plant does not have any incremental transportation costs for any of the three scenarios studied. The concept co-located with the repository has an incremental cost only in the delayed reprocessing scenario where spent fuel is shipped 2500 miles to the MRS/IS facility[a] and then 2500 miles back to the reprocessing plant once space becomes available at the plant. In this case, the transportation costs are a large portion of the total undiscounted cost (about 55 to 60 percent). The stand-alone MRS/IS facility has incremental transportation costs in all cases. They range from 11 to 23 percent of the total undiscounted cost.

6.1.3 Technical Merits of Casks Versus Drywells

The technical merits of casks and drywells are evaluated in this section for the three major functions of the MRS/IS facility: a) receipt, handling, and packaging; b) transfer; and c) storage.

Because the storage cask is loaded at the MRS/IS facility, it has no advantage over the drywell in the receiving and handling functions. It does have an advantage in packaging spent fuel since no canister is required. If the storage casks were transportable, they would be loaded with spent fuel at the reactor site and with HLW at the reprocessing plant, thus eliminating the need for a transfer system, increasing material handling capacity, and greatly reducing personnel requirements at the MRS/IS facility.

The transfer system for casks has merit over drywells because the transfer to storage is accomplished in larger quantities of material per transfer and in the final storage configuration. The drywell concept requires

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(a) Only 2000 miles of the trip to the storage facility are counted in assessing incremental transportation charges; since a 500-mile trip to the reprocessing plant would have been incurred without the storage facility.

single canister transfer and involves several operations at the storage site before the material is in the storage configuration.

The storage system for casks has advantages over drywells in the monitoring, and heat dissipation functions. Monitoring of casks for leakage can be done both visually and with radiation contamination surveys whereas drywells cannot be visually inspected and must rely on secondary methods to determine the status of canisters and encasements. Casks are capable of dissipating heat better than drywells since both conduction and convection are enhanced by the material involved. If the thermal criterion for spent fuel is set too, low drywells may be unable to cool the fuel sufficiently without complex cooling systems.

In summary, transportable storage casks have a definite technical advantage over drywells in all major functions of the MRS/IS facility.

6.1.4 Possibilities for Life-Cycle Cost Reductions

Several possibilities exist for reducing the costs of an MRS/IS facility, including consolidation of spent fuel assemblies and utilization of the large metal storage casks for transport between the source site and the storage site.

6.1.4.1 Consolidation of Spent Fuel Assemblies

Consolidating spent fuel assemblies into closely packed arrays within containers results in packing the equivalent of two assemblies into the space formerly occupied by one assembly. Cost components affected by consolidation are transportation, storage containers and storage pads, and staff labor. The number of spent fuel shipments is reduced by half, as is the number of metal casks or drywells required to store the spent fuel. Staff labor is reduced since the number of units to be handled is also reduced by half.

Consolidation is most effective for the delayed reprocessing scenario since that scenario deals almost exclusively with spent fuel.

6.1.4.2 Shipment in Large Metal Storage Casks

In the three principal scenarios, the spent fuel and HLW canisters are assumed to be shipped 50 percent by volume by truck and 50 percent by volume by rail. If it were possible to license the reference metal storage cask for shipment of spent fuel and HLW canisters, the number of shipments could be greatly reduced. As with consolidation of fuel, use of the storage cask for shipment is most cost effective when there are large quantities of spent fuel to transport, as in the delayed reprocessing scenario.

Shipment of the ratioactive wastes in the large storage casks would also reduce facility capital costs by eliminating the need for a handling facility, since the casks would be loaded and sealed at the source site. All that would be required at the storage site is a receiving station for removing the casks from the rail cars and a transporter system for placing the casks in the storage array.

6.1.5 Advantages/Disadvantages of the Three MRS/IS Facility Concepts

Each of the three concepts examined in this study has certain advantages and disadvantages relative to the other two concepts. These advantages and disadvantages are discussed in this section.

6.1.5.1 MRS/IS/Reprocessing Plant

Co-location with a reprocessing plant reduces the capital cost of the MRS/IS facility since the receiving and handling station and other supporting facilities at the reprocessing plant can also serve the storage facility.

Since the site is already approved for nuclear applications, the time required to obtain the necessary permits and licenses should be reduced, as compared with a new site. Thus, authorization, construction and utilization of the storage facility could be accomplished at an earlier date.

The incremental transportation links for this concept (transport in addition to the normal reactor-to-reprocessor-to-repository links) are zero, minimizing waste management transportation costs.

Storage at the reprocessing plant may be publicly perceived as likely to become permanent disposal, and could, therefore, receive substantial public opposition.

6.1.5.2 MRS/IS Stand-Alone

The stand-alone facility can be sited in many places, since the location does not have to be suitable for either a reprocessing plant or a geologic repository. Thus, selection of a site and the obtaining of necessary permits and licenses might be accomplished more quickly, compared with a repository-based site.

The incremental transportation links for this concept are longer than the repository concept except for the delayed reprocessing scenario.

Storage at the stand-alone facility may also be publicly perceived as likely to become permanent disposal and could, therefore, receive substantial public opposition.

6.1.5.3 MRS/IS/Repository

Co-location with a geologic repository reduces the overall capital investment in the waste management system since the waste handling facility and its supporting facilities become the surface installations for the repository. Using these facilities over the life span of the repository approximately doubles the useful life of the structures and permits amortization of the capital costs over a longer time period.

Except for the delayed reprocessing scenario, the incremental transportation links are zero, thus minimizing waste management transportation costs.

The stored materials are transferred directly from storage to the repository without leaving the site, thereby minimizing the potential for transportation accidents and the possible exposure of the public that could otherwise result from such accidents.

6.2 OTHER GENERIC CONSIDERATIONS

A number of areas requiring consideration when developing a conceptual design for an MRS/IS facility are essentially independent of the particular facility concept. These areas are discussed generically in the following subsections.

6.2.1 Licensing and Safety Considerations

The rules, regulations, and regulatory guides generally applicable to an MRS/IS facility are identified in Section 6.2.1.1. A discussion of a number of possible safety issues related to MRS/IS facilities is presented in Section 6.2.1.2.

6.2.1.1 Licensing

The various bills before Congress all require that the MRS/IS facility be licensed by the Nuclear Regulatory Commission under the appropriate parts of Title 10, Code of Federal Regulations (10 CFR). Principal among these is Part 72, which deals specifically with storage of spent nuclear reactor fuel and other radioactive materials in facilities independent of the reactor. Other parts of 10 CFR relevant to the design, construction, and operation of an MRS/IS facility include:

10 CFR 20 - Standards for Protection Against Radiation

10 CFR 50 - Appendix B (Quality Assurance) and Appendix E (Emergency Planning)

10 CFR 51 - Licensing and Regulatory Policy and Procedures for Environmental Protection

10 CFR 60 - Disposal of High-Level Radioactive Wastes in Geologic Repositories

10 CFR 70 - Domestic Licensing of Special Nuclear Material

10 CFR 71 - Packaging of Radioactive Materials for Transport

10 CFR 73 - Physical Protection of Plants and Materials

10 CFR 100 - Appendix A, Seismic and Geologic Siting Criteria

10 CFR 170 - Fees for Facilities and Materials Licenses and Other Regulatory Services.

Part 72, "Licensing Requirements for the Storage of Spent Fuel in an Independent Spent Fuel Storage Installation," contains a number of sections dealing with required licensing documentation. These sections are:

10 CFR 72.14 - License Application
10 CFR 72.15 - Safety Analysis Report
10 CFR 72.18 - Decommissioning Plan
10 CFR 72.19 - Emergency Plan
10 CFR 72.20 - Environmental Report
10 CFR 72.35 - Report of ISFSI Design and Procedure Changes
10 CFR 72.36 - Application for Transfer of License
10 CFR 72.38 - Application for Termination of License
10 CFR 72.39 - Amendment to License
10 CFR 72.80 - Quality Assurance Program
10 CFR 72.81 - Physical Security Plan
10 CFR 72.82 - Design for Physical Protection
10 CFR 72.83 - Safeguards Contingency Plan
10 CFR 72.84 - Changes to Physical Security and Contingency Plans
10 CFR 72.92 - Personnel Training Program.

In addition to the regulations already mentioned, several Regulatory Guides have been issued that provide specific guidance for potential licenses. Principal among these are:

- Reg. Guide 3.48, Standard Format and Content for the Safety Analysis Report for an Independent Spent Fuel Installation (dry storage).
- Reg. Guide 3.50, Guidance on Preparing a License Application to Store Spent Fuel in an Independent Spent Fuel Storage Installation.
- Reg. Guide 3.53, Applicability of Existing Regulatory Guides to the Design and Operation of an Independent Spent Fuel Storage Installation.

Depending upon the location of the facility, there may be permits and/or licenses required by state and local agencies. All required licenses and permits must be identified and a schedule established to ensure the availability of necessary information and the timely submission of applications for the necessary licenses/permits.

6.2.1.2 Safety

The principal concerns at the MRS/IS facility in regard to safety deal with the handling of the nuclear waste or spent fuel. Considerations for facility safety include layout, design, construction, and, in particular, proper design for nuclear materials handling, such as the use of work zones to limit personnel exposure to radiation, the use of an adequate facility security system, and the use of high safety factors and significant redundance for all systems that receive, handle, and store the nuclear waste.

Containment and filtering is provided to minimize the potential for release of radioactive materials. Criticality incidents and radiation exposure are prevented by careful attention to design concepts and configuration. Comprehensive fire detection and protection equipment are used throughout the entire facility. Potential noise excesses are controlled by equipment isolation, sound-absorbent material, and personnel protection where required. Personnel exposure to high temperatures is reduced by ventilation, air-conditioning and worker protection where required. All facilities are designed to withstand the effects of natural phenomena as appropriate for the safety classification of the individual facility.

Systems and operational procedures are used in the MRS/IS facility to protect facility personnel and the public from nuclear radiation and contamination and to protect against industrial accidents. Three circumstances are considered--normal operating conditions; abnormal operating conditions; and conditions resulting from improbable events.

Normal Facility Operation. Containers of wastes are received, handled, stored and eventually retrieved on a routine basis. Protection from radioactivity is provided by the integrity of the waste form and its container and cask, or by the isolation provided for in the waste handling building and in the storage modes.

During normal operations, insignificant quantities of airborne radioactivity could be released into the atmosphere. In any event, exposure of the public shall not be greater than that allowed by 10 CFR 20 and

Appendix I to 10 CFR 50. Engineered confinement systems prevent major releases of radioactivity from the waste handling building or from the storage areas.

The waste handling facility is treated as a "controlled area" in which building ventilation pressure(s) is maintained below ambient atmospheric or adjacent area pressure, thus ensuring that possible leakage through the walls is into, not outward from, any potential source of contamination. Additionally, all exhaust air from the building is passed through filter systems that include high-efficiency particulate air (HEPA) filters and then released through a stack. The stack height is established according to atmospheric conditions at the site; dispersion provides sufficient dilution to ensure that any radioactivity reaching ground level is at or below permissible concentrations.

Abnormal Operating Conditions. Anticipated occurrences that could result from equipment failures, operator errors, or unplanned process variations during the operating life of the facilities are considered in a Failure Modes and Effects Analysis (FMEA) for cask storage and for drywell storage.

The FMEA indicates that significant failure modes for the storage cask concept fall into two major categories: 1) damage to a cask containing spent fuel assemblies, resulting in radionuclide release, and 2) damage to bare spent fuel assemblies being transferred from a shipping cask to a storage cask. A qualitative evaluation of these failure modes identified no postulated events that would pose any significant risk to the health and safety of the public.

The FMEA of the drywell concept was performed only for the interface and storage facilities. The results indicate that potential for radionuclide release is principally associated with transporter failures or accidents. The dominant condition appears to be the movement of the transporter while the canister is partially in place, leading to actual shearing of the canister.

Improbable Events. Although they have a very low probability of occurring, some upper-limit accidents or improbable events justify the incorporation of additional design features to further reduce the probability of their occurrence or to mitigate their effects. Improbable events considered include earthquakes, high winds and tornadoes, and floods. Risks due to these natural phenomena are assessed and adequate design provisions made for them. The frequency of natural phenomena such as earthquakes and tornadoes is too low to have any significant impact on the safety of the facility.

The rare, non-design basis occurrences that could result in severe consequences, such as a plane crash or a meteorite impact are not examined in this study. Multiple failures of certain subsystems and equipment following the more credible initiating events could also result in large radiological effects. However, the quantification of event trees for such initiating events would show very low branch sequence probabilities for any large radionuclide releases that might be associated with the events.

6.2.2 Environmental Considerations

The construction, operation, and decommissioning of an MRS/IS facility raise a number of environmental issues. Although most of these issues are encountered elsewhere within the nuclear industry (e.g., construction and operation of a reactor facility), they must still be carefully addressed. The environmental considerations relevant to an MRS/IS facility are generically discussed in Section 6.2.2.1 and the particular considerations specific to each of the siting alternatives are addressed in Section 6.2.2.2.

6.2.2.1 Generic Environmental Considerations

Construction, operation, and decommissioning of an MRS/IS facility by the federal government must comply with the National Environmental Policy Act (NEPA). These activities will almost certainly be viewed as major federal actions requiring the preparation of an environmental impact statement (EIS) in accordance with the regulations of the Council on Environmental Quality (CEQ). In reality, two EISs may be prepared, one covering construction and operation of the facility and the other covering decommissioning. In addition, since the facility is to be licensed by the U.S. Nuclear Regulatory Commission (NRC), a safety analysis report (SAR) covering operation of the facility will be required. Together, these documents will include descriptions of the facility and alternatives to the facility; the environmental impacts of constructing, operating, and decommissioning the facility; and the measures taken to monitor and assure environmental safety.

The potential environmental impacts associated with the various phases of the MRS/IS facility life, which will require consideration during preparation of the EISs, are discussed briefly in the following paragraphs.

Environmental Impacts During Construction. The potential environmental impacts of construction of an MRS/IS facility are similar to those of any major construction project, except that the MRS/IS construction work force at any time is likely to be relatively small (i.e., several hundred people). Therefore, the impacts normally associated with the presence of extra temporary workers or with many people concentrated in a small geographic area will be minimal. Some of the environmental impacts from construction will be:

- removal of the land from production or other uses
- possible removal of timber from the land
- irreversible use of some construction materials
- irreversible use of fuels and electricity
- occasional minor traffic congestion
- dust from construction activities
- noise from construction activities
- minor socioeconomic impacts.

Environmental Impacts During Operation. Radioactive materials, including spent fuel, will be handled during operation of the MRS/IS facility. Appropriate measures will be taken at all times to avoid criticality and the possibility of any other accident, as well as to minimize occupational or public radiation dose from routine radioactive waste handling activities. Probably the most significant environmental impact from operation of the facility will be the large number of shipments of radioactive material to and from the facility.

The possible impacts from operation include:

- potential occupational radiation doses to workers at the facility
- substantial freight traffic hauling radioactive shipments to and from the facility
- potential low level public radiation doses due to transportation activities
- low probability of accidental offsite releases of radioactivity.

Environmental Impacts During Decommissioning. Before decommissioning of the facility begins, all packaged radioactive waste materials will be removed and placed in a repository, leaving only minimal amounts of radioactivity to be removed during decommissioning. Significant quantities of construction materials (e.g., iron) could be reclaimed. The decommissioning work force will be small, so socioeconomic impacts will be small. Some of the impacts from decommissioning will be:

- small occupational radiation doses from decommissioning activities
- small public radiation doses from the transportation of radioactive wastes to low-level waste burial grounds
- some noise
- traffic to and from land fills.

Because the storage facilities are expected to be essentially uncontaminated, or readily decontaminated at the time of decommissioning, only the last of the listed impacts is expected to be significant.

6.2.2.2 Environmental Considerations Specific to Siting Concepts

As stated previously, environmental considerations relevant to an MRS/IS facility are principally routine issues. Owing to the high integrity of the containers and storage facilities, the expected impact on the environment is minimal. However, unique environmental considerations exist for each of the specific siting concepts considered in this study. Those considerations for each siting concepts that merit particular discussion are covered in the following paragraphs.

Co-location with Reprocessing Facility. The particular environmental considerations of concern for the MRS/IS facility co-located with a reprocessing facility are site surface drainage and groundwater monitoring.

Surface drainage for the reprocessing facility site is accommodated by runoff through natural drainage features. Construction of the reprocessing facility resulted in hardening of surface features and construction of engineered drainage, increasing the rate of runoff of drainage for the southerly portion of the site to the upper limit that could be handled by the natural system. Construction of the MRS/IS facility requires further surface hardening and engineered drainage. To prevent erosion that has the potential for destruction of important site features and facilities, runoff control features include drainage ditches, rip-raps, engineered ponds, and construction of an outfall to a local creek. The construction of runoff control features will require obtaining a National Pollutant Discharge Elimination System (NPDES) permit for the discharge point into the creek.

The berm structures are resistant to penetration by surface moisture and are protected from discharge of potentially radioactively contaminated liquid into the ground by a relatively impervious underlayer. To further ensure that moisture in the storage structures is diverted from infusion into groundwater, drainage is promoted by drain lines which penetrate the structures.

Several programs of monitoring and sampling will be pursued to provide early detection of leaks of radioactive material so that appropriate corrective measures may be taken. In addition, the installation of one or more groundwater observation wells will permit routine determination of groundwater contamination levels (or absence thereof). The number and placement of such wells will be determined by the hydrological properties of the site and by the proposed monitoring and sampling program.

Stand-Alone MRS Facility. The particular environmental considerations of concern for the stand-alone MRS/IS facility depend upon the site chosen for the facility. The stand-alone MRS/IS facility could be located in most states of the U.S., because it does not use the geological features of the site as one of the radionuclide containment boundaries. In reality, however, the characteristics of a particular site may have an impact on the design and operation of the facility. In addition, the licensing of a particular site for storage of radioactive material may be more or less difficult depending upon the seismic or meteorological conditions of the site.

Environmental considerations that would be taken into account during the site selection process for the stand-alone MRS/IS facility include the following:

- good drainage and a low water table
- adequate surface area
- adequate protection of environmental quality of the area
- satisfactory meteorological conditions
- good transportation access.

These factors would be weighed against other factors relevant to site selection in order to determine the desirability of any given site. Clearly, the siting process would not permit the selection of a site that would result in unacceptable impacts to the environment.

The major difference relevant to environmental concerns between the stand-alone siting of an MRS/IS facility and the co-location of the facility with other nuclear facilities is the need for additional transportation. The use of a stand-alone MRS/IS requires at least one additional transportation step within the nuclear waste management system. This step results in additional radiation exposures of both the public and the work force even though no significant release of activity is expected. However, these extra exposures are well below the expected background doses and within allowable regulatory standards.

Both MRS/IS technologies (i.e., cask and drywell storage) require the shipping of significant quantities of construction materials (to support both the handling and storage facilities) as well as the nuclear waste itself. The need for highway and rail construction, however, depends on the site chosen. The cask MRS/IS facility may require a greater number of transportation links because of the need to import the storage casks. (Concrete materials required for drywells will most likely be available locally.) In any event, the traffic flows required are not unusual for many industrial facilities and, thus, their transportation impacts are not considered to be of particular concern.

Co-location with Repository. The assumed location of the MRS/IS facility co-located with a geologic repository is within the boundaries of a federal reservation in the semiarid western part of the U.S.

The major environmental concern at the site is the disruption of the fragile native vegetation that would result from construction and operation of the MRS/IS facility. This disruption, coupled with the low precipitation and the occasional high winds characteristic of the site, is likely to lead to substantial fugitive dust emissions from time to time. In site areas disturbed by construction activities or fires, scarcity of grass allows the invasion of tumbleweed and cheatgrass, displacing the native vegetation.

Hydrological considerations are of little concern at the site. Annual precipitation is low. Groundwater levels on the site are on the order of hundreds of feet below the surface. Past and current hydrological investigations provide a solid understanding of the site's hydrological characteristics.

Impacts on local populations from activities at the MRS/IS facility are also of little concern. The activities associated with the facility would be carried out at a location that is isolated from the local population centers. In addition, location within the boundaries of the federal reservation ensures against the encroachment of new communities.

Finally, the reservation is already equipped with the necessary infrastructure (transportation facilities, services, etc.) to support the MRS/IS facility. No extensive new infrastructure additions which could result in environmental disruptions will be required for the facility.

6.2.3 Transportation Considerations

Transportation is an important element in implementating of the MRS/IS concept. The major bases and assumptions for transportation in this study are summarized in Section 3.3.2 and given in detail in Appendix B.3. Pertinent background and the impacts of transportation on an MRS/IS facility are discussed in this section.

6.2.3.1 Transport Licensing Considerations

The transport of radioactive materials is regulated by the Department of Transportation (49 CFR 171-181) and the Nuclear Regulatory Commission (10 CFR 71). The regulations classify radioactive material transport into several categories according to quantities and/or toxicity of the radionuclides present. Spent fuel and high-level waste are in the category of Type B, large quantities (or the category with the most amount of radionuclides), and many or all of the transuranic wastes will be in the same category. The principal performance requirement for transport of these materials regards containment, which is generally provided by the outer transportation packaging (i.e., the cask). Type B large quantities require that containment of radioactive materials be maintained for normal conditions encountered during transport, for which there are specified physical tests that a package must endure. More important, the containment by the transport cask must be maintained under accident conditions, for which there are severe physical tests that the outer packaging must endure without loss of containment. The most important of these tests are, in the following sequence to the same cask: impact, puncture, fire, and submersion under water. All licensed casks must be capable of passing these tests. These tests are sufficiently severe that they encompass the performance needs for all but the most severe accidents, for which the probability of occurrence is very low. Thus, the primary purpose of a canister, if present, for transport of Type B radioactive materials is for handling and contamination control for routine operations.

For most shipments containing more than 20 Ci of plutonium, (which would include the three materials of concern here), the regulations that require the packaging system (i.e., outer cask and inner packagings) must retain two levels of containment if the total package is exposed to the severe regulatory test conditions. The NRC regulations specifically exempt spent fuel from this requirement and allow for possible NRC exemption of other materials. It remains to be determined whether this rule is to be applied to high-level and transuranic wastes. If it does apply, the waste canister (full of its contents) or an overpack canister must provide the second level of containment; if the rule does not apply to these waste shipments (i.e., these materials would be exempt from the double containment category), the canister need not endure the tests on the total cask-plus contents. In any case, the canister may be much less rugged than the cask, which must absorb nearly all of the accident environment. In this study, it is assumed that, if needed, the canisters as described for high-level and transuranic wastes will provide the second level of containment.

As stated above, the transport cask must be shown to withstand the severe regulatory dynamic tests without loss of containment and with only modest loss of shielding effectiveness. These conditions are much more severe than the requirements for storage or handling at an MRS/IS or at any other fuel cycle facility.

Most of the reference transport casks used in this study (designated by NAC-1, IF-300, CNS-14-170, CNS-7-100) have been shown to meet these regulatory tests for their respective cargoes.[a] The design of the two casks used in this study to transport fuel cladding hulls (designated HLW-T and HLW-R) and the packaging to transport CHTRU wastes (TRUPACT) are not yet completed, but they are being designed for transport licensability, and it is assumed here that they will be licensable for their respective purposes designated in this study. The reference metal storage cask in this study is designed for storage and used only for storage in this study. There is a financial incentive for these casks to also be used for transport in the metal storage cask concept. Their design may require modifications and or additions (e.g., impact limiters, special tie-downs, etc.) to be licensed for this use. Their licensing would also require considerable effort and perhaps several years.

(a) The NAC-1 and IF-300 casks are licensed to carry spent fuel. It is assumed here that with appropriate internal spacers they are licensable to carry high-level waste. The CNS-14-170 and CN-7-100 casks are licensed to carry type B radioactive materials. It is assumed here that their licenses apply to transuranic wastes.

Another storage cask concept that could be considered for transporting is the GNS Castor Cask which is licensed for transportation in Europe. Licensing requirements in Europe are based on IAEA transportation standards which are the same in principle as those in the U.S. Thus it seems very likely that a storage cask design can be developed for transport in the U.S.

Transportation Assumptions

The bases and assumptions for offsite transportation of the waste materials are summarized in Section 3.3.2 and given in detail in Appendix B.3. The reference shipping systems selected, with 50 percent by volume of each waste category shipped by rail and 50 percent by truck, are given in Table 6.2. The overall sizes of the spent fuel and waste canisters for transport are summarized in Table 6.3.

The offsite transport scenarios for the three MRS/IS site evaluations are summarized in Figure 6.6. The transportation links are either 500 mi (800 km) or 2500 mi (4030 km) depending upon the site location for the repository. The offsite transportation links for the three principal scenarios are given in Figure 6.6 for each of the three study locations of the MRS/IS site. As indicated, all offsite transportation links for each scenario are not identical. Note that for this study the mixed-oxide fuel fabrication plant is always co-located with the fuel reprocessing plant in the east, the geologic disposal repository is located in the west (2500 miles from the other fuel cycle facilities), and the reactors are located in the east (500 miles from other fuel cycle facilities).

Transport Costs

Transportation is a significant cost element in the operation of an MRS/IS system. However, it is also a significant cost element in operaion of a fuel cycle that does not require an MRS/IS. The main interest for offsite transportation costs in this study is to determine those costs for an MRS/IS system that are incremental to those for a recycle fuel cycle where an MRS/IS is not needed (i.e., reprocessing and MOX fuel refabrication, and geologic repository capabilities are operating). These would be the incremental transport costs associated with operating an MRS/IS system. The transportation links for spent fuel, high-level and transuranic wastes which are required in

TABLE 6.2 Reference Shipping Systems Selected for This Study

Material	Shipping Mode	Shipping Container	Waste Packages Per Shipment
Spent fuel	Truck	NAC-1	1 PWR or 2 BWR
	Rail	IF-300	7 PWR or 18 BWR
High-level wastes	Truck	NAC-1	1 canister
	Rail	IF-300	5 canisters
RHTRU special canister	Truck	HLW-T	1 canisters
	Rail	HLW-R	5 canisters
RHTRU drums >5 R/hr	Truck	CNS 7-100	7 drums
	Rail(a)	CNS 7-100	21 drums
RHTRU drums <5 R/hr	Truck	CNS 14-170	14 drums
	Rail(a)	CNS 14-170	42 drums
CHTRU wastes	Truck	TRU-PACT	36 drums or 3 boxes
	Rail	TRU-PACT	72 drums or 6 boxes

(a) It is assumed that three of these shipping containers are transported per rail car.
(b) Assumes two truck TRUPACT versions are transported per rail car.

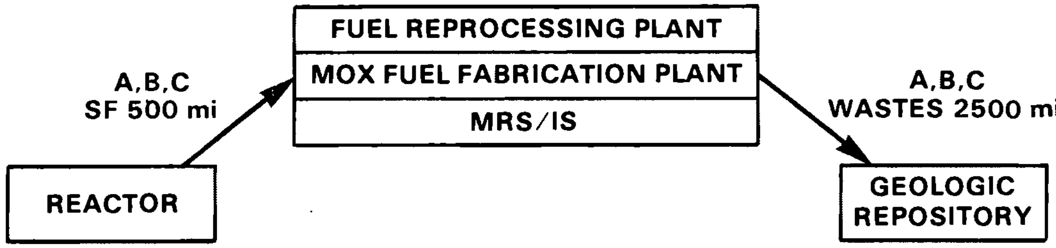
TABLE 6.3. Reference Canister Sizes and Weights for Offsite Transportation

Fuel Cycle Material	Dimensions, m	Net[(a)] Capacity, m^3 (ft^3)	Average Weight Loaded, kg (lb)
Spent fuel			
PWR assembly	NA	NA	658 (1448)
BWR assembly	NA	NA	284 (625)
Solidifed high-level waste canister	0.31 D x 3.1	0.17 (6.0)	1050 (2310)
RHTRU wastes			
Hulls canister	0.62 D x 3.1	0.75 (2.6)	3500 (7700)
210 L (55 gal) drum	0.62 D x 0.92	0.17 (6.0)	
CHTRU wastes			
210 L (55-gal) drum	0.62 D x 0.92	0.19 (6.7)	300 (660)
Metal box	1.2 x 1.9 x 1.9	3.5 (123.6)	4000 (8800)

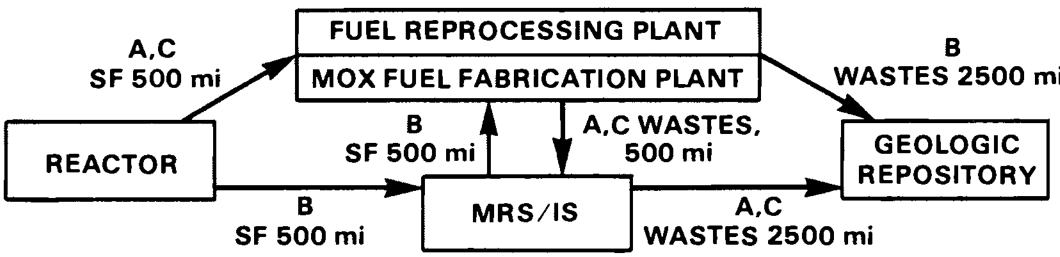
NA = Not Applicable
(a) Based on maximum of 80 percent full.

a recycle fuel cycle that does not utilize an MRS/IS facility are the same as those shown in Figure 6.6(a) for an MRS/IS facility located at a fuel reprocessing plant.

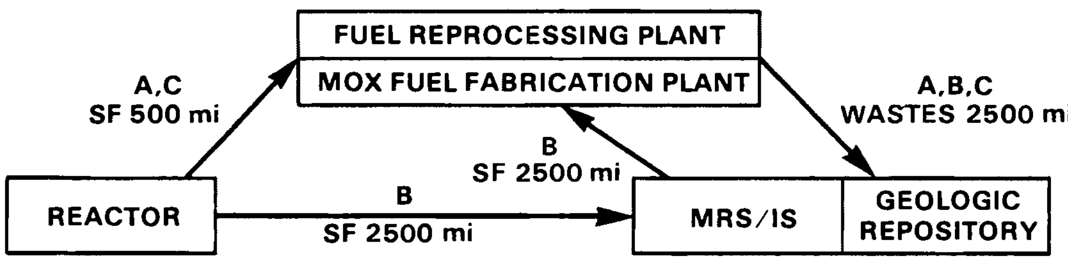
Thus, the incremental offsite transportation links attributed to operation of an MRS/IS facility are the differences between those in Figure 6.6(b) and 6.6(c) and those in Figure 6.6(a). These transportation links and the incremental links for the three scenarios for each of the three MRS/IS facility site locations,are tabulated in Table 6.4. There is one incremental 500-mile transportation link for each scenario for the stand-alone facility, there are no incremental links for the facility at a fuel reprocessing plant, and there are incremental links (two long ones) for only the delayed reprocessing scenario with the MRS/IS facility located at the repository. Thus incremental offsite transportation costs for the MRS/IS facility at the fuel reprocessing plant are zero, they are modest for each scenario for the stand-alone facility, and for the MRS/IS facility at the repository they are zero for two scenarios and significant for the delayed reprocessing scenario.



a. SPENT FUEL AND WASTE FLOW FOR AN MRS/IS AT A REPROCESSING PLANT



b. SPENT FUEL AND WASTE FLOW FOR A STAND-ALONE MRS/IS



c. SPENT FUEL AND WASTE FLOW FOR AN MRS/IS AT A REPOSITORY

LEGEND: A = REFERENCE SCENARIO
B = SCENARIO WITH DELAYED REPROCESSING
C = SCENARIO WITH DELAYED REPOSITORY
SF = SPENT FUEL
WASTES = HIGH-LEVEL AND TRANSURANIC WASTES

FIGURE 6.6. Spent Fuel and Waste Flow Routes for an MRS/IS Facility

TABLE 6.4. Transportation Link Comparisons

MRS/IS Location and Scenario	Transportation Link, miles: Spent Fuel: Reactor to FRP/FFP	Reactor to MRS/IS	MRS/IS to FRP/FFP	HLW and TRUW: FRP/FFP to Repository	FRP/FFP to MRS/IS	MRS/IS to Repository	Incremental Transportation Link Compared to No MRS/IS: Material	Transport from ---to---	Miles
Fuel Cycle Without MRS/IS	500	--	--	2500	--	--	--	--	--
MRS/IS Co-located with Reprocessing Plant									
Reference Scenario	500	--	--	--	--	2500	--	--	--
Delayed Reprocessing	--	500	--	2500	--	--	--	--	--
Delayed Disposal	500	--	--	--	--	2500	--	--	--
Stand-Alone MRS/IS									
Reference Scenario	500	--	--	--	500	2500	Wastes	FRP/FFP to MRS	500
Delayed Reprocessing	--	500	500	2500	--	--	Sp. Fuel	Reactor to MRS	500
Delayed Disposal	500	--	--	--	500	2500	Wastes	FRP/FFP to MRS	500
MRS/IS Co-located with Repository									
Reference Scenario	500	--	--	--	2500	--	--	--	--
Delayed Reprocessing	--	2500	2500	2500	--	--	Sp. Fuel	Reactor to MRS MRS to FRP/FFP	2000[a] 2500
Delayed Disposal	500	--	--	--	2500	--	--	--	--

(a) Difference in trip length between 2500 miles and 500 miles.

These life-cycle costs, taken from Section 6.1, are summarized in Table 6.5. Also shown for information are the anticipated costs for offsite transportation without an MRS/IS facility.

Savings in transportation costs can be achieved when using metal storage casks if the casks are also suitable for transportation. These reductions improve the overall costs of the metal cask concept but not enough to reach the level of the drywell concept. The dual-purpose casks reduce the offsite transportation costs, but also reduce significantly the capital and operating costs for the MRS/IS, by eliminating the need or the spent fuel and waste transfer facility.

Transportation costs are evaluated for the stand-alone MRS/IS if the amounts of materials shipped by rail were increased from 50 percent to 80 percent. As shown in Table 6.6, rail shipments are slightly more cost-effective for spent fuel and truck shipments are more cost-effective for shipping the wastes. Changing the rail/truck split impacts the MRS/IS facility since the number of rail and truck receiving bays is dependent on the rate of rail and truck shipments. An increase in rail shipments will reduce

TABLE 6.5. Life-Cycle Offsite Transportation Costs for Waste Management System (millions of mid-1982 dollars, undiscounted)

MRS/IS Facility Location and Scenario	Costs Without MRS/IS Facility	Costs With MRS/IS Facility	Incremental Cost With MRS/IS Facility
MRS/IS/Reprocessor			
Reference Scenario	462	462	0
Delayed Reprocessing	230	230	0
Delayed Disposal	2119	2119	0
MRS/IS Stand-Alone			
Reference Scenario	462	622	160
Delayed Reprocessing	230	425	195
Delayed Disposal	2119	2815	696
MRS/IS/Repository			
Reference Scenario	462	462	0
Delayed Reprocessing	230	1423	1193
Delayed Disposal	2119	2119	0

TABLE 6.6. Sensitivity of Transportation Costs to Rail/Truck Split

Scenario	Transportation Cost for 50/50 Rail/Truck Split ($ million, mid-1982)	Transportation Cost Increase/<Decrease> ( )	
		80 Rail/ 20 Truck	20 Rail/ 80 Truck
Reference	622	10	<13>
Delayed reprocessing	425	<5>	16
Delayed disposal	2815	4	<18>

facility costs, and an increase in truck shipments will increase facility costs because of the large number of shipments to be handled.

There are several of other considerations that could tend to reduce the transportation costs:

a. design casks for transport of older fuel and wastes

b. design casks for transport of other fuel and wastes

c. for spent fuel, consolidate the fuel

d. for truck shipments, use overweight trucks

e. for train shipments, use special trains

f. design casks and radioactive materials packagings to optimize the pay load

g. security and special equipment costs for HLW.

Items b through f all involve increasing the payload per shipment, thereby reducing the number of shipments and the costs. These changes would also reduce facility costs as discussed above. Item a may also be affected by a better and more competitive market condition for transportation. Currently, there is little commercial business in transportation of the materials of concern here, so few packagings or casks are available and there is no incentive for commercial entities to expand their activities. Obviously, a larger market should tend to reduce unit costs. The unit leasing costs used for casks in this study are based on limited information and on short-term lease rates (about 1 month). Indications are that long-term lease rates could reduce these costs in the order of a factor of two, which is very significant. In practice, actual lease rates will be negotiated and could vary significantly.

The casks assumed for use in transport of spent fuel and high-level wastes in this study were designed to transport spent fuel out of the reactor about 120 days. The materials transported in this study are all out of the reactor at least 10 years, and have significantly lower decay heat and radiation levels. These lower radiation levels would allow reduction in gamma shielding thickness. With this reduced shielding and the resultant larger cask cavity for the same outside dimensions and total weight of the cask, the cavity volume and pay load can be increased by as much as 100 percent (for truck casks). Also, if spent fuel were consolidated into half their volume, the number of shipments could be reduced by as much as a factor of two.

The truck shipments in this study assumed the use of casks which, when combined with the tractor-trailer, would not exceed the legal limit of 80,000 pounds, beyond which a special permit is required in many states for each shipment. Cost savings may be possible for a truck plus cask that weigh 1.46 times the legal weight transporter assumed in this study. The payload can be increased by a factor of about 7, thereby reducing truck transportation trips and costs for spent fuel or high-level waste by as much as a factor of 5. Additional administrative costs and special permit fees, however, would be incurred to process overweight shipment requests. Furthermore, overweight shipments may be limited to certain routes and time of day.

For train shipments, the use of special trains (i.e., those carrying only radioactive materials on several cars) offer the possibility of cost reduction. The use of such trains would generally reduce the travel time and improve the resultant transport logistics and costs. However, the railroads are reluctant to use special trains without increasing the unit transport charges, and a recent court ruling concluded that such higher charges were not legal. This matter remains to be resolved.

