CONTRACTOR REPORT

SAND89 – 7006
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UC – 814

Yucca Mountain Site Characterization Project

MRS System Study for the Repository

Volume 1

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Prepared by Sandia National Laboratories Albuquerque, New Mexico 87185 and Livermore, California 94550 for the United States Department of Energy under Contract DE-AC04-76DP00789

Printed December 1990

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SAND--89-7006-Vol.1

DE91 008314

SAND89-7006
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by

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ABSTRACT

For each of nine scenarios (cases) defined by the U. S. Department of Energy, this study evaluates the repository construction and design costs, operating costs, decommissioning costs, required staffing, and construction schedules.

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QUALITY ASSURANCE LEVEL ASSIGNMENT

The engineering activities in support of this document have been performed at Quality Assurance Level III; the administrative activities do not have an associated quality assurance level. In general, engineering activities include the development of facility general arrangement drawings and waste package configurations, the planning of waste-handling operations, and all calculations associated with waste receipt, preparation, storage, and emplacement. Activities also include the development of the facility life-cycle cost estimates and construction schedules.

The work in this study was performed under Work Breakdown Structure No. 1.2.4.1.1.4, Engineering Design Support and Special Studies in response to DIM 43.

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EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE), Office of Civilian Radioactive Waste Management (OCRWM), has initiated a waste management system study to identify the impacts of the presence or absence of a monitored retrievable storage facility (hereinafter referred to as "MRS") on system costs and program schedules. To support this study, life-cycle cost estimates and construction schedules have been prepared for the surface and underground facilities and operations of a geologic nuclear waste repository at Yucca Mountain, Nye County, Nevada. The Yucca Mountain site was designated for characterization as a site for a nuclear waste repository in the 1987 amendment to the Nuclear Waste Policy Act.

Nine different operating scenarios (cases) have been identified by OCRWM for inclusion in this study. For each case, the following items are determined: the repository design and construction costs, operating costs, closure and decommissioning costs, required staffing, construction schedules, uncertainties associated with the costs and schedules, and shipping cask and disposal container throughputs. To develop the costs and schedules, the throughputs are used as input.

The estimates of costs and schedules are based on published repository designs. The cost estimates have been modified to address the requirements of the nine cases examined in this study. The modifications are generally minimal and may not result in optimal designs, costs, or schedules.

Table ES-1 summarizes the functions, life-cycle costs, schedules, and staffing requirements for the nine study cases.

Table ES-2 summarizes the repository design, licensing, and construction activities as developed in this study.

TABLE ES-1

SUMMARY OF FUNCTIONS, REPOSITORY LIFE-CYCLE COSTS, SCHEDULES, AND STAFFING FOR CASES 1 THROUGH 9

Case Number	MRS Function	Repository Function	No. of Containers Emplaced (a)	Repository Life-Cycle Cost ($M)	Start of Emplacement Operations	Repository Operations Staffing Requirements
1	N/A (no MRS)	Consolidate and containerize	39,086	7,450	Jan 2003	1,179
2	N/A (no MRS)	Containerize intact	44,700	7,086	Jan 2003	1,133
3	Store intact/ship	Consolidate and containerize	39,086	7,381	Jan 2003	1,163
4	Store intact/ship	Containerize intact	44,700	7,011	Jan 2003	1,118
5	Consolidate and canisterize	Containerize canisters	42,553	6,548 (b)	Jan 2003	1,095
6	Containerize	Inspect: return to MRS or emplace	44,700	5,404 (c)	Jan 2003	1,066
7	Containerize	Inspect: repair and emplace	44,700	5,427 (c)	Jan 2003	1,077
8	Consolidate and containerize	Inspect: return to MRS or emplace	38,237	5,121 (c)	Jan 2003	1,004
9	Consolidate and containerize	Inspect: repair and emplace	38,237	5,139 (c)	Jan 2003	1,013

a. Excludes containers used for performance confirmation.
b. Excludes cost of MRS canisters.
c. Excludes cost of containers purchased and applied to MRS.