When there is sufficient business for transport of the wastes and spent fuel of concern in this study, it would be cost effective to design the packagings and canisters to maximize the payload. For example, casks for high-level wastes may be shorter (and larger in diameter) to carry the high-level waste canisters, which are shorter than spent fuel assemblies. The diameters of waste canisters may be adjusted to allow a significant increase in the amount of waste that will fit into the casks. The same concept could apply to packagings for RHTRU wastes.

6.2.4 Socioeconomic Considerations

Several nontechnical considerations are important when planning for the development of an MRS/IS facility. Principal among these are the acceptability of the facility to the local and regional populace, and the impacts of facility construction, operation, and eventual closure on the economy of the region.

6.2.4.1 Public Acceptability

The acceptability to the local and regional populace of a facility for the long-term storage of spent fuel, HLW, and TRU wastes is recognized as an important consideration. All bills presently pending in Congress contain mechanisms for consultation with local regional governmental agencies, and with interested Indian tribes, in the selection of sites for waste storage and disposal facilities, and provide the framework for local rejection and Congressional override when appropriate.

The acceptability of an MRS/IS facility may depend strongly on whether the facility is seen as a step toward the eventual solution of the waste disposal question or as simply a delaying action to postpone difficult decisions. A storage facility located on a site selected for a repository is more likely to be favorably received than are facilities located at a reprocessing plant or located separately, since the selection of a repository site is seen as a positive step toward final disposition of the wastes. Locating the storage facility at a reprocessing plant or at a separate location is likely to be perceived as 1) just another delaying action, and 2) possibly becoming a permanent disposition site by failure to proceed with geologic repositories. The reprocessing plant location may be slightly more favorable than a separate facility, since a nuclear installation is already present on the site.

6.2.4.2 Economic Considerations

Construction, operation, and decommissioning of an MRS/IS facility will have economic impacts on the local community. The labor force necessary to construct the facility is not expected to be large, probably a few hundred workers, and would not present any significant stress to the local community services in most locations. However, location of an MRS/IS facility in regions of low population could significantly burden existing community services. The use of federal impact funds might be required to ensure that sufficient municipal services are available to support the MRS/IS work force. The construction force payroll would contribute to the overall local prosperity, but would not be a major factor. Operation of the facility is expected to require a permanent staff of workers, who would be permanent local residents and would contribute to local business community and the local tax base.

Closure of the facility would result in a loss of permanent jobs in the community, which would be partially mitigated by the employment of a decommissioning staff. The decommissioning staff would be relatively small, and the decommissioning effort would be relatively brief, probably less than 3 years.

Overall, an MRS/IS facility would provide an employment base for a period of 15 to 20 years. If co-located with a repository, the facility staff would continue with repository operations after closure of the storage activities, thus extending the duration of the employment base.

6.2.5 Relation to Other Facilities

The monitored retrievable storage/interim storage (MRS/IS) facility, as one part of the overall nuclear fuel cycle system, has interfaces with several other parts of the system, such as the nuclear power stations and the geologic repositories.

6.2.5.1 Reactor Power Stations

As presently conceived, the MRS/IS facility could receive spent fuel from the reactor stations as necessary for the stations to maintain their full core reserve storage capacity. This fuel would be stored until either a reprocessing plant is operating, at which time the fuel would be shipped to the reprocessor, or, if the operation of reprocessing plants is delayed until after a geologic repository is available, some or all of the fuel might be emplaced in the repository without reprocessing. In any event, the principal interface between the MRS/IS facility and the reactor stations is the transportation link by which the spent fuel is transported from the reactors to the MRS/IS facility. Thus, it is essential that the facility is capable of receiving, unloading, loading, and decontaminating any of the present generation of spent fuel shipping casks.

6.2.5.2 Geologic Repositories

The main interface with the MRS/IS facility and the geologic repository is the transportation link. Spent fuel, solidified high level waste and transuranic wastes that have been in interim storage are shipped from the MRS/IS facility to the repository for permanent disposal. Depending upon the concept employed, this link may be an onsite transfer or a transcontinental shipment.

6.2.6 Advantages/Disadvantages of Utilizing an Existing Federal Site

This section addresses the advantages and disadvantages of using an existing federal site as the location of an MRS/IS facility. Site selection for an MRS/IS facility can be relatively independent of local geologic features and is likely to be made based on other factors. e.g., transportation costs, availability of resources (material and labor), and socioeconomic considerations.

Advantages. Currently active DOE nuclear facilities already have a number of the resource and support facilities required by an MRS/IS facility. Such facilities typically include:

- a work force experienced in constructing and operating nuclear facilities
- an established security force and site boundary
- an in-place municipal service system to support a construction labor force

- the potential availability of a nearby low-level waste disposal facility
- established local site support systems.

The experience of the local population living in the vicinity of a nuclear facility should result in a minimum of local opposition to nearby MRS/IS facility siting. In fact, the local population may lobby strongly in support of an MRS/IS facility for its occupational opportunities. This may become pronounced as other nuclear programs [e.g., the liquid metal fast breeder reactor (LMFBR) program] are cut back.

The use of existing DOE facilities eliminates many procedural difficulties with land acquisition as well as the political difficulties of purchasing land and relocating an indigeneous population. In many cases, the DOE sites were originally chosen for their remoteness, and use of such sites would have the least adverse effect on the population.

There are significant economic advantages to locating an MRS/IS facility on a site at which a repository will subsequently be located. If both facilities are on adjacent sites, significant economic advantages arise from the ease of transporting waste from storage to the repository, even under the design constraint that the storage and repository facilities be independent. Adjacent siting eliminates much of the transportation cost inherent in using an independently-sited storage facility. Transportation distances are short, and the potential for using economical, but unlicensed, casks is attractive. (Cask economies may arise from the ability to reduce cask shielding or use a dedicated roadway or rail line.)

Disadvantages. The siting of an MRS/IS facility at an existing DOE site may have potential risks and costs. It is likely to arouse public concern that site selection is being made on the basis of convenience (i.e., prior ownership) rather than technical superiority. Although the portion of the public benefiting from MRS/IS economic opportunities may be supportive, others more distant from the site are likely to oppose the site selection, which will add impetus to their opposition to existing activities.

The two presently identified DOE repository candidate sites are not well located. Because they were originally chosen, in part, for their remoteness, the construction, operating, and transport costs of an MRS/IS facility may be substantially increased. The lack of locally available construction materials, and at the Nevada Site lack of an adequate water supply, is certain to increase construction costs. The remoteness of the site from nuclear reactors and fuel reprocessing plants will contribute to high spent fuel and waste transport costs.

Many current legislative proposals call for MRS facilities to be subjected to the NRC licensing process. Co-locating NRC-licensed commercial waste management facilities with unlicensed nuclear research and development facilities may allow the regulatory authorities to claim jurisdiction over currently unlicensed activities. This risk can be minimized only by maintaining separation between the MRS/IS facility and the existing research and development facilities. Such separation, however, reduces (or eliminates) the ability of the MRS/IS facility to utilize existing facilities and negates some of the advantages of using existing DOE facilities.

Local Site Support Systems. The selection of a federal nuclear site as the location of an MRS/IS facility makes possible the utilization of many support services already available on the site. These services are discussed briefly in this subsection.

Transportation Services. An existing network of rail lines extends to nearly all parts of the site. The site rail network is connected directly to the principal railroads operating in the area, with connections to other major railroads in the U.S. Extension of the existing rail networks to the MRS/IS facility site can be accomplished relatively easily, with the length of new track likely to be in the vicinity of 5 miles or less, depending on the specific site selected.

The site is also served by a network of onsite highways, with connections to major state and interstate highways. Extensions of the existing highway network to the MRS/IS facility site can also be accomplished relatively easily, with the length of roadway to be added likely to be in the vicinity of 5 miles or less, depending on the specific site selected.

Essential Services. The site is served by a large network of electric power transmission lines. These lines interconnect the principal electricity generating stations in the area and provide an assured source of electrical energy to the site facilities. Extension of the existing site distribution system to the MRS/IS facility site can be accomplished readily.

Water for use at the site would be pumped from a nearby river at an existing pumping station by the installation of new pumps and delivered to the site through a new delivery line. Alternatively, if the demand for water is not too great, wells could be drilled into the underlying aquifer and the necessary water pumped to the surface. In any event, ample water supplies can be made available.

Sludges from the sanitary waste disposal system and from process waste evaporation ponds would be disposed of at existing site sludge disposal facilities.

In view of the close proximity of the MRS/IS facility to existing site waste treatment facilities, and since the quantities of radioactive waste generated within the storage complex are expected to be quite small, extensive systems for treatment of radioactive wastes should not be required at the complex.

The site is served by an existing telephone system which is connected into the national telephone network. Additional communications are available through the plant radio network, under the control of the plant security forces.

Security for the government-owned facilities on the site is provided by the Site Patrol organization. Rapid response to any situations requiring such a response is made possible by a closely integrated communications system, a fleet of emergency response vehicles, and a large force of well-trained personnel. It is expected that security at the MRS/IS facility site would be provided by the Site Patrol organization.

Other Support Services. The existing central stores, employee transport, contaminated laundry service, central heavy equipment and vehicle maintenance, and central computing services already in operation on the Site are available as needed by the MRS/IS facility.

6.2.7 Technical Status of System Components

The methods and systems to be used at a monitored retrievable storage/interim storage (MRS/IS) facility are, for the most part, well within the state-of-the-art and most have either been used or demonstrated at various facilities in the United States or abroad. The status of each of the principal components of an MRS/IS facility is discussed in this section.

6.2.7.1 Receiving and Handling

A considerable amount of experience has been gained in the use of rail and truck casks, both wet and dry, for the transportation of irradiated fuel elements in the United States.

Shipping cask wet unloading and fuel handling storage have been routinely performed at two reprocessing plants and in the spent fuel storage basin at commercial LWRs for a number of years. Dry receiving, unloading and storage have been considered and proposed in a number of different types of facilities ranging from reprocessing plants to repositories. They have been performed at the Nevada Test Site (NTS) in support of both the Spent Fuel Dry Surface Storage Program conducted by ONWI at the E-MAD facility and the disposal demonstration program conducted by the Lawrence Livermore Laboratory at the CLIMAX facility.

Transporter/emplacement systems for use with both casks and drywells of equivalent weight and configuration being considered for the MRS/IS facility have been demonstrated at E-MAD as part of the Spent Fuel Surface Storage Program.

6.2.7.2 Storage Casks

Early cask storage concepts used hollow, reinforced-concrete cylinders to provide storage for spent fuel and HLW cylinders. In the U.S., surface storage casks have been demonstrated at NTS under the spent fuel storage program. More recent cask designs have centered around metal casks and considerable development work is under way at several firms. Although the bulk of the work is proprietary, it can be concluded that the technology for metal casks will soon be adequate to allow the concept to develop into a commercially available and licensable product.

Three metal casks are now at the stage where prototype units are undergoing final design and fabrication. Table 6.7 contains a brief summary of the specifications for these three casks. In this study, all cask storage designs and calculations are based on the REA-2023.

The spent fuel capacity of the REA cask may be doubled (48 PWR or 104 BWR assemblies) over that shown in Table 6.7 by loading it with consolidated rods. However, exterior cooling fins must be added, and the maximum cladding temperature is expected to rise.

No designs are yet available for the placement of solidified HLW canisters in the REA cask. A new basket would be required to support the 1-ft O.D. canisters. Because each canister generates about 2.1 kW, it seems reasonable to assume that 14 HLW canisters could be put into one cask without exceeding the 30-kW thermal load limit for the nonfinned cask. This assumption must be confirmed by more detailed heat transfer and shielding calculations and/or experiments.

TABLE 6.7. Storage Cask Specifications

	REA-2023	TN-2100	CASTOR-V(B and C)
Designer/manufacturer	REA/Brooks and Perkins (USA)	Transnuklear (W. Germany)	GNS (W. Germany)
Capacity			
PWR assemblies	24	21	20–24
BWR assemblies	52	37	50–52
Weight, loaded (tons)	87.5–97.5	110–120	100–125
Age of fuel (yr)	5	5–8	5
Thermal load (kW)	30[a]	15	45–55

(a) Can be increased to 47 kW by addition of special fins at the storage site.

6.2.7.3 Drywells

The technology needed to design and construct drywells is well-established. Drywell development programs and projects at NTS, Hanford and the Idaho National Engineering Laboratory (INEL) have all provided experience with procedures and equipment, heat transfer data in soil and confirmation of the feasibility of the method.

The use of drywells has been demonstrated at NTS/E-MAD as part of the Spent Fuel Surface Storage Program. Drywells have been used to store HTGR and LMFBR fuels at INEL for over ten years. However, available test data for dry storage have not covered the full range of possible spent fuel performance variables including different fuel manufacturers, reactor types, fuel burnups, air storage environment, etc. Qualified shielding, criticality, and structural analysis models and techniques for dry storage systems are available and well-established. The open-field drywell has direct qualification data from operating experience and demonstrations. With respect to structural analysis for drywell concepts, extensive seismic analysis has already been performed on systems which are directly comparable.

The BNFP drywell design is similar to those for various test holes at federal sites in Nevada, Idaho, and Washington, but differs from the other designs in that the storage drywells are enclosed in an engineered berm, built above the normal ground level. An engineered berm can be constructed with predictable heat dissipation design characteristics. Moisture and nuclide transport within an engineered berm can also be predicted.

This design package, which formed the basis for the BNFP solid waste storage area design, is complete and has been issued for construction. Concurrently, the BNFP SAR has been amended and the concept has undergone NRC licensing review.

6.2.7.4 TRU Waste Storage

Commercial experience in handling and storing TRU waste is limited, due to the delays in startup of commercial fuel reprocessing. Substantial experience has been gained, however, in the handling and storing of defense TRU wastes, and numerous design concepts have been considered as storage alternatives.

For the most part, the requirements for handling and storing TRU waste at an MRS/IS site can be satisfied by the available technology. The technical status for the handling and storage methods considered in this report are briefly reviewed below.

Contact-Handled TRU. Above-ground, indoor, unshielded storage of TRU low-level waste on a long-term basis is being successfully used by the national laboratories. The absence of significant heat output or radiation from CHTRU waste makes simple warehouses sufficient for meeting storage needs. No special handling equipment is required for placement or retrieval of the waste drums and boxes. Decommissioning of the facilities involves only routine salvage procedures. Buried storage has been used by national laboratories and the use of buried cargo containers presents no additional technological problems.

Remote-Handled TRU. Above-ground storage of intermediate-level TRU waste requires either a heavily shielded storage building and remote operations or storage casks. Limited experience with this method of storage has been gained at government facilities. The design and construction of suitable, shielded buildings and the necessary remote handling equipment are less sophisticated than that found in existing nuclear facilities. The storage facilities will be free of radioactive contamination after removal of the stored waste, and decommissioning should require only routine salvage procedures.

Fuel Residue. The radioactivity of the fuel residue necessitates remote handling and shielded storage. The interim storage concept involves storing canisters of compacted fuel residue in subsurface drywells or in concrete casks. Some failed equipment (RHTRU) packaged in identical containers may be stored along with the fuel residue. Similar techniques have been used for retrievable storage of radioactive wastes at government installations. Commercial experience with handling and storing fuel residue has been gained at the Nuclear Fuels Services facility in New York.

Monitoring Systems. Required storage monitoring such as gas sampling and measuring, and temperature measuring systems are all well-developed and can be applied to either storage concept.

6.2.8 Research and Development Requirements

As noted above in Section 6.2.1, the general systems and components required at an MRS/IS facility have been developed and demonstrated. It is anticipated that the R&D requirements will essentially be the same for all MRS/IS facilities no matter where they are located. An exception for the MRS/IS/Repository is that geological, hydrological and geotechnical exploration and data evaluation will be required to assure the facility is located on an acceptable and viable geologic repository site.

Although much of the technology required for the design and construction of an MRS/IS facility is currently available, two areas that pertain to all the storage concepts considered in this study will require development: (1) generic design and operational criteria including temperature limits for the material stored and (2) monitoring methods and instruments. Criteria must be developed so that an MRS/IS facility can be econonomically designed, operated, and decommissioned in compliance with applicable government regulations. This will involve identification of the specific requirements of an MRS/IS facility, pertinent regulations, and facility operating parameters. Monitoring methods and instrumentation must be developed that will verify the integrity of the storage system during the operational life of the facility. If the integrity of the storage system depends on the integrity of the spent fuel cladding or the HLW canisters, then the monitoring system must verify the condition of the stored contents. Additional development areas specific to transportation, handling, and storage concepts are described in the following sections.

6.2.8.1 Transportation

Additional R&D efforts will be required to develop:

- licensed truck and rail casks designed for dry transfers of contents
- licensed transportable storage casks

- efficient licensed TRU waste containers and shipping casks
- standardized and licensed waste containers.

6.2.8.2 Handling and Processing

The need to achieve a relatively large facility throughput and capacity will require additional development and improvements to some of the present systems and methods. Development and prototype testing should be conducted on:

- grapples to handle canisters and waste packages
- automated cask decontamination station
- remotely operated contamination detection equipment
- container leak testing systems.

6.2.8.3 Cask Storage

Research and development needs for dry cask storage include:

- experiments using prototypical components to demonstrate the satisfactory thermal behavior of the cask storing spent fuel or solidified HLW canisters and to establish large surface storage cask heat transfer parameters for site-specific environments
- models and computer codes to permit accurate calculation of the thermal behavior of the cask and the material stored in it
- optimization of the design of the HLW canister to include consideration of cask storage
- experiments to determine the seismic response of the cask and its contents
- experiments to determine the long-term performance of the casks (e.g., degradation of heat transfer capability or structural integrity)
- simpler, less expensive casks and methods to permit transport of storage casks.

6.2.8.4 Drywell Storage

Research and development needs for drywell storage include:

- heat transfer models and programs to define the thermal behavior of the waste, the canister, and the surrounding soil for a large array of drywells, and to establish drywell heat transfer parameters for site-specific environments
- methods and/or equipment to prevent animals from burrowing in the vicinity of drywells
- methods or selection of materials to prevent corrosion from affecting storage, monitoring, or retrieval of the waste
- evaluation of requirements for spent fuel canisters
- design development of high-thermal-efficiency drywells.

6.2.8.5 TRU Waste

Although no new requirements for research are identified for TRU waste storage, there does appear to be a need for development in the following areas:

- improved definition of compacted and consolidated TRU wastes in terms of heat output and radiation levels
- development of handling and transfer systems for RHTRU (fuel residue), viz., wet or dry transfer as discussed in Section 6.2.8.2
- selection of corrosion protection methods and materials for subsurface storage.

APPENDIX A

DETAILS OF ECONOMIC COMPARISONS

A.1 MRS/IS FACILITY CO-LOCATED WITH A REPROCESSING PLANT
Tables A.1 - A.18

A.2 MRS/IS STAND-ALONE FACILITY
Tables A.19 - A.36

A.3 MRS/IS FACILITY CO-LOCATED WITH A REPOSITORY
Tables A.37 - A.45

APPENDIX A

DETAILS OF ECONOMIC COMPARISONS

This appendix contains supplemental data on the economic evaluations and comparisons of the three MRS/IS concepts included in this study. The data are provided in support of the economic comparisons given in the body of the report.

In each section of this appendix, cost tables are provided for one of the three concepts. Presented in order in each section are 1) life-cycle cash flows for each of the three scenarios considered, for alternatives of storage in casks and in drywells (or in berm-protected dry wells, in the case of the site co-located with a reprocessing plant); 2) capital costs for each scenario and storage method; and 3) operating costs, presented as annual costs or as unit costs, for each alternative.

Explanations and further details of these costs and the underlying assumptions may be found in the draft reports for the three concepts.

TABLE A.1. MRS/IS Facility Co-located With a Reprocessing Plant--Reference Scenario, Life-Cycle Cash Flows: Cask Storage (millions mid-1982 dollars)

Year	Capital Costs: Handling and Support	Capital Costs: Storage	Operating Costs	Transport Costs[a]	Total
1985					
1986					
1987	0.200	2.000			2.200
1988	3.100	15.200			18.300
1989	3.000	32.000			35.000
1990		14.100	0.785		14.885
1991		45.100	1.508		46.608
1992		45.100	2.226		47.326
1993		45.100	2.287		47.387
1994		45.100	2.308		47.408
1995		45.100	2.349		47.449
1996		31.000	2.390		33.390
1997			2.431		2.431
1998			1.160		1.160
1999			1.140		1.140
2000			1.156		1.156
2001			0.640		0.640
2002			2.461		2.461
2003			3.353		3.353
2004			3.285		3.285
2005			2.724		2.724
2006			0.213		0.213
2007			0.100		0.100
2008			0.100		0.100
2009			0.100		0.100
2010			0.372		0.372
2011			0.424		0.424
2012			0.402		0.402
2013			1.266		1.266
2014			1.076		1.076
2015			1.504		1.504
2016			14.600		14.600
2017			0.100		0.100
2018					
2019					
2020					
Total	319.800	6.300	52.460	0.0	378.560
Discounted Total					299.671

(a) Transportation costs are incremental to those which would be incurred if no MRS existed.

TABLE A.2. MRS/IS Facility Co-located With a Reprocessing Plant--Reference Scenario, Life-Cycle Cash Flows: Drywell Storage (millions mid-1982 dollars)

Year	Capital Costs: Handling and Support	Capital Costs: Storage	Operating Costs	Transport Costs[a]	Total
1985					0
1986	0.500	1.400			1.900
1987	1.100	2.900			4.000
1988	5.500	14.500			20.000
1989	3.900	10.200			14.100
1990		15.000	1.243		16.243
1991		25.800	2.515		28.315
1992		25.800	3.516		29.316
1993		25.800	3.556		29.356
1994		25.800	3.597		29.397
1995		25.800	3.638		29.438
1996		10.800	3.678		14.478
1997			3.719		3.719
1998			1.632		1.632
1999			1.289		1.289
2000			1.254		1.254
2001			1.459		1.459
2002			4.294		4.294
2003			5.187		5.187
2004			5.120		5.120
2005			3.300		3.300
2006			1.030		1.030
2007			0.100		0.100
2008			0.100		0.100
2009			0.100		0.100
2010			1.140		1.140
2011			0.800		0.800
2012			0.553		0.553
2013			2.493		2.493
2014			4.817		4.817
2015			1.870		1.870
2016			19.600		19.600
2017			0.100		0.100
2018					
2019					
2020					
Total	11.000	183.800	81.700	0.0	276.500
Discounted Total					213.159

(a) Transportation costs are incremental to those which would be incurred if no MRS existed.

TABLE A.3. MRS/IS Facility Co-located With a Reprocessing Plant--Delayed Reprocessing Scenario, Life-Cycle Cash Flows: Cask Storage (millions mid-1982 dollars)

Year	Capital Costs: Handling and Support	Capital Costs: Storage	Operating Costs	Transport Costs[a]	Total
1985					
1986					
1987	0.200	0.500			0.700
1988	1.300	6.500			7.800
1989	1.400	124.600			126.000
1990			0.939		0.939
1991		6.200	1.020		7.220
1992		124.000	1.134		125.134
1993		6.200	1.158		7.358
1994		130.200	1.709		131.909
1995		130.200	2.053		132.253
1996		130.200	2.840		133.040
1997		124.000	2.849		126.849
1998			2.849		2.849
1999			0.152		0.152
2000			0.100		0.100
2001			0.100		0.100
2002			0.100		0.100
2003			0.100		0.100
2004			0.100		0.100
2005			0.100		0.100
2006			0.100		0.100
2007			0.100		0.100
2008			0.100		0.100
2009			0.100		0.100
2010			0.100		0.100
2011			0.100		0.100
2012			1.116		1.116
2013			0.881		0.881
2014			1.550		1.550
2015			3.209		3.209
2016			4.729		4.729
2017			3.762		3.762
2018			19.850		19.850
2019			0.100		0.100
2020					
Total	2.900	782.600	53.100	0.0	838.600
Discounted Total					654.389

(a) Transportation costs are incremental to those which would be incurred if no MRS existed.

TABLE A.4. MRS/IS Facility Co-located With a Reprocessing Plant--Delayed Reprocessing Scenario, Life-Cycle Cash Flows: Drywell Storage (millions mid-1982 dollars)

Year	Capital Costs: Handling and Support	Capital Costs: Storage	Operating Costs	Transport Costs[a]	Total
1985					
1986	0.200	1.200			1.400
1987	0.800	2.400			3.200
1988	3.400	11.500			14.900
1989	3.000	8.800			11.800
1990			9.047		9.047
1991		10.600	12.534		23.134
1992		12.000	12.687		24.687
1993		10.600	12.706		23.306
1994		22.600	19.731		42.331
1995		22.600	22.492		45.092
1996		22.600	28.355		50.955
1997		12.000	29.707		41.707
1998			0.502		0.502
1999			0.100		0.100
2000			0.100		0.100
2001			0.100		0.100
2002			0.100		0.100
2003			0.100		0.100
2004			0.100		0.100
2005			0.100		0.100
2006			0.100		0.100
2007			0.100		0.100
2008			0.100		0.100
2009			0.100		0.100
2010			0.100		0.100
2011			0.100		0.100
2012			2.427		2.427
2013			1.955		1.955
2014			3.432		3.432
2015			6.839		6.839
2016			9.724		9.724
2017			8.062		8.062
2018			14.500		14.500
2019			0.100		0.100
2020					
Total	7.400	136.900	196.100	0.0	340.400
Discounted Total					256.590

(a) Transportation costs are incremental to those which would be incurred if no MRS existed.

TABLE A.5. MRS/IS Facility Co-located With a Reprocessing Plant--Delayed Disposal Scenario, Life-Cycle Cash Flows: Cask Storage (millions mid-1982 dollars)

Year	Capital Costs		Operating Costs	Transport Costs[a]	Total
	Handling and Support	Storage			
1985		0			
1986		0			
1987	0.200	2.000			2.200
1988	3.100	15.200			18.400
1989	3.000	32.000			35.000
1990		14.100	0.591		14.691
1991		45.100	1.226		46.326
1992		45.100	1.790		46.890
1993		45.100	1.802		46.902
1994		45.100	1.810		46.910
1995		45.100	1.815		46.915
1996		45.100	1.820		46.920
1997	0.200	45.100	1.824		47.124
1998	3.100	47.100	1.829		58.029
1999	3.000	60.300	1.834		65.134
2000		77.100	2.431		79.531
2001		59.200	3.066		62.266
2002		90.200	3.645		93.845
2003		94.200	3.659		97.859
2004	0.400	120.600	3.672		124.672
2005	6.200	154.200	4.891		165.291
2006	6.000	118.400	6.013		130.413
2007		166.300	6.278		172.578
2008	0.400	139.300	5.520		145.200
2009	6.200	151.600	5.567		163.367
2010	6.000	109.100	6.854		121.954
2011		76.100	7.013		83.113
2012		45.100	5.497		50.597
2013		31.000	5.264		36.264
2014			2.009		2.009
2015			1.608		1.608
2016			1.704		1.704
2017			3.112		3.112
2018			3.248		3.248
2019			4.578		4.578
2020			5.576		5.576
2021			7,897		7.897
2022			8.154		8.154
2023			9.348		9.348
2024			10.462		10.462
2025			11.800		11.800
2026			13.228		13.228
2027			15.397		15.397
2028			14.257		14.257
2029			12.874		12.874
2030			12.394		12.394
2031			10.103		10.103
2032			10.051		10.051
2033			12.789		12.789
2034			4.523		4.523
2035			6.787		6.787
Total	37.800	1918.800	267.610	0.0	2224.210
Discounted Total					1424.786

(a) Transportation costs are incremental to those which would be incurred if no MRS existed.

TABLE A.6. MRS/IS Facility Co-located With a Reprocessing Plant--Delayed Disposal Scenario, Life-Cycle Cash Flows: Drywell Storage (millions mid-1982 dollars)

Year	Capital Costs: Handling and Support	Capital Costs: Storage	Operating Costs	Transport Costs[a]	Total
1985					
1986	0.500	1.400			1.900
1987	1.100	2.900			4.000
1988	5.500	14.500			20.000
1989	3.900	10.200			14.100
1990		15.000	0.916		15.916
1991		25.800	2.110		27.910
1992		25.800	3.104		28.904
1993		25.800	3.022		28.822
1994		25.800	3.029		28.829
1995		25.800	3.034		28.834
1996	0.500	25.800	3.038		29.338
1997	1.100	27.200	3.043		31.343
1998	5.500	28.700	3.047		37.247
1999	3.900	40.300	3.051		47.251
2000		36.000	3.972		39.972
2001		40.800	5.144		45.944
2002		54.400	6.152		60.552
2003	1.000	57.400	6.087		64.487
2004	2.200	80.600	6.101		88.901
2005	11.000	72.000	7.960		90.960
2006	7.800	66.600	10.104		84.504
2007	1.000	80.200	9.790		90.990
2008	2.200	83.200	9.113		94.513
2009	11.000	91.400	9.188		111.588
2010	7.800	82.800	11.154		101.754
2011		25.800	10.862		36.662
2012		25.800	11.437		37.237
2013		10.800	11.043		21.843
2014			1.551		1.551
2015			5.034		5.034
2016			3.889		3.889
2017			6.593		6.593
2018			5.748		5.748
2019			12.664		12.664
2020			9.704		9.704
2021			15.291		15.291
2022			15.518		15.518
2023			19.993		19.993
2024			20.024		20.024
2025			20.747		20.747
2026			21.391		21.391
2027			24.573		24.573
2028			22.793		22.793
2029			20.655		20.655
2030			19.207		19.207
2031			16.278		16.278
2032			16.187		16.187
2033			53.807		53.807
2034			27.000		27.000
2035			40.500		40.500
Total	66.000	1102.800	544.650	0.0	1713.450
Discounted Total					1032.053

(a) Transportation costs are incremental to those which would be incurred if no MRS existed.

TABLE A.7. MRS/IS Facility Co-located With a Reprocessing Plant Reference Scenario, Capital Costs: Cask Storage (thousands of mid-1982 dollars)

Descriptions	Units	Storage Costs	Handling and Support Costs	Total Costs
First Module				
Site improvements		--	755	755
Cask pads and structures		636	--	636
Casks	37	25,900	--	25,900
Hulls/HLGPT drywells	549	3,598	--	3,598
HLGPT drum drywells	140	1,263	--	1,263
LLGPT drum storage containers	48	665	--	665
Transporters		--	1,750	1,750
Other equipment		--	1,512	1,512
Total-Direct Costs		32,062	4,017	36,079
Indirect Cask		2,810	417	3,227
A-E Services		2,932	368	3,300
Owners Costs		1,600	200	1,800
Contingency		9,796	1,298	11,094
Total-First Module		49,200	6,300	55,500
Additional Modules				
Cask pads and structures		636	--	636
Casks		25,900	--	25,900
Hulls/HLGPT drywells		3,598	--	3,598
HLGPT drum drywells		1,263	--	1,263
LLGPT drum storage containers		665	--	655
Total-Direct Costs		32,062	--	32,062
Indirect Cask		3,153	--	3,153
A-E Services		180	--	180
Owners Costs		700	--	700
Contingency		9,005	--	9,005
Total-Additional Modules		45,100	--	45,100

TABLE A.8. MRS/IS Facility Co-located With a Reprocessing Plant--Reference Scenario, Capital Costs: Drywell Storage (thousands of mid-1982 dollars)

Descriptions	Units	Storage Costs	Handling and Support Costs	Total Costs
First Module				
Site improvements		--	1,014	1,014
Glass log drywells		6,843	--	6,843
Hulls/HLGPT drywells		3,598	--	3,598
HLGPT drum drywells		1,263	--	1,263
LLGPT drum storage containers		665	--	665
Transporters		--	3,420	3,420
Other equipment		--	1,712	1,712
Total-Direct Costs		12,369	6.146	18,515
Indirect Cask		6,552	537	7,089
A-E Services		2,605	1,295	3,900
Owners Costs		1,670	830	2,500
Contingency		5,804	2,192	7,996
Total-First Module		29,000	11,000	40,000
Additional Modules				
Glass log drywells		6,843	--	6,843
Hulls/HLGPT drywells		3,598	--	3,598
HLGPT drum drywells		1,263	--	1,263
LLGPT drum storage containers		665	--	665
Total-Direct Costs		12,369	--	12,369
Indirect Cask		6,989	--	6,989
A-E Services		180	--	180
Owners Costs		1,100	--	1,100
Contingency		5,162	--	5,162
Total-Additional Modules		25,800	--	25,800

TABLE A.9. MRS/IS Facility Co-located With a Reprocessing Plant--Delayed Reprocessing Scenario, Capital Costs: Cask Storage (thousands of mid-1982 dollars)

Descriptions	Units	Storage Costs	Handling and Support Costs	Total Costs
First Module				
Site improvements			801	801
Cask pads and structures		5,002	--	5,002
Casks	140	98,000		98,000
Hulls/HLGPT drywells	--	--		--
HLGPT drum drywells	--	--		--
LLGPT drum storage containers	--	--		--
Transporters		--	65	65
Other equipment		--	601	601
Total-Direct Costs		103,002	4,017	104,469
Indirect Cask		360	64	424
A-E Services		767	133	900
Owners Costs		1,100	700	1,800
Contingency		26,371	536	26,907
Total-First Module		131,600	2,900	134,500
Additional Modules				
Cask pads and structures		5,002	--	5,002
Casks	140	98,000	--	98,000
Hulls/HLGPT drywells	--	--	--	--
HLGPT drum drywells	--	--	--	--
LLGPT drum storage containers	--	--	--	--
Total-Direct Costs		103,002	--	103,002
Indirect Cask		385	--	385
A-E Services		120	--	120
Owners Costs		700	--	700
Contingency		25,993	--	25,993
Total-Additional Modules		130,200	--	130,200

TABLE A.10. MRS/IS Facility Co-located With a Reprocessing Plant--Delayed Reprocessing Scenario, Capital Costs: Drywell Storage (thousands of mid-1982 dollars)

Descriptions	Units	Storage Costs	Handling and Support Costs	Total Costs
First Module				
Site improvements		--	1,445	1,445
Glass log drywells	1,100	10,899	--	10,899
Hulls/HLGPT drywells		--	--	--
HLGPT drum drywells		--	--	--
LLGPT drum storage containers		--	--	--
Transporters		--	1,700	1,700
Other equipment		--	842	842
Total-Direct Costs		10,899	3,987	14,886
Indirect Cask		5,252	828	6,080
A-E Services		1,142	418	1,560
Owners Costs		1,830	670	2,500
Contingency		4,777	1,497	6,274
Total-First Module		23,900	7,400	31,300
Additional Modules				
Glass log drywells		10,899	--	10,899
Hulls/HLGPT drywells	1,100	--	--	--
HLGPT drum drywells		--	--	--
LLGPT drum storage containers		--	--	--
Total-Direct Costs		10,899	--	10,899
Indirect Cask		5,988	--	5,988
A-E Services		120	--	120
Owners Costs		1,100	--	1,100
Contingency		4,493	--	4,493
Total-Additional Modules		22,600	--	22,600

TABLE A.11. MRS/IS Facility Co-located With a Reprocessing Plant--Delayed Disposal Scenario, Capital Costs: Cask Storage (thousands of mid-1982 dollars)

Descriptions	Units	Storage Costs	Handling and Support Costs	Total Costs
First Module				
Site improvements		--	755	755
Cask pads and structures		636	--	636
Casks	37	25,900	--	25,900
Hulls/HLGPT drywells	549	3,598	--	3,598
HLGPT drum drywells	140	1,263	--	1,263
LLGPT drum storage containers	48	665		665
Transporters		--	1,750	1,750
Other equipment		--	1,512	1,512
Total-Direct Costs		32,062	4,017	36,079
Indirect Cask		2,810	417	3,227
A-E Services		2,932	368	3,300
Owners Costs		1,600	200	1,800
Contingency		9,796	1,298	11,094
Total-First Module		49,200	6,300	55,500
Additional Modules				
Cask pads and structures		636	--	636
Casks		25,900	--	25,900
Hulls/HLGPT drywells		3,598	--	3,598
HLGPT drum drywells		1,263	--	1,263
LLGPT drum storage containers		665	--	665
Total-Direct Costs		32,062	--	32,062
Indirect Cask		3,513	--	3,513
A-E Services		180	--	180
Owners Costs		700	--	700
Contingency		9,005	--	9,005
Total-First Modules		45,100	--	45,100

TABLE A.12. MRS/IS Facility Co-located With a Reprocessing Plant--Delayed Disposal Scenario, Capital Costs: Drywell Storage (thousands of mid-1982 dollars)

Descriptions	Units	Storage Costs	Handling and Support Costs	Total Costs
First Module				
Site improvements		--	1,014	1,014
Glass log drywells		6,843	--	6,843
Hulls/HLGPT drywells		3,598	--	3,598
HLGPT drum drywells		1,263	--	1,263
LLGPT drum storage containers		665	--	665
Transporters		--	3,420	3,420
Other equipment		--	1,712	1,712
Total-Direct Costs		12,369	6,146	18,515
Indirect Cask		6,552	537	7,089
A-E Services		2,605	1,295	3,900
Owners Costs		1,670	830	2,500
Contingency		5,804	2,192	7,996
Total-First Module		29,000	11,000	40,000
Additional Modules				
Glass log drywells		6,843	--	6,843
Hulls/HLGPT drywells		3,598	--	3,598
HLGPT drum drywells		1,263	--	1,263
LLGPT drum storage containers		665	--	655
Total-Direct Costs		12,369	--	12,369
Indirect Cask		6,989	--	6,989
A-E Services		180	--	180
Owners Costs		1,100	--	1,100
Contingency		5,162	--	5,162
Total-Additional Modules		25,800	--	25,800

TABLE A.13. MRS/IS Facility Co-located With a Reprocessing Plant--Reference Scenario, Operating Costs: Cask Storage (thousands of mid-1982 dollars)

Year	Manpower	Supplies	Utilities	Decom.	Total
1990	579	134	72	0	785
1991	1,019	269	220	0	1,508
1992	1,473	403	350	0	2,226
1993	1,473	403	411	0	2,287
1994	1,473	403	432	0	2,308
1995	1,473	403	473	0	2,349
1996	1,473	403	514	0	2,390
1997	1,473	403	555	0	2,431
1998	723	63	374	0	1,160
1999	723	61	356	0	1,140
2000	723	92	341	0	1,156
2001	364	15	261	0	640
2002	1,789	184	488	0	2,461
2003	2,508	276	569	0	3,353
2004	2,508	276	501	0	3,285
2005	2,149	128	357	0	2,724
2006	193	7	13	0	213
2007	97	0	3	0	100
2008	97	0	3	0	100
2009	97	0	3	0	100
2010	192	165	15	0	372
2011	300	93	31	0	424
2012	364	13	25	0	402
2013	817	309	140	0	1,266
2014	817	90	169	0	1,076
2015	1,176	125	203	0	1,504
2016	99	0	1	14,500	14,600
2017	100	0	0	0	100
2018	0	0	0	0	0
2019	0	0	0	0	0
2020	0	0	0	0	0
Totals	26,272	4,788	6,880	14,500	52,460

TABLE A.14. MRS/IS Facility Co-located With a Reprocessing Plant--Reference Scenario, Operating Costs: Drywell Storage (thousands of mid-1982 dollars)

Year	Manpower	Supplies	Utilities	Decom.	Total
1990	1,014	99	125	0	1,243
1991	1,991	198	326	0	2,515
1992	2,710	196	510	0	3,516
1993	2,710	296	550	0	3,556
1994	2,710	296	591	0	3,597
1995	2,710	296	632	0	3,638
1996	2,710	296	672	0	3,678
1997	2,710	296	713	0	3,719
1998	1,082	115	435	0	1,632
1999	817	87	385	0	1,284
2000	817	78	359	0	1,254
2001	973	110	376	0	1,459
2002	3,277	339	678	0	4,294
2003	3,996	431	760	0	5,187
2004	3,996	431	693	0	5,120
2005	2,571	287	442	0	3,300
2006	818	93	119	0	1,030
2007	97	0	3	0	100
2008	97	0	3	0	100
2009	97	0	3	0	100
2010	926	93	121	0	1,140
2011	660	57	83	0	800
2012	457	39	57	0	553
2013	1,991	203	299	0	2,493
2014	3,840	410	567	0	4,817
2015	1,441	170	259	0	1,870
2016	99	0	1	19,500	19,600
2017	100	0	0	0	100
2018	0	0	0	0	0
2019	0	0	0	0	0
2020	0	0	0	0	0
Totals	47,422	5,016	9,762	19,500	81,700

TABLE A.15. MRS/IS Facility Co-located With a Reprocessing Plant--Delayed Reprocessing Scenario, Operating Costs: Cask Storage (thousands of mid-1982 dollars)

Year	Manpower	Supplies	Utilities	Decom.	Total
1990	458	35	446	0	939
1991	458	41	521	0	1,020
1992	458	50	626	0	1,134
1993	458	51	649	0	1,158
1994	660	77	972	0	1,709
1995	754	95	1,204	0	2,053
1996	1,273	115	1,452	0	2,840
1997	1,273	115	1,461	0	2,849
1998	1,273	115	1,461	0	2,849
1999	149	0	3	0	152
2000	97	0	3	0	100
2001	97	0	3	0	100
2002	97	0	3	0	100
2003	97	0	3	0	100
2004	97	0	3	0	100
2005	97	0	3	0	100
2006	97	0	3	0	100
2007	97	0	3	0	100
2008	97	0	3	0	100
2009	97	0	3	0	100
2010	97	0	3	0	100
2011	97	0	3	0	100
2012	457	48	611	0	1,116
2013	364	37	480	0	881
2014	629	67	854	0	1,550
2015	1,335	138	1,736	0	3,209
2016	2,057	197	2,475	0	4,729
2017	1,539	164	2,059	0	3,762
2018	100	0	0	19,750	19,850
2019	100	0	0	0	100
2020	0	0	0	0	0
Totals	14,959	1,345	17,046	19,750	53,100

TABLE A.16. MRS/IS Facility Co-located With a Reprocessing Plant--Delayed Reprocessing Scenario, Operating Costs: Drywell Storage (thousands of mid-1982 dollars)

Year	Manpower	Supplies	Utilities	Decom.	Total
1990	1,165	7,431	451	0	9,047
1991	1,196	10,822	516	0	12,534
1992	1,430	10,624	633	0	12,687
1993	1,430	10,619	657	0	12,706
1994	2,231	16,519	981	0	19,731
1995	2,844	18,423	1,225	0	22,492
1996	3,203	23,681	1,471	0	28,355
1997	3,204	25,029	1,474	0	29,707
1998	371	43	88	0	502
1999	97	0	3	0	100
2000	97	0	3	0	100
2001	97	0	3	0	100
2002	97	0	3	0	100
2003	97	0	3	0	100
2004	97	0	3	0	100
2005	97	0	3	0	100
2006	97	0	3	0	100
2007	97	0	3	0	100
2008	97	0	3	0	100
2009	97	0	3	0	100
2010	97	0	3	0	100
2011	97	0	3	0	100
2012	1,430	373	624	0	2,427
2013	1,165	295	495	0	1,955
2014	2,044	523	865	0	3,432
2015	4,018	1,070	1,751	0	6,839
2016	5,697	1,531	2,496	0	9,724
2017	4,725	1,270	2,067	0	8,062
2018	100	0	0	14,400	14,500
2019	100	0	0	0	100
2020		0	0	0	0
Totals	37,614	128,253	15,833	14,400	196,100

TABLE A.17. MRS/IS Facility Co-located With a Reprocessing Plant--Delayed Disposal Scenario, Operating Costs: Cask Storage (thousands of mid-1982 dollars)

Year	Manpower	Supplies	Utilities	Decom.	Total
1990	457	134	0	0	591
1991	817	269	140	0	1,226
1992	1,176	403	211	0	1,790
1993	1,176	403	223	0	1,802
1994	1,176	403	231	0	1,810
1995	1,176	403	236	0	1,815
1996	1,176	403	241	0	1,820
1997	1,176	403	245	0	1,824
1998	1,176	403	250	0	1,829
1999	1,176	403	255	0	1,834
2000	1,633	538	260	0	2,431
2001	1,993	673	400	0	3,066
2002	2,352	807	486	0	3,645
2003	2,352	807	500	0	3,659
2004	2,352	807	513	0	3,672
2005	3,286	1,075	530	0	4,891
2006	3,986	1,341	686	0	6,013
2007	3,828	1,468	982	0	6,278
2008	3,628	1,209	683	0	5,520
2009	3,628	1,209	730	0	5,567
2010	4,562	1,478	814	0	6,854
2011	4,386	1,599	1,028	0	7,013
2012	3,728	922	847	0	5,497
2013	3,728	804	732	0	5,264
2014	1,100	259	650	0	2,009
2015	857	36	715	0	1608
2016	763	25	916	0	1704
2017	1,836	155	1,121	0	3,112
2018	1,836	205	1,207	0	3,248
2019	3,011	250	1,317	0	4,578
2020	3,562	488	1,526	0	5,576
2021	5,607	652	1,638	0	7,897
2022	5,607	805	1,742	0	8,154
2023	6,517	960	1,871	0	9,348
2024	7,527	949	1,986	0	10,462
2025	8,722	1,042	2,036	0	11,800
2026	9,766	1,288	2,174	0	13,228
2027	11,609	1,571	2,217	0	15,397
2028	10,714	1,428	2,115	0	14,257
2029	9,589	1,382	1,903	0	12,874
2030	9,276	1,291	1,327	0	12,394
2031	7,570	1,122	1,411	0	10,103
2032	7,570	1,074	1,411	0	10,051
2033	3,863	537	699	7,690	12,789
2034	0	0	0	4,523	4,523
2035	0	0	0	6,787	6,787
Totals	173,026	33,879	41,705	19,000	267,610

TABLE A.18. MRS/IS Facility Co-located With a Reprocessing Plant--Delayed Disposal Scenario, Operating Costs: Drywell Storage (thousands of mid-1982 dollars)

Year	Manpower	Supplies	Utilities	Decom.	Total
1990	817	99	0	0	916
1991	1,665	198	247	0	2,110
1992	2,438	296	370	0	3,104
1993	2,344	296	382	0	3,022
1994	2,344	296	389	0	3,029
1995	2,344	296	394	0	3,034
1996	2,344	296	398	0	3,038
1997	2,344	296	403	0	3,043
1998	2,344	296	407	0	3,047
1999	2,344	296	411	0	3,051
2000	3,161	395	416	0	3,972
2001	4,009	494	641	0	5,144
2002	4,782	592	778	0	6,152
2003	4,688	592	807	0	6,087
2004	4,688	592	821	0	6,101
2005	6,322	790	848	0	7,960
2006	8,018	988	1,098	0	10,104
2007	7,320	899	1,571	0	9,790
2008	7,132	888	1,093	0	9,113
2009	7,132	888	1,168	0	9,188
2010	8,766	1,086	1,302	0	11,154
2011	8,218	999	1,645	0	10,862
2012	9,764	318	1,355	0	11,437
2013	9,576	246	1,171	0	11,043
2014	500	11	1,040	0	1,551
2015	3,545	345	1,144	0	5,034
2016	2,218	205	1,466	0	3,889
2017	4,618	181	1,794	0	6,593
2018	3,291	526	1,931	0	5,748
2019	9,406	1,151	2,107	0	12,664
2020	6,439	823	2,442	0	9,704
2021	11,871	799	2,621	0	15,291
2022	11,676	1,055	2,787	0	15,518
2023	15,343	1,656	2,994	0	19,993
2024	15,330	1,516	3,178	0	20,024
2025	14,740	1,712	3,295	0	20,747
2026	16,037	1,876	3,478	0	21,391
2027	18,767	2,260	3,546	0	24,573
2028	17,321	2,158	3,314	0	22,793
2029	15,527	2,079	3,049	0	20,655
2030	14,618	1,917	2,672	0	19,207
2031	12,287	1,733	2,258	0	16,278
2032	12,287	1,642	2,258	0	16,187
2033	5,970	821	1,118	45,900	53,809
2034	0	0	0	27,000	27,000
2035	0	0	0	40,500	40,500
Total	327,695	36,948	66,607	113,400	544,650

TABLE A.19. Stand-Alone Facility--Reference Scenario, Life-Cycle Cash Flows: Cask Storage (millions mid-1982 dollars)

Year	Capital Costs: Handling and Support	Capital Costs: Storage	Operating Costs	Transport Costs[a]	Total
1984	15.649	2.707			18.356
1985	31.298	5.416			36.714
1986	46.949	8.124			55.073
1987	78.248	13.539			91.787
1988	80.748	13.539			94.287
1989	65.097	32.263			97.360
1990		29.750	12.783	6.200	48.733
1991		43.750	14.734	11.920	70.404
1992		43.750	15.313	18.040	77.103
1993		49.213	15.313	18.040	82.566
1994		66.342	15.313	18.040	99.695
1995		43.750	15.400	18.040	77.190
1996		43.750	15.400	18.040	77.190
1997			15.400	18.040	33.440
1998			12.870		12.870
1999			12.870		12.870
2000			12.870		12.870
2001			12.506		12.506
2002			15.622		15.622
2003			16.413		16.413
2004			16.413		16.413
2005			16.096		16.096
2006			14.035		14.035
2007			14.035		14.035
2008			12.506		12.506
2009			12.506		12.506
2010			12.506		12.506
2011			12.559	8.970	21.529
2012			12.559		12.559
2013			14.662	10.020	24.682
2014			14.662	14.780	29.442
2015			15.243		15.243
2016			13.721		13.721
2017			13.721		13.721
2018			13.721		13.721
2019			13.721		13.721
2020			20.338		20.338
2021			20.338		20.338
Total	317.989	395.893	466.149	160.130	1340.161
Discounted Total					1026.256

(a) Transportation costs are incremental to those which would be incurred if no MRS existed.

TABLE A.20. Stand-Alone Facility--Reference Scenario, Life-Cycle Cash Flows: Drywell Storage (millions mid-1982 dollars)

	Capital Costs				
Year	Handling and Support	Storage	Operating Costs	Transport Costs[a]	Total
1984	16.083	2.707			18.790
1985	32.165	5.416			37.581
1986	48.248	8.124			56.372
1987	80.414	13.539			93.953
1988	80.414	15.113			95.527
1989	64.330	12.405			76.735
1990		6.075	13.853	6.200	26.128
1991		9.119	15.846	11.920	36.885
1992		9.119	16.425	18.040	43.584
1993		14.582	16.425	18.040	49.047
1994		25.506	16.425	18.040	59.971
1995		9.119	16.425	18.040	43.584
1996		9.119	16.425	18.040	43.584
1997			16.425	18.040	34.465
1998			13.853		13.853
1999			13.853		13.853
2000			13.853		13.853
2001			13.512		13.512
2002			16.646		16.646
2003			17.438		17.438
2004			17.438		17.438
2005			17.121		17.121
2006			15.060		15.060
2007			15.060		15.060
2008			13.489		13.489
2009			13.489		13.489
2010			13.489	8.970	22.459
2011			13.542		13.542
2012			13.542	10.020	23.562
2013			15.687	14.780	30.467
2014			15.687		15.687
2015			16.267		16.267
2016			14.745		14.745
2017			14.745		14.745
2018			14.745		14.745
2019			14.745		14.745
2020			23.080		23.080
2021			23.080		23.080
Total	321.654	139.943	502.415	160.130	1124.142
Discounted Total					846.394

(a) Transportation costs are incremental to those which would be incurred if no MRS existed.

TABLE A.21. Stand-Alone Facility--Delayed Reprocessing Scenario, Life-Cycle Cash Flows: Cask Storage (millions mid-1982 dollars)

Year	Capital Costs: Handling and Support	Capital Costs: Storage	Operating Costs	Transport Costs[a]	Total
1984	13.882				13.882
1985	27.764				27.764
1986	41.647				41.647
1987	69.411				69.411
1988	71.911				71.911
1989	80.157	45.056			125.213
1990	66.386	43.750	15.163	13.160	138.459
1991	—	53.375	17.888	15.470	86.733
1992	—	61.328	17.888	18.710	97.927
1993	22.128	83.125	17.976	19.060	142.289
1994	66.386	109.454	20.823	28.620	225.284
1995		124.250	26.483	14.080	164.813
1996		130.454	26.483	42.680	199.618
1997			26.571	42.840	69.411
1998			1.529		1.529
1999			1.529		1.529
2000			1.529		1.529
2001			1.529		1.529
2002			1.529		1.529
2003			1.529		1.529
2004			1.529		1.529
2005			1.529		1.529
2006			1.529		1.529
2007			1.529		1.529
2008			1.529		1.529
2009			1.529		1.529
2010			1.529		1.529
2011			1.529		1.529
2012			17.976		17.976
2013			17.976		17.976
2014			20.823		20.823
2015			26.396		26.396
2016			26.396		26.396
2017			26.396		26.396
2018			20.823		20.823
2019			20.823		20.823
2020			24.242		24.242
2021			24.242		24.242
Total	459.674	650.795	416.774	194.620	1721.863
Discounted Total					1334.844

(a) Transportation costs are incremental to those which would be incurred if no MRS existed.

TABLE A.22. Stand-Alone Facility--Delayed Reprocessing Scenario, Life-Cycle Cash Flows: Drywell Storage (millions mid-1982 dollars)

Year	Capital Costs: Handling and Support	Capital Costs: Storage	Operating Costs	Transport Costs[a]	Total
1984	17.214				17.214
1985	34.429				34.429
1986	51.643				51.643
1987	86.072				86.072
1988	86.072	6.287			92.359
1989	91.689	6.287			97.976
1990	68.495	11.747	23.385	13.160	116.787
1991		16.976	26.834	15.470	59.280
1992		17.705	28.976	18.710	65.391
1993		26.277	29.275	19.060	74.612
1994	22.832	33.523	32.787	28.620	117.762
1995	68.495	39.689	39.340	14.080	161.604
1996		39.287	49.388	42.680	131.355
1997			49.223	42.840	92.063
1998			1.529		1.529
1999			1.529		1.529
2000			1.529		1.529
2001			1.529		1.529
2002			1.529		1.529
2003			1.529		1.529
2004			1.529		1.529
2005			1.529		1.529
2006			1.529		1.529
2007			1.529		1.529
2008			1.529		1.529
2009			1.529		1.529
2010			1.529		1.529
2011			1.529		1.529
2012			22.022		22.022
2013			22.022		22.022
2014			25.607		25.607
2015			33.129		33.129
2016			33.129		33.129
2017			33.129		33.129
2018			25.607		25.607
2019			25.607		24.607
2020			36.236		36.236
2021			36.236		36.236
Total	526.941	197.778	593.338	194.620	1512.676
Discounted Total					1151.448

(a) Transportation costs are incremental to those which would be incurred if no MRS existed.

TABLE A.23. Stand-Alone Facility--Delayed Disposal Scenario, Life-Cycle Cash Flows: Cask Storage (millions mid-1982 dollars)

	Capital Costs				
Year	Handling and Support	Storage	Operating Costs	Transport Costs[a]	Total
1984	15.863	2.707			18.570
1985	31.727	5.416			37.143
1986	47.591	8.124			55.715
1987	79.318	13.539			92.857
1988	81.818	13.539			95.357
1989	65.954	32.262			98.216
1990		29.750	12.783	6.200	48.733
1991		43.750	14.734	12.060	70.544
1992		43.750	15.313	18.080	77.143
1993		53.439	15.313	18.080	86.832
1994		79.022	15.313	18.080	112.415
1995		43.750	15.400	18.080	77.230
1996		44.356	15.400	18.080	77.836
1997		46.294	15.400	18.080	79.774
1998		61.813	15.400	18.080	95.293
1999		72.818	15.488	18.080	106.386
2000	22.129	58.625	15.488	18.080	114.322
2001	66.385	90.081	17.555	24.100	198.121
2002		122.063	20.790	31.430	174.283
2003		106.518	21.370	34.180	162.068
2004		116.568	21.458	34.180	172.206
2005		133.593	21.458	34.180	189.231
2006		185.393	25.298	48.100	258.791
2007		132.796	26.336	60.270	219.402
2008		170.164	25.386	49.970	245.520
2009		158.969	25.473	49.970	234.412
2010		170.906	25.561	77.930	274.397
2011		113.943	26.598	32.330	172.871
2012		0	21.210	9.540	30.750
2013		70.876	20.946	29.030	120.852
2014			20.946		20.946
2015			18.990		18.990
2016			18.553		18.553
2017			19.918		19.918
2018			19.918		19.918
2019			19.918		19.918
2020			21.247		21.247
2021			21.247		21.247
2022			21.247		21.247
2023			21.247		21.247
2024			21.247		21.247
2025			26.055		26.055
2026			26.055		26.055
2027			26.055		26.055
2028			26.055		26.055
2029			26.055		26.055
2030			24.789		24.789
2031			24.789		24.789
2032			24.736		24.736
2033			21.086		21.086
2034			21.086		21.086
2035			21.086		21.086
2036			43.230		43.230
2037			43.230		43.230
Total	410.785	2224.824	1044.232	696.190	4376.026
Discounted Total					2833.522

(a) Transportation costs are incremental to those which would be incurred if no MRS existed.

TABLE A.24. Stand-Alone Facility--Delayed Disposal Case Life-Cycle Cash Flows: Drywell Storage (millions mid-1982 dollars)

Year	Capital Costs: Handling and Support	Capital Costs: Storage	Operating Costs	Transport Costs[a]	Total
1984	16.162	2.707			18.869
1985	32.323	5.416			37.739
1986	48.485	8.124			56.609
1987	80.809	13.539			94.348
1988	80.809	15.113			95.922
1989	64.647	12.405			77.051
1990		6.075	13.879	6.200	26.154
1991		9.119	15.884	12.060	37.063
1992		9.119	16.463	18.080	43.662
1993		18.808	16.463	18.080	53.351
1994		38.187	16.463	18.080	72.730
1995		9.119	16.463	18.080	43.662
1996		9.725	16.463	18.080	44.268
1997		11.663	16.463	18.080	46.206
1998		20.978	16.463	18.080	55.521
1999		38.187	16.463	18.080	72.730
2000	22.832	9.119	16.463	18.080	66.494
2001	68.494	23.416	18.582	24.100	134.592
2002		49.757	21.886	31.430	103.073
2003		30.176	22.465	34.180	86.821
2004		47.306	22.465	34.180	103.951
2005		29.251	22.465	34.180	85.896
2006		57.377	26.272	48.100	131.749
2007		40.684	22.222	60.270	123.176
2008		57.120	26.272	49.970	133.362
2009		55.685	26.272	49.970	131.927
2010		38.862	26.272	77.930	143.064
2011		60.679	27.222	32.330	120.231
2012		17.627	21.781	9.540	48.948
2013		0	21.516	29.030	50.546
2014		17.627	21.516		39.143
2015			19.561		19.561
2016			19.561		19.561
2017			20.926		20.926
2018			20.926		20.926
2019			20.926		20.926
2020			22.254		22.254
2021			22.254		22.254
2022			22.254		22.254
2023			22.254		22.254
2024			22.254		22.254
2025			27.116		27.116
2026			27.116		27.116
2027			27.116		27.116
2028			27.116		27.116
2029			27.116		27.116
2030			25.850		25.850
2031			25.850		25.850
2032			25.797		25.797
2033			22.147		22.147
2034			22.147		22.147
2035			22.147		22.147
2036			58.876		58.876
2037			58.876		58.876
Total	414.561	762.969	1115.578	696.190	2989.298
Discounted Total					1993.563

(a) Transportation costs are incremental to those which would be incurred if no MRS existed.

TABLE A.25. Stand-Alone Facility--Reference Scenario, Capital Cost: Cask Storage (thousands of mid-1982 dollars)

	1st Module	2nd Module	3rd Module	Total
Site Improvements	7,408			7,408
Support Facilities	59,208			59,208
Spent Fuel/HLW Handling				
Facility	99,311			99,311
Transfer System	2,967			2,967
TRU Receiving Transfer Facility	19,796			19,796
Subtotal - Direct Costs	188,690			188,690
Engineering Services	49,059			49,059
Contingency	59,437			59,437
Owner's Cost	20,803			20,803
Total Cost - Handling Support Structures	317,989			317,989
(Cask/Drywell) Cost	11,900	233,800		245,700
Other SF/HLW Storage Costs	3,890	3,890		7,780
CH-TRU Storage	1,910	-		1,910
RH-TRU Storage	3,525	-		3,525
Fuel Residue Storage	26,700	13,700		40,400
Subtotal - Direct Cost	47,925	251,390		299,315
Engineering Services	9,367	3,386		12,753
Contingency	14,323	63,694		78,017
Owner's Cost	3,972	1,836		5,808
Total Cost - Storage Systems	75,587	320,306		395,893
Total Capital Cost	393,576	320,306		713,882

TABLE A.26. Stand-Alone Facility--Reference Scenario, Capital Cost: Drywell Storage (thousands of mid-1982 dollars)

	1st Module	2nd Module	3rd Module	Total
Site Improvements	6,488			6,488
Support Facilities	59,208			59,208
Spent Fuel/HLW Handling				
Facility	101,502			101,502
Transfer System	3,870			3,870
TRU Receiving & Transfer Facility	19,796			19,796
Subtotal - Direct Costs	190,864			190,864
Engineering Services	49,625			49,625
Contingency	60,122			60,122
Owner's Cost	21,043			21,043
Total Cost - Handling & Support Structures	321,654			321,654
(Cask/Drywell) Cost	2,353	46,987		49,340
Other SF/HLW Storage Costs	-	-		-
CH-TRU Storage	1,910	-		1,910
RH-TRU Storage	3,525	-		3,525
Fuel Residue Storage	26,700	13,700		40,400
Subtotal - Direct Cost	34,488	60,687		95,175
Engineering Services	8,355	2,637		10,992
Contingency	10,711	15,831		26,542
Owner's Cost	3,749	3,485		7,234
Total Cost - Storage Systems	57,303	82,640		139,943
Total Capital Cost	378,957	82,640		461,597

TABLE A.27. Stand-Alone Facility--Delayed Reprocessing Scenario, Capital Cost: Cask Storage (thousands of mid-1982 dollars)

	1st Module	2nd Module	3rd Module	Total
Site Improvements	6,230	-	-	6,230
Support Facilities	59,208	-	-	59,208
Spent Fuel/HLW Handling				
Facility	99,311	55,496	55,496	210,303
Transfer System	2,967	-	-	2,967
TRU Receiving & Transfer Facility	-	-	-	
Subtotal - Direct Costs	167,716	55,496	55,496	278,708
Engineering Services	43,606	10,683	10,683	64,972
Contingency	52,831	16,545	16,545	85,921
Owner's Cost	18,491	5,791	5,791	30,073
Total Cost - Handling & Support Structures	282,644	88,515	88,515	459,674
(Cask/Drywell) Cost	30,800	469,700	-	500,500
Other SF/HLW Storage Costs	3,890	3,890	7,780	15,560
CH-TRU Storage	-	-	-	-
RH-TRU Storage	-	-	-	-
Fuel Residue Storage	-	-	-	-
Subtotal - Direct Cost	34,690	473,590	7,780	516,060
Engineering Services	1,011	749	1,498	3,258
Contingency	8,925	118,585	2,320	129,830
Owner's Cost	429	406	812	1,647
Total Cost - Storage Systems	45,055	593,330	12,410	650,795
Total Capital Cost				

TABLE A.28. Stand-Alone Facility--Delayed Reprocessing Scenario, Capital Cost: Drywell Storage (thousands of mid-1982 dollars)

	1st Module	2nd Module	3rd Module	Total
Site Improvements	6,630	-	-	6,630
Support Facilities	59,208	-	-	59,208
Spent Fuel/HLW Handling				
Facility	136,531	57,259	57,259	251,049
Transfer System	1,926	-	-	1,926
TRU Receiving & Transfer Facility	-	-	-	-
Subtotal - Direct Costs	204,295	57,259	57,259	318,813
Engineering Services	53,117	11,022	11,022	75,161
Contingency	64,353	17,070	17,070	98,493
Owner's Cost	22,524	5,975	5,975	34,474
Total Cost - Handling & Support Structures	344,289	91,326	91,326	526,941
(Cask/Drywell) Cost	9,401	143,153	-0-	152,554
Other SF/HLW Storage Costs	-	-	-	-
CH-TRU Storage	-	-	-	-
RH-TRU Storage	-	-	-	-
Fuel Residue Storage	-	-	-	-
Subtotal - Direct Cost	9,401	143,153	-	152,554
Engineering Services	-	-	-	-
Contingency	2,350	35,788	-	38,138
Owner's Cost	823	6,263	-	7,086
Total Cost - Storage Systems	12,574	185,204	-0-	197,778
Total Capital Cost	356,863	276,350	91,326	724,719

TABLE A.29. Stand-Alone Facility--Delayed Disposal Scenario, Capital Cost: Cask Storage (thousands of mid-1982 dollars)

	1st Module	2nd Module	3rd Module	Total
Site Improvements	9,948	-		9,948
Support Facilities	59,208	-		59,208
Spent Fuel/HLW Handling				
Facility	99,311	55,496		154,807
Transfer System	2,967	-		2,967
TRU Receiving & Transfer Facility	19,796	-		19,796
Subtotal - Direct Costs	191,230	55,496		246,726
Engineering Services	49,720	10,683		60,403
Contingency	60,237	16,545		76,782
Owner's Cost	21,083	5,791		26,874
Total Cost - Handling & Support Structures	322,270	88,515		410,785
(Cask/Drywell) Cost	11,900	1,404,900		1,416,800
Other SF/HLW Storage Costs	3,890	35,010		38,900
CH-TRU Storage	1,910	7,340		9,250
RH-TRU Storage	3,525	7,320		10,845
Fuel Residue Storage	26,700	196,800		223,500
Subtotal - Direct Cost	47,925	1,651,370		1,699,295
Engineering Services	9,367	47,445		56,812
Contingency	14,323	424,704		439,027
Owner's Cost	3,972	25,718		29,690
Total Cost - Storage Systems	75,587	2,149,237		2,224,824
Total Capital Cost	397,857	2,237,752		2,635,609

TABLE A.30. Stand-Alone Facility--Delayed Disposal Scenario, Capital Cost: Drywell Storage (thousands of mid-1982 dollars)

	1st Module	2nd Module	3rd Module	Total
Site Improvements	6,775	-		6,775
Support Facilities	59,208	-		59,208
Spent Fuel/HLW Handling				
Facility	101,502	57,259		158,761
Transfer System	4,521	-		3,870
TRU Receiving & Transfer Facility	19,796	-		19,796
Subtotal - Direct Costs	191,802	57,259		249,061
Engineering Services	49,869	11,022		60,891
Contingency	60,418	17,070		77,488
Owner's Cost	21,146	5,975		27,121
Total Cost - Handling & Support Structures	323,235	91,326		414,561
(Cask/Drywell) Cost	2,353	284,748		287,101
Other SF/HLW Storage Costs	-	-		-
CH-TRU Storage	1,910	7,340		9,250
RH-TRU Storage	3,525	7,320		10,845
Fuel Residue Storage	26,700	196,800		223,500
Subtotal - Direct Cost	34,488	496,208		530,696
Engineering Services	8,355	40,706		49,061
Contingency	10,711	134,229		144,940
Owner's Cost	3,749	34,523		38,272
Total Cost - Storage Systems	57,303	705,666		762,969
Total Capital Cost	380,538	796,992		1,177,530

TABLE A.31. Stand-Alone Facility--Reference Scenario, Operating Costs: Cask Storage (thousands of mid-1982 dollars)

Year	Labor	Consumables	Maint./ Contract Labor	G&A Utilities	Other	Total
1990	7,190	719	3,925	949		12,783
1991	8,774	877	3,925	1,158		14,734
1992	9,244	924	3,925	1,220		15,313
1993	9,244	924	3,925	1,220		15,313
1994	9,244	924	3,925	1,220		15,313
1995	9,244	924	4,012	1,220		15,400
1996	9,244	924	4,012	1,220		15,400
1997	9,244	924	4,012	1,220		15,400
1998	7,190	719	4,012	949		12,870
1999	7,190	719	4,012	949		12,870
2000	7,190	719	4,012	949		12,870
2001	7,019	702	3,859	926		12,506
2002	9,287	929	4,180	1,226		15,622
2003	9,929	993	4,180	1,311		16,413
2004	9,929	993	4,180	1,311		16,413
2005	9,672	967	4,180	1,277		16,096
2006	8,260	826	3,859	1,090		14,035
2007	8,260	826	3,859	1,090		14,035
2008	7,019	702	3,859	926		12,506
2009	7,019	702	3,859	926		12,506
2010	7,019	702	3,859	926		12,506
2011	7,062	706	3,859	932		12,559
2012	7,062	706	3,859	932		12,559
2013	8,645	864	4,012	1,141		14,662
2014	8,645	864	4,012	1,141		14,662
2015	9,116	912	4,012	1,203		15,243
2016	8,046	805	3,808	1,062		13,721
2017	8,046	805	3,808	1,062		13,721
2018	8,046	805	3,808	1,062		13,721
2019	8,046	805	3,808	1,062		13,721
2020					20,338	20,338
2021					20,338	20,338
TOTALS	249,125	24,911	118,557	32,880	40,676	466,149

TABLE A.32. Stand-Alone Facility--Reference Scenario, Operating Costs: Drywell Storage (thousands of mid-1982 dollars)

Year	Labor	Consumables	Maint./ Contract Labor	G&A Utilities	Other	Total
1990	6,933	693	5,306	921		13,853
1991	8,560	856	5,306	1,124		15,846
1992	9,030	903	5,306	1,186		16,425
1993	9,030	903	5,306	1,186		16,425
1994	9,030	903	5,306	1,186		16,425
1995	9,030	903	5,306	1,186		16,425
1996	9,030	903	5,306	1,186		16,425
1997	9,030	903	5,306	1,186		16,425
1998	6,933	693	5,306	921		13,853
1999	6,933	693	5,306	921		13,853
2000	6,933	693	5,306	921		13,853
2001	6,762	676	5,153	921		13,512
2002	9,073	907	5,474	1,192		16,646
2003	9,715	972	5,474	1,277		17,438
2004	9,715	972	5,474	1,277		17,448
2005	9,458	946	5,474	1,243		17,121
2006	8,046	805	5,153	1,056		15,060
2007	8,046	805	5,153	1,056		15,060
2008	6,762	676	5,153	898		13,489
2009	6,762	676	5,153	898		13,489
2010	6,762	676	5,153	898		13,489
2011	6,805	680	5,153	904		13,542
2012	6,805	680	5,153	904		13,542
2013	8,431	843	5,306	1,107		15,687
2014	8,431	843	5,306	1,107		15,687
2015	8,902	890	5,306	1,169		16,267
2016	7,832	783	5,102	1,028		14,745
2017	7,832	783	5,102	1,028		14,745
2018	7,832	783	5,102	1,028		14,745
2019	7,832	783	5,102	1,028		14,745
2020					23,080	23,080
2021					23,080	23,080
TOTALS	242,275	24,225	157,812	31,943	46,160	502,415

TABLE A.33. Stand-Alone Facility--Delayed Reprocessing Scenario, Operating Costs: Cask Storage (thousands of mid-1982 dollars)

Year	Labor	Consumables	Maint./ Contract Labor	G&A Utilities	Other	Total
1990	9,287	929	3,721	1,226		15,163
1991	10,486	1,049	4,969	1,384		17,888
1992	10,486	1,049	4,969	1,384		17,888
1993	10,486	1,049	5,057	1,384		17,976
1994	12,797	1,280	5,057	1,689		20,823
1995	16,306	1,631	6,393	2,153		26,483
1996	16,306	1,631	6,393	2,153		26,483
1997	16,306	1,631	6,481	2,153		26,571
1998	1,241	124		164		1,529
1999	1,241	124		164		1,529
2000	1,241	124		164		1,529
2001	1,241	124		164		1,529
2002	1,241	124		164		1,529
2003	1,241	124		164		1,529
2004	1,241	124		164		1,529
2005	1,241	124		164		1,529
2006	1,241	124		164		1,529
2007	1,241	124		164		1,529
2008	1,241	124		164		1,529
2009	1,241	124		164		1,529
2010	1,241	124		164		1,529
2011	1,241	124		164		1,529
2012	10,486	1,049	5,057	1,384		17,976
2013	10,486	1,049		1,384		17,976
2014	12,797	1,280		1,689		20,823
2015	16,306	1,631	6,306	2,153		26,396
2016	16,306	1,631		2,153		26,396
2017	16,306	1,631		2,153		26,396
2018	12,797	1,280	5,057	1,689		20,823
2019	12,797	1,280		1,689		20,823
2020					24,242	24,242
2021					24,242	24,242
TOTALS	228,115	22,816	87,243	30,116	48,484	416,774

TABLE A.34. Stand-Alone Facility--Delayed Reprocessing Scenario, Operating Costs: Drywell Storage (thousands of mid-1982 dollars)

Year	Labor	Consumables	Maint./ Contract Labor	G&A Utilities	Other	Total
1990	9,886	989	6,222	1,305	4,983	23,385
1991	11,342	1,134	8,049	1,497	4,812	26,834
1992	11,342	1,134	8,049	1,497	6,954	28,976
1993	11,342	1,134	8,049	1,497	7,253	29,275
1994	11,342	1,134	8,049	1,497	10,765	32,787
1995	14,252	1,425	8,049	1,881	13,733	39,340
1996	18,874	1,887	9,876	2,492	16,259	49,388
1997	18,874	1,887	9,876	2,492	16,094	49,223
1998	1,241	124		164		1,529
1999	1,241	124		164		1,529
2000	1,241	124		164		1,529
2001	1,241	124		164		1,529
2002	1,241	124		164		1,529
2003	1,241	124		164		1,529
2004	1,241	124		164		1,529
2005	1,241	124		164		1,529
2006	1,241	124		164		1,529
2007	1,241	124		164		1,529
2008	1,241	124		164		1,529
2009	1,241	124		164		1,529
2010	1,241	124		164		1,529
2011	1,241	124		164		1,529
2012	11,342	1,134	8,049	1,497		22,022
2013	11,342	1,134	8,049	1,497		22,022
2014	14,252	1,425	8,049	1,881		25,607
2015	18,874	1,887	9,876	2,492		33,129
2016	18,874	1,887	9,876	2,492		33,129
2017	18,874	1,887	9,876	2,492		33,129
2018	14,252	1,425	8,049	1,881		25,607
2019	14,252	1,425	8,049	1,881		25,607
2020					36,236	36,236
2021					36,236	36,236
TOTALS	246,690	24,664	136,092	32,567	153,325	593,338

TABLE A.35. Stand-Alone Facility--Delayed Disposal Scenario, Operating Costs: Cask Storage (thousands of mid-1982 dollars)