TABLE ES-2

REPOSITORY DESIGN, LICENSING, AND CONSTRUCTION ACTIVITIES SCHEDULE

Item	Duration (mo)	Start Date	Finish Date
Advanced Conceptual Design	27	Oct 89	Jan 92
License Application Design	30	Jan 92	Jul 94
Prepare License Application	6	Jul 94	Jan 95
Final Procurement and Construction Design	36	Jan 95	Jan 98
NRC License Review	36	Jan 95	Jan 98
Site Construction Facilities	6	Jan 98	Jul 98
Site Preparation -- Onsite	9	Feb 98	Nov 98
-- Offsite	37	Feb 98	Mar 01
Waste Handling			
Building #1 (Cases 1 and 3)[a]	39	Oct 98	Jan 02
Building #2 (Cases 1 and 3)[b]	54	Jan 99	Jul 03
Building #1 (Cases 2 and 4)[c]	48	Oct 98	Oct 02
Building #1 (Cases 5-9)[d]	43	Oct 98	May 02
Other Surface Facility	45	Mar 98	Dec 01
Underground Facility (All Cases)	60	Jan 98	Jan 03

a. Duration, including site preparation, is 48 mo.
b. Duration, including site preparation, is 66 mo.
c. Duration, including site preparation, is 57 mo.
d. Duration, including site preparation, is 52 mo.

1.0 INTRODUCTION

1.1 General

The purpose of this study is to define the repository design and to prepare repository cost estimates and construction schedules for nine different high-level waste disposal system scenarios (cases). The nine cases have been defined by the U.S. Department of Energy (DOE), Office of Civilian Radioactive Waste Management (OCRWM).

Three types of high-level waste are received by the OCRWM waste management system for encapsulation and emplacement: spent nuclear fuel (SNF) from commercial nuclear reactors, defense high-level waste (DHLW) from various DOE nuclear facilities, and commercial West Valley high-level waste (WVHLW) from the former West Valley Nuclear Fuel Reprocessing Facility.

Brief descriptions of the nine cases are given below.

1.2 Case Descriptions

1.2.1 Case 1

There is no monitored retrievable storage facility (hereinafter referred to as "MRS"). All SNF is shipped directly from the reactors to the repository, where it is consolidated and containerized for emplacement. DHLW and WVHLW are received in canisters at the repository and then containerized for emplacement. Containerization is in accordance with the Site Characterization Plan Conceptual Design Report (SCP-CDR) design (SNL, 1987).

1.2.2 Case 2

There is no MRS. All SNF is shipped directly from the reactors to the repository, where it is containerized for emplacement. There is no consolidation at the repository. DHLW and WVHLW are received in canisters at the repository and then containerized for emplacement.

1.2.3 Case 3

Intact SNF assemblies are shipped from the reactors to the MRS, stored there and then shipped to the repository. At the repository, the intact SNF assemblies are consolidated and containerized for emplacement. DHLW and WVHLW are received in canisters at the repository and then containerized for emplacement. Intact SNF assemblies from reactors in the West are shipped directly from the reactors to the repository.

1.2.4 Case 4

Intact SNF assemblies are shipped from the reactors to the MRS, stored there and then shipped to the repository. At the repository, the intact SNF assemblies are containerized for emplacement. There is no consolidation at the repository. DHLW and WVHLW are received in canisters at the repository and then containerized for emplacement. Intact SNF assemblies from the western reactors are shipped directly from the reactors to the repository.

1.2.5 Case 5

SNF assemblies are consolidated and placed in canisters at the MRS, stored at the MRS, and then shipped to the repository. At the repository, the canisters are containerized for emplacement. There is no consolidation at the repository. DHLW and WVHLW are received in canisters at the repository and then containerized for emplacement. Intact SNF assemblies from western reactors are shipped directly from the reactors to the repository.

1.2.6 Case 6

Intact SNF assemblies are placed in containers at the MRS, stored there, and then shipped to the repository for inspection and emplacement. DHLW and WVHLW canisters are also containerized at the MRS and then shipped to the repository for inspection and emplacement. There is no consolidation or containerizing at the repository. Defective containers are returned to the MRS. All SNF from western reactors is shipped to the MRS.