Year	Labor	Consumables	Maint./ Contract Labor	G&A Utilities	Other	Total
1990	7,190	719	3,925	949		12,783
1991	8,774	877	3,925	1,158		14,734
1992	9,244	924	3,925	1,220		15,313
1993	9,244	924	3,925	1,220		15,313
1994	9,244	924	3,925	1,220		15,313
1995	9,244	924	4,012	1,220		15,400
1996	9,244	924	4,012	1,220		15,400
1997	9,244	924	4,012	1,220		15,400
1998	9,244	924	4,012	1,220		15,400
1999	9,244	924	4,100	1,220		15,488
2000	9,244	924	4,100	1,220		15,488
2001	10,785	1,078	4,268	1,424		17,555
2002	12,326	1,233	5,604	1,627		20,790
2003	12,797	1,280	5,604	1,689		21,370
2004	12,797	1,280	5,692	1,689		21,458
2005	12,797	1,280	5,692	1,689		21,458
2006	15,707	1,571	5,947	2,073		25,298
2007	16,478	1,648	6,035	2,175		26,336
2008	15,707	1,571	6,035	2,073		25,386
2009	15,707	1,571	6,122	2,073		25,473
2010	15,707	1,571	6,210	2,073		25,561
2011	16,478	1,648	6,297	2,175		26,598
2012	12,241	1,224	6,129	1,616		21,210
2013	12,027	1,203	6,129	1,587		20,946
2014	12,027	1,203	6,129	1,587		20,946
2015	10,700	1,070	5,808	1,412		18,990
2016	10,700	1,070	5,371	1,412		18,553
2017	11,684	1,168	5,524	1,542		19,918
2018	11,684	1,168	5,524	1,542		19,918
2019	11,684	1,168	5,524	1,542		19,918
2020	12,626	1,263	5,692	1,666		21,247
2021	12,626	1,263	5,692	1,666		21,247
2022	12,626	1,263	5,692	1,666		21,247
2023	12,626	1,263	5,692	1,666		21,247
2024	12,626	1,263	5,692	1,666		21,247
2025	16,392	1,639	5,860	2,164		26,055
2026	16,392	1,639	5,860	2,164		26,055
2027	16,392	1,639	5,860	2,164		26,055
2028	16,392	1,639	5,860	2,164		26,055
2029	16,392	1,639	5,860	2,164		26,055
2030	15,365	1,536	5,860	2,028		24,789
2031	15,365	1,536	5,860	2,028		24,789
2032	15,322	1,532	5,860	2,022		24,736
2033	12,797	1,280	5,320	1,689		21,086
2034	12,797	1,280	5,320	1,689		21,086
2035	12,797	1,280	5,320	1,689		21,086
2036					43,230	43,230
2037					43,230	43,230
TOTALS	578,726	57,871	244,817	76,382	86,460	1,044,256

TABLE A.36. Stand-Alone Facility--Delayed Disposal Scenario, Operating Costs: Drywell Storage (thousands of mid-1982 dollars)

Year	Labor	Consumables	Maint./ Contract Labor	G&A Utilities	Other	Total
1990	6,933	693	5,338	915		13,879
1991	8,560	856	5,338	1,130		15,884
1992	9,030	903	5,338	1,192		16,463
1993	9,030	903	5,338	1,192		16,463
1994	9,030	903	5,338	1,192		16,463
1995	9,030	903	5,338	1,192		16,463
1996	9,030	903	5,338	1,192		16,463
1997	9,030	903	5,338	1,192		16,463
1998	9,030	903	5,338	1,192		16,463
1999	9,030	903	5,338	1,192		16,463
2000	9,030	903	5,338	1,192		16,463
2001	10,614	1,061	5,506	1,401		18,582
2002	11,813	1,181	7,333	1,559		21,886
2003	12,283	1,228	7,333	1,621		22,465
2004	12,283	1,228	7,333	1,621		22,465
2005	12,283	1,228	7,333	1,621		22,465
2006	15,236	1,524	7,501	2,011		26,272
2007	16,007	1,601	7,501	2,113		27,222
2008	15,236	1,524	7,501	2,011		26,272
2009	15,236	1,524	7,501	2,011		26,272
2010	15,236	1,524	7,501	2,011		26,272
2011	16,007	1,601	7,501	2,113		27,222
2012	11,727	1,173	7,333	1,548		21,781
2013	11,513	1,151	7,333	1,519		21,516
2014	11,513	1,151	7,333	1,519		21,516
2015	10,186	1,019	7,012	1,344		19,561
2016	10,186	1,019	7,012	1,344		19,561
2017	11,170	1,117	7,165	1,474		20,926
2018	11,170	1,117	7,165	1,474		20,926
2019	11,170	1,117	7,165	1,474		20,926
2020	12,112	1,211	7,333	1,598		22,254
2021	12,112	1,211	7,333	1,598		22,254
2022	12,112	1,211	7,333	1,598		22,254
2023	12,112	1,211	7,333	1,598		22,254
2024	12,112	1,211	7,333	1,598		22,254
2025	15,921	1,592	7,501	2,102		27,116
2026	15,921	1,592	7,501	2,102		27,116
2027	15,921	1,592	7,501	2,102		27,116
2028	15,921	1,592	7,501	2,102		27,116
2029	15,921	1,592	7,501	2,102		27,116
2030	14,894	1,489	7,501	1,966		25,850
2031	14,894	1,489	7,501	1,966		25,850
2032	14,851	1,485	7,501	1,960		25,797
2033	12,326	1,233	6,961	1,627		22,147
2034	12,326	1,233	6,961	1,627		22,147
2035	12,326	1,233	6,961	1,627		22,147
2036					58,876	58,876
2037					58,876	58,876
TOTALS	559,414	55,941	313,636	73,835	117,752	1,115,578

TABLE A.37. MRS/IS Facility Co-located With a Repository--Reference Scenario, Life-Cycle Cash Flows: Cask Storage (millions mid-1982 dollars)[a]

Year	Capital Costs: Handling and Support	Capital Costs: Storage	Operating Costs	Transport Costs[b]	Total
1985	8.900				8.900
1986	26.700				26.700
1987	35.600				35.600
1988	44.500	1.300			45.800
1989	44.500				44.500
1990	17.800	16.900	11.530		46.230
1991		32.925	11.530		44.455
1992		50.975	11.530		62.505
1993		50.075	11.530		61.605
1994		50.975	11.530		62.505
1995		49.775	11.530		61.305
1996		50.355	11.530		61.885
1997		49.800	11.530		61.330
1998			6.000		6.000
1999			6.000		6.000
2000			6.000		6.000
2001			6.000		6.000
2002			6.000		6.000
2003			6.000		6.000
2004			6.000		6.000
2005			6.000		6.000
2006			6.000		6.000
2007			6.000		6.000
2008			6.000		6.000
2009			6.000		6.000
2010			6.000		6.000
2011			6.000		6.000
2012			6.000		6.000
2013			6.000		6.000
2014			6.000		6.000
2015			6.000		6.000
Total	178.000	353.080	200.24	0.0	731.320
Discounted Total[c]					578.165

(a) The number of significant figures is for computational accuracy and does not imply precision to the nearest $1000.
(b) Transportation costs are incremental to those which would be incurred if no MRS existed.
(c) Discount rate of 2 percent per year.

TABLE A.38. MRS/IS Facility Co-located With a Repository--Reference Scenario, Life-Cycle Cash Flows: Drywell Storage (millions mid-1982 dollars)[a]

Year	Capital Costs: Handling and Support	Capital Costs: Storage	Operating Costs	Transport Costs[b]	Total
1985	9.000				9.000
1986	27.000				27.000
1987	36.000				36.000
1988	45.000	19.600			64.600
1989	45.000				45.000
1990	18.000	2.025	11.530		31.555
1991		13.350	11.530		24.880
1992		25.325	11.530		36.855
1993		74.625	11.530		36.155
1994		16.025	11.530		27.555
1995		15.325	11.530		26.855
1996		15.405	11.530		26.935
1997		6.050	11.530		17.580
1998			6.000		6.000
1999			6.000		6.000
2000			6.000		6.000
2001			6.000		6.000
2002			6.000		6.000
2003			6.000		6.000
2004			6.000		6.000
2005			6.000		6.000
2006			6.000		6.000
2007			6.000		6.000
2008			6.000		6.000
2009			6.000		6.000
2010			6.000		6.000
2011			6.000		6.000
2012			6.000		6.000
2013			6.000		6.000
2014			6.000		6.000
2015			6.000		6.000
Total	180.000	137.730	200.240	0.0	517.970
Discounted Total[c]					412.430

(a) The number of significant figures is for computational accuracy and does not imply precision to the nearest $1000.
(b) Transportation costs are incremental to those which would be incurred if no MRS existed.
(c) Discount rate of 2 percent per year.

TABLE A.39. MRS/IS Facility Co-located With a Repository--Delayed Reprocessing Scenario, Life-Cycle Cash Flows: Cask Storage (millions mid-1982 dollars)[(a)]

Year	Capital Costs: Handling and Support	Capital Costs: Storage	Operating Costs	Transport Costs[(b)]	Total
1985	8.775				8.775
1986	26.325				27.325
1987	35.100				35.100
1988	43.875				43.875
1989	43.875				43.875
1990	17.550	41.325	11.530	32.816	103.221
1991		47.250	11.530	37.548	96.328
1992		58.825	11.530	46.151	116.506
1993		58.825	11.530	47.166	117.521
1994		89.450	11.530	71.308	172.288
1995		111.525	11.530	88.816	211.871
1996		133.160	11.530	106.462	251.152
1997		135.625	11.530	106.490	253.645
1998			6.000		6.000
1999			6.000		6.000
2000			6.000		6.000
2001			6.000		6.000
2002			6.000		6.000
2003			6.000		6.000
2004			6.000		6.000
2005			6.000		6.000
2006			6.000		6.000
2007			6.000		6.000
2008			6.000		6.000
2009			6.000		6.000
2010			6.000		6.000
2011			6.000		6.000
2012			6.000	54.262	60.262
2013			6.000	42.799	48.799
2014			6.000	76.229	82.229
2015			6.000	155.783	161.783
2016			6.000	238.458	244.458
2017			6.000	88.851	94.851
Total	175.500	675.985	212.240	1193.139	2256.864
Discounted Total[(c)]					1592.323

(a) The number of significant figures is for computational accuracy and does not imply precision to the nearest $1000.

(b) Transportation costs are incremental to those which would be incurred if no MRS existed.

(c) Discount rate of 2 percent per year.

TABLE A.40. MRS/IS Facility Co-located With a Repository--Delayed Reprocessing Scenario, Life-Cycle Cash Flows: Drywell Storage (millions mid-1982 dollars)[a]

Year	Capital Costs: Handling and Support	Capital Costs: Storage	Operating Costs	Transport Costs[b]	Total
1985	8.775				8.775
1986	26.325				26.325
1987	34.600				34.600
1988	43.875				62.175
1989	43.875	18.300			43.875
1990	17.550	27.600	17.052	32.816	95.018
1991		27.300	17.371	37.548	82.219
1992		27.600	19.230	46.151	92.981
1993		36.600	19.566	47.166	103.332
1994		54.900	23.438	71.308	149.646
1995		54.900	26.826	88.816	170.542
1996		54.900	29.559	106.462	190.921
1997			29.312	106.490	135.802
1998			6.000		6.000
1999			6.000		6.000
2000			6.000		6.000
2001			6.000		6.000
2002			6.000		6.000
2003			6.000		6.000
2004			6.000		6.000
2005			6.000		6.000
2006			6.000		6.000
2007			6.000		6.000
2008			6.000		6.000
2009			6.000		6.000
2010			6.000		6.000
2011			6.000		6.000
2012			6.000	54.262	60.262
2013			6.000	42.799	48.799
2014			6.000	76.229	82.229
2015			6.000	155.783	161.783
2016			6.000	238.458	244.458
2017			6.000	88.851	94.851
Total	175.000	302.100	302.354	1193.139	1972.593
Discounted Total[c]					1375.594

(a) The number of significant figures is for computational accuracy and does not imply precision to the nearest $1000.
(b) Transportation costs are incremental to those which would be incurred if no MRS existed.
(c) Discount rate of 2 percent per year.

TABLE A.41. MRS/IS Facility Co-located With a Repository--Delayed Reprocessing Scenario, Life-Cycle Cash Flows: Cask Storage (millions mid-1982 dollars)[a]

Year	Capital Costs: Handling and Support	Capital Costs: Storage	Operating Costs	Transport Costs[b]	Total
1985	8.900				8.900
1986	26.700				26.700
1987	35.600				35.600
1988	44.500	1.300			45.800
1989	44.500				44.500
1990	17.800	16.900	11.530		46.230
1991		32.925	11.530		44.455
1992		50.975	11.530		62.505
1993		50.075	11.530		61.605
1994		50.975	11.530		62.505
1995		49.775	11.530		61.305
1996		50.975	11.530		62.505
1997	2.500	50.300	11.530		64.330
1998		50.975	11.530		62.505
1999		49.975	11.530		61.505
2000		51.075	11.530		62.605
2001		67.875	11.530		79.405
2002	2.500	84.175	11.530		98.205
2003		100.750	11.530		112.280
2004		101.350	11.530		112.880
2005		100.775	11.530		112.305
2006	2.500	136.025	11.530		150.055
2007		166.775	11.530		178.305
2008		139.750	6.000		145.750
2009		139.800	6.000		145.800
2010		140.800	6.000		146.800
2011		173.175	6.000		179.175
2012		93.920	6.000		99.920
2013	2.500	7.975	6.000		16.475
2014		77.950	6.000		83.950
2015			6.000		6.000
2016			6.000		6.000
Total	188.000	2037.320	261.540	0.0	2486.860
Discounted Total[c]					1660.739

(a) The number of significant figures is for computational accuracy and does not imply precision to the nearest $1000.
(b) Transportation costs are incremental to those which would be incurred if no MRS existed.
(c) Discount rate of 2 percent per year.

TABLE A.42. MRS/IS Facility Co-located With a Repository-- Delayed Disposal Scenario, Life-Cycle Cash Flows: Drywell Storage (millions mid-1982 dollars)[a]

Year	Capital Costs: Handling and Support	Capital Costs: Storage	Operating Costs	Transport Costs[b]	Total
1985	9.000				9.000
1986	27.000				27.000
1987	35.500				35.500
1988	45.000	19.600			64.600
1989	45.000				45.000
1990	18.000	2.025	11.530		31.555
1991		13.350	11.530		24.880
1992		25.325	11.530		36.855
1993		24.625	11.530		36.155
1994		16.025	11.530		27.555
1995	2.500	15.325	11.530		29.355
1996		16.025	11.530		27.555
1997		24.650	11.530		36.180
1998		16.325	11.530		27.855
1999		15.025	11.530		26.555
2000		25.625	11.530		37.155
2001		36.650	11.530		48.180
2002	2.500	29.650	11.530		43.680
2003		40.350	11.530		51.880
2004		40.950	11.530		52.480
2005		49.675	11.530		61.205
2006	2.500	54.975	11.530		69.005
2007		57.725	11.530		69.255
2008		53.650	6.000		59.650
2009		53.700	6.000		59.700
2010		63.700	6.000		69.700
2011		48.425	6.000		54.425
2012		19.220	6.000		25.220
2013	2.500	13.375	6.000		21.875
2014		7.950	6.000		13.950
2015			6.000		6.000
2016			6.000		6.000
Total	189.500	783.92	261.540		1234.960
Discounted Total[c]					867.676

(a) The number of significant figures is for computational accuracy and does not imply precision to the nearest $1000.
(b) Transportation costs are incremental to those which would be incurred if no MRS existed.
(c) Discount rate of 2 percent per year.

TABLE A.43. MRS/IS Facility Co-located With a Repository--Capital Costs of Handling and Support Systems (thousands of mid-1982 dollars)

Offsite Development (electrical, roads, railroads, water)		$7,500
Land Improvements (railroads, roads, sidewalks)		4,200
Waste Handling Facility		44,200
Cargo Receiving and Shipping	8,000	
Hot Cell	11,000	
Radwaste System	10,800	
Hot Maintenance Shop	700	
Mechanical Electrical Instrument System	5,200	
HVAC and Personnel	8,500	
Service Facilities (standby generator, security buildings)		6,000
Storage Facilities (warehouse, rail cars)		2,500
Other Facilities		1,850
Waste Handling System		2,450
Area Service Systems (electrical, security, water, radiological waste management, lighting)		31,800
TRUSS Building		2,500[(a)]
Transporter and Gantry Crane		2,000[(b)]
Subtotal		$105,000
Cask Storage Yard (100 pads)		500
Indirect Costs (12.5% of A + B)		13,200
Engineering and Services (12% of A + B + C)		14,250
Contingency (25% of A + B + C + D)		33,250
Owners Cost (7% of A + B + C + D + E)		11,800
Total Cost		$178,000

(a) TRUSS building is used for storage of contact handled transuranic wastes (CHTRU). Not required for storage of spent fuel.
(b) Required for loading/unloading metal storage cask and concrete TRU storage casks. If drywell storage is used a second transporter (also $2 million) is required to service the drywells.

TABLE A.44. MRS/IS Facility Co-located With a Repository--Capital Costs of Storage Systems (mid-1982 dollars)

Metal Cask Systems[a]	(HLW or Spent Fuel Storage)
Metal Casks, each	$700,000[b]
Cask Pads, each	2,000
Cask Fields, each	300,000[c]
Concrete Cask Systems[a]	(Remote-Handled TRU Storage)
Concrete Casks, each	$25,000
Cask Pads, each	2,000
Cask Fields, each	300,000[c]
Drywell Systems[a]	(HLW or Spent Fuel Storage)
Drywells, each	$18,00
Drywell Fields, each	300,000[d]

(a) Storage systems are added as needed
(b) A 25% contingency is applied to metal cask costs
(c) A cask field accommodates 1000 metal or concrete casks (separate fields). Cask pads required.
(d) A drywell field accommodates 1000 drywells

TABLE A.45. MRS/IS Facility Co-located With a Repository--Operating Costs (thousands of mid-1982 dollars)

Fixed Annual Costs	
Labor	7,440
Consumables	740
Maintenance	2,370
Utilities, G&A, etc	980
Total	11,530[(a)]

Variable Operating Cost (dollars)
Spent fuel canisters $5,500 each
(used for dry storage only)

(a) Following repository startup, fixed costs are shared with the repository. The MRS share is $6 million annually

APPENDIX B

STUDY DATA BASE AND EVALUATION GUIDELINES

B.1 MRS/IS FUEL CYCLE AND WASTE SCENARIOS
Tables B.1 - B.18

B.2 CONSIDERATIONS FOR MRS/IS COST EVALUATION
Tables B.19 - B.25

B.3 TRANSPORTATION UNIT COSTS
Tables B.26 - B.34

APPENDIX B

STUDY DATA BASE AND EVALUATION GUIDELINES

B.1 MRS/IS FUEL CYCLE AND WASTE SCENARIOS

Five MRS/IS scenarios are to be used by all MRS/IS projects. Each MRS/IS facility should be designed to satisfy the reference scenario, the delayed reprocessing scenario, and the delayed disposal scenario. The early disposal scenario and the delayed disposal-no reprocessing scenario are included for information only.

Basis for Projections

The bases and assumptions used in developing the projections are as follows:

- Maximum pool expansion at reactors is assumed based on utility estimates.
- Each pool maintains a full core reserve.
- Historic spent fuel inventory data are used as reported by utilities.
- Discharge projections used are as given by utilities.
- Generic reactors added beginning in 1996 have lifetime storage capability.
- TRU wastes are sent to disposal or storage the year after reprocessing.
- The maximum receiving rate for each repository for spent fuel or equivalent HLW is 1800 MTHM/yr the first five years and 3000 MTHM/yr for the next 21 years.
- The maximum TRU receiving rates are designed to be compatible with the HLW receiving rates and are about 15 percent greater than those rates in terms of equivalent MTHM.

- Solidified HLW is sent to disposal or storage one year after reprocessing or 10 years after reactor discharge, whichever is later.
- Time from discharge is determined by youngest fuel in the mixture.
- Oldest fuel is shipped first to MRS/IS or reprocessing.
- Shipping the oldest fuel first is assumed to relieve the at-reactor storage problems.
- Spent fuel can be sent to disposal if the overflow from reactor basins is 10 years old and reprocessing is limited.
- The first two reprocessing plants have capacities of 1500 MTHM/yr and the next two have capacities of 3000 MTHM/yr.
- The fourth reprocessing plant is a replacement for the first plant, which is assumed to be retired after about 20 years service.
- Each reprocessing plant operates at 1/3 and 2/3 capacity in its first two years.
- Spent fuel requiring storage prior to 1990 is stored in casks at reactor sites or at government-owned emergency storage.

The startup dates for reprocessing plants and repositories which define the scenarios are summarized in Table B.1. MRS/IS activity concludes before 2025 for all except the delayed disposal scenario; a fourth repository is needed in the delayed disposal scenario to permit retiring the MRS/IS at a reasonable date.

Reprocessing Plant Waste Quantities

Reprocessing plant waste quantities are based on information provided by AGNS in a draft report.[a] The projection is based on:

- Compaction of the hulls (after separation of hardware) and other compactible and noncombustible wastes

(a) W. H. Carr, Estimation of Nuclear Waste from the Barnwell Nuclear Fuel Plant, Allied-General Nuclear Services, April 26, 1982 (Draft).

TABLE B.1. Startup Dates for the Scenarios

Scenario	Reprocessing	Disposal
Reference	1989, 2000, 2005, 2010	1998, 2002, 2015
Delayed Reprocessing	1999, 2010, 2015, 2020	1998, 2002, 2015
Delayed Disposal	1989, 2000, 2005, 2010	2008, 2012, 2015, 2025
Early Disposal[a]	1989, 2000, 2005, 2010	1993, 1998, 2010
Delayed Disposal[a] no Reprocessing		2008, 2012, 2015

(a) Information only

- Incineration of combustible wastes with cement immobilization of the ash and incinerator scrubber solution
- Immobilization of UF_6 plant particulates with cement
- Volume reduction factors based on data developed for the GEIS on commercial radioactive waste (DOE/ET-0028)
- Use of a 2-ft diameter x 10-ft long canister for hulls and other canistered wastes (excluding HLW). This size is assumed to be more compatible with storage and shipping casks than the 4-ft diameter x 8-ft long canister.

The annual quantities of waste from the 1500 MT/yr AGNS plant are summarized in Table B.2 for the volume-reduced and immobilized wastes. Table B.2 also shows the number of HLW canisters, if a standard 1-ft diameter x 10-ft long canister is used. The TRU wastes are divided into five surface dose rate categories: 0.2, 0.2-5, 5-50, 50-500, and >500 R/hr. Waste containers with surface dose rates greater than 0.2 R/hr are identified here as remote handled TRU (RHTRU). Those less than 0.2 R/hr are identified as

TABLE B.2. Annual AGNS Plant HLW and TRU Wastes with Volume Reduction and Immobilization (Per 1500 MTU)[a]

Waste[b]	Ft^3/yr	Container	Containers/yr 0.2 R/hr	0.2–5	5–50	50–500	>500 R/hr
HLW Glass	4,900	1'D x 10' can	--	--	--	--	700
Hulls Compacted	9,600	2'D x 10' can	--	--	--	--	340
Fuel Hdwr.	3,900	2'D x 10' can	--	--	--	--	140
RHTRU	1,600	2'D x 10' can	--	40	7	4	18
RHTRU	4,600	55 gal. Drums	--	614	76	8	--
CHTRU	1,380	4' x 6' x 6' Stl. Boxes	25	--	--	--	--
CHTRU	19,500	55 gal. Drums	3,293	--	--	--	--
Mox Plant							
CHTRU	10,400	55 gal. Drums	1,575	--	--	--	--
CHTRU	2,000	4' x 6' x 6' Stl. Boxes	15	--	--	--	--

(a) Based on information available at the time the RFP was prepared.
(b) Waste quantities are based on data from W. H. Carr, "Estimation of Nuclear Waste Types, Characteristics and Quantities from the Barnwell Nuclear Fuel Plant," document E-512-09600R dated May 1982, Allied-General Nuclear Services for "as generated" quantities and volume reduction ratio obtained from DOE/ET0028, Technology for Commercial Radioactive Waste Management, U.S. Department of Energy, May 1979. (Estimates are based on a 10 nanocuries/gram for TRU waste.)

contact handled (CHTRU). The AGNS data included a category 0.05 to 0.5 R/hr. For this analysis one-half the waste in that category is assumed to have a surface dose rate of less than 0.2 R/hr and, therefore, to be CHTRU. The remainder is assumed to be greater than 0.2 R/hr and, therefore, to be RHTRU.

Scenario Projection

The reference scenario is summarized in Table B.3. All numbers on this table are expressed as metric tons of spent fuel or metric tons equivalent of HLW (i.e., metric tons of spent fuel reprocessed to produce the HLW). To convert from MTHM to fuel assemblies or HLW canisters, divide the listed MTHM values by 0.18 MTHM/BWR, 0.42 MTHM/PWR, 2.143 MTHM/Canister. Column headings can be defined as follows:

Column	Label	Definition
2	Discharge	MT spent fuel discharged per year
3	AR Inv.	At-reactor spent fuel storage inventories, MT
4	MRS Inv.	Spent fuel inventory at the MRS/IS, MT
4	MRS Inv.	Spent fuel inventory at the MRS/IS, MT
5	Reprocess	Reprocessing rate, MT/yr
6	Disposal	Spent fuel shipped to disposal, MT/yr
7	Disposal Inv.	Spent fuel inventory in repositories, MT
8	HLW AR	HLW stored at reprocessing plant, MT equivalent
9	HLW MRS	HLW stored at MRS/IS, MT equivalent
10	Disposal	HLW sent to disposal, MT/yr
11	Disposal Inv.	HLW inventories in repositories, MT equivalent

TABLE B.3. Reference Scenario Summary

REFERENCE CASE JUNE 21, 1982

YEAR	DISCHARGE	AR INV	MRS INV	REPROCESS	DISPOSAL	DISP INV	HLW A R	HLW MRS	DISPOSAL	DISP INV
1981	1090.	7871.	0.	0.	0.	0.	0.	0.	0.	0.
1982	1237.	9106.	0.	0.	0.	0.	0.	0.	0.	0.
1983	1607.	10719.	0.	0.	0.	0.	0.	0.	0.	0.
1984	1744.	12447.	13.	0.	0.	0.	0.	0.	0.	0.
1985	2167.	14614.	13.	0.	0.	0.	0.	0.	0.	0.
1986	2610.	17181.	116.	0.	0.	0.	0.	0.	0.	0.
1987	2622.	19567.	292.	0.	0.	0.	0.	0.	0.	0.
1988	2866.	22196.	530.	0.	0.	0.	0.	0.	0.	0.
1989	3223.	24949.	503.	500.	0.	0.	500.	0.	0.	0.
1990	3071.	27507.	12.	1000.	0.	0.	1000.	500.	0.	0.
1991	3078.	29097.	0.	1500.	0.	0.	1500.	1500.	0.	0.
1992	3490.	31095.	0.	1500.	0.	0.	1500.	3000.	0.	0.
1993	3420.	33023.	0.	1500.	0.	0.	1500.	4500.	0.	0.
1994	3389.	34912.	0.	1500.	0.	0.	1500.	6000.	0.	0.
1995	3374.	36986.	0.	1500.	0.	0.	1500.	7500.	0.	0.
1996	3470.	38956.	0.	1500.	0.	0.	1500.	9000.	0.	0.
1997	3498.	40954.	0.	1500.	0.	0.	1500.	10500.	0.	0.
1998	3674.	43328.	0.	1500.	0.	0.	1500.	10400.	1800.	1800.
1999	3660.	45668.	0.	1500.	0.	0.	1500.	9900.	1800.	3600.
2000	3964.	47652.	0.	2000.	0.	0.	2000.	9600.	1800.	5400.
2001	4386.	49538.	0.	2500.	0.	0.	2500.	9800.	1800.	7200.
2002	4407.	50945.	0.	3000.	0.	0.	3000.	8700.	3600.	10800.
2003	4569.	52515.	0.	3000.	0.	0.	3000.	6900.	4800.	15600.
2004	4919.	54434.	0.	3000.	0.	0.	3000.	5100.	4800.	20400.
2005	4841.	55274.	0.	4000.	0.	0.	4000.	3300.	4800.	25200.
2006	5226.	55500.	0.	5000.	0.	0.	5000.	2500.	4800.	30000.
2007	6081.	55581.	0.	6000.	0.	0.	6000.	1500.	6000.	36000.
2008	6043.	55625.	0.	6000.	0.	0.	6000.	1500.	6000.	42000.
2009	6537.	56161.	0.	6000.	0.	0.	6000.	1500.	6000.	48000.
2010	6251.	55412.	0.	7000.	0.	0.	7000.	1500.	6000.	54000.
2011	6228.	55140.	0.	6500.	0.	0.	6500.	2500.	6000.	60000.
2012	6381.	54022.	0.	7500.	0.	0.	7500.	3000.	6000.	66000.
2013	6485.	53006.	0.	7500.	0.	0.	10500.	2700.	4800.	70800.
2014	6727.	52233.	0.	7500.	0.	0.	10500.	4200.	6000.	76800.
2015	7033.	51767.	0.	7500.	0.	0.	15000.	480.	6720.	83520.
2016	6690.	50957.	0.	7500.	0.	0.	18000.	0.	4980.	88500.
2017	6869.	50326.	0.	7500.	0.	0.	18000.	0.	7500.	96000.
2018	7258.	50084.	0.	7500.	0.	0.	18000.	0.	7500.	103500.
2019	6692.	49276.	0.	7500.	0.	0.	22500.	0.	3000.	106500.
2020	7046.	48822.	0.	7500.	0.	0.	22500.	0.	7500.	114000.

The 13 tons in MRS/IS before 1986 come from Surry-2. It is possible the ulitity will find another solution to its storage problem. Columns six and seven are provided for spent fuel disposal in other scenarios. Column eight represents the HLW inventory at the reprocessing plant, based on a minimum of one year hold up or until 10 years after reactor discharge.

Table B.4 contains the details of shipments of fuel and HLW to and from the MRS/IS. The left half of the table has BWR data and the right half PWR data. Positive numbers represent additions or shipment to the facility while negative values represent shipments or removals from the facility. In Table B.4, the amount of each shipment is given as the tonnes of heavy metal in the original fuel. Thus the HLW shipments must be converted to canisters to obtain storage requirements (see Table B.5). The exposure is the average exposure in MWd/kg. The discharge year is the year the youngest fuel in the mixture was discharged.

Table B.6 contains similar data for TRU. On this table, the left-hand column of each pair represents TRU generated while reprocessing BWR fuel and the right-hand column of each pair represents TRU generated while reprocessing PWR fuel. Number of packages of treated wastes handled each year is also given in Table B.6. In addition to the data given in Table B.6, the MOX plant is assumed to produce one 4 ft x 6 ft x 6 ft box for each 100 drums.

Tables B.7 and B.8 are similar to Tables B.3 and B.4 and present data for the delayed reprocessing scenario. Table B.8, however, does not include TRU since the MRS/IS will not receive any TRU in this scenario. Tables B.9-11 are similar to Tables B.4-6 and present data for the delayed disposal scenario. Tables B.12 through B.16 present data for the early disposal and delayed disposal-no reprocessing scenarios and are for information only.

The spent fuel and HLW requirements at MRS/IS were summarized in Table B.5. The peak rates given in Tables B.4, B.8, and B.10 were averaged over 2 or 3 years since the peaks are the result of setting the age of a year's reprocessing plant production of HLW equal to the age of the youngest fuel in the mixture. This causes large and unrealistic variations in

TABLE B.4. Reference Scenario, Fuel and HLW Shipments at MRS

REFERENCE CASE JUNE 21, 1982

YEAR	BWR FUEL: FUEL STORAGE TONNE	EXP	DISCHG	HLW STORAGE TONNE	EXP	DISCHG	REP PLNT POOL INV	PWR FUEL: FUEL STORAGE TONNE	EXP	DISCHG	HLW STORAGE TONNE	EXP	DISCHG	REP PLNT POOL INV
1981	0.	0.	1971	0.	0.	1970	0.	0.	0.	1971	0.	0.	1970	0.
1982	0.	0.	1971	0.	0.	1970	0.	0.	0.	1971	0.	0.	1970	0.
1983	0.	0.	1971	0.	0.	1970	0.	0.	0.	1971	0.	0.	1970	0.
1984	0.	0.	1971	0.	0.	1970	0.	13.	21.	1971	0.	0.	1970	0.
1985	0.	0.	1971	0.	0.	1970	0.	0.	0.	1971	0.	0.	1970	0.
1986	0.	0.	1971	0.	0.	1970	0.	103.	21.	1972	0.	0.	1970	0.
1987	11.	9.	1972	0.	0.	1970	0.	165.	23.	1974	0.	0.	1970	0.
1988	177.	15.	1974	0.	0.	1970	0.	61.	21.	1974	0.	0.	1970	0.
1989	-4.	9.	1972	0.	0.	1970	200.	-22.	21.	1972	0.	0.	1970	300.
1990	-183.	15.	1974	200.	16.	1975	400.	-307.	22.	1974	300.	21.	1975	600.
1991	0.	0.	1974	400.	16.	1976	600.	-12.	21.	1974	500.	22.	1976	900.
1992	0.	0.	1974	600.	17.	1977	600.	0.	0.	1974	900.	23.	1978	900.
1993	0.	0.	1974	600.	20.	1979	600.	0.	0.	1974	900.	24.	1979	900.
1994	0.	0.	1974	600.	22.	1980	600.	0.	0.	1974	900.	26.	1980	900.
1995	0.	0.	1974	600.	23.	1981	600.	0.	0.	1974	900.	29.	1981	900.
1996	0.	0.	1974	600.	25.	1982	600.	0.	0.	1974	900.	30.	1983	900.
1997	0.	0.	1974	600.	25.	1983	600.	0.	0.	1974	900.	30.	1984	900.
1998	0.	0.	1974	-120.	16.	1975	600.	0.	0.	1974	-180.	21.	1975	900.
1999	0.	0.	1974	-120.	16.	1976	600.	0.	0.	1974	-180.	21.	1976	900.
2000	0.	0.	1974	-120.	16.	1976	800.	0.	0.	1974	-180.	22.	1976	1200.
2001	0.	0.	1974	30.	25.	1987	1000.	0.	0.	1974	120.	30.	1986	1500.
2002	0.	0.	1974	-440.	16.	1977	1200.	0.	0.	1974	-660.	22.	1978	1600.
2003	0.	0.	1974	-720.	18.	1979	1200.	0.	0.	1974	-1080.	23.	1979	1600.
2004	0.	0.	1974	-720.	21.	1980	1200.	0.	0.	1974	-1080.	25.	1980	1800.
2005	0.	0.	1974	-720.	23.	1981	1600.	0.	0.	1974	-1080.	26.	1981	2400.
2006	0.	0.	1974	-320.	25.	1982	2000.	0.	0.	1974	-480.	30.	1983	3000.
2007	0.	0.	1974	-400.	25.	1983	2400.	0.	0.	1974	-600.	30.	1983	3600.
2008	0.	0.	1974	0.	0.	1970	2400.	0.	0.	1974	0.	0.	1970	3600.
2009	0.	0.	1974	0.	0.	1970	2400.	0.	0.	1974	0.	0.	1970	3600.
2010	0.	0.	1974	0.	0.	1970	2800.	0.	0.	1974	0.	0.	1970	4200.
2011	0.	0.	1974	400.	25.	2001	2600.	0.	0.	1974	600.	35.	1999	3900.
2012	0.	0.	1974	200.	25.	2002	3000.	0.	0.	1974	300.	35.	2001	4500.
2013	0.	0.	1974	-1200.	25.	2002	6000.	0.	0.	1974	900.	35.	2003	4500.
2014	0.	0.	1974	600.	25.	2004	6000.	0.	0.	1974	900.	35.	2004	4500.
2015	0.	0.	1974	-120.	25.	2004	6000.	0.	0.	1974	-3600.	34.	2004	9000.
2016	0.	0.	1974	-400.	25.	2004	9000.	0.	0.	1974	0.	0.	1970	9000.
2017	0.	0.	1974	0.	0.	1970	9000.	0.	0.	1974	0.	0.	1970	9000.
2018	0.	0.	1974	0.	0.	1970	9000.	0.	0.	1974	0.	0.	1970	9000.
2019	0.	0.	1974	0.	0.	1970	9000.	0.	0.	1974	0.	0.	1970	13500.
2020	0.	0.	1974	0.	0.	1970	9000.	0.	0.	1974	0.	0.	1970	13500.

TABLE B.5. Spent Fuel and HLW (MTHM) Storage Capacity Requirements at MRS/IS Facility

	Reference	Delayed Reprocessing	Delayed Disposal
Fuel capacity	--[a]	7,547	--[a]
HLW capacity	10,500	--	60,600
Annual receiving rate[b]	1,500	1,500	4,500
Annual removal rate[c]	1,800	2,200	4,800

(a) No spent fuel is stored at MRS/IS facility prior to startup in 1990.
(b) Peak rates averaged over 2 years.
(b) Peak rates averaged over 3 years.

TABLE B.6. Reference Scenario, Number of TRU Packages Handled at MRS

REFERENCE CASE JUNE 21, 1982

YEAR	HULLS & HDW 2X10 CAN		REMOTE H 2X10 CAN		REMOTE H 55 GA DRUM		CONTACT H 4X6X6 BOX		CONTACT H 55 GA DRUM		BOX PLANT 55 G DRUMS	
1981	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1982	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1983	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1984	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1985	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1986	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1987	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1988	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1989	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1990	64.	96.	9.	14.	93.	140.	3.	5.	439.	659.	210.	315.
1991	128.	192.	19.	28.	186.	279.	7.	10.	878.	1317.	420.	630.
1992	192.	288.	28.	41.	279.	419.	10.	15.	1317.	1976.	630.	945.
1993	192.	288.	28.	41.	279.	419.	10.	15.	1317.	1976.	630.	945.
1994	192.	288.	28.	41.	279.	419.	10.	15.	1317.	1976.	630.	945.
1995	192.	288.	28.	41.	279.	419.	10.	15.	1317.	1976.	630.	945.
1996	192.	288.	28.	41.	279.	419.	10.	15.	1317.	1976.	630.	945.
1997	192.	288.	28.	41.	279.	419.	10.	15.	1317.	1976.	630.	945.
1998	-73.	-109.	-10.	-16.	-106.	-159.	-4.	-6.	-501.	-751.	-239.	-359.
1999	-73.	-109.	-10.	-16.	-106.	-159.	-4.	-6.	-501.	-751.	-239.	-359.
2000	-73.	-109.	-10.	-16.	-106.	-159.	-4.	-6.	-501.	-751.	-239.	-359.
2001	-9.	-13.	-1.	-2.	-13.	-20.	-0.	-1.	-61.	-92.	-29.	-44.
2002	-210.	-315.	-30.	-45.	-305.	-458.	-11.	-16.	-1440.	-2160.	-689.	-1033.
2003	-323.	-484.	-46.	-70.	-467.	-704.	-17.	-25.	-2213.	-3319.	-1058.	-1586.
2004	-323.	-484.	-46.	-70.	-467.	-704.	-17.	-25.	-2213.	-3319.	-1058.	-1586.
2005	-261.	-392.	-38.	-56.	-380.	-570.	-14.	-20.	-1791.	-2687.	-857.	-1285.
2006	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2007	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2008	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2009	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2010	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2011	13.	19.	2.	3.	19.	28.	1.	1.	88.	132.	42.	63.
2012	-13.	-19.	-2.	-3.	-19.	-28.	-1.	-1.	-88.	-132.	-42.	-63.
2013	77.	115.	11.	17.	112.	168.	4.	6.	527.	790.	252.	378.
2014	77.	115.	11.	17.	112.	168.	4.	6.	527.	790.	252.	378.
2015	-154.	-230.	-22.	-33.	-223.	-335.	-8.	-12.	-1054.	-1581.	-504.	-756.
2016	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2017	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2018	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2019	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2020	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

TABLE B.7. Delayed Reprocessing Scenario Summary

JUNE 21, 1982 DELAYED REPROCESSING

YEAR	DISCHARGE	AR INV	HRS INV	REPROCESS	DISPOSAL	DISP INV	HLW A R	HLW HRS	DISPOSAL	DISP INV
1981	1090.	7871.	0.	0.	0.	0.	0.	0.	0.	0.
1982	1237.	9108.	0.	0.	0.	0.	0.	0.	0.	0.
1983	1607.	10715.	0.	0.	0.	0.	0.	0.	0.	0.
1984	1744.	12447.	13.	0.	0.	0.	0.	0.	0.	0.
1985	2167.	14614.	13.	0.	0.	0.	0.	0.	0.	0.
1986	2610.	17121.	116.	0.	0.	0.	0.	0.	0.	0.
1987	2622.	19567.	292.	0.	0.	0.	0.	0.	0.	0.
1988	2866.	22196.	530.	0.	0.	0.	0.	0.	0.	0.
1989	3223.	24945.	1003.	0.	0.	0.	0.	0.	0.	0.
1990	3071.	27535.	1463.	0.	0.	0.	0.	0.	0.	0.
1991	3078.	30110.	1987.	0.	0.	0.	0.	0.	0.	0.
1992	3498.	32962.	2633.	0.	0.	0.	0.	0.	0.	0.
1993	3428.	35721.	3302.	0.	0.	0.	0.	0.	0.	0.
1994	3389.	38115.	4302.	0.	0.	0.	0.	0.	0.	0.
1995	3574.	40434.	5552.	0.	0.	0.	0.	0.	0.	0.
1996	3470.	42408.	7052.	0.	0.	0.	0.	0.	0.	0.
1997	3498.	44404.	8550.	0.	0.	0.	0.	0.	0.	0.
1998	3874.	46350.	8478.	0.	1800.	1800.	0.	0.	0.	0.
1999	3860.	48456.	8475.	500.	1454.	3254.	500.	0.	0.	0.
2000	3964.	50333.	8478.	1000.	1087.	4341.	1000.	0.	500.	500.
2001	4386.	52328.	8478.	1500.	891.	5232.	1500.	91.	909.	1409.
2002	4407.	53949.	8478.	1500.	1286.	6518.	1500.	0.	1591.	3000.
2003	4569.	55822.	8478.	1500.	1197.	7715.	1500.	0.	1500.	4500.
2004	4919.	57654.	8478.	1500.	1586.	9302.	1500.	0.	1500.	6000.
2005	4841.	59550.	8478.	1500.	1441.	10743.	1500.	0.	1500.	7500.
2006	5226.	61807.	8478.	1500.	1472.	12215.	1500.	0.	1500.	9000.
2007	6081.	64591.	8478.	1500.	1798.	14013.	1500.	0.	1500.	10500.
2008	6043.	67936.	8478.	1500.	1190.	15211.	1500.	0.	1500.	12000.
2009	6537.	71287.	8478.	1500.	1686.	16896.	1500.	0.	1500.	13500.
2010	6281.	74706.	8478.	2000.	832.	17728.	2000.	0.	1500.	15000.
2011	6228.	78370.	8478.	2500.	64.	17793.	2500.	0.	2000.	17000.
2012	6381.	82377.	7852.	3000.	0.	17793.	3000.	0.	2500.	19500.
2013	6485.	86358.	7356.	3000.	0.	17793.	3000.	0.	3000.	22500.
2014	6727.	90962.	6479.	3000.	0.	17793.	3000.	0.	3000.	25500.
2015	7033.	95787.	4687.	4000.	0.	17793.	4000.	0.	3000.	28500.
2016	6690.	100221.	1943.	5000.	0.	17793.	5000.	0.	4000.	32500.
2017	6869.	103033.	0.	6000.	0.	17793.	6000.	0.	5000.	37500.
2018	7254.	104291.	0.	6000.	0.	17793.	6000.	0.	6000.	43500.
2019	6692.	104984.	0.	6000.	0.	17793.	6000.	0.	6000.	49500.
2020	7046.	105030.	0.	7000.	0.	17793.	7000.	0.	6000.	55500.

TABLE B.8. Delayed Reprocessing Scenario, Fuel and HLW Shipment at MRS

JUNE 21, 1982 DELAYED REPROCESSING

YEAR	BWR FUEL: FUEL STORAGE TONNE	EXP	DISCHG	HLW STORAGE TONNE	EXP	DISCHG	REP PLNT POOL INV	PWR FUEL: FUEL STORAGE TONNE	EXP	DISCHG	HLW STORAGE TONNE	EXP	DISCHG	REP PLNT POOL INV
1981	0.	0.	1971	0.	0.	1970	0.	0.	0.	1971	0.	0.	1970	0.
1982	0.	0.	1971	0.	0.	1970	0.	0.	0.	1971	0.	0.	1970	0.
1983	0.	0.	1971	0.	0.	1970	0.	0.	0.	1971	0.	0.	1970	0.
1984	0.	0.	1971	0.	0.	1970	0.	13.	21.	1971	0.	0.	1970	0.
1985	0.	0.	1971	0.	0.	1970	0.	0.	0.	1971	0.	0.	1970	0.
1986	0.	0.	1971	0.	0.	1970	0.	103.	21.	1972	0.	0.	1970	0.
1987	11.	9.	1972	0.	0.	1970	0.	165.	23.	1974	0.	0.	1970	0.
1988	177.	15.	1974	0.	0.	1970	0.	61.	21.	1974	0.	0.	1970	0.
1989	196.	16.	1975	0.	0.	1970	0.	277.	21.	1975	0.	0.	1970	0.
1990	168.	17.	1976	0.	0.	1970	0.	293.	21.	1976	0.	0.	1970	0.
1991	331.	17.	1977	0.	0.	1970	0.	193.	22.	1978	0.	0.	1970	0.
1992	448.	17.	1977	0.	0.	1970	0.	398.	23.	1977	0.	0.	1970	0.
1993	214.	18.	1978	0.	0.	1970	0.	435.	23.	1978	0.	0.	1970	0.
1994	388.	21.	1978	0.	0.	1970	0.	612.	23.	1979	0.	0.	1970	0.
1995	353.	22.	1979	0.	0.	1970	0.	898.	26.	1980	0.	0.	1970	0.
1996	518.	23.	1980	0.	0.	1970	0.	981.	29.	1981	0.	0.	1970	0.
1997	598.	24.	1981	0.	0.	1970	0.	900.	30.	1983	0.	0.	1970	0.
1998	-71.	14.	1974	0.	0.	1970	0.	-1.	21.	1971	0.	0.	1970	0.
1999	0.	0.	1970	0.	0.	1970	200.	0.	0.	1970	0.	0.	1970	300.
2000	0.	0.	1970	0.	0.	1970	450.	0.	0.	1970	0.	0.	1970	550.
2001	0.	0.	1970	2.	25.	1985	550.	0.	0.	1970	88.	30.	1985	950.
2002	0.	0.	1970	-2.	25.	1985	600.	0.	0.	1970	-88.	30.	1985	900.
2003	0.	0.	1970	0.	0.	1970	600.	0.	0.	1970	0.	0.	1970	900.
2004	0.	0.	1970	0.	0.	1970	600.	0.	0.	1970	0.	0.	1970	900.
2005	0.	0.	1970	0.	0.	1970	600.	0.	0.	1970	0.	0.	1970	900.
2006	0.	0.	1970	0.	0.	1970	600.	0.	0.	1970	0.	0.	1970	900.
2007	0.	0.	1970	0.	0.	1970	600.	0.	0.	1970	0.	0.	1970	900.
2008	0.	0.	1970	0.	0.	1970	600.	0.	0.	1970	0.	0.	1970	900.
2009	0.	0.	1970	0.	0.	1970	600.	0.	0.	1970	0.	0.	1970	900.
2010	0.	0.	1970	0.	0.	1970	800.	0.	0.	1970	0.	0.	1970	1400.
2011	0.	0.	1970	0.	0.	1970	1000.	0.	0.	1970	0.	0.	1970	1500.
2012	-184.	16.	1975	0.	0.	1970	1200.	-442.	22.	1975	0.	0.	1970	1800.
2013	-78.	16.	1975	0.	0.	1970	1200.	-418.	21.	1976	0.	0.	1970	1800.
2014	-313.	17.	1977	0.	0.	1970	1200.	-564.	22.	1977	0.	0.	1970	1800.
2015	-688.	17.	1978	0.	0.	1970	1600.	-1103.	23.	1979	0.	0.	1970	2400.
2016	-963.	22.	1980	0.	0.	1970	2000.	-1781.	27.	1981	0.	0.	1970	3000.
2017	-923.	23.	1981	0.	0.	1970	2400.	-1019.	30.	1983	0.	0.	1970	3600.
2018	0.	0.	1981	0.	0.	1970	2400.	0.	0.	1983	0.	0.	1970	3600.
2019	0.	0.	1981	0.	0.	1970	2400.	0.	0.	1983	0.	0.	1970	3600.
2020	0.	0.	1981	0.	0.	1970	2800.	0.	0.	1983	0.	0.	1970	4200.

TABLE B.9. Delayed Disposal Scenario Summary

JUNE 21, 1982 DELAYED DISPOSAL

YEAR	DISCHARGE	AR INV	MRS INV	REPROCESS	DISPOSAL	DISP INV	HLW A R	HLW MRS	DISPOSAL	DISP INV
1981	1090.	7871.	0.	0.	0.	0.	0.	0.	0.	0.
1982	1237.	9108.	0.	0.	0.	0.	0.	0.	0.	0.
1983	1607.	10715.	0.	0.	0.	0.	0.	0.	0.	0.
1984	1744.	12447.	13.	0.	0.	0.	0.	0.	0.	0.
1985	2167.	14614.	13.	0.	0.	0.	0.	0.	0.	0.
1986	2610.	17121.	116.	0.	0.	0.	0.	0.	0.	0.
1987	2622.	19567.	292.	0.	0.	0.	0.	0.	0.	0.
1988	2666.	22196.	530.	0.	0.	0.	0.	0.	0.	0.
1989	3225.	24945.	503.	500.	0.	0.	500.	0.	0.	0.
1990	3071.	27507.	12.	1000.	0.	0.	1000.	500.	0.	0.
1991	3078.	29097.	0.	1500.	0.	0.	1500.	1500.	0.	0.
1992	3498.	31095.	0.	1500.	0.	0.	1500.	3000.	0.	0.
1993	3428.	33023.	0.	1500.	0.	0.	1500.	4500.	0.	0.
1994	3389.	34912.	0.	1500.	0.	0.	1500.	6000.	0.	0.
1995	3574.	36906.	0.	1500.	0.	0.	1500.	7500.	0.	0.
1996	3470.	38956.	0.	1500.	0.	0.	1500.	9000.	0.	0.
1997	3498.	40954.	0.	1500.	0.	0.	1500.	10500.	0.	0.
1998	3674.	43328.	0.	1500.	0.	0.	1500.	12000.	0.	0.
1999	3360.	45666.	0.	1500.	0.	0.	1500.	13500.	0.	0.
2000	3964.	47652.	0.	2000.	0.	0.	2000.	15000.	0.	0.
2001	4386.	49538.	0.	2500.	0.	0.	2500.	17000.	0.	0.
2002	4407.	50945.	0.	3000.	0.	0.	3000.	19500.	0.	0.
2003	4569.	52315.	0.	3000.	0.	0.	4000.	22500.	0.	0.
2004	4919.	54438.	0.	3000.	0.	0.	3000.	25500.	0.	0.
2005	4941.	55278.	0.	4000.	0.	0.	4000.	28500.	0.	0.
2006	5226.	55506.	0.	5000.	0.	0.	5000.	32500.	0.	0.
2007	6081.	55591.	0.	6000.	0.	0.	6000.	37500.	0.	0.
2008	6043.	55625.	0.	6000.	0.	0.	6000.	41700.	1800.	1800.
2009	6337.	56161.	0.	6000.	0.	0.	6000.	45900.	1800.	3600.
2010	6251.	55412.	0.	7000.	0.	0.	7000.	50100.	1800.	5400.
2011	6228.	55140.	0.	6500.	0.	0.	6500.	55300.	1800.	7200.
2012	6381.	54022.	0.	7500.	0.	0.	7500.	58200.	3600.	10800.
2013	6485.	53006.	0.	7500.	0.	0.	10500.	57900.	4800.	15600.
2014	6727.	52233.	0.	7500.	0.	0.	10500.	60600.	4800.	20400.
2015	7033.	51767.	0.	7500.	0.	0.	15000.	57000.	6600.	27000.
2016	6690.	50957.	0.	7500.	0.	0.	18000.	54900.	6600.	33600.
2017	6869.	50326.	0.	7500.	0.	0.	18000.	54600.	7600.	41400.
2018	7258.	50064.	0.	7500.	0.	0.	18000.	54300.	7600.	49200.
2019	6692.	49276.	0.	7500.	0.	0.	22500.	49500.	7800.	57000.
2020	7046.	48822.	0.	7500.	0.	0.	22500.	48000.	9000.	66000.

TABLE B.9 (contd)

JUNE 21, 1982 DELAYED DISPOSAL (CONTINUED)

YEAR	DISCHARGE	AR INV	MRS INV	REPROCESS	DISPOSAL	DISP INV	[illegible]	[illegible]	DISPOSAL	DISP INV
2021	7000.	48322.	0.	7500.	0.	0.	25500.	43500.	9000.	75000.
2022	7000.	47822.	0.	7500.	0.	0.	25500.	42000.	9000.	84000.
2023	7000.	47322.	0.	7500.	0.	0.	25500.	40500.	9000.	93000.
2024	7000.	46822.	0.	7500.	0.	0.	25500.	39000.	9000.	102000.
2025	7500.	46822.	0.	7500.	0.	0.	25500.	35700.	10600.	112600.
2026	7500.	46822.	0.	7500.	0.	0.	25500.	32400.	11000.	123600.
2027	7500.	46822.	0.	7500.	0.	0.	30000.	24600.	10800.	134400.
2028	7500.	46822.	0.	7500.	0.	0.	30000.	21300.	10800.	145200.
2029	7500.	46822.	0.	7500.	0.	0.	30000.	16000.	10800.	156000.
2030	7500.	46822.	0.	7500.	0.	0.	30000.	13500.	12000.	168000.
2031	7500.	46822.	0.	7500.	0.	0.	30000.	9000.	12000.	180000.
2032	7500.	46822.	0.	7500.	0.	0.	30000.	4500.	12000.	192000.
2033	7500.	46822.	0.	7500.	0.	0.	30000.	0.	12000.	204000.
2034	7500.	46822.	0.	7500.	0.	0.	30000.	0.	7500.	211500.
2035	7500.	46822.	0.	7500.	0.	0.	30000.	0.	7500.	219000.
2036	7500.	46822.	0.	7500.	0.	0.	30000.	0.	7500.	226500.
2037	7500.	46822.	0.	7500.	0.	0.	30000.	0.	7500.	234000.
2038	7500.	46822.	0.	7500.	0.	0.	30000.	0.	7500.	241500.
2039	7500.	46822.	0.	7500.	0.	0.	30000.	0.	7500.	249000.
2040	7500.	46822.	0.	7500.	0.	0.	30000.	0.	7500.	256500.

TABLE B.10. Delayed Disposal Scenario, Fuel and HLW Shipments at MRS

JUNE 21, 1982 DELAYED DISPOSAL

YEAR	BWR FUEL: FUEL STORAGE TONNE	BWR FUEL: FUEL STORAGE EXP	BWR FUEL: FUEL STORAGE DISCHG	BWR FUEL: HLW STORAGE TONNE	BWR FUEL: HLW STORAGE EXP	BWR FUEL: HLW STORAGE DISCHG	BWR FUEL: REP PLNT POOL INV	PWR FUEL: FUEL STORAGE TONNE	PWR FUEL: FUEL STORAGE EXP	PWR FUEL: FUEL STORAGE DISCHG	PWR FUEL: HLW STORAGE TONNE	PWR FUEL: HLW STORAGE EXP	PWR FUEL: HLW STORAGE DISCHG	PWR FUEL: REP PLNT POOL INV
1981	0.	0.	1971	0.	0.	1970	0.	0.	0.	1971	0.	0.	1970	0.
1982	0.	0.	1971	0.	0.	1970	0.	0.	0.	1971	0.	0.	1970	0.
1983	0.	0.	1971	0.	0.	1970	0.	0.	0.	1971	0.	0.	1970	0.
1984	0.	0.	1971	0.	0.	1970	0.	13.	21.	1971	0.	0.	1970	0.
1985	0.	0.	1971	0.	0.	1970	0.	0.	0.	1971	0.	0.	1970	0.
1986	0.	0.	1971	0.	0.	1970	0.	103.	21.	1972	0.	0.	1970	0.
1987	11.	9.	1972	0.	0.	1970	0.	165.	23.	1974	0.	0.	1970	0.
1988	177.	15.	1974	0.	0.	1970	0.	61.	21.	1974	0.	0.	1970	0.
1989	-4.	9.	1972	0.	0.	1970	200.	-22.	21.	1972	0.	0.	1970	300.
1990	-183.	15.	1974	200.	16.	1975	400.	-307.	22.	1974	300.	21.	1975	600.
1991	0.	0.	1974	400.	16.	1976	600.	-12.	21.	1974	600.	22.	1976	900.
1992	0.	0.	1974	600.	17.	1977	600.	0.	0.	1974	900.	23.	1978	900.
1993	0.	0.	1974	600.	20.	1979	600.	0.	0.	1974	900.	24.	1979	900.
1994	0.	0.	1974	600.	22.	1980	600.	0.	0.	1974	900.	26.	1980	900.
1995	0.	0.	1974	600.	23.	1981	600.	0.	0.	1974	900.	29.	1981	900.
1996	0.	0.	1974	600.	25.	1982	600.	0.	0.	1974	900.	30.	1983	900.
1997	0.	0.	1974	600.	25.	1983	600.	0.	0.	1974	900.	30.	1983	900.
1998	0.	0.	1974	600.	25.	1984	600.	0.	0.	1974	900.	30.	1984	900.
1999	0.	0.	1974	600.	25.	1985	600.	0.	0.	1974	900.	30.	1985	900.
2000	0.	0.	1974	600.	25.	1986	800.	0.	0.	1974	900.	30.	1986	1200.
2001	0.	0.	1974	600.	25.	1987	1000.	0.	0.	1974	1200.	30.	1986	1500.
2002	0.	0.	1974	1000.	25.	1988	1200.	0.	0.	1974	1500.	30.	1987	1600.
2003	0.	0.	1974	1200.	25.	1989	1200.	0.	0.	1974	1800.	30.	1988	1800.
2004	0.	0.	1974	1200.	25.	1990	1200.	0.	0.	1974	1800.	30.	1989	1800.
2005	0.	0.	1974	1200.	25.	1991	1600.	0.	0.	1974	1800.	30.	1990	2400.
2006	0.	0.	1974	1600.	25.	1992	2000.	0.	0.	1974	2400.	33.	1991	3000.
2007	0.	0.	1974	2000.	25.	1994	2400.	0.	0.	1974	3000.	35.	1993	3600.
2008	0.	0.	1974	1640.	25.	1995	2400.	0.	0.	1974	2520.	35.	1994	3000.
2009	0.	0.	1974	1640.	25.	1997	2400.	0.	0.	1974	2520.	35.	1996	3600.
2010	0.	0.	1974	1640.	25.	1999	2800.	0.	0.	1974	2520.	35.	1998	4200.
2011	0.	0.	1974	2080.	25.	2001	2600.	0.	0.	1974	3120.	35.	1999	3900.
2012	0.	0.	1974	1160.	25.	2002	3000.	0.	0.	1974	1740.	35.	2001	4500.
2013	0.	0.	1974	-1920.	16.	1980	6000.	0.	0.	1974	1020.	35.	2003	4500.
2014	0.	0.	1974	1080.	25.	2004	6000.	0.	0.	1974	1620.	35.	2004	4500.
2015	0.	0.	1974	360.	25.	2009	6000.	0.	0.	1974	-3960.	24.	1981	9000.
2016	0.	0.	1974	-2640.	24.	1984	9000.	0.	0.	1974	540.	35.	2006	9000.
2017	0.	0.	1974	-120.	25.	1984	9000.	0.	0.	1974	-180.	29.	1981	9000.
2018	0.	0.	1974	-120.	25.	1984	9000.	0.	0.	1974	-180.	29.	1981	9000.
2019	0.	0.	1974	-120.	25.	1985	9000.	0.	0.	1974	-4680.	30.	1980	13500.
2020	0.	0.	1974	-600.	25.	1988	9000.	0.	0.	1974	-900.	30.	1986	13500.

TABLE B.10 (contd)

JUNE 21, 1982 DELAYED DISPOSAL (CONTINUED)

YEAR	FUEL STORAGE TONNE	EXP	DISCHG	BWR FUEL NEW STORAGE TONNE	EXP	DISCHG	REP PLNT POOL INV	FUEL STORAGE TONNE	EXP	DISCHG	PWR FUEL NEW STORAGE TONNE	EXP	DISCHG	REP PLNT POOL INV
2021	0.	0.	1974	-3600.	25.	1990	12000.	0.	0.	1974	-900.	30.	1987	13500.
2022	0.	0.	1974	-600.	25.	1990	12000.	0.	0.	1974	-900.	30.	1987	13500.
2023	0.	0.	1974	-600.	25.	1991	12000.	0.	0.	1974	-900.	30.	1988	13500.
2024	0.	0.	1974	-600.	25.	1991	12000.	0.	0.	1974	-900.	30.	1988	13500.
2025	0.	0.	1974	-1320.	25.	1992	12000.	0.	0.	1974	-1960.	30.	1990	13500.
2026	0.	0.	1974	-1320.	25.	1994	12000.	0.	0.	1974	-1960.	31.	1991	13500.
2027	0.	0.	1974	-1320.	25.	1994	12000.	0.	0.	1974	-6400.	34.	1998	18000.
2028	0.	0.	1974	-1320.	25.	1995	12000.	0.	0.	1974	-1900.	35.	1995	18000.
2029	0.	0.	1974	-1320.	25.	1997	12000.	0.	0.	1974	-1900.	35.	1995	18000.
2030	0.	0.	1974	-1800.	25.	1999	12000.	0.	0.	1974	-2700.	35.	1999	18000.
2031	0.	0.	1974	-1800.	25.	2001	12000.	0.	0.	1974	-2700.	35.	2001	18000.
2032	0.	0.	1974	-1800.	25.	2002	12000.	0.	0.	1974	-2700.	35.	2003	18000.
2033	0.	0.	1974	-1800.	25.	2005	12000.	0.	0.	1974	-2700.	35.	2006	18000.
2034	0.	0.	1974	0.	0.	1970	12000.	0.	0.	1974	0.	0.	1970	18000.
2035	0.	0.	1974	0.	0.	1970	12000.	0.	0.	1974	0.	0.	1970	18000.
2036	0.	0.	1974	0.	0.	1970	12000.	0.	0.	1974	0.	0.	1970	18000.
2037	0.	0.	1974	0.	0.	1970	12000.	0.	0.	1974	0.	0.	1970	18000.
2038	0.	0.	1974	0.	0.	1970	12000.	0.	0.	1974	0.	0.	1970	18000.
2039	0.	0.	1974	0.	0.	1970	12000.	0.	0.	1974	0.	0.	1970	18000.
2040	0.	0.	1974	0.	0.	1970	12000.	0.	0.	1974	0.	0.	1970	18000.

TABLE B.11. Delayed Disposal Scenario, Number of TRU Packages Handled at MRS

JUNE 21, 1982 DELAYED DISPOSAL

YEAR	HULLS & HDW 2X10 CAN		REMOTE H 2X10 CAN		REMOTE H 55 GA DRUM		CONTACT H 4X6X6 BOX		CONTACT H 55 GA DRUM		MOX PLANT 55 G DRUMS	
1981	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1982	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1983	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1984	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1985	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1986	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1987	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1988	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1989	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1990	64.	96.	9.	14.	93.	140.	3.	5.	439.	659.	210.	315.
1991	128.	192.	18.	28.	186.	279.	7.	10.	878.	1317.	420.	630.
1992	192.	288.	28.	41.	279.	419.	10.	15.	1317.	1976.	630.	945.
1993	192.	288.	28.	41.	279.	419.	10.	15.	1317.	1976.	630.	945.
1994	192.	288.	28.	41.	279.	419.	10.	15.	1317.	1976.	630.	945.
1995	192.	288.	28.	41.	279.	419.	10.	15.	1317.	1976.	630.	945.
1996	192.	288.	28.	41.	279.	419.	10.	15.	1317.	1976.	630.	945.
1997	192.	288.	28.	41.	279.	419.	10.	15.	1317.	1976.	630.	945.
1998	192.	288.	28.	41.	279.	419.	10.	15.	1317.	1976.	630.	945.
1999	192.	288.	28.	41.	279.	419.	10.	15.	1317.	1976.	630.	945.
2000	192.	288.	28.	41.	279.	419.	10.	15.	1317.	1976.	630.	945.
2001	256.	384.	37.	55.	372.	558.	13.	20.	1756.	2634.	840.	1260.
2002	320.	480.	46.	69.	465.	698.	17.	25.	2195.	3293.	1050.	1575.
2003	384.	576.	55.	83.	558.	838.	20.	30.	2634.	3952.	1260.	1890.
2004	384.	576.	55.	83.	558.	838.	20.	30.	2634.	3952.	1260.	1890.
2005	384.	576.	55.	83.	558.	838.	20.	30.	2634.	3952.	1260.	1890.
2006	512.	768.	74.	110.	744.	1117.	27.	40.	3512.	5269.	1680.	2520.
2007	640.	960.	92.	138.	931.	1396.	33.	50.	4391.	6586.	2100.	3150.
2008	503.	755.	72.	108.	731.	1097.	26.	39.	3451.	5177.	1651.	2476.
2009	503.	755.	72.	108.	731.	1097.	26.	39.	3451.	5177.	1051.	2476.
2010	503.	755.	72.	108.	731.	1097.	26.	39.	3451.	5177.	1651.	2476.
2011	631.	947.	91.	136.	918.	1376.	33.	49.	4329.	6494.	2071.	3106.
2012	302.	453.	43.	65.	439.	659.	16.	24.	2072.	3109.	991.	1487.
2013	253.	380.	36.	55.	369.	553.	13.	20.	1739.	2608.	832.	1247.
2014	253.	380.	36.	55.	369.	553.	13.	20.	1739.	2608.	632.	1247.
2015	-12.	-17.	-2.	-2.	-17.	-25.	-1.	-1.	-79.	-119.	-38.	-57.
2016	-12.	-17.	-2.	-2.	-17.	-25.	-1.	-1.	-79.	-119.	-38.	-57.
2017	-188.	-282.	-27.	-41.	-274.	-410.	-10.	-15.	-1291.	-1936.	-617.	-926.
2018	-188.	-282.	-27.	-41.	-274.	-410.	-10.	-15.	-1291.	-1936.	-617.	-926.
2019	-188.	-232.	-27.	-41.	-274.	-410.	-10.	-15.	-1291.	-1936.	-617.	-926.
2020	-365.	-547.	-52.	-79.	-530.	-796.	-19.	-29.	-2503.	-3754.	-1197.	-1795.

TABLE B.11 (contd)

JUNE 21, 1982 DELAYED DISPOSAL (CONTINUED)

YEAR	HULLS & HDW 2X10 CAN		REMOTE H 2X10 CAN		REMOTE H 55 GA DRUM		CONTACT H 4X6X6 BOX		CONTACT H 55 GA DRUM		HUX PLANT 55 G DRUMS	
2021	-365.	-547.	-52.	-79.	-530.	-796.	-19.	-29.	-2503.	-3754.	-1197.	-1795.
2022	-365.	-547.	-52.	-79.	-530.	-796.	-19.	-29.	-2503.	-3754.	-1197.	-1795.
2023	-365.	-547.	-52.	-79.	-530.	-796.	-19.	-29.	-2503.	-3754.	-1197.	-1795.
2024	-365.	-547.	-52.	-79.	-530.	-796.	-19.	-29.	-2503.	-3754.	-1197.	-1795.
2025	-630.	-945.	-91.	-136.	-916.	-1374.	-33.	-49.	-4320.	-6481.	-2066.	-3100.
2026	-630.	-945.	-91.	-136.	-916.	-1374.	-33.	-49.	-4320.	-6481.	-2066.	-3100.
2027	-630.	-945.	-91.	-136.	-916.	-1374.	-33.	-49.	-4320.	-6481.	-2066.	-3100.
2028	-630.	-945.	-91.	-136.	-916.	-1374.	-33.	-49.	-4320.	-6481.	-2066.	-3100.
2029	-630.	-945.	-91.	-136.	-916.	-1374.	-33.	-49.	-4320.	-6481.	-2066.	-3100.
2030	-806.	-1210.	-116.	-174.	-1173.	-1759.	-42.	-63.	-5532.	-8298.	-2646.	-3969.
2031	-806.	-1210.	-116.	-174.	-1173.	-1759.	-42.	-63.	-5532.	-8298.	-2646.	-3969.
2032	-576.	-864.	-83.	-124.	-836.	-1256.	-30.	-45.	-3952.	-5927.	-1890.	-2835.
2033	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2034	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2035	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2036	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2037	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2038	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2039	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2040	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

TABLE B.12. Early Disposal Scenario Summary

JUNE 21, 1982 EARLY DISPOSAL

YEAR	DISCHARGE	AR INV	MRS INV	REPROCESS	DISPOSAL	DISP INV	HLW AR	HLW MRS	DISPOSAL	DISP INV
1981	1090.	7871.	0.	0.	0.	0.	0.	0.	0.	0.
1982	1237.	9108.	0.	0.	0.	0.	0.	0.	0.	0.
1983	1607.	10715.	0.	0.	0.	0.	0.	0.	0.	0.
1984	1744.	12447.	13.	0.	0.	0.	0.	0.	0.	0.
1985	2167.	14614.	13.	0.	0.	0.	0.	0.	0.	0.
1986	2610.	17121.	116.	0.	0.	0.	0.	0.	0.	0.
1987	2622.	19567.	292.	0.	0.	0.	0.	0.	0.	0.
1988	2866.	22196.	530.	0.	0.	0.	0.	0.	0.	0.
1989	3223.	24945.	503.	500.	0.	0.	500.	0.	0.	0.
1990	3071.	27507.	12.	1000.	0.	0.	1000.	500.	0.	0.
1991	3078.	29097.	0.	1500.	0.	0.	1500.	1500.	0.	0.
1992	3498.	31095.	0.	1500.	0.	0.	1500.	3000.	0.	0.
1993	3428.	33043.	0.	1500.	0.	0.	1500.	2700.	1800.	1800.
1994	3389.	34912.	0.	1500.	0.	0.	1500.	2400.	1800.	3600.
1995	3574.	36986.	0.	1500.	0.	0.	1500.	2100.	1800.	5400.
1996	3470.	38956.	0.	1500.	0.	0.	1500.	1800.	1800.	7200.
1997	3498.	40954.	0.	1500.	0.	0.	1500.	1500.	1800.	9000.
1998	3478.	43328.	0.	1500.	0.	0.	1500.	0.	3000.	12000.
1999	3860.	45608.	0.	1500.	0.	0.	1500.	0.	1500.	13500.
2000	3964.	47352.	0.	2000.	0.	0.	2000.	0.	1500.	15000.
2001	4386.	49538.	0.	2500.	0.	0.	2500.	0.	2000.	17000.
2002	4407.	50945.	0.	3000.	0.	0.	3000.	0.	2500.	19500.
2003	4569.	52515.	0.	3000.	0.	0.	3000.	0.	3000.	22500.
2004	4919.	54434.	0.	3000.	0.	0.	3000.	0.	3000.	25500.
2005	4881.	55274.	0.	4000.	0.	0.	4000.	0.	3000.	28500.
2006	5226.	55500.	0.	5000.	0.	0.	5000.	0.	4000.	32500.
2007	6081.	55591.	0.	6000.	0.	0.	6000.	0.	5000.	37500.
2008	6043.	55625.	0.	6000.	0.	0.	6000.	0.	6000.	43500.
2009	6537.	56161.	0.	6000.	0.	0.	6000.	0.	6000.	49500.
2010	6251.	55412.	0.	7000.	0.	0.	7000.	0.	6000.	55500.
2011	6228.	55140.	0.	6500.	0.	0.	6500.	0.	7000.	62500.
2012	6381.	54022.	0.	7500.	0.	0.	7500.	0.	6500.	69000.
2013	6485.	53006.	0.	7500.	0.	0.	10500.	0.	4500.	73500.
2014	6727.	52233.	0.	7500.	0.	0.	10500.	0.	7500.	81000.
2015	7033.	51767.	0.	7500.	0.	0.	15000.	0.	3000.	84000.
2016	6690.	50957.	0.	7500.	0.	0.	18000.	0.	4500.	88500.
2017	6869.	50326.	0.	7500.	0.	0.	18000.	0.	7500.	96000.
2018	7258.	50384.	0.	7500.	0.	0.	18000.	0.	7500.	103500.
2019	6692.	49276.	0.	7500.	0.	0.	22500.	0.	3000.	106500.
2020	7046.	48822.	0.	7500.	0.	0.	22500.	0.	7500.	114000.

TABLE B.13. Early Disposal Scenario, Fuel and HLW Shipment at MRS

JUNE 21, 1982 EARLY DISPOSAL

YEAR	BWR FUEL							PWR FUEL						
	FUEL STORAGE			HLW STORAGE			REP PLNT	FUEL STORAGE			HLW STORAGE			REP PLNT
	TONNE	EXP	DISCHG	TONNE	EXP	DISCHG	POOL INV	TONNE	EXP	DISCHG	TONNE	EXP	DISCHG	POOL INV
1981	0.	0.	1971	0.	0.	1970	0.	0.	0.	1971	0.	0.	1970	0.
1982	0.	0.	1971	0.	0.	1970	0.	0.	0.	1971	0.	0.	1970	0.
1983	0.	0.	1971	0.	0.	1970	0.	0.	0.	1971	0.	0.	1970	0.
1984	0.	0.	1971	0.	0.	1970	0.	13.	21.	1971	0.	0.	1970	0.
1985	0.	0.	1971	0.	0.	1970	0.	0.	0.	1971	0.	0.	1970	0.
1986	0.	0.	1971	0.	0.	1970	0.	103.	21.	1972	0.	0.	1970	0.
1987	11.	9.	1972	0.	0.	1970	0.	165.	23.	1974	0.	0.	1970	0.
1988	177.	15.	1974	0.	0.	1970	0.	61.	21.	1974	0.	0.	1970	0.
1989	-4.	9.	1972	0.	0.	1970	200.	-22.	21.	1972	0.	0.	1970	300.
1990	-183.	15.	1974	200.	16.	1975	400.	-307.	22.	1974	300.	21.	1975	600.
1991	0.	0.	1974	400.	16.	1976	600.	-12.	21.	1974	600.	22.	1976	900.
1992	0.	0.	1974	600.	17.	1977	600.	0.	0.	1974	900.	23.	1978	900.
1993	0.	0.	1974	-120.	16.	1975	600.	0.	0.	1974	-180.	21.	1975	900.
1994	0.	0.	1974	-120.	16.	1976	600.	0.	0.	1974	-180.	21.	1976	900.
1995	0.	0.	1974	-120.	16.	1976	600.	0.	0.	1974	-180.	22.	1976	900.
1996	0.	0.	1974	-120.	16.	1976	600.	0.	0.	1974	-180.	22.	1976	900.
1997	0.	0.	1974	-120.	16.	1976	600.	0.	0.	1974	-180.	22.	1976	900.
1998	0.	0.	1974	-600.	17.	1977	600.	0.	0.	1974	-900.	23.	1978	900.
1999	0.	0.	1974	0.	0.	1970	600.	0.	0.	1974	0.	0.	1970	900.
2000	0.	0.	1974	0.	0.	1970	800.	0.	0.	1974	0.	0.	1970	1200.
2001	0.	0.	1974	0.	0.	1970	1000.	0.	0.	1974	0.	0.	1970	1500.
2002	0.	0.	1974	0.	0.	1970	1200.	0.	0.	1974	0.	0.	1970	1800.
2003	0.	0.	1974	0.	0.	1970	1200.	0.	0.	1974	0.	0.	1970	1800.
2004	0.	0.	1974	0.	0.	1970	1200.	0.	0.	1974	0.	0.	1970	1800.
2005	0.	0.	1974	0.	0.	1970	1600.	0.	0.	1974	0.	0.	1970	2400.
2006	0.	0.	1974	0.	0.	1970	2000.	0.	0.	1974	0.	0.	1970	3000.
2007	0.	0.	1974	0.	0.	1970	2400.	0.	0.	1974	0.	0.	1970	3600.
2008	0.	0.	1974	0.	0.	1970	2400.	0.	0.	1974	0.	0.	1970	3600.
2009	0.	0.	1974	0.	0.	1970	2400.	0.	0.	1974	0.	0.	1970	3600.
2010	0.	0.	1974	0.	0.	1970	2800.	0.	0.	1974	0.	0.	1970	4200.
2011	0.	0.	1974	0.	0.	1970	2600.	0.	0.	1974	0.	0.	1970	3900.
2012	0.	0.	1974	0.	0.	1970	3000.	0.	0.	1974	0.	0.	1970	4500.
2013	0.	0.	1974	0.	0.	1970	6000.	0.	0.	1974	0.	0.	1970	4500.
2014	0.	0.	1974	0.	0.	1970	6000.	0.	0.	1974	0.	0.	1970	4500.
2015	0.	0.	1974	0.	0.	1970	6000.	0.	0.	1974	0.	0.	1970	9000.
2016	0.	0.	1974	0.	0.	1970	9000.	0.	0.	1974	0.	0.	1970	9000.
2017	0.	0.	1974	0.	0.	1970	5000.	0.	0.	1974	0.	0.	1970	9000.
2018	0.	0.	1974	0.	0.	1970	9000.	0.	0.	1974	0.	0.	1970	9000.
2019	0.	0.	1974	0.	0.	1970	9000.	0.	0.	1974	0.	0.	1970	13500.
2020	0.	0.	1974	0.	0.	1970	9000.	0.	0.	1974	0.	0.	1970	13500.