1.2.7 Case 7

Intact SNF assemblies are placed in containers at the MRS, stored there, and then shipped to the repository for inspection and emplacement. DHLW and WVHLW canisters are also containerized at the MRS and then shipped to the repository for inspection and emplacement. There is no consolidation or containerizing at the repository. Defective containers are repaired at the repository. All SNF from western reactors is shipped to the MRS.

1.2.8 Case 8

SNF assemblies are consolidated, placed in containers, and stored at the MRS. The containers are then shipped to the repository for inspection and emplacement. Defective containers are returned to the MRS. DHLW and WVHLW canisters are containerized at the MRS and shipped to the repository for inspection and emplacement. There is no consolidation or containerizing at the repository. All SNF from western reactors is shipped to the MRS.

1.2.9 Case 9

SNF assemblies are consolidated, placed in containers, and stored at the MRS. The containers are then shipped to the repository for inspection and emplacement. DHLW and WVHLW canisters are also containerized at the MRS and shipped to the repository for inspection and emplacement. There is no consolidation or containerizing at the repository. Defective containers are repaired at the repository. All SNF from the western reactors is shipped to the MRS.

The above information for Cases 1 through 9 is summarized in Table 1-1.

1.3 Background

The repository designs addressing these cases have been derived from previously published repository design documents, namely, the SCP-CDR (SNL, 1987) and the Rod Consolidation Study (RCS) (O'Brien, 1988). These designs have been evaluated against the design requirements for each of the nine cases to select an appropriate repository configuration for each MRS study case and to modify the configuration to match the requirements for the case. Typically, the modifications to surface facilities have involved the elimination of hot cell space and equipment. However, the remaining building area has not been rearranged to optimize the designs. Such optimization is outside the scope of the study.

1.4 Contents

Section 2 summarizes the study results.

Section 3 discusses parameters common to all nine cases.

Sections 4 through 12 discuss the selected repository configuration and the nature of the modifications for Cases 1 through 9.

Appendix A gives details of repository throughput calculations.

Appendix B contains summary and detailed tables of cost information.

TABLE 1-1

MRS SYSTEM STUDY CASE DESCRIPTION SUMMARY

Case Number	MRS Function	Repository Function	DHLW to MRS
1	N/A (no MRS)	Consolidate and containerize	No
2	N/A (no MRS)	Containerize intact	No
3	Store intact/ship	Consolidate and containerize	No
4	Store intact/ship	Containerize intact	No
5	Consolidate and canisterize	Containerize canisters	No
6	Containerize	Inspect: return to MRS or emplace	Yes
7	Containerize	Inspect: repair and emplace	Yes
8	Consolidate and containerize	Inspect: return to MRS or emplace	Yes
9	Consolidate and containerize	Inspect: repair and emplace	Yes

Appendix C contains an MRS sensitivity studies report, which consists of four MRS sensitivity studies that evaluate additional options in the MRS System.

Appendix D contains documentation that established the bases and assumptions that have been used in this study.

2.0 SUMMARY

In this section, summary information is presented that can be used to compare various aspects of the nine cases evaluated in this study.

For each case, Table 2-1 shows the total number of shipping casks received annually at the repository, the total number of containers emplaced or stored for emplacement at the repository, the number of cask unloading ports required at the repository, and the waste disposal container used. These containers are shown in Figures 2-1, 2-2, and 2-3. The DHLW and WVHLW container is shown in Figure 2-4. There are also hardware containers that are similar to the SNF containers, but do not have any internal supports. The requirements for repository surface facilities are based on (1) the number of casks received; (2) the number of assemblies, canisters, or containers being removed from a cask; and (3) the estimated unloading times for casks. The estimated unloading times for casks are based on timelines that were developed for the Waste Handling Operations Study (Dennis, A. W., Draft. "An Analysis of Repository Waste-Handling Operations," SAND87-0088, Sandia National Laboratories, Albuquerque, NM).

For each case, Table 2-2 shows the number of casks used to ship SNF assemblies and DHLW to the repository every year. Also included in this table is a summation of the total number of casks received annually at the repository, along with the cask capacities.

Spent fuel assemblies are consolidated at the repository for Cases 1 and 3 only. For Cases 2, 4, 6, and 7, spent fuel assemblies are emplaced intact. For Cases 5, 8, and 9, spent fuel assemblies are emplaced consolidated, as received from the MRS. Spent fuel is containerized at the repository for Cases 1 through 5. For Cases 6 through 9, spent fuel is containerized at the MRS. For Cases 6 and 8, defective containers received at the repository are returned to the MRS.' For Cases 7 and 9, defective containers received at the repository are repaired at the repository rather than returned to the MRS.

TABLE 2-1

SUMMARY OF REPOSITORY DESIGN PARAMETERS

Case Number	Repository Function	Annual Cask Receipt	Annual Rate of Container Emplacement	Cask Unloading Ports	Waste Disposal Container
1	Consolidate and containerize	1,401	2,002	7	Figure 2-1
2	Containerize intact	1,401	2,310	7	Figure 2-2
3	Consolidate and containerize	587	2,002	5	Figure 2-1
4	Containerize intact	587	2,310	5	Figure 2-2
5	Containerize canisters	463	2,208	3	Figure 2-3
6	Inspect: return to MRS or emplace	537	2,310	3	Figure 2-2
7	Inspect: repair and emplace	537	2,310	3	Figure 2-2
8	Inspect: return to MRS or emplace	460	2,002	2	Figure 2-1
9	Inspect: repair and emplace	460	2,002	2	Figure 2-1