TABLE B.14. Early Disposal Scenario, Number of TRU Packages Handled at MRS

JUNE 21, 1982 EARLY DISPOSAL

YEAR	HULLS & HPH 2X10 CAN		REMOTE H 2X10 CAN		REMOTE H 55 GA DRUM		CONTACT H 4X6X6 BOX		CONTACT H 55 GA DRUM		PUX PLANT 55 G DRUMS	
1981	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1982	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1983	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1984	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1985	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1986	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1987	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1988	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1989	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1990	64.	96.	9.	14.	93.	140.	3.	5.	439.	659.	210.	315.
1991	128.	192.	19.	28.	186.	279.	7.	10.	878.	1317.	420.	630.
1992	192.	288.	28.	41.	279.	419.	10.	15.	1317.	1976.	630.	945.
1993	-73.	-109.	-10.	-16.	-106.	-159.	-4.	-6.	-501.	-751.	-239.	-359.
1994	-73.	-109.	-10.	-16.	-106.	-159.	-4.	-6.	-501.	-751.	-239.	-359.
1995	-73.	-109.	-10.	-16.	-106.	-159.	-4.	-6.	-501.	-751.	-239.	-359.
1996	-73.	-109.	-10.	-16.	-106.	-159.	-4.	-6.	-501.	-751.	-239.	-359.
1997	-73.	-109.	-10.	-16.	-106.	-159.	-4.	-6.	-501.	-751.	-239.	-359.
1998	-19.	-29.	-3.	-4.	-28.	-42.	-1.	-2.	-132.	-198.	-63.	-94.
1999	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2000	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2001	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2002	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2003	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2004	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2005	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2006	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2007	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2008	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2009	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2010	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2011	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2012	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2013	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2014	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2015	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2016	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2017	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2018	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2019	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2020	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

TABLE B.15. Delayed Disposal No Reprocessing Scenario Summary

JUNE 21, 1982 DELAYED DISPOSAL NO REPROCESSING

YEAR	DISCHARGE	AR INV	NRS INV	REPROCESS	DISPOSAL	DISP INV	HLW AR	HLW NRS	DISPOSAL	DISP INV
1981	1090.	7871.	0.	0.	0.	0.	0.	0.	0.	0.
1982	1237.	9108.	0.	0.	0.	0.	0.	0.	0.	0.
1983	1607.	10719.	0.	0.	0.	0.	0.	0.	0.	0.
1984	1744.	12447.	13.	0.	0.	0.	0.	0.	0.	0.
1985	2167.	14614.	13.	0.	0.	0.	0.	0.	0.	0.
1986	2610.	17121.	114.	0.	0.	0.	0.	0.	0.	0.
1987	2622.	19567.	292.	0.	0.	0.	0.	0.	0.	0.
1988	2666.	22196.	530.	0.	0.	0.	0.	0.	0.	0.
1989	3223.	24945.	1003.	0.	0.	0.	0.	0.	0.	0.
1990	3071.	27595.	1463.	0.	0.	0.	0.	0.	0.	0.
1991	3078.	30110.	1987.	0.	0.	0.	0.	0.	0.	0.
1992	3498.	32962.	2633.	0.	0.	0.	0.	0.	0.	0.
1993	3428.	35721.	3302.	0.	0.	0.	0.	0.	0.	0.
1994	3389.	38110.	4302.	0.	0.	0.	0.	0.	0.	0.
1995	3574.	40434.	5552.	0.	0.	0.	0.	0.	0.	0.
1996	3470.	42404.	7052.	0.	0.	0.	0.	0.	0.	0.
1997	3498.	44404.	8550.	0.	0.	0.	0.	0.	0.	0.
1998	3874.	46590.	10278.	0.	0.	0.	0.	0.	0.	0.
1999	3360.	48456.	12232.	0.	0.	0.	0.	0.	0.	0.
2000	3964.	50333.	14319.	0.	0.	0.	0.	0.	0.	0.
2001	4386.	52328.	16710.	0.	0.	0.	0.	0.	0.	0.
2002	4407.	53949.	19496.	0.	0.	0.	0.	0.	0.	0.
2003	4569.	55622.	22193.	0.	0.	0.	0.	0.	0.	0.
2004	4919.	57654.	25280.	0.	0.	0.	0.	0.	0.	0.
2005	4841.	59554.	28221.	0.	0.	0.	0.	0.	0.	0.
2006	5226.	61807.	31193.	0.	0.	0.	0.	0.	0.	0.
2007	6081.	64591.	34491.	0.	0.	0.	0.	0.	0.	0.
2008	6043.	67936.	35383.	0.	1800.	1800.	0.	0.	0.	0.
2009	6537.	71287.	36774.	0.	1800.	3600.	0.	0.	0.	0.
2010	6251.	74706.	37406.	0.	1800.	5400.	0.	0.	0.	0.
2011	6228.	78370.	38570.	0.	1800.	7200.	0.	0.	0.	0.
2012	6381.	82377.	37344.	0.	3600.	10800.	0.	0.	0.	0.
2013	6485.	86358.	35049.	0.	4800.	15600.	0.	0.	0.	0.
2014	6727.	90962.	32371.	0.	4800.	20400.	0.	0.	0.	0.
2015	7033.	95787.	27980.	0.	6600.	27000.	0.	0.	0.	0.
2016	6690.	100221.	23635.	0.	6600.	33600.	0.	0.	0.	0.
2017	6469.	105269.	17656.	0.	7800.	41400.	0.	0.	0.	0.
2018	7254.	110646.	11738.	0.	7800.	49200.	0.	0.	0.	0.
2019	6692.	115706.	5571.	0.	7800.	57000.	0.	0.	0.	0.
2020	7046.	119322.	0.	0.	9000.	66000.	0.	0.	0.	0.

TABLE B.16. Delayed Disposal No Reprocessing Scenario, Fuel and HLW Shipments at MRS

JUNE 21, 1982 DELAYED DISPOSAL NO REPROCESSING

YEAR	BWR FUEL FUEL STORAGE TONNE	 EXP	 DISCHG	 HLW STORAGE TONNE	 EXP	 DISCHG	 REP PLNT FUEL INV	PWR FUEL FUEL STORAGE TONNE	 EXP	 DISCHG	 HLW STORAGE TONNE	 EXP	 DISCHG	 REP PLNT FUEL INV
1981	0.	0.	1971	0.	0.	1970	0.	0.	0.	1971	0.	0.	1970	0.
1982	0.	0.	1971	0.	0.	1970	0.	0.	0.	1971	0.	0.	1970	0.
1983	0.	0.	1971	0.	0.	1970	0.	0.	0.	1971	0.	0.	1970	0.
1984	0.	0.	1971	0.	0.	1970	0.	13.	21.	1971	0.	0.	1970	0.
1985	0.	0.	1971	0.	0.	1970	0.	0.	0.	1971	0.	0.	1970	0.
1986	0.	0.	1971	0.	0.	1970	0.	103.	21.	1972	0.	0.	1970	0.
1987	11.	9.	1972	0.	0.	1970	0.	165.	23.	1974	0.	0.	1970	0.
1988	177.	15.	1974	0.	0.	1970	0.	61.	21.	1974	0.	0.	1970	0.
1989	196.	16.	1975	0.	0.	1970	0.	277.	21.	1975	0.	0.	1970	0.
1990	166.	17.	1976	0.	0.	1970	0.	293.	21.	1976	0.	0.	1970	0.
1991	331.	17.	1977	0.	0.	1970	0.	193.	22.	1976	0.	0.	1970	0.
1992	288.	17.	1977	0.	0.	1970	0.	398.	23.	1977	0.	0.	1970	0.
1993	234.	16.	1978	0.	0.	1970	0.	435.	23.	1978	0.	0.	1970	0.
1994	388.	21.	1978	0.	0.	1970	0.	612.	23.	1979	0.	0.	1970	0.
1995	353.	22.	1979	0.	0.	1970	0.	698.	26.	1980	0.	0.	1970	0.
1996	518.	23.	1980	0.	0.	1970	0.	981.	29.	1981	0.	0.	1970	0.
1997	598.	24.	1981	0.	0.	1970	0.	900.	30.	1983	0.	0.	1970	0.
1998	528.	25.	1982	0.	0.	1970	0.	1199.	30.	1984	0.	0.	1970	0.
1999	759.	25.	1984	0.	0.	1970	0.	1195.	30.	1985	0.	0.	1970	0.
2000	854.	25.	1985	0.	0.	1970	0.	1233.	30.	1986	0.	0.	1970	0.
2001	822.	25.	1986	0.	0.	1970	0.	1568.	30.	1987	0.	0.	1970	0.
2002	987.	25.	1987	0.	0.	1970	0.	1795.	30.	1988	0.	0.	1970	0.
2003	1147.	25.	1988	0.	0.	1970	0.	1550.	30.	1988	0.	0.	1970	0.
2004	1190.	25.	1989	0.	0.	1970	0.	1698.	30.	1989	0.	0.	1970	0.
2005	1190.	25.	1990	0.	0.	1970	0.	1751.	30.	1990	0.	0.	1970	0.
2006	1254.	25.	1991	0.	0.	1970	0.	1718.	33.	1991	0.	0.	1970	0.
2007	1230.	25.	1992	0.	0.	1970	0.	2068.	35.	1992	0.	0.	1970	0.
2008	324.	25.	1993	0.	0.	1970	0.	573.	35.	1993	0.	0.	1970	0.
2009	754.	25.	1994	0.	0.	1970	0.	631.	35.	1994	0.	0.	1970	0.
2010	349.	25.	1995	0.	0.	1970	0.	683.	35.	1995	0.	0.	1970	0.
2011	330.	25.	1996	0.	0.	1970	0.	434.	35.	1995	0.	0.	1970	0.
2012	-424.	16.	1976	0.	0.	1970	0.	-602.	21.	1976	0.	0.	1970	0.
2013	-798.	17.	1978	0.	0.	1970	0.	-1498.	23.	1979	0.	0.	1970	0.
2014	-1033.	21.	1980	0.	0.	1970	0.	-1644.	26.	1981	0.	0.	1970	0.
2015	-1728.	24.	1984	0.	0.	1970	0.	-2063.	30.	1985	0.	0.	1970	0.
2016	-1603.	25.	1986	0.	0.	1970	0.	-2741.	30.	1987	0.	0.	1970	0.
2017	-2460.	25.	1988	0.	0.	1970	0.	-3519.	30.	1988	0.	0.	1970	0.
2018	-2187.	25.	1990	0.	0.	1970	0.	-3731.	30.	1990	0.	0.	1970	0.
2019	-2443.	25.	1992	0.	0.	1970	0.	-3725.	35.	1992	0.	0.	1970	0.
2020	-2264.	25.	1996	0.	0.	1970	0.	-3307.	35.	1995	0.	0.	1970	0.

repository delivery rates when a full year's production of HLW is held at the reprocessing plant and a portion of it is not yet 10 years old. The TRU capacity requirements are summarized in Table B.17 and the annual handling requirements in Table B.18. The peak rates for the Delayed Disposal case are based on the average removal rates in 2030, 2031, and 2032; however, if a design is modular, it may be desirable to design for a lower rate and add capacity as needed.

TABLE B.17. Required Capacity for TRU Packages at MRS/IS Facility

	Reference	Delayed Reprocessing	Delayed Disposal
Hulls and hardware cans	3,400	0	19,400
RHTRU 2 x 10 ft cans	500	0	2,800
RHTRU 55 gal drums	5,000	0	28,200
CHTRU 4 x 6 x 6 ft boxes	175	0	1,010
CHTRU 55 gal drums	24,000	0	133,000
MOX Plant 55 gal drums	12,000	0	64,000
MOX Plant 4 x 6 x 6 ft boxes	120	0	640

TABLE B.18. Annual Receiving or Removal Rate for TRU Packages at MRS/IS Facility

	Reference	Delayed Reprocessing	Delayed Disposal
Hulls and hardware cans	760	0	1,850
RHTRU 2 x 10 ft cans	110	0	270
RHTRU 55-gal drums	1,100	0	2,700
CHTRU 4 x 6 x 6 ft boxes	40	0	95
CHTRU 55 gal drums	5,200	0	12,500
MOX Plant 55-gal drums	2,500	0	6,000
MOX Plant 4 x 6 x 6 ft boxes	25	0	60

B.2 CONSIDERATIONS FOR MRS/IS COST EVALUATION

The MRS/IS facility is conceived as a government-owned facility for providing temporary storage capability for spent fuel and/or reprocessing wastes while reprocessing capability and repositories for geologic disposal are introduced.

To provide compatibility with other studies performed in evaluation of spent fuel and waste disposal, all costs should be presented in terms of constant-value, mid-1982 dollars (without cost escalation or inflation). All costs from the present to the final year of decommissioning are to be entered into a cash flow table (Table B.1) and presented both as undiscounted costs and as discounted at 2 percent per year. The annual costs should be summed over all years included, to provide undiscounted program costs and the present worth costs at 2 percent discount. The discounted (present worth) costs will be used in comparing alternatives.

To ensure that all alternatives are equitably treated during comparisons, the details of component costs, background, and cost bases must be presented in support of the costs given in Table B.19. Tables B.20 through B.25 are provided for this purpose. These tables in turn should be supported by the cost schedules indicating the cost bases or components for each category in the tables. Typical cost categories are outlined in Attachment 1, following these tables. Insofar as possible, cost breakdowns by these categories should be provided. If other cost bases are used, these should be detailed.

Table B.20 summarizes the capital construction costs for the first module of the MRS/IS; costs for additional modules should be entered on Table B.24 (in multiple copies if needed). Costs for each module should be prorated into the appropriate years, using Table B.21, and the prorated annual costs should then be included in the cash flow summary of Table B.19.

Owner's costs are defined separately for three periods: those costs incurred during the construction period (Table B.23), annual operating costs for the facility (Table B.24), and decommissioning costs (Table B.25). The costs summarized on Tables B.23 and B.25 should, as before, be prorated into the appropriate years using Table B.21.

TABLE B.19. Cash Flow and Present Worth for ____________________

Year	Discount Factor	Costs, $1000's Capital	Operating	Total	Discounted Total
1982	1.0000				
1983	0.9804				
1984	0.9612				
1985	0.9423				
1986	0.9238				
1987	0.9057				
1988	0.8880				
1989	0.8706				
1990	0.8535				
1991	0.8368				
1992	0.8203				
1993	0.8043				
1994	0.7885				
1995	0.7730				
1996	0.7579				
1997	0.7430				
1998	0.7284				
1999	0.7142				
2000	0.7002				
2001	0.6864				
2002	0.6730				
2003	0.6598				
2004	0.6468				
2005	0.6342				

TABLE B.19. (contd)

Year	Discount Factor	Costs, $1000's Capital	Operating	Total	Discounted Total
2006	0.6217				
2007	0.6095				
2008	0.5976				
2009	0.5859				
2010	0.5744				
2011	0.5631				
2012	0.5521				
2013	0.5412				
2014	0.5306				
2015	0.5202				
2016	0.5100				
2017	0.5000				
2018	0.4912				
2019	0.4806				
2020	0.4712				
2021	0.4619				
2022	0.4529				
2023	0.4440				
2024	0.4353				
2025	0.4268				
2026	0.4184				
2027	0.4102				
2028	0.4022				
2029	0.3943				
2030	0.3865				
SUM					

TABLE B.20. First Module Capital Cost Estimate for ________________

Cost Element	Manhours, 1000's		Costs, $1000's		
	Non-Manual	Manual	Labor	Material	Total
Site and improvments					
Receiving facility					
Canning facility					
Drywells or casks					
Balance of storage facility					
Other buildings					
Canning equipment					
Transporter					
Other engineered equipment					
Total directs					
Indirects					
A-E services					
Contingency					
TOTAL					

B.21. Cost Distribution for ______________
(from Tables B.20, B.22 and B.25

Year	Distribution Fraction	Annual Cost

TABLE B.22. Estimate of Additional Module Capital Cost for ____________________

Cost Element	Manhours, 1000's Non-Manual	Manhours, 1000's Manual	Costs, $1000's Labor	Costs, $1000's Material	Costs, $1000's Total
Site preparation					
Drywells or casks					
Balance of storage facility					
Total directs					
Indirects					
A-E services					
Contingency					
TOTAL					

TABLE B.23. Estimate of Owner's Costs During Construction for ____________________

Cost Element	Manhours or Other Basis	Cost
Hearing preparation and testimony		
Contract management		
Inspection and QA		
Training program		
Security		
General and administrative		
TOTAL		

TABLE B.24. Estimate of Owner's Annual Operating Costs During ________________ for ________________

Cost Element	Manhours or Other Basis	Cost
Supplies		
Capital replacement allowance		
Cans and lids		
Security		
Maintenance		
Receiving and shipping		
Hot cell (canning, etc.)		
Placement or removal		
Surveillance		
Outside support services		
Subtotal		
General and administrative		
Utility costs		
Other		
TOTAL ANNUAL COST		

TABLE B.25. Estimate of Owner's Costs During Decommissioning for ____________________

Cost Element	Manhours or Other Basis	Cost
Casks or drywells		
Engineered equipment		
Buildings		
Site restoration		
Supplies (decontamination, cutting, packaging)		
Security		
Shipping and burial fees		
Subtotal		
General and administrative		
Utilities		
Other		
TOTAL		

Table B.24 should be used for estimates of annual operating costs. Normally one table will be required for each year of operation. However, if operating costs are identical for successive years, a single table may be used with the notation in the heading as to the years the table applies to. Again, the total cost for each year should be included in the cash flow summary of Table B.19. Transportation-related expenses inside the facility fence (except transportation equipment lease or use fees) are to be estimated and included in annual operating expenses.

Cost Bases

Bases for estimates should be given in all instances. Design and construction costs are generally influenced by physical conditions at a site. Attachment 2 lists the pertinent conditions that should be described as part of this cost basis. Attachment 3 provides guidelines for social and economic factors that need to be considered and described in the bases. These procedures, should be followed, are based upon work initially done for PNL by Bechtel Corporation during preparation of DOE/ET-0028 (Technology for Commercial Waste Management).

A contingency of 25 percent should be used in defining construction costs.

If the design does not require a facility or an operation given in a table, a cost of zero may be entered. The detail in the tables is not intended to dictate design, only to permit normalization.

ATTACHMENT 1: OUTLINE OF COST CATEGORIES

A. Possible capital expenses at MRS/IS

1. Reports and testimony for site approval, cost of permits and licenses
2. Design engineering
3. Site preparation, access control, abatement of impacts on air and water quality
4. Buildings
    a) Receiving facility including holding areas for incoming and outgoing casks
    b) Canning facility, transfer facility
    c) Storage facility including drywells or casks
    d) Administration auxiliary, etc.
5. Engineered equipment
    a) Cranes
    b) Canning equipment
    c) Decontamination and waste treatment equipment
    d) Ventilation and contamination control
    e) Spare parts inventory
    f) Transporter for 100 ton cask or shielded transporter for cans
6. Contractor indirects (percent of 4, 5 and 6)
7. Construction management and inspection
8. Licensing and safety reports
9. Contingency

B. Owner's costs for MRS/IS

1. Payroll for personnel at hearings and for preparation of presentation and testimony
2. Contract management
   a) Engineering
   b) Licensing consultants
   c) Construction contractor
3. Inspection and quality assurance
4. Operating supplies
   a) Decontamination chemicals, wipes, protective clothing, dosimeters, etc.
   b) Filter aids, demineralizers, regeneration chemicals
   c) Annual capital replacement as used from spare parts inventory
   d) Cans and lids
5. Payroll for personnel to:
   a) Operate training program
   b) Guard plant and storage yard
   c) Maintain cranes, decontamination equipment, waste treatment equipment, heating and ventilating equipment, and transporter
   d) Receive, prepare, inspect, survey, cool, flush, and decontaminate shipping casks, storage casks, and/or shielded transporter
   e) Move shipping cask and storage cask into hot cell and open them
   f) Bring fuel, fuel can, hardware can and lids to work station

g) Disassemble fuel and place fuel pins in fuel cans and hardware in hardware cans

h) When cans are full, seal, test seal, decontaminate exterior and survey

i) Place completed cans in a cask, shielded transporter or lag storage

j) Mark each can and record the contents and location

k) Move fuel assemblies from shipping cask to storage cask or transporter or cans from storage to the storage cask or transporter

l) Close, inspect, survey and decontaminate a cask or shielded transporter

m) Reassemble and ship the shipping cask

n) Remove the storage cask from the hot cell and place in the storage yard

o) Remove the shielded transporter from the hot cell, place the fuel or can in a drywell, seal the drywell, test the seal, survey, and decontaminate.

6. Maintenance and operating supplies for the storage period.

7. Payroll during storage period

   a) Guards

   b) Maintenance to keep plant in standby and counteract weathering of casks or drywells

   c) Leak test casks or drywells and repair as necessary

8. Maintenance and operating supplies for removal

   a) Decontamination chemicals, wipes, etc.

   b) Filter aids, demineralizer regeneration chemicals

   c) Capital replacements as used from spare parts inventory.

9. Payroll during removal for personnel to:

   a) Guard plant and storage yard

   b) Maintain cranes, decontamination equipment, waste treatment equipment, heating ventilating equipment and transporter

   c) Receive, prepare, inspect, survey, cool, flush and decontaminate storage casks, shipping casks, and/or shielded transporter

   d) Move storage cask or fuel from shielded transporter and shipping cask into hot cell and open casks

   e) Move fuel assembly or can into shipping cask

   f) Record location of all fuel moved

   g) Close, inspect, survey ana decontaminate casks and/or transporter

   h) Prepare and ship the shipping cask to reprocessing or disposal (if storage cask becomes licensed for shipping, this step may replace many of the above steps)

10. Pay premium or receive credit for condition of fuel relative to normal uncanned assemblies based upon impact on reprocessing or disposal.

11. Decommission facility

   a) Survey, decontaminate and sell for scrap, send to shallow-land burial or disposal the storage casks or drywells

   b) Decontaminate, disassemble, and sell for scrap or package and ship for shallow burial or disposal all engineered equipment

   c) Convert to other use or demolish and sell for scrap or send to shallow burial or disposal all buildings and storage structures

   d) Prepare land for conversion to other uses.

12. Shipping and burial fees for decontamination wastes generated during fuel placement, storage, and removal, and during decommissioning.

13. General and overhead expenses (as a percentage of 4 through 12)

14. Contracted services.

15. Fuel and utilities.

ATTACHMENT 2: DESIGN AND CONSTRUCTION BASES

Please describe the following items in your basis.

1. Site Location

2. Meterological Conditions

   2.1 Wind conditions as indicated below:
   - Maximum velocity
   - Average velocity
   - Design velocity (basic wind speed)
   - Design pressure.

   2.2 Tornado

   2.3 Tornado Missiles

   2.4 Rainfall (Precipitation)
   - Annual average precipitation
   - Maximum precipitation
   - Design maximum rate (peak 1 hr rate 50 yr recurrence)
   - Design maximum duration.

   2.5 Snow

   2.6 Temperature design basis temperature conditions
   - Summer maximum (July)
   - Winter minimum (January)
   - Design maximum, summer
     dry bulb
     wet bulb
   - Design minimum, winter.

3. Surface Conditions

   3.1 Obstructions

   3.2 Topography

   3.3 Vegetation

   3.4 Drainage

3.5 Flooding

3.6 Roads

Approximate new road construction required to provide access to the site from an existing highway suitable for heavy transport.

3.7 Railroads

Approximate new railroad required to provide a rail spur service to the site.

3.8 Utilities

Will temporary facilities be required during construction, or are permanent facilities part of site preparation.

4. Subsurface Conditions

4.1 Obstructions

Are there any major underground obstructions to facility construction.

4.2 Soils - Thickness

4.3 Rock - Depth type and load bearing ability

4.4 Groundwater - Depth and need for dewatering

4.5 Frost - Design ground penetration

4.6 Cavities and Small Voids

Do they exist in the soils or rock underlying the site

5. Geologic and Seismic Conditions

5.1 Faults - The nearest known or inferred fault

5.2 Seismic Design

ATTACHMENT 3: COST ESTIMATE BASES AND METHODS

1. Construction Conditions

As a basis for cost estimating, the construction conditions described below are assumed to prevail at all sites.

1.1 Construction Labor will follow a 40-hour, single-shift work week schedule except for casual overtime (e.g., to complete a concrete pour), and in instances where twoor three-shift concrete work operations are planned to meet the construction schedule.

1.2 Severe Work Stoppages such as extensive jurisdictional disputes between labor crafts will not occur during construction.

1.3 Labor Availability in each craft will be adequate so that importing labor, except for general foremen, will not be required.

1.4 Craft Labor Wage Rates, including fringe benefits are those prevailing in the geographic region of the construction site in mid-1982.

2. Pricing: Field Costs

The various elements comprising the field costs will be priced by the methods described below:

2.1 Major Equipment Costs will be determined using estimated prices of similar or nearly similar equipment from other cost estimates of fuel reprocessing plants, radioactive wastes disposal processes and other plants dealing with the nuclear fuel cycle.

2.2 Bulk Materials. Except for instances where enough information exists to warrant quantity assessments and unit pricing of certain specifically identified material, bulk materials costs will be determined either as a function of major equipment costs or as a cost allowance.

2.3 Direct Labor Costs will be evaluated from estimated manhours for erection and installation sequences and operations and craft wage rates and fringe benefits in effect at mid-1982. Labor manhours are representative of the craft production rates in the area of reference jobsites.

2.4 Indirect Site Construction Costs such as contractor's fee, supervision, construction equipment, tools and consumable supplies, temporary facilities and utilities, material handling, cleanup and the like will be combined and evaluated as a factor of the total direct labor.

3. Architect-Engineer (A-E) Services

The costs of A-E services will be estimated as a percentage of the total field costs and will include burden and fee.

4. Owner's Cost

Owner's costs during construction will be estimated in conjunction with the operating and maintenance costs.

5. Costs Not Included

Exclusions from the estimate are generally limited to the following particular cost classifications:

- Site acquisition costs
- Escalation of costs beyond mid-1982
- Process and patent royalties
- General research and development costs
- Costs incurred beyond those that reflect the current degree of involvement in securing approvals from regulatory agencies monitoring environmental and safety considerations
- Costs generated directly by any governing or regulatory agency for administration, engineering, procurement and construction
- Sales/use tax
- Local property tax or payments in lieu thereof
- Impact payments to local government
- Insurance or prorate cost of self insurance
- Nuclear hazards insurance that may be required if nuclear hazards exist on site before completion of project
- Housing for construction workers.

B.3 TRANSPORTATION UNIT COSTS

Summary

This section provides unit transportation costs to the contractors performing pre-conceptual design studies for the Monitored Retrievable Storage/Interim Storage (MRS/IS) program in FY-82. The bases and assumptions pertaining to transportation for use by the preconceptual design contractors in their FY-82 studies are also documented in this section. Unit transportation costs are calculated for four fuel-cycle materials; spent fuel, high-level wastes (HLW), remote-handled transuranic (RHTRU) wastes, and contact-handled (CH) TRU wastes. RHTRU wastes are further subdivided into three categories; wastes that are packaged in special cylindrical canisters (including compacted cladding hulls), wastes that are packaged in "standard" 210-liter (55 gal) drums with surface dose rates less than 5 R/hr, and drummed wastes with surface dose rates greater than 5 R/hr. Transportation costs are calculated for shipments by truck and by rail.

Three waste management scenarios are currently under study by the MRS/IS program. They include interim storage facilities located either at a fuel reprocessing plant, a geologic waste disposal repository, or a stand-alone facility. The transportation links and the assumed mileages between each facility are defined. Transportation in this study stops at the fences of the terminal facilities; i.e., onsite transportation is considered as facility handling operations. The reference shipping systems for transporting the spent fuel and HL and TRU wastes between the facilities are selected. Several criteria were used for selecting these systems, in particular the use of existing or near-existing technology, licensability, and compatibility with reference canister sizes. The reference shipping systems selected for use in this study are shown in Table B.26. The reference canister dimensions are also defined.

TABLE B.26. Reference Shipping Systems Selected for Study

Material	Shipping Mode	Shipping Container	Canisters per Shipment	Leasing Fee, $/Day
Spent fuel	Truck	NAC-1	1 PWR or 2 BWR	2000(a)
	Rail	IF-300	7 PWR or 18 BWR	5750
High-level wastes	Truck	NAC-1	1 canister	2000
	Rail	IF-300	5 canisters	5750
RHTRU special canister	Truck	HLW-T	1 canister	1750
	Rail	HLW-R	5 canisters	4375
RHTRU drums <5 R/hr	Truck	CNS 14-170	14 drums	175
	Rail(b)	CNS 14-170	42 drums	525
RHTRU drums >5 R/hr	Truck	CNS 7-100	7 drums	175
	Rail(b)	CNS 7-100	21 drums	525
CHTRU wastes	Truck	TRUPACT	36 drums or 3 boxes	700
	Rail(c)	TRUPACT	72 drums or 6 boxes	1400

(a) Leasing fee for the NAC-1 is calculated from a schedule.
(b) It is assumed that three of these shipping containers can be transported per railcar.
(c) Assumes two truck TRUPACT versions are transported per railcar.

Transportation costs for the FY-82 MRS/IS program studies are based on the assumption that private industry will provide the transportation services as a commercial venture, although the services could be owned and provided by the government. Therefore, total transportation costs are the sum of the shipping charges, special equipment and security costs (where applicable) and shipping container rental fees. The unit transportation costs for truck and rail shipments of the six different cargoes are summarized in Table B.27. The MRS/IS program design contractors will multiply the values shown in Table B.26 by the appropriate number of shipments their facilities will deal with to calculate total transportation costs over the assumed lifetimes of their facilities. Use of the unit costs shown in Table B.27 provides a common baseline for comparing the total life-cycle transportation costs for the three siting alternatives for MRS/IS facilities.

Special equipment charges and security costs are currently required for shipments of spent fuel and may be required for shipments of high-level wastes in the future. The costs for HLW shipments shown in Table B.27 include these additional costs.

INTRODUCTION

The objectives of the Monitored Retrievable Storage/Interim Storage Program are to provide Federal contingency capability for storing spent nuclear fuel until a reprocessing facility can eliminate the need for such storage and to provide Federal capability for storing solidified high-level wastes (HLW) and transuranic (TRU) wastes until a waste disposal repository becomes available. Currently, two dry storage concepts are being evaluated to determine their effectiveness for reducing near-term spent fuel and waste storage space shortages. The two concepts consist of storage in large metal casks and drywells. Both concepts offer passive, low cost, easily maintained systems that can be expanded in increments which can be constructed according to demand. The degree of flexibility of these storage concepts is being assessed by comparing the results of using casks and drywells to provide interim storage at three potential sites: co-located at a repository,

TABLE B.27. Round-Trip Transportation Costs for Truck and Rail Shipments of Spent Fuel and High-Level and Transuranic Wastes[a]

Material	Shipping Mode	Round-Trip Unit Transportation Costs One Way Miles, $/Shipment[b,c] 500	2000	2500
Spent fuel[d]	Truck	12,190	29,010	34,710
	Rail	91,140	216,920	26,240
High-level[d] wastes	Truck	12,200		31,510
	Rail	91,210		262,410
RHTRU wastes; special canisters	Truck	9,280		23,030
	Rail	69,670		193,770
RHTRU wastes; drums <5 R/hr	Truck	3,450		10,825
	Rail	21,090		57,530
RHTRU wastes; drums >5 R/hr	Truck	3,380		10,645
	Rail	20,770		55,680
CHTRU wastes	Truck	5,310		14,380
	Rail	25,600		70,600

(a) Transportation costs include shipping charges, special equipment and security costs (where applicable) and shipping system rental fees.
(b) Rounded to the nearest ten dollars.
(c) These costs do not include demurrage fees for truck shipments. These are, on the average, $29.30 for each hour of turnaround time at the terminal facilities. Rail demurrage fees are calculated using shipping system rental fees.
(d) Costs include charges for special equipment and escort services.

co-located at a fuel reprocessing plant (FRP), and a strategically located stand-alone facility. The two storage concepts are being evaluated for each siting alternative as to their technical status, life cycle costs, safety and licensing issues, environmental issues, transportation considerations, and research and development requirements.

The purpose of this document is to transmit standardized assumptions and unit costs for transportation to the contractors preparinq pre-conceptual and reference designs of interim storage facilities for the three siting alternatives. This standard set of numbers is to be used in all three studies to set a baseline for common comparison of lifetime transportation costs. Unit costs are developed for transporting four types of radioactive materials: spent fuel, solidified high-level wastes, remote-handled transuranic (RH-TRU) wastes, and contact-handled TRU (CH-TRU) wastes. RH-TRU wastes are further divided into special canisters and two types of drummed wastes so a total of six fuel cycle materials are considered in this study. In addition to transmitting standardized assumptions and transportation unit costs, this report defines the reference transportation systems for the MRS/IS Program. Also included is an estimate of the costs of requiring security provisions for high-level waste shipments similar to those required for spent fuel in transit.

Bases and Assumptions

The bases for calculating unit transportation costs and key assumptions that were made to facilitate these calculations are discussed in this section. The section includes definition of the transport links connecting the fuel cycle facilities considered in this study. Transportation in this study refers only to offsite shipments, in the general public domain (i.e., between fences of the terminal facilities). Onsite transportation is considered as handling at the facility and is not included here. However, onsite handling of the cross-country vehicles and packagings can affect facility turnaround times and thus the cost of cross-country transport. Shipping parameters and transportation costs for six fuel cycle materials are considered: spent fuel, solidified high-level wastes, RHTRU cladding hulls, other RHTRU wastes, and CHTRU wastes.

At this time in the U.S., no commercial reprocessing of spent nuclear fuel to reclaim valuable uranium and plutonium is occurring. As a result, the spent fuel is being stored in reactor fuel storage basins. The maximum capacity of many of these basins is being reached. The strategy used in the MRS/IS studies assumes that: 1) the government will accept and store excess spent fuel in a federally owned facility until a fuel reprocessing plant (FRP) becomes available; 2) in the reference case, a 1500 MgHM/year FRP will open in 1989 and the MRS/IS will accept and store HL and TRU waste from that operation until a repository is available; 3) the HL and TRU waste generated by the FRP will ultimately be shipped to a repository for final isolation; and 4) a generic mixed-oxide fuel fabrication plant will begin operation in 1989. A gap exists between the 1998 planned opening date for the repository and the FRP opening date of 1989. The HLW and TRU wastes generated during this period will be shipped to an MRS/interim storage facility until they can be shipped to the repository for final isolation.

Three general waste management scenarios are currently envisioned by the MRS/Interim Storage program. The basic scenarios are defined by the site selected for construction of the MRS/IS facility, either co-located with an FRP (assumed in this study to be Barnwell Nuclear Fuel Plant), co-located with the repository, or a strategically located stand-alone facility. Transport links connecting these facilities and power reactors are shown in Figures B.1, B.2, and B.3 for each scenario. From these figures it can be seen that co-locating the MRS/IS facility with either the FRP or the repository eliminates some transport steps. If the MRS/IS facility is co-located with the FRP, transport of spent fuel from interim storage to the FRP and of solidified HLW and TRU wastes from the FRP to interim storage are both eliminated. Co-locating the MRS/IS facility at the repository eliminates transportation of HLW and TRU wastes from interim storage to the repository. All transport steps between these facilities are required if the MRS/IS facility is a stand-alone facility.