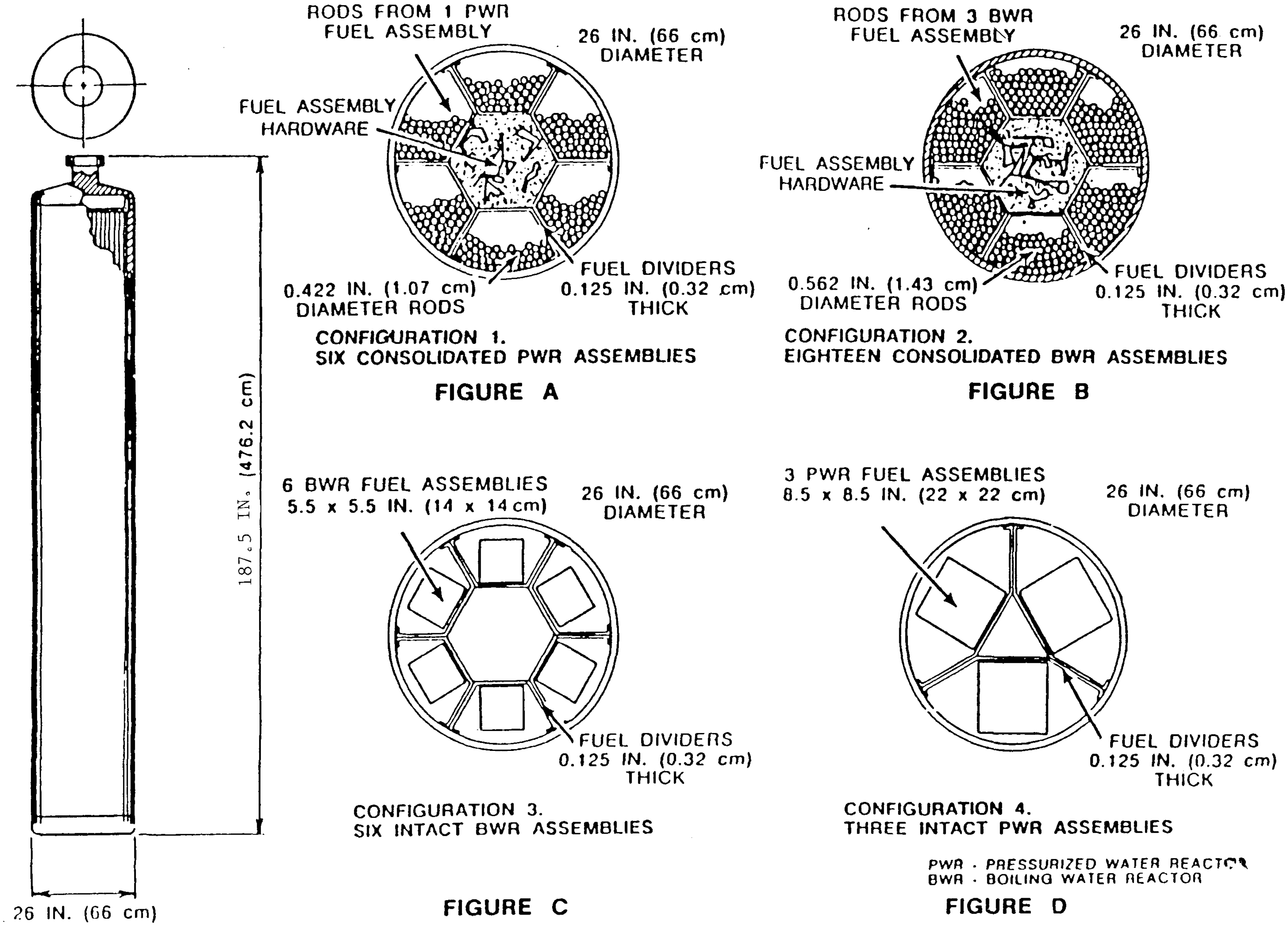

Figure 2-1. Reference Design Containers

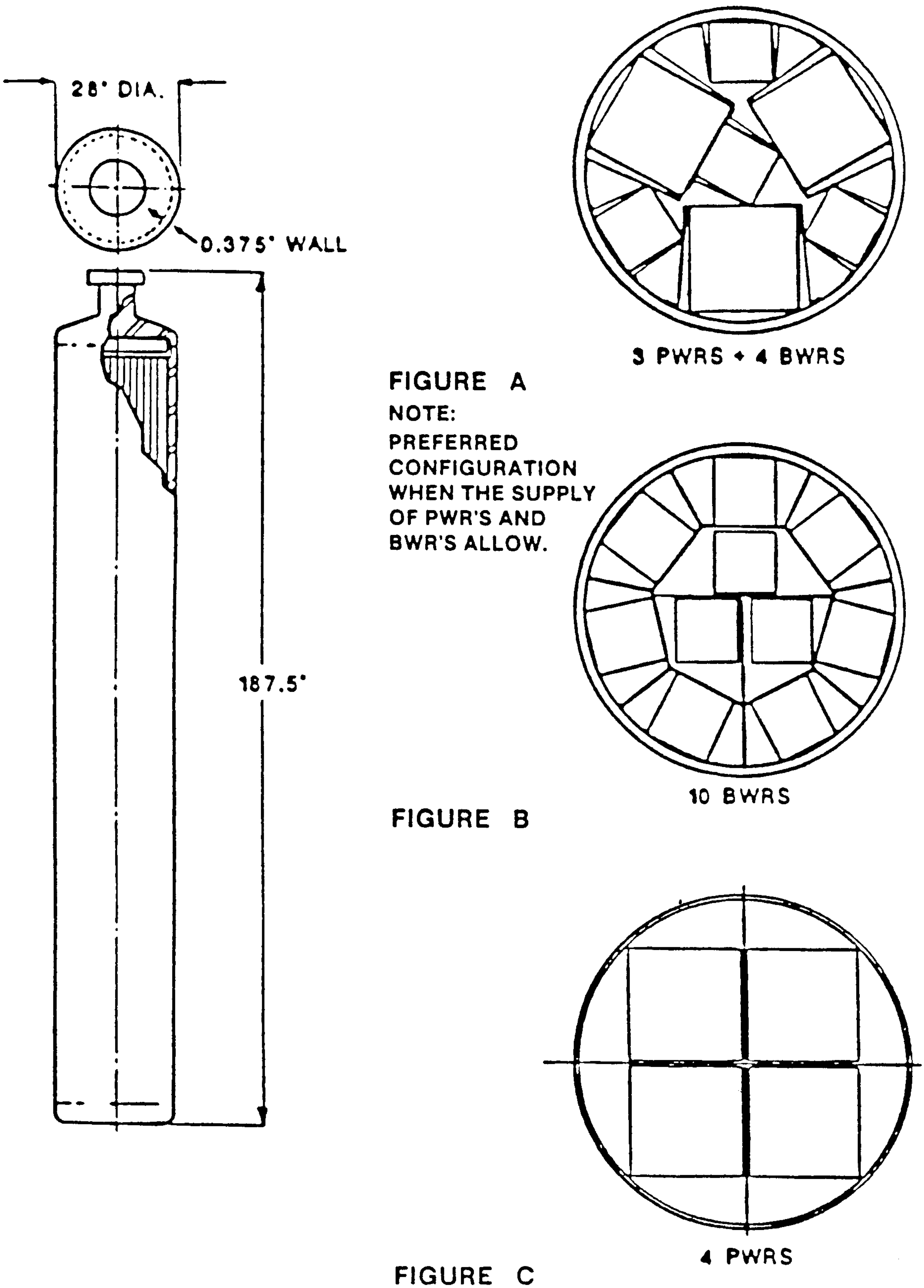

Figure 2-2. Intact Fuel Configurations

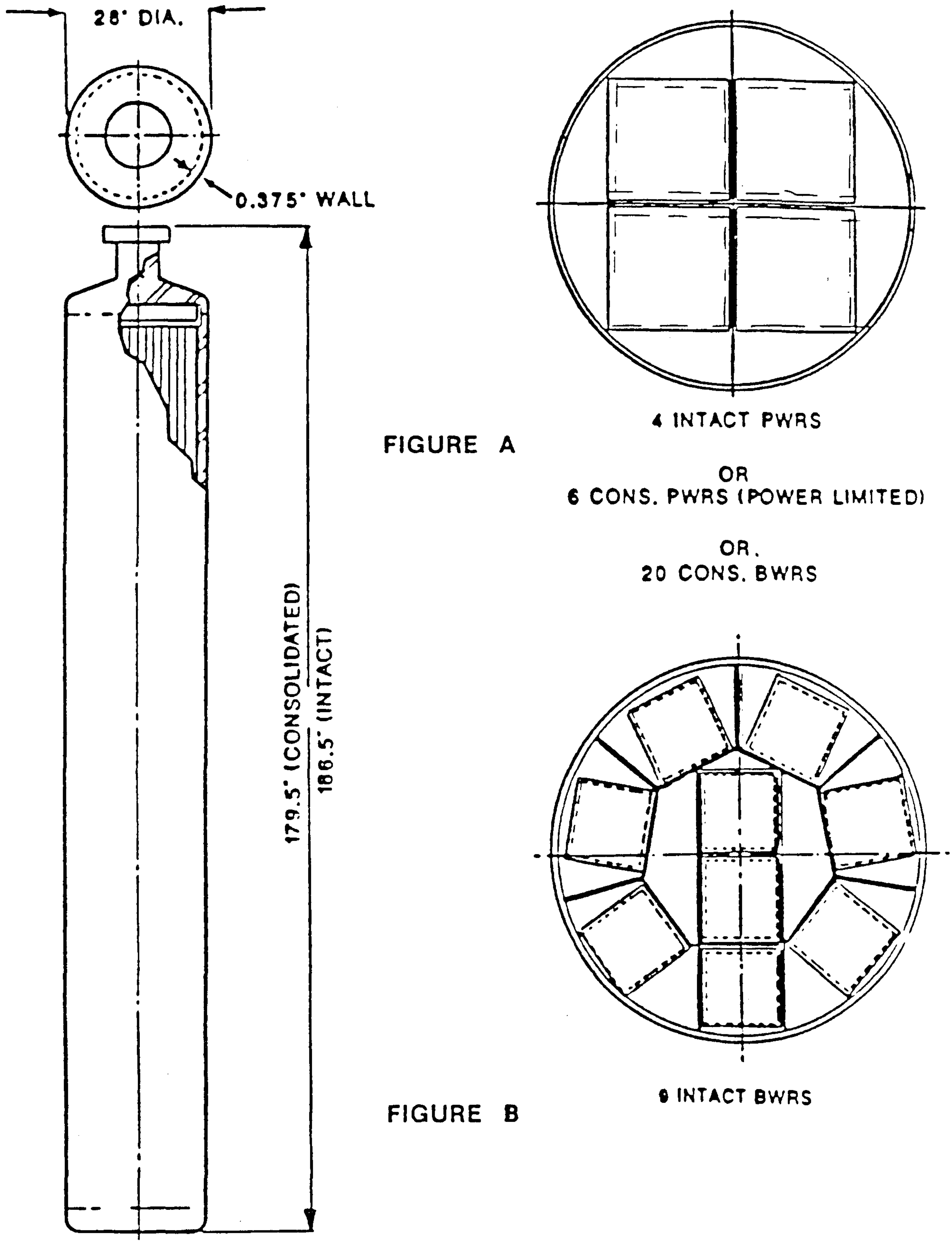

Figure 2-3. Canistered Fuel Configurations

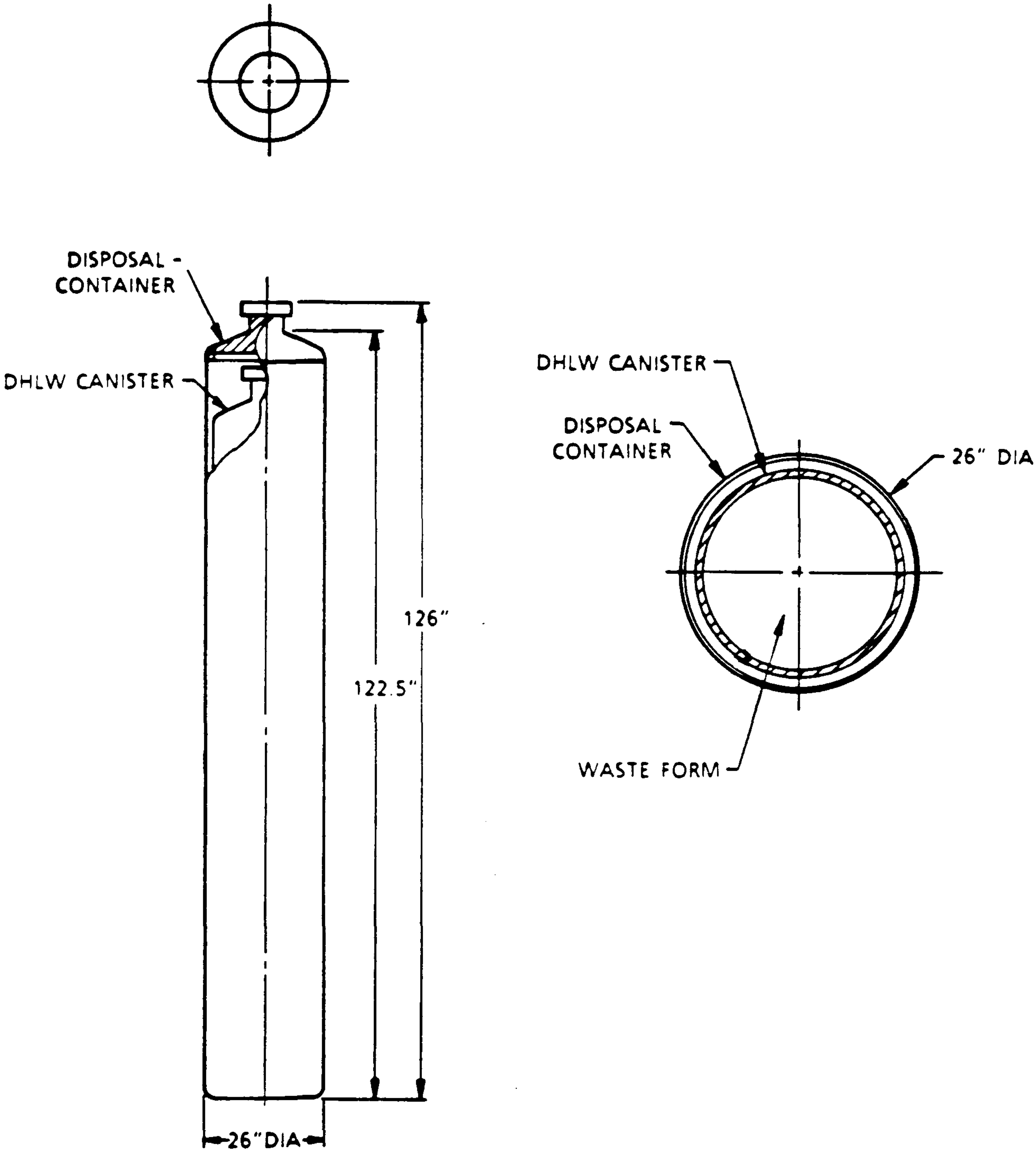

Figure 2-4. DHLW and WVHLW Container

TABLE 2-2

ANNUAL CASK RECEIPT AT THE REPOSITORY

Casks		MRS System Study Case Number								
Cask Type	Assemblies Per Cask	1	2	3	4	5	6	7	8	9
Reactor										
BWR Rail	48	64	64	110	110	6				
BWR Truck	7	357	357	36	36	36				
PWR Rail	21	122	122	211	211	12				
PWR Truck	3	698	698	70	70	70				
MRS (Case 5)										
BWR Intact	61					4				
BWR Consolidated	140					34				
PWR Intact	28					7				
PWR Consolidated	56					71				
MRS (Cases 6&7)										
BWR/PWR Intact	16/12						347	347		
PWR Intact	16						30	30		