One purpose of this report is to define the reference transportation systems for use in the facility evaluations. There is no intent to endorse or reject any particular shipping system. Reference systems, however, were selected to provide consistency within this study using state-of-the-art

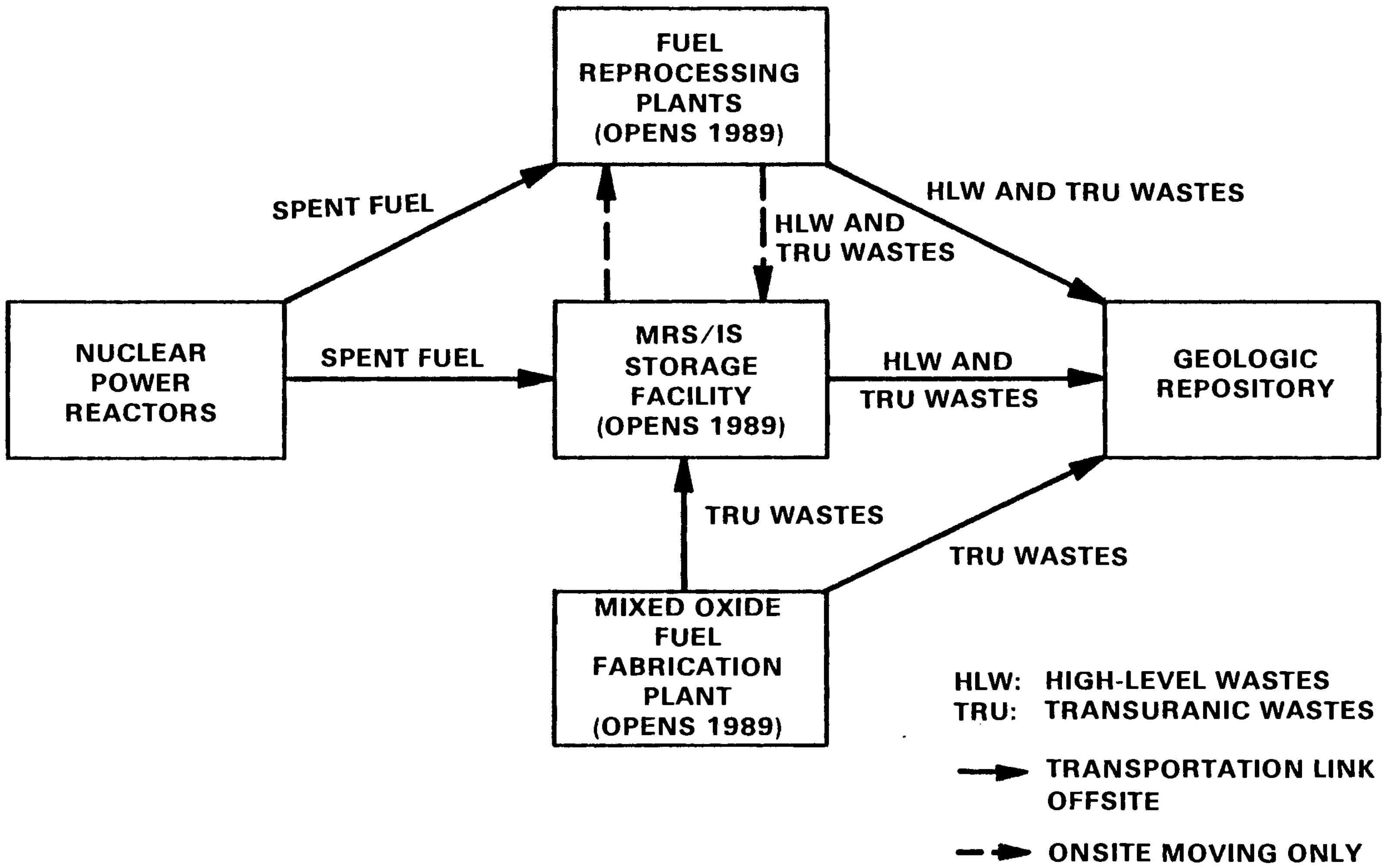


FIGURE B.1. Transportation Links for Co-locating the Interim Waste Storage Facility with the Reprocessing Plant

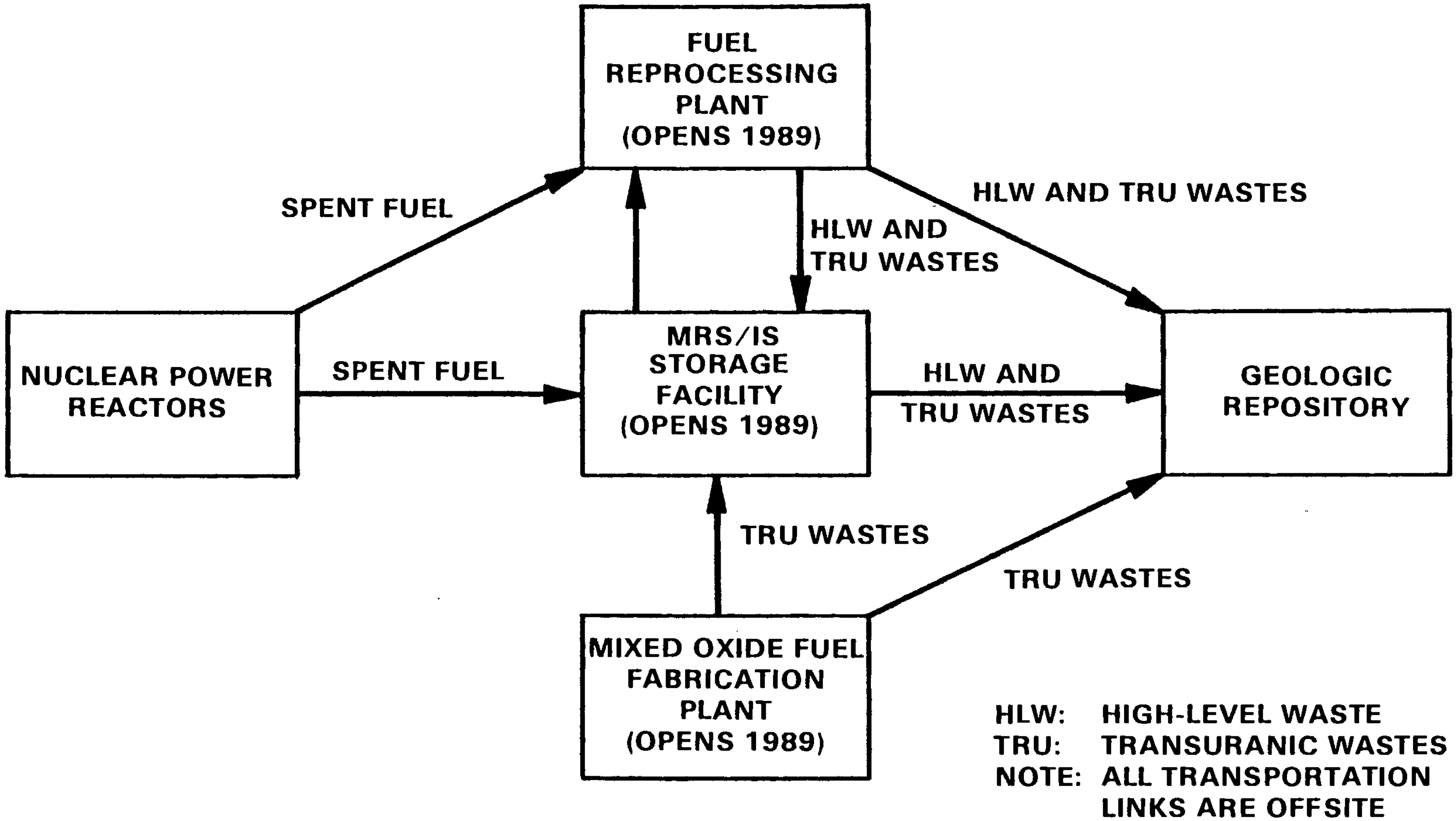


FIGURE B.2. Transportation Links for a Strategically Located, Stand-Alone Interim Storage Facility

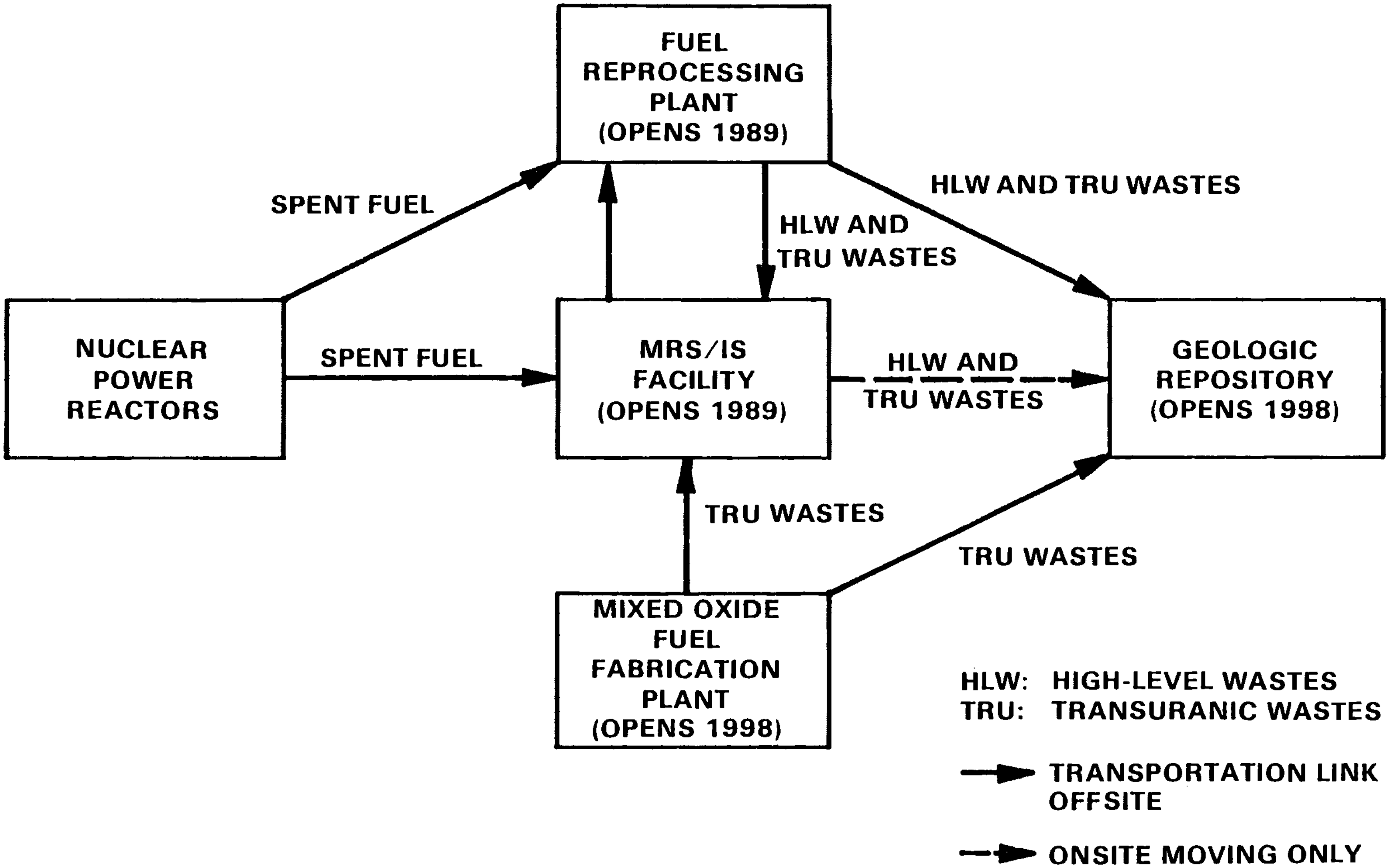


FIGURE B.3. Transportation Links for Co-locating the Interim Waste Storage Facility with the Repository hardware. Primarily, the systems selected were existing and licensed where available. If no such systems exist, those that are well along in the design stage were selected. Another criterion that must be met by the shipping system is that of licensability. Application of this criterion requires judgment as to whether or not a conceptual shipping system is expected to eventually meet the packaging regulations in 10 CFR 71.

A third criterion concerning the selection of the shipping systems is the sizes of the reference canisters assumed as the primary container for the high-level and transuranic wastes. The reference canister sizes for this study are shown in Table B.28.

The reference shipping systems in this study were selected to accommodate these sizes of canisters. Some inconsistencies may exist between these canisters and the canisters that the FRP is planning to use. For example, the cladding hulls canister the FRP is planning to use is 1.1 m (3.7 ft) in diameter and 2.3 m (7.5 ft) long. This canister, due to its large diameter,

TABLE B.28. Reference Canister Sizes and Weights for Definition of Shipping Systems and Shipment Parameters

Fuel Cycle Material	Dimensions, m	Net[(a)] Capacity, m^3 (ft^3)	Average Weight Loaded, kg (lb)
Spent fuel			
PWR assembly	NA	NA	658 (1448)
BWR assembly	NA	NA	284 (625)
Solidified high-level waste canister	0.31D x 3.1	0.17 (6.0)	1050 (2310)
RHTRU wastes			
Hulls canister	0.62D x 3.1	0.75 (2.6)	3500 (7700)
210 L (55 gal) drum	0.62D x 0.92	0.17 (6.0)	
CH-TRU Wastes			
210 L (55-gal) drum	0.62D x 0.92	0.19 (6.7)	300 (660)
Metal box	1.2 x 1.9 x 1.9	3.5 (123.6)	4000 (8800)

NA = Not applicable.
(a) Based on maximum of 80 percent full.

was not transportable in any of the spent fuel or high-level waste truck shipping casks. Therefore, to be more compatible with storage and shipping casks, the equivalent volume of waste is assumed to be transported in a larger number of 0.62 m (2 ft) diameter canisters for this study.

A key assumption that simplifies the selection of the shipping systems is that the canister provides the second level of containment for plutonium bearing wastes, as required in federal regulations (10 CFR 71). The casks or shipping packagings provide only one level of containment. A final assumption concerning selection of the truck shipping systems is that they will all be legal-weight systems, i.e., gross-vehicle weight (tractor plus trailer plus loaded cask weights) do not exceed 36,400 kg (80,000 lb). It is recognized that over-weight truck shipments may be more economical than legal-weight shipments, but for this study, there was insufficient time to adequately calculate the charges for over-weight shipments. This would include defining specific routes and finding what each state on each route charges as an over-weight penalty. In addition, the use of overweight trucks routinely for numerous shipments would require considerable administrative efforts to obtain repeatedly the special permits from the states involved.

Shipping distances must be defined to calculate transportation costs. For the purposes of this study, two distances that represent somewhat bounding cases are defined. The first distance is 4000 km (2500 miles), which represents a cross-country shipment. The second distance is 800 km (500 miles), which was chosen because it approximates a typical distance between eastern power reactors and BNFP. The cost for each transport link in the evaluation studies of three sites for MRS/IS facilities is calculated using both of these distances.

The assumed distances must be assigned to the various transportation links in Figures B.1 through B.3. Since most of the commercial reactors are in the east and the FRP will be in the east, the transportation link connecting these facilities is assumed to be 800 km (500 miles). The disposal repository is assumed to be in the west, which results in the 4000 km (2500 mile) transport distance between the FRP and repository and the MOX-FFP and repository. Depending upon where the MRS/IS facility is co-located, it is assumed to be either 800 km or 4000 km from the reactors (i.e., if the storage facility is co-located with the repository, the transportation link between the reactors and the MRS/IS facility is 4000 km; it is 800 km if the MRS/IS facility is co-located at the FRP). The stand-alone MRS/IS facility is assumed to be 800 km from reactors and from the FRP and 4000 km from the final isolation repository. In all cases, the MOX-FFP is assumed to be the same distance from the other sites as the FRP.

It is assumed in this study that 50 percent of the spent fuel and waste transported to the IS facility is to be shipped by truck and 50 percent by rail. This shipping mode split was chosen because it is not clear what mode of transport will be most extensively used in the future. Each has its own advantages and disadvantages. The reference truck/rail shipping split reflects no bias toward either mode. If such a split significantly affects the operating costs for any preconceptual MRS/IS facility, the respective contractor may, if desired, select other splits as sensitivity cases to this reference case.

Mid-year 1982 dollars were used when calculating transportation unit costs. Transportation costs are calculated as though private industry was shipping on a commercial basis even though that may eventually not be the case. Costs include operating costs plus amortization costs of hardware plus profits, at commercial rates. Therefore, transportation costs include the shipping charges assessed by carriers and the rental fees assessed by transportation hardware suppliers. A third factor in transportation costs is a fee for demurrage or detention of a carrier's equipment (railcars or truck-trailer rigs) and for drivers while unloading at terminal facilities. These three transportation factors are assumed to be supplied by the private sector as a commercial venture. Thus the total transportation costs are calculated as follows:

$$\begin{array}{c}\text{Total}\\\text{Transportation}\\\text{Costs}\end{array} = \begin{array}{c}\text{Round-trip}\\\text{Shipping}\\\text{Charges}\end{array} + \begin{array}{c}\text{Special}\\\text{Equipment/}\\\text{Security}\\\text{Costs}\end{array} + \begin{array}{c}\text{Shipping}\\\text{Container}\\\text{Leasing}\\\text{Fees}\end{array} + \begin{array}{c}\text{Demurrage}\\\text{Fees}\end{array}$$

Transportation System Descriptions

This section describes transportation systems selected for this study for the five fuel cycle materials under consideration in this study: spent fuel, solidified HLW, TRU-contaminated fuel cladding hulls, other RHTRU wastes, and CHTRU wastes. Two shipping systems, one truck version and one rail version, are described for each material. It is believed that the future nuclear waste management system will integrate their waste container designs with transportation system designs to provide compatible and optimum shipping configurations. Therefore, if a minor modification to the shipping containers results in significantly increased capacities, it is assumed this will be done. These modifications are noted where they occur.

Table B.29 lists the important shipping parameters and characteristics of the truck and rail shipping systems used in this study. Supplementary descriptive information is contained in the following sections.

Spent Fuel Shipping System

The representative truck and rail shipping systems used in this study are the NAC-1 owned by the Nuclear Assurance Corporation and the IF-300 owned by the General Electric Company, respectively. The NAC-1 and IF-300 shipping casks are depicted in Figures B.4 and B.5, respectively. The NAC-1 legal weight truck system uses a water-filled cask designed to transport one PWR or two BWR spent fuel assemblies. Decay heat from the spent fuel is removed by conduction and convection through the cask body and is released to the atmosphere by natural convection and radiation. The NAC-1 is currently shipped at a reduced heat loading.

The IF-300 cask of General Electric Company is a water-filled cask (although it is currently shippped dry), designed for rail transport of 7 PWR or 18 BWR spent fuel assemblies. Decay heat is removed from the fuel by natural circulation of the coolant (water, when used), by natural convection and conduction to the external surface, and by forced convection from the external surface to the environment. The forced convection (air impingement) system consists of two diesel-driven blowers and appropriate air ducts. In addition, the cask outer surface is corrugated to facilitate external cooling. The maximum heat-rejection capacity is 76 kW with blowers operating and 62 kW without blowers.

TABLE B.29. Characteristics of Transportation Systems for the MRS/IS Program

Fuel Cycle Material	Shipping Container Designation	Transport Mode	Shipment Capacity	External Dimensions, m	Cargo Compartment Dimensions, m	Thermal Limit, kW	Shielding Material	Shielding Equiv. Stl. Thick, cm	Weight, kg	Gross Vehicle Weight, kg Loaded
Spent fuel	IF-300	Rail	7 PWR or 18 BWR elements	1.91D x 5.03 PWR 5.28 BWR	0.95D x 4.25 PWR 4.57 BWR	61.5 Wet 11.7 Dry	U/St/H_2O	37	63,490	119,270
	NAC-1	Truck	1 PWR or 2 BWR elements	1.27D x 5.13	0.34D x 4.52	2.5 Dry 11.5 Wet	Pb/St/H_2O	27	22,660	33,200
Solidified HLW[b]	IF-300	Rail	5 canis-ters of HLW glass	1.91D x 5.28	0.95D x 4.57	61.5 Wet 11.7 Dry	U/St/H_2O	37	63,490	119,270
	NAC-1	Truck	1 HLW canister	1.27D x 5.13	0.34D x 4.52	2.5 Dry 11.5 Wet	P/St/H_2O	27	22,660	33,200[h]
Canistered RH-TRU Wastes	HLW-R[d]	Rail	5 canis-ters	2.69D x 3.84	2.25D x 3.20	2.7 Dry	Al/St	23	52,150	119,600
	HLW-T[d]	Truck	1 canis-ter	1.26D x 4.12	0.83D x 3.43	0.5 Dry	Al/St	15	11,700	33,000
RH-TRU wastes[e] <5 R/hr	CNS 14-170[f]	Rail	42 drums	2.1D x 2.2	1.9D x 1.9	NA	Pb/St	5.4 (Pb)	15,400 (each CNS 14-170)	97,000
	CNS 14-170	Truck	14 drums	2.1D x 2.2	1.9D x 1.9	NA	Pb/St	5.4 (Pb)	15,400	35,500
RH-TRU wastes[e] >5 R/hr	CNS-7-100[f]	Rail	21 drums	2.2D x 1.4	1.9D x 1.1	NA	Pb/St	8.9 (Pb)	16,100 (each CNS 7-100)	93,000
	CNS-7-100	Truck	7 drums	2.2D x 1.4	1.9D x 1.1	NA	Pb/St	8.9 (Pb)	16,100	34,100
CH-TRU wastes[g]	TRUPACT	Rail	72 drums or 6 boxes	2.4 x 2.7 x 7.5	NA	NA	Essentially None		10,000 (each TRUPACT)	83,000
	TRUPACT	Truck	36 drums or 3 boxes	2.4 x 2.7 x 7.5	1.8 x 2.1 x 5.6	NA	Essentially None		10,000	33,000

NA = Not Available.

(a) Gross vehicle weights include cooling systems, tie-down systems, transport vehicles and other miscellaneous equipment.
(b) Solidified HLW are assumed to be packaged in 0.3 m (1 ft) diameter by 3.1 m (10 ft) long stainless steel canisters.
(c) Cladding hulls are assumed to be treated to reduce volumes and placed inside stainless steel canisters measuring 0.6 m (2 ft) in diameter by 3.1 m (10 ft) long.
(d) Cask designed for transportation of defense HLW by the General Atomic Co. for the DOE.
(e) Assumed to be packaged in 210 L (55 gal) steel drums.
(f) Truck and rail containers are identical. Three can be shipped per railcar; one per truck.
(g) Assumed to be packaged in 210 L (55 gal) drums or 1.9 m x 1.3 m x 0.95 m (6.2 ft x 4.2 ft x 3.1 ft) modular boxes. TRUPACT = Transuranic Package Transporter. Rail TRUPACT is assumed to be identical to truck version. One TRUPACT is shipped per truck trailer and two per railcar.
(h) It is assumed that the modification required in this cask to transport HLW can reduce the cask weight enough to keep this a legal-weight truck shipment, e.g., drainage of the neutron shield tank.

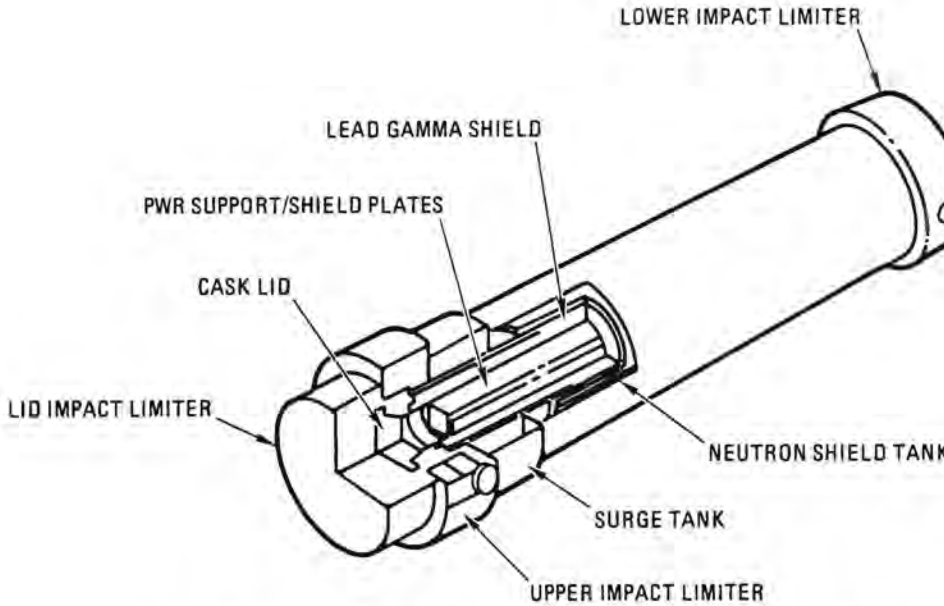


FIGURE B.4. NAC-1 Truck Spent Fuel Shipping Cask

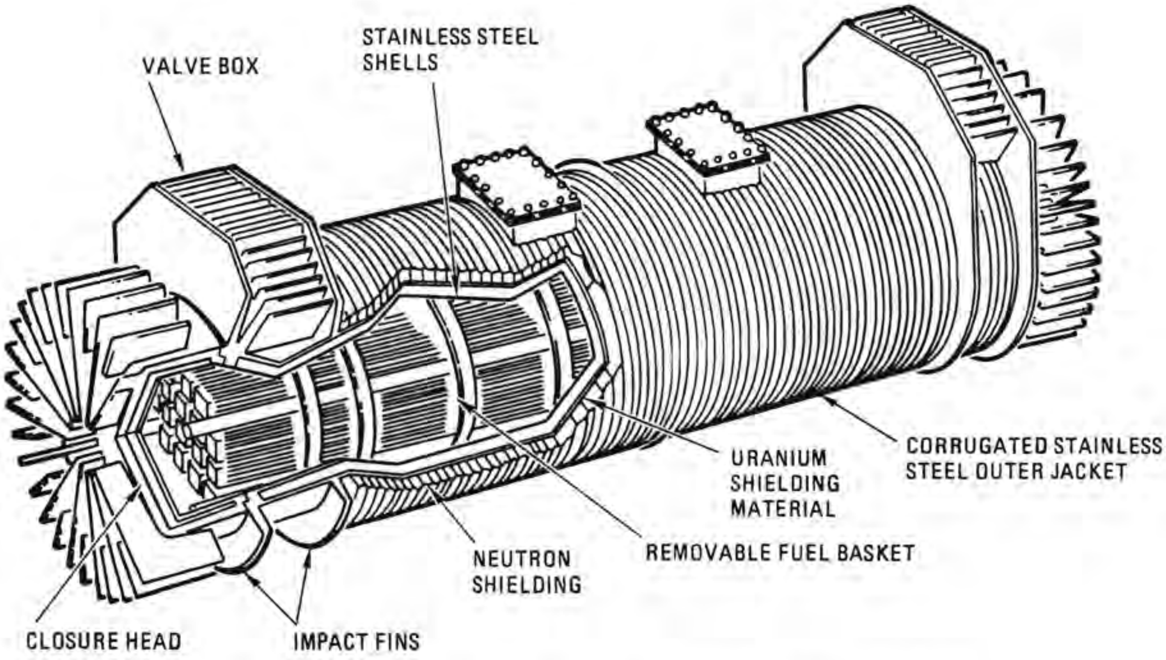


FIGURE B.5. IF-300 Rail Spent Fuel Shipping Cask

High-Level Waste Shipping Systems

Transportation systems for solidified high-level wastes have been conceptually designed but not built. These systems are expected to resemble the current generation of spent fuel shipping casks. Therefore, the shipping systems previously described for transport of spent fuel are also assumed to be used to transport high-level wastes in this study. Some minor modifications to the spent fuel casks are required, e.g., designing a new internal basket for the IF-300 with a capacity for five HLW canisters, but it is assumed that these casks would be licensable for HLW shipments by using appropriate baskets and spacer inserts. The only change to the "cask characteristics" is the cargo weights. It is recognized that the NAC-1 and IF-300 are not optimized for transporting high-level wastes and that future transportation systems may have higher cargo capacities for a given gross weight.

RHTRU Waste Shipping Systems

Different shipping systems are required to transport "standard" 55 gal drums and other special canisters for RHTRU wastes. Special canisters (0.62 m in diameter and 3.1 m long) are assumed to be transported in casks currently designated HLW-T and HLW-R for truck and rail versions, respectively. These casks are being designed by the General Atomic Company to transport defense high-level wastes for the DOE. They are assumed in this study to be licensable for transporting commercial RH-TRU wastes. The HLW-T cask is a thick-walled steel cylinder similar to the current generation of spent fuel truck casks. This cask can accommodate one special canister. The HLW-R cask is a cylindrical, solid steel cask capable of transporting five canisters. Conceptual drawings of these casks are shown in Figures B.6 and B.7 respectively.

RHTRU wastes are also packaged in standard 55-gal drums, having various dose rates from 200 mR/hr to several hundred R/hr. To make the economics of transport more realistic for the additional shielding needs, two shipping containers with different features are assumed to be used. For RHTRU waste drums with surface dose rates less than 5 R/hr, the shipping container

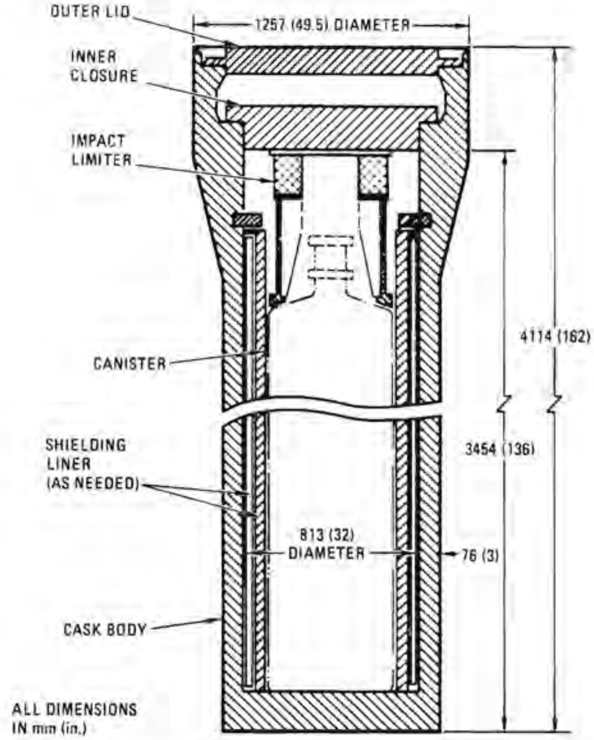


FIGURE B.6. Reference Truck Cask for Transportation of Hulls Canisters (HLW-T cask)

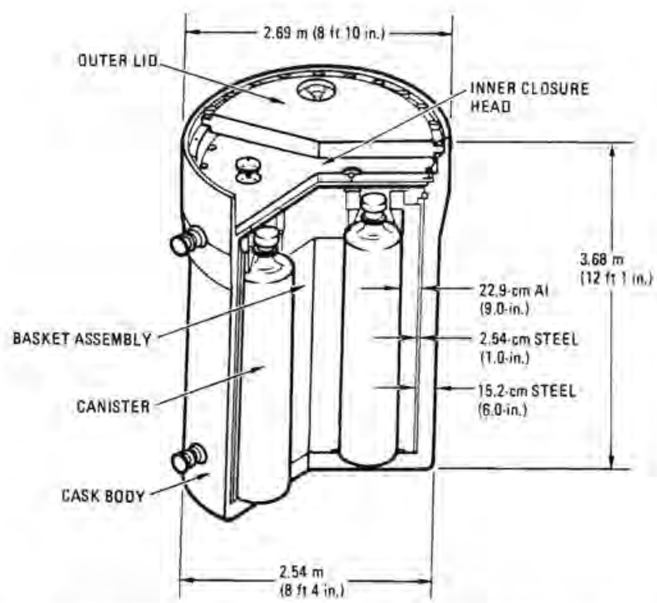


FIGURE B.7. Reference Rail Cask for Transportation of Hulls Canister (HLW-R cask) selected is the Chem-Nuclear Systems, Inc. cask designated CNS 14-170 (Figure B.8 shows a drawing of the CNS 14-170). This is a top-loading, lead and steel shipping cask for dewatered or solidified waste material. It is assumed to be licensable for transportation of TRU wastes.

RHTRU waste drums with surface dose rates exceeding 5 R/hr are assumed to be shipped in the CNS 7-100 cask. The maximum dose rate for drums in the CNS 7-100 is 100 R/hr. Any exceeding this value are assumed to be shipped in the HLW-T and HLW-R casks. The CNS 7-100 is a lead and steel shipping cask (Figure B.9) currently used to transport dewatered or solidified waste material. It is also assumed to be licensable for transporting transuranic wastes.

CHTRU Waste Shipping Systems

The TRansUranic PACkage Transporter is the reference CHTRU waste shipping system selected for use in this study. The TRUPACT is being developed by the Sandia National Laboratories/Transportation Technology Center and the General Atomic Company for the DOE specifically to provide the containment required to haul large quantities of defense CHTRU wastes. Both truck and rail versions of the TRUPACT are being developed. However, because there are more uncertainties about the availability of a rail version, the TRUPACT system used for rail transport in this study consists of two truck versions shipped on a railroad flatcar. The truck system consists of a single TRUPACT shipped on a flatbed truck trailer.

As presently conceived, the TRUPACT (Figure B.10) will have inner and outer steel frameworks made of rectangular tubing. Steel sheets covering the inner and outer surfaces of the inner and outer frameworks are separated by about 0.3 m (12 in.) of high-temperature insulation and rigid polyurethane foam.

The inner liner is built of stainless steel sheets; the outer shell may be carbon steel or stainless steel. A steel puncture-resistant plate is located between the two frameworks to prevent puncture damage to the inner liner. Access to the cargo cavity is through two hinged, sealed closures in series at one end that are bolted in place during transport.

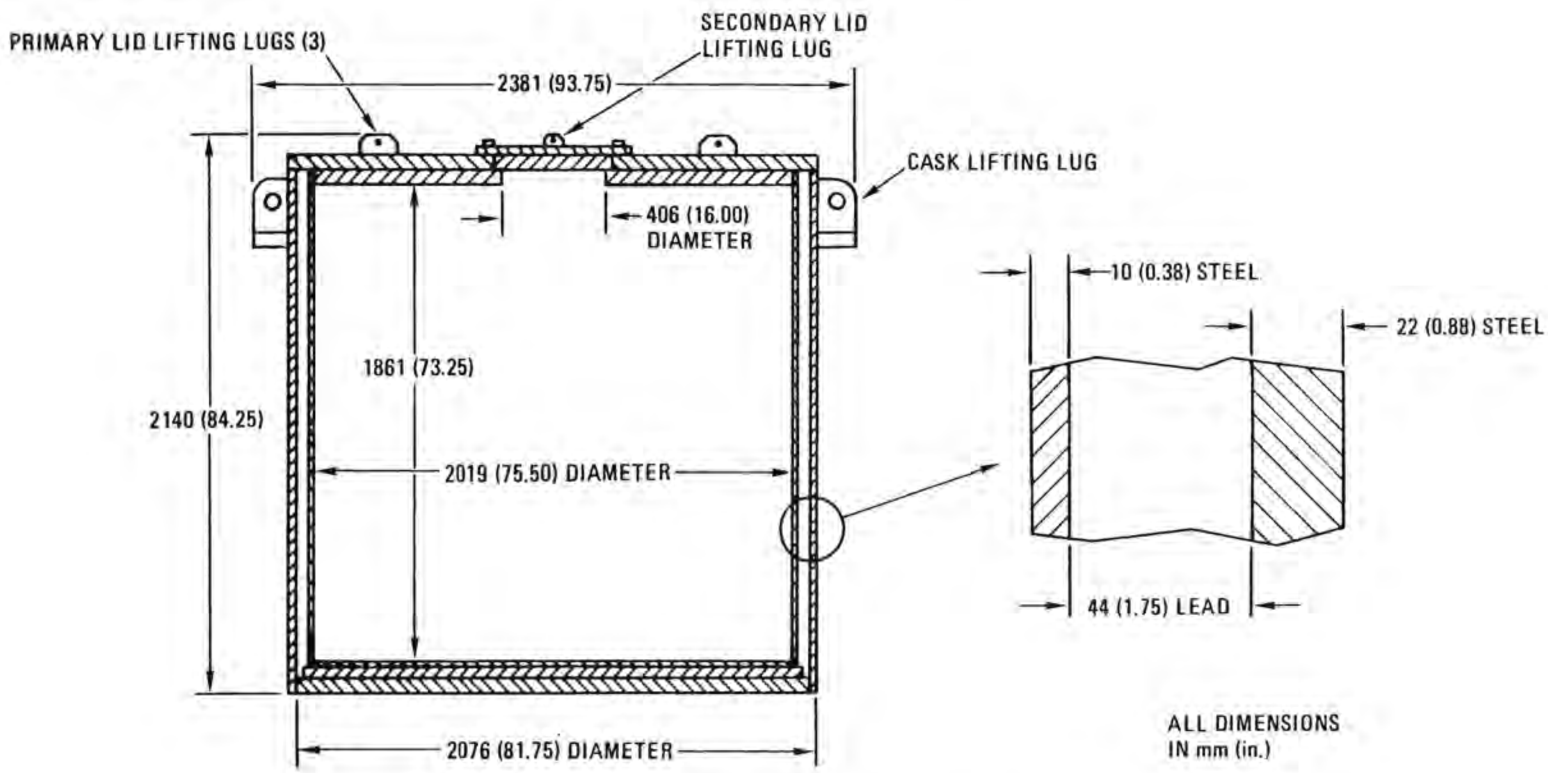


FIGURE B.8. CNS 14-170 Shipping Container

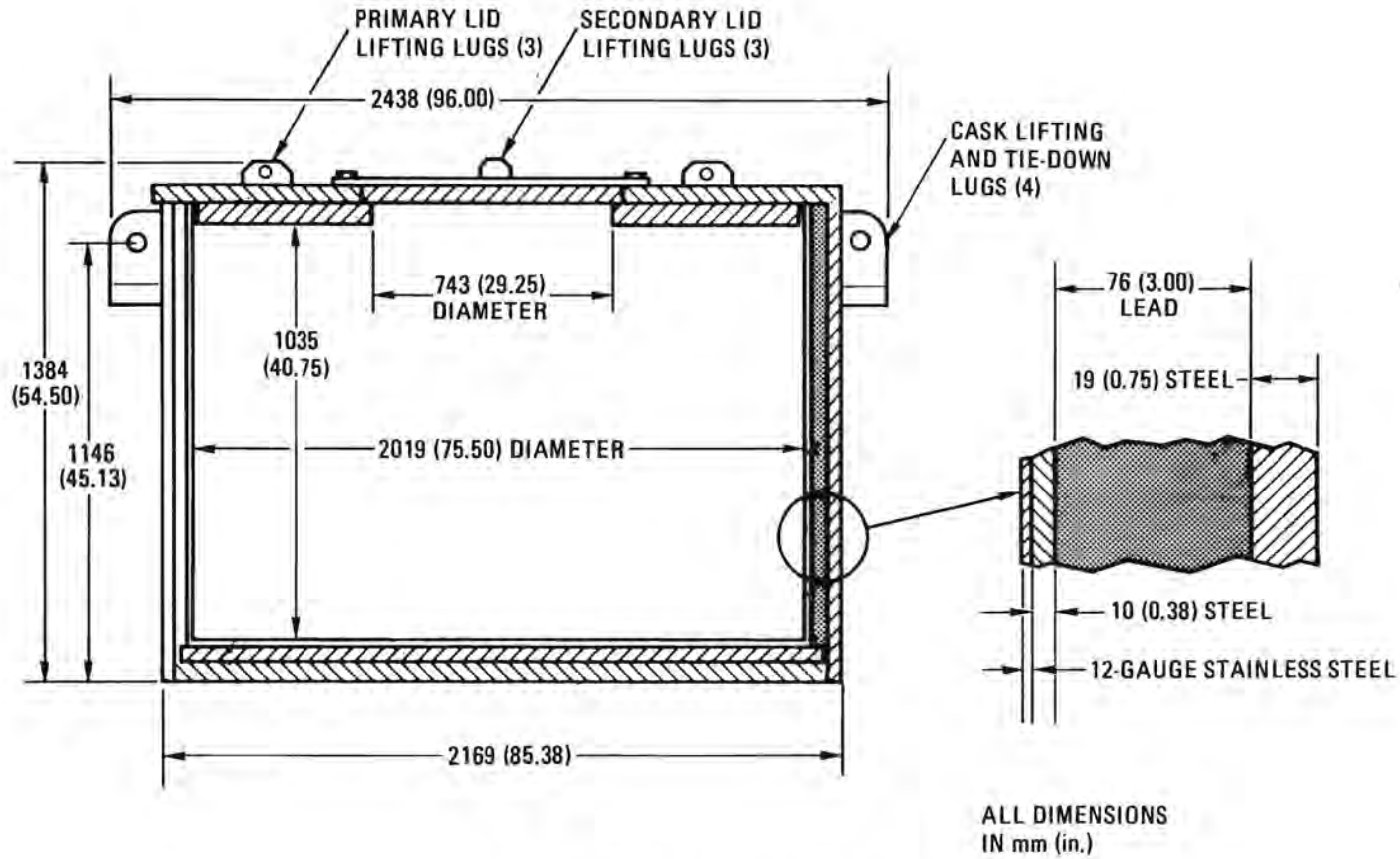


FIGURE B.9. CNS 7-100 Shipping Cask

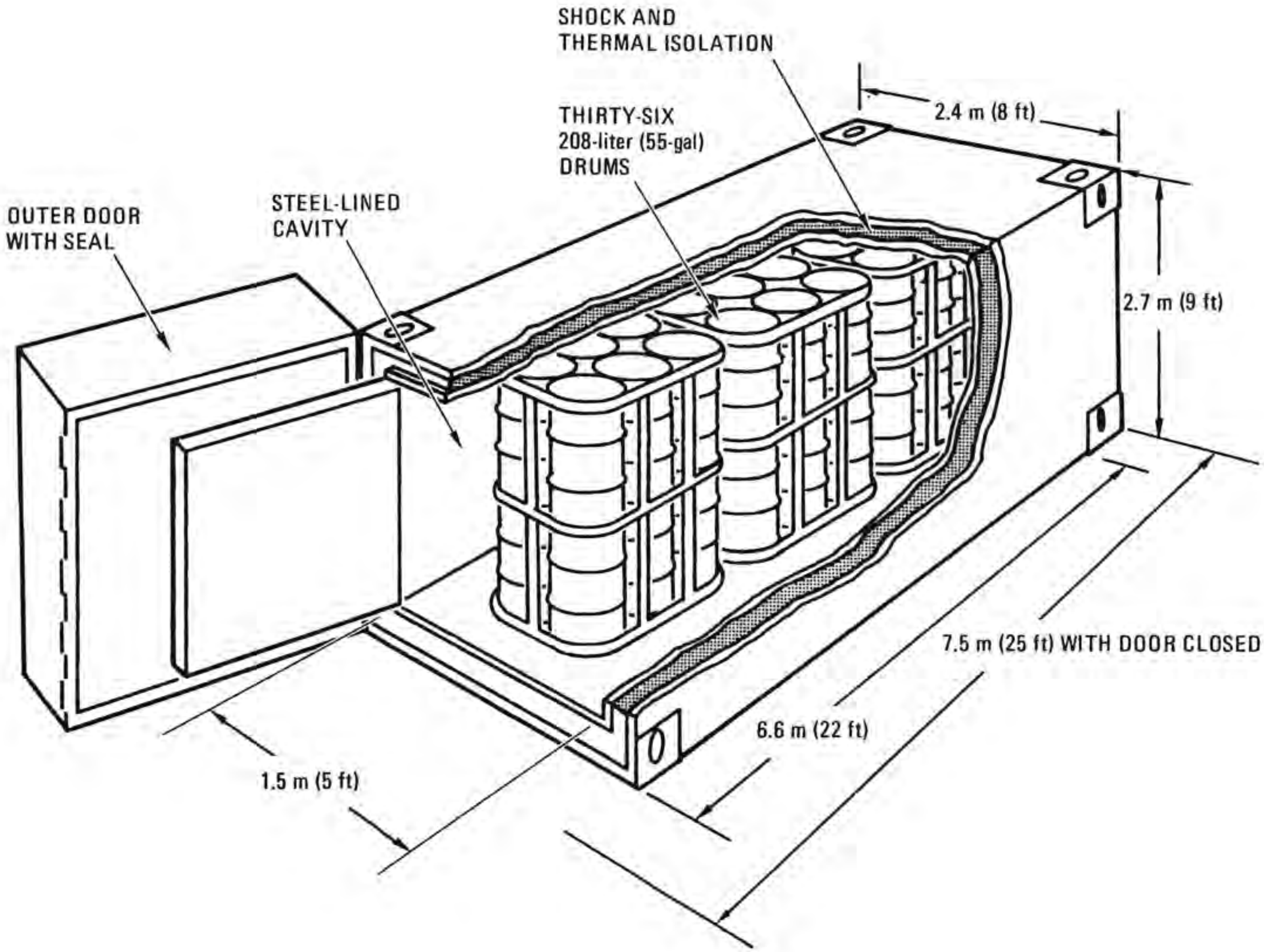


FIGURE B.10. TRUPACT Truck Version. One TRUPACT is shipped per rail truck and two are shipped per rail car.

Unit Transportation Costs for MRS/IS

The bases for the various elements of transportation costs are given in this section. The cost elements include shipping charges, special equipment and security charges, shipping container leasing fees, and demurrage fees. Total transport costs are provided at the end of this section.

The actual fee charged by a truck or rail carrier to transport spent fuel, high-level wastes, or transuranic wastes cannot be determined until a contract is negotiated. These charges are based on several conditions, including shipment origins and destinations, shipment weight, shipment size, the route, volume shipped, frequency of shipments, and the existing competition. Fortunately, basic shipping charge structures for these materials do exist in various forms in the U.S. Shipping container rental fees are based on personal contacts with cask suppliers. The purpose of this report is to provide transportation unit costs for the aforementioned materials to be utilized in the preconceptual designs of MRS/IS facilities.

Charges for Shipments by Truck

The truck shipping charges included in this report are from a single carrier (Tri-State Motor Transit Co. 1981). This carrier services the 48 contiguous states and has the capability to comply with NRC requirements for shipping spent fuel. Since transportation requirements for spent fuel are the most stringent, it is expected that this carrier can also comply with the regulations for shipping HL and TRU waste. In addition, the use of a single carrier provides a uniform basis for calculating truck shipping charges.

Basic charges for shipping spent fuel and wastes with legal-weight and legal-dimension vehicles do not vary across the country. Basic weight and dimension charges for spent fuel, high-level wastes and transuranic wastes are shown in Table B.30.

In addition to the charges listed in Table B.30, other charges are imposed on shipments of spent fuel and potentially will be imposed on HLW shipments. If a shipment requires specially equipped vehicles and specially trained personnel, as specified in NRC regulations (10 CFR 73), an additional charge per loaded mile will be imposed on shipments. The regulations require

TABLE B.30. Truck Shipping Charges for Spent Fuel and High-Level Wastes (Tri-State Motor Transit Co. 1981[a]

Rates in Dollars per 100 Pounds[b]

Miles-Not Over	Full	Empty	Miles-Not Over	Full	Empty
100	1.52	.98	950	4.68	3.71
110	1.60	.99	975	4.76	3.81
120	1.61	1.03	1000	4.84	3.89
130	1.65	1.06	1025	4.93	4.01
140	1.71	1.08	1050	5.10	4.10
150	1.77	1.10	1075	5.20	4.17
160	1.84	1.11	1100	5.35	4.27
170	1.90	1.14	1125	5.45	4.42
180	2.02	1.17	1150	5.56	4.48
190	2.07	1.21	1175	5.72	4.56
200	2.16	1.24	1200	5.80	4.68
225	2.23	1.31	1225	5.94	4.76
250	2.35	1.39	1250	6.07	4.87
275	2.42	1.40	1275	6.19	4.96
300	2.49	1.45	1300	6.31	5.08
325	2.59	1.56	1325	6.41	5.15
350	2.68	1.60	1350	6.57	5.25
375	2.73	1.61	1375	6.66	5.36
400	2.83	1.65	1400	6.79	5.45
425	2.94	1.77	1425	6.91	5.54
450	3.02	1.82	1450	7.01	5.63
475	3.09	1.90	1475	7.17	5.75
500	3.19	1.97	1500	7.27	5.82
525	3.24	2.12	1525	7.38	5.95
550	3.32	2.20	1550	7.53	6.05
575	3.44	2.29	1575	7.63	6.12
600	3.51	2.39	1600	7.77	6.21
625	3.60	2.50	1625	7.90	6.33
650	3.67	2.62	1650	7.98	6.41
675	3.76	2.66	1675	8.13	6.52
700	3.84	2.72	1700	8.24	6.61
725	3.93	2.89	1725	8.35	6.79
750	4.01	2.98	1750	8.49	6.87
775	4.08	3.03	1775	8.59	6.98
800	4.16	3.11	1800	8.73	7.11

TABLE B.30 (contd)

Miles- Not Over	Full	Empty	Miles- Not Over	Full	Empty
	Rates in Dollars per 100 Pounds[b]				
825	4.26	3.22	1825	8.84	7.17
850	4.31	3.30	1850	8.96	7.25
875	4.44	3.39	1875	9.08	7.37
900	4.49	3.50	1900	9.23	7.50
925	4.57	3.63	1925	9.34	7.57
1950	9.43	7.64	3200	15.53	12.55
1975	9.60	7.76	3250	15.77	12.78
2000	9.68	7.84	3300	16.02	12.92
2025	9.83	7.93	3350	16.22	13.14
2050	9.94	8.65	3400	16.49	13.35
2075	10.07	8.16	3450	16.74	13.53
2100	10.19	8.24	3500	16.98	13.72
2125	10.30	8.32	3550	17.20	13.91
2150	10.40	8.44	3600	17.45	14.12
2175	10.56	8.53	3650	17.69	14.33
2200	10.67	8.65	3700	17.95	14.48
2250	10.92	8.82	3750	18.18	14.74
2300	11.16	9.04	3800	18.42	14.92
2350	11.40	9.23	3850	18.64	15.11
2400	11.65	9.42	3900	18.92	15.29
2450	11.91	9.62	3050	19.16	15.50
2500	12.10	9.83	4000	19.41	15.69
2550	12.35	10.00	4050	19.63	15.92
2600	12.60	10.21	4100	19.87	16.09
2650	12.85	10.39	4150	20.10	16.29
2700	13.09	10.61	4200	20.38	16.48
2750	13.34	10.77	4250	20.61	16.65
2800	13.57	11.00	4300	20.84	16.87
2850	13.83	11.18			
2900	14.05	11.39			
2950	14.32	11.53			
3000	14.52	11.78			
3050	14.79	11.96			
3100	15.03	12.12			
3150	15.27	12.32			

(a) Updated April 22, 1982.
(b) Source: Tri-State Motor Transit Co., Docket MC-109397. Item No. 200, First Revision.

that these shipments must be scheduled, in writing, at least seven days in advance. If a shipment is cancelled or rescheduled during that seven-day period, a $1000 fee is charged. When the carrier is required to furnish armed driver(s) or escort(s), an additional charge is assessed. If a separate escort vehicle is required or necessary, another fee is added to the shipping charge.

NRC regulations (10 CFR 73) state that a spent fuel transport vehicle within a heavily populated area must be occupied by at least two individuals, one of whom serves as an escort. It must be escorted by an armed member of the local law enforcement agency or by a vehicle ahead and one behind, each of which contains at least one armed guard. A spent fuel transport vehicle not within heavily populated areas must be occupied by at least one driver and one escort, or occupied by one driver and escorted by a separate vehicle occupied by at least two escorts, or escorted as required for transport vehicles in heavily populated areas. It is not known at this time whether high-level waste shipments will require these security considerations, but such is assumed here. For this study, security costs are assumed to include one driver and one escort.

The Code of Federal Regulations does not reference security clearance requirements for drivers or escorts. However, if clearances are required, an additional charge will be assessed. These charges are not included in the transportation costs.

A fuel use surcharge was assessed in the past on top of all other charges and surcharges per shipment. This charge was adopted in 1979 when fuel costs became unstable. However, this surcharge has recently been incorporated into the basic shipping charges shown in Table B.30. Many other charges can apply if any deviations occur in the original route, schedule, delivery acceptance, or in-transit stops, but these are ignored in this study.

Summarized in Table B.31 are the additional fees or surcharges that are imposed on spent fuel shipments and assumed here to be imposed on HLW shipments.

TABLE B.31. Truck Surcharges for Spent Fuel and High-Level Waste Shipments

Type of Charge	Cost	NRC Requirement
Special equipment	$0.92 per loaded mile	X
Armed driver/escort	$0.20 per mile	X
Separate escort vehicle	$1.28 per mile[(a)]	X[(b)]
"L" cleared driver	$0.12 per mile	
"Q" cleared driver[(c)]	$0.15 per mile	

(a) Total miles are normally based on special equipment and personnel domiciled at Joplin, Missouri. Mileages are computed to point of origin of shipment, then through to the destination, then back to domicile point of shipment. Mileages to Joplin, Missouri, are not included for simplification purposes.
(b) Required in heavily populated areas.
(c) Each additional "Q" cleared driver is a fixed charge of $200 per shipment.

A final fee charged by truck carriers is a charge for their equipment being idle at the terminal facilities while the shipping container is being loaded, unloaded, or held up by the facility operator. Drivers are assumed to deliver their shipment, wait for it to be unloaded, and then depart with the same shipping system they arrived with. Typically, this demurrage fee is negotiated prior to the shipment and the actual fee varies between contracts. This fee is assessed to compensate for idle equipment and the driver's wages and living expenses while the truck is not with a load. To keep additional calculations as simple as possible, the average fee per hour (based on 24 hours demurrage using a schedule from Tri-State Motor Transit Co., Docket No. MC-109397, Item No. 500) will be utilized. From this basis, the demurrage fee used in this study is $29.30 per hour.

Charges for Shipments by Rail

Rail shipping charges are much more complicated than truck shipping charges. Rail charges are often not uniform with the distance traveled and can be affected by topography, state regulations, competition, and the route traveled. It is assumed in this study that Special Trains[(a)] will not be used, so the rail shipping charges that are developed are for general freight service.

Shipping charges assessed by rail carriers are specific for each origin-destination combination. Each origin and destination lies in a particular "rate-basing area" which is a major rail point where branch lines connect to local towns or communities. The shipping charges are assessed for transporting a commodity between specific rate-basing areas, regardless of the route or mileages traveled. Therefore, there is no such thing as a "generic" rail shipping charge. Specific origin-destination combinations must be defined. To obtain meaningful cost numbers for this study, charges were obtained for transporting radioactive materials between the locations shown in Table B.32. Shipping charges are the same regardless of the direction the materials were being transported; i.e., east to west or west to east. Also shown on this table are the approximate mileages between each location and the approximate transit times. Note that in some cases, especially in long hauls, the mileages and charges quoted may be the same for two different shipment origins. This is because shipping charges are established between rate-basing areas regardless of the route or distance traveled. The rail transit times are the hardest to define with any certainty. Too many variables are involved between any origin/destination combination to obtain a precise value. The times reported in Table B.32 are based on past experience and judgment for the areas and/or routes involved.

The charges for general freight service for spent fuel and HL and TRU wastes are somewhat uniform when based on the mileages shown in Table B.32. Curves showing the shipping charges (per 100 lb) as a function of one-way miles are shown in Figure B.11 for loaded and empty containers. Minor variations are evident between shipments entirely within the East and entirely within the West. It appears that western shipments have higher charges, but there are too few data points to establish a conclusive pattern.

(a) Special Trains are defined as trains made up solely for the shipment of one commodity or for one shipper.

TABLE B.32. Rail Shipping Charges, Distances, and Transit Times for Several Origin/Destination Combinations

From (Origin)	To (Destination)	Dollars per 100 pounds		Approximate One-way Mileages	Approximate One-way Transit Time (Days)
		Loaded	Empty		
Hanford, WA	Barnwell, SC	16.89	15.83	2700	12-15
Mercury, NV	Barnwell, SC	16.89	15.83	2200	10-13
Berwick, PA	Barnwell, SC	7.13	6.69	750	5-7
Palo, IA	Barnwell, SC	8.82	8.27	1050	9-12
Port Gibson, MS	Barnwell, SC	6.79	6.37	700	6-8
Waterford, CT	Barnwell, SC	7.88	7.39	900	8-11
Eureka, CA	Barnwell, SC	19.15	17.95	2950	12-15
Hanford, WA	Mercury, NV	11.09	10.40	1000	9-12
Berwick, PA	Mercury, NV	16.89	15.83	2400	12-15
Palo, IA	Mercury, NV	13.39	12.55	1500	10-13
Port Gibson, MS	Mercury, NV	14.78	13.86	1600	10-13
Waterford, CT	Mercury, NV	16.89	15.83	2650	12-15
Eureka, CA	Mercury, NV	9.25	8.67	800	7-9
Rainier, OR	Hanford, WA	5.22	4.90	300	3-5
Satsop, WA	Hanford, WA	5.03	4.72	350	4-7
Eureka, CA	Hanford, WA	10.86	10.18	1200	7-9

Source: Personal communication with Mr. Frank Votaw, Rockwell, Hanford Operations, Traffic Division, Motor Rates and Routes.

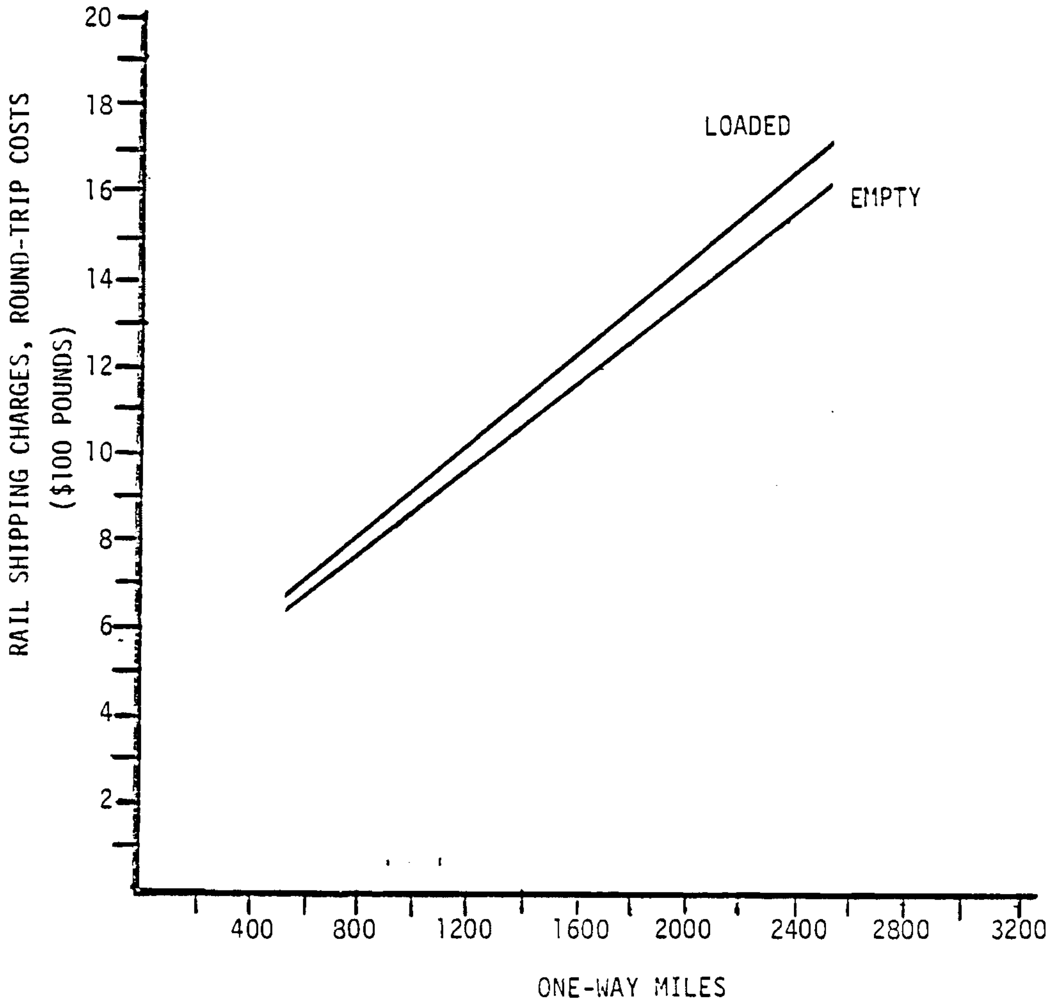


FIGURE B.11. Rail Shipping Charges for Loaded and Empty Shipments

Rail shipments of spent fuel require security provisions as do truck shipments. Rail shipments within heavily populated areas must be accompanied by two armed escorts that may or may not be members of a local law enforcement agency. A shipment not within a heavily populated area must be accompanied by at least one escort (10 CFR 73).

Rail carriers have no provisions to supply an armed escort service, and it is expected that this service will be provided by the shipper. Rail carriers have indicated they will supply a car or caboose for the escorts to ride in. The charge for this service would be the price of a coach-class passenger ticket, or approximately 9 cents per mile per escort (Cole 1981).

The total security costs must also include the wages and living expenses of the escorts. The charge for rail escorts can be estimated by using the truck charge of 20 cents per mile as an index. A truck with two drivers can travel about 900 miles in one day (Cole 1981). The salary and expenses per escort is thus $180 per day. At least two escorts per trip are required so that the shipment can be constantly under surveillance. Using the approximate mileages and transit times shown in Table B.32, the average distance travelled per day by rail is 119 miles, which works out to an average speed of 5 miles per hour. This average makes the charge for rail escort service about $1.50 per escort per mile or $3.00 per mile for continuous surveillance. Adding the cost of the coach-class passenger ticket for each escort brings the total for rail escort service to about $3.18 per mile.

Demurrage charges for rail shipments are included in the shipping system rental fees. This is because there are no guards or drivers who must wait for the shipping system to be loaded or unloaded. Demurrage charges for the transport vehicle (rail car or flatbed trailer) are included in the rental fees.

Shipping Container Rental Fees

One basis for this study is that transportation services for spent fuel, HL and TRU wastes will be supplied by private industry as a commercial venture. Therefore, the total transportation costs must include a fee for rental or lease of the shipping containers from their suppliers. These additional costs include operating costs, amortization of transport hardware, and profits. These costs would be calculated differently if, in the future, the U.S. Government decides to procure and operate its own transportation hardware.

Rental fees charged by shipping container suppliers are a negotiable item that can vary in each contract. These cask use and service charges include some field services, training, and maintenance of equipment in addition to operating and amortization costs and profits. Typical rental fees for the shipping system used in this study were obtained from contacts with the supplier companies. The reference rental fees are shown in Table B.33. Use and service charges for conceptual transportation equipment (i.e., HLW-T, HLW-R, and TRUPACT) are assumed to be the same portion of the capital costs as those for the equipment currently in use. It should be noted that the use and service charges shown in Table B.33 are based on short-term leases and are not the charges that would be assessed if the shipping containers were leased for a year or longer. Long-term use of shipping containers would result in significantly lower use and service charges than those shown in Table B.33. One factor that may tend to balance this effect is that the rental fees reported do not include fabrication of new equipment (that is, these fees are based partially on recovering the capital costs of equipment fabricated several years ago). The costs of fabricating new equipment have increased significantly, and therefore the rental fees charged by suppliers will most likely increase.

Calculation of Unit Transportation Costs

The final information required for transportation costs is the average weights of shipments or the average commodity (i.e., waste plus canister) unit weights. For the materials in this study, the average commodity unit weights are expressed in kilograms. Transportation unit costs will be expressed primarily in dollars per shipment for each type of waste and shipping system.

The average commodity unit weights for the high-level waste, RH-TRU waste special canister, and RHTRU waste drum shipping containers are straightforward because they haul only a single type of waste container. Their average commodity unit weights are calculated by multiplying the capacity of the shipping containers (see Table B.29) by the average weights of the loaded waste canisters (see Table B.28). To develop the average commodity unit weight for spent fuel truck shipments, the information in Tables B.28 and B.29 is used. Also, since about two-thirds of the commercial reactors are PWRs, an estimated two-thirds of the shipments will be PWR fuel elements. This ratio provides an average commodity weight of 628 kg (1385 lb) for truck shipments and 4775 kg (10,500 lb) for rail shipments. Similar procedures were used to calculate the average commodity weights for the TRUPACT. The ratio of drum shipments to box shipments was calculated from data derived by Fletcher (1982) from estimates of waste quantities and characteristics from the Barnwell

TABLE B.33. Shipping Container Rental and Service Charges (Mid-1982 Dollars)

Shipping Container	Charge, $/Day	Single Shipment Cost, $ 500 One-Way Miles	Single Shipment Cost, $ 2500 One-Way Miles
G.E. IF-300	5,750[(a)]	57,500	184,000
NAC-1	2,000[(b)]	6,000	16,000
HLW-T	1,750[(c)]	5,250	14,000
HLW-R	4,375[(d)]	43,750	140,000
CNS-7-100	175/container	525(T)[(f)] and 5250(R)	1,400(T) and 16,800(R)
CNS-14-170	75/container	525(T) and 5,250(R)	1400(T) and
TRUPACT	700/container[(e)]	2,100(T) and 14,000(R)	5,600(T) 44,800(R)

(a) Based on truck and round-trip transit times of 3 and 8 days and rail transit times of 10 and 32 days for 500 and 2500 one-way mile trips, respectively.
(b) Calculate from first 30 days of use in schedule below:

No. Days of Use		Charge
1-10		30,000
11-30	ADD	1500/day
31-90	ADD	1100/day
91-180	ADD	900/day
over 180	ADD	800/day

(c) Fabrication costs for HLW-T cask are estimated at about $1 M. This is a conceptual cask system, and rental fees have not been calculated. The value in this table was calculated as follows. The estimated fabrication costs of the CNS-14170 is $100,000. Assume the same ratio of fabrication costs to rental fee for HLW-T cask.
(d) Fabrication costs for HLW-R cask are estimated at about $2.5 M. See footnote (c) for rental fee calculation.
(e) Fabrication costs for TRUPACT are estimated at about $400,000. See footnote (c) for rental fee calculation.
(f) (T) = Truck, (R) = Rail.

Nuclear Fuel Plant (Carr 1982). The average commodity weights and empty and loaded shipping container weights used to calculate transportation unit costs are shown in Table B.34.

Figures B.12 and B.13 show the transportation costs for each type of shipment under consideration in this study for truck and rail shipments, respectively. Each curve represents a different type of shipment. All curves represent the sum of the truck or rail shipping charges, cask use and service

TABLE B.34. Average Commodity Weights and Empty and Loaded Shipping Container Weights Used In Transportation Unit Cost Calculations

Material/ Shipping Container	Average Commodity Weight, kg/Shipment	Shipping Container Weight, kg	
		Empty	Loaded
Spent fuel			
IF-300	4,775	63,490	68,265
NAC-1	628	22,660	23,288
High-level wastes			
IF-300	5,250	63,490	68,740
NAC-1	1,050	22,660	23,710
RHTRU canisters			
HLW-R	17,500	52,150	69,650
HLW-T	3,500	11,700	15,200
RHTRU drums (<5 R/hr)			
CNS 14-170 (R)[(a)]	12,600	46,200	58,800
CNS 14-170 (T)	4,200	15,400	19,600
RHTRU drums (>5R/hr)			
CNS 7-100 (R)	6,300	48,300	54,600
CNS 7-100 (T)	2,100	26,100	18,200
CHTRU wastes			
TRUPACT (R)[(b)]	21,950	20,000	41,950
TRUPACT (T)	9,610	10,000	19,610

(a) Rail version consists of three shipping containers, transported on a railcar. Reported weights include this factor.
(b) Two TRUPACTs shipped per railcar. Reported weights include this factor.

charges, and security costs (if applicable). These curves were drawn by plotting two points, one at 800 km (500 miles) and one at 4000 km (2500 miles). Therefore the uncertainty of these curves increases with the distance along the curve from these points. Care must be taken when using these data due to the many assumptions and uncertainties outlined throughout the text. Note that the unit transportation costs in these figures are the costs per shipment. To convert these costs to dollars per kilogram (waste plus canister), the appropriate factors can be found in Table B.30. Demurrage charges for truck shipments must be added to the total shipments costs by applying the charge rate previously reported to the facility turnaround times (to be determined by the individual contractors).

Special equipment charges and security costs are included in the curves for spent fuel and high-level waste shipping costs. If these additional charges are later determined to be not required for high-level waste shipments, the transportation costs for truck shipments would be reduced by 14 percent and 19 percent for 500 mile and 2500 mile one-way trips, respectively. The corresponding reductions in rail costs for 500 and 2500 one-way mile trips are 5 percent and 7 percent, respectively.

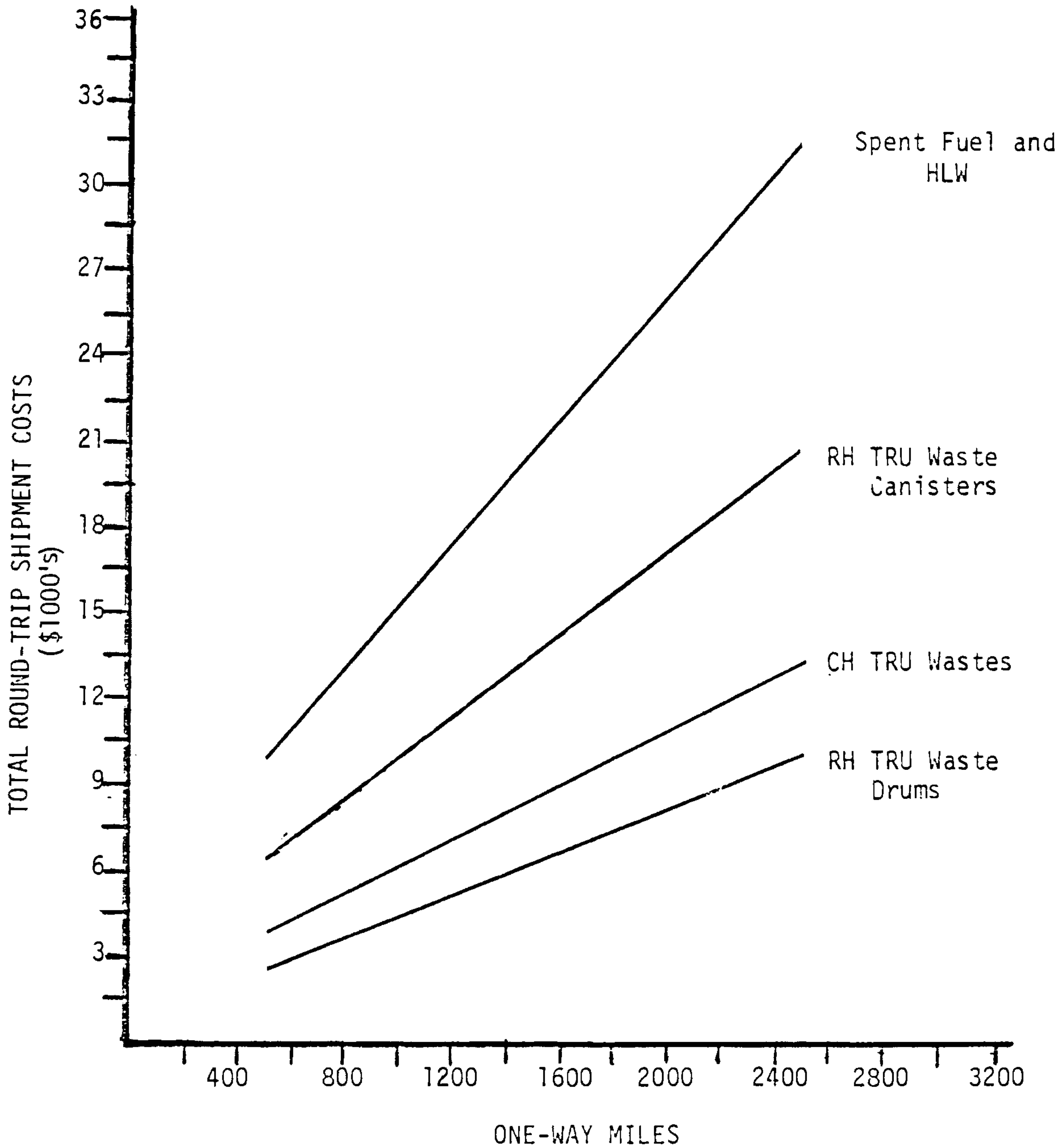


FIGURE B.12. Transportation Costs for Shipping Spent Fuel, High-Level and Transuranic Wastes by Truck

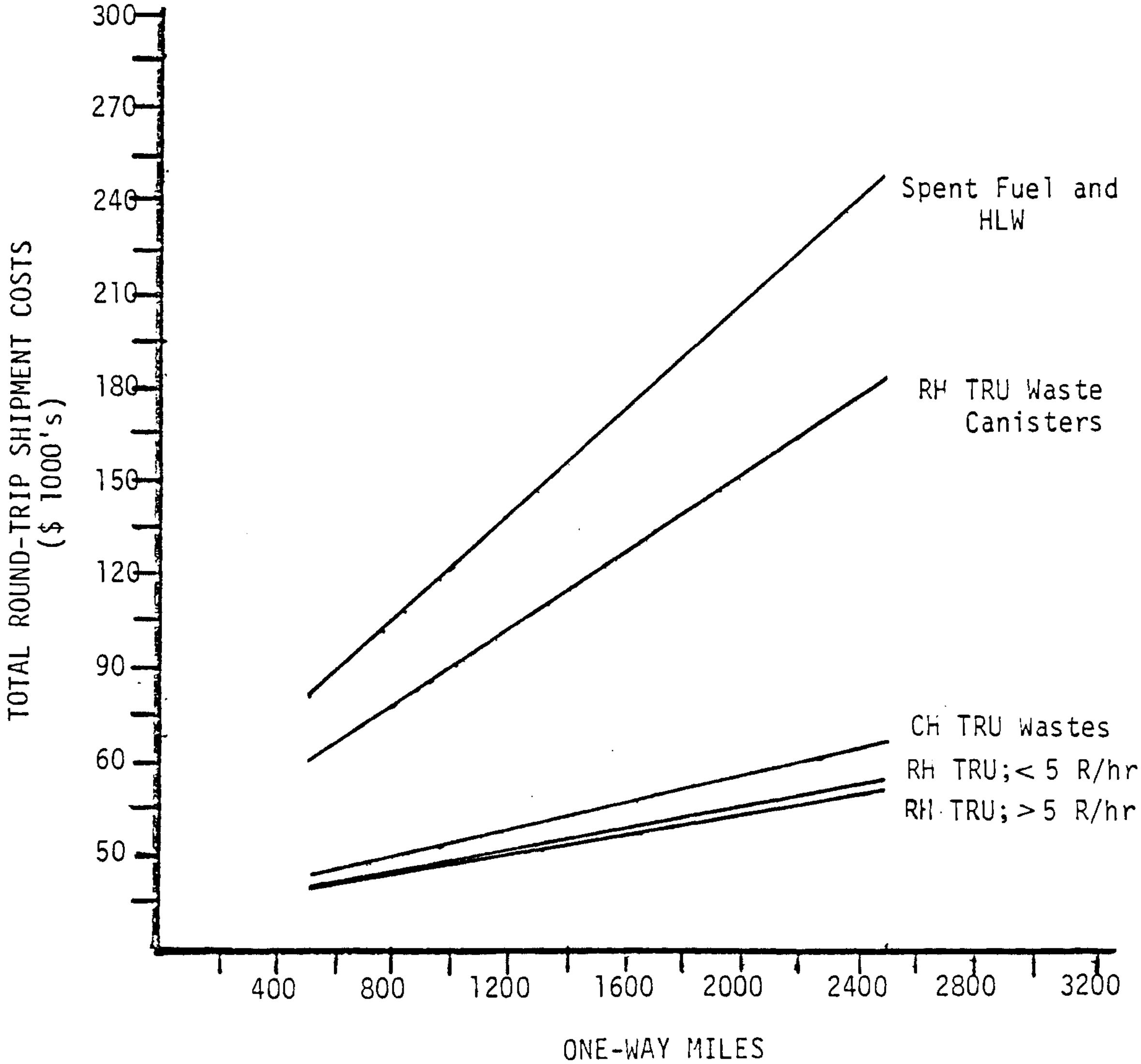


FIGURE B.13. Transportation Costs for Shipping Spent Fuel, High-Level and Transuranic Wastes by Rail

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