MRS (Cases 8&9)										
BWR Intact	24								12	12
BWR Consolidated	72								73	73
PWR Intact	12								19	19
PWR Consolidated	24								184	184
DHLW Rail	5 *	160	160	160	160	160	160	160	160	160
Hardware Rail	4 *					63			12	12
Total		1,401	1,401	587	587	463	537	537	460	460

* Canister per cask

DHLW is shipped directly to the repository for containerizing and emplacement for Cases 1 through 5. For Cases 6 through 9, DHLW is shipped to the MRS for containerizing and then to the repository for emplacement.

Table 2-3 gives the number of each type of disposal container emplaced during the life of the repository for each case. Also included is the total number of containers emplaced during the life of the repository for each case.

Table 2-4 summarizes the total repository life-cycle costs for management and integration, surface facilities, subsurface facilities, and waste containers for all nine cases. In Cases 6 through 9, the waste container costs will be included in the MRS cost estimate because the waste is encapsulated in the containers at the MRS. Some containers will be used at the repository for performance assessment purposes, and their costs are included in the repository cost estimates for all nine cases.

Table 2-5 summarizes the total repository life-cycle costs for three repository life-cycle phases for each of the nine cases.

Table 2-6 shows the total required repository staffing during the operations phase of the facility.

Table 2-7 summarizes the schedule for repository design, licensing, and construction activities as developed in this study.

TABLE 2-3

NUMBER OF CONTAINERS EMPLACED DURING
THE LIFE OF THE REPOSITORY*

Container Types	MRS System Study Case Number								
	1	2	3	4	5	6	7	8	9
Spent Nuclear Fuel									
PWR:									
Intact	2,610	2,544	2,610	2,544	3,542	2,544	2,544	1,628	1,628
Consolidated	14,979	0	14,979	0	13,923	0	0	15,470	15,470
Hardware	0	0	0	0	2,387	0	0	0	0
BWR:									
Intact	1,559	0	1,559	0	1,881	0	0	973	973
Consolidated	5,964	0	5,964	0	4,989	0	0	6,159	6,159
Hardware	994	0	994	0	2,851	0	0	1,027	1,027
PWR/BWR Hybrid	0	29,176	0	29,176	0	29,176	29,176	0	0
DHLW	12,680	12,680	12,680	12,680	12,680	12,680	12,680	12,680	12,680
WVHLW	300	300	300	300	300	300	300	300	300
Total	39,086	44,700	39,086	44,700	42,553	44,700	44,700	38,237	38,237

* Excludes containers used for performance confirmation.

TABLE 2-4

COST ESTIMATES BY MAJOR COST CATEGORY
FOR THE LIFE OF THE REPOSITORY
(in Millions of 1988 Constant Dollars)

Cost Category	Costs by Case 1	2	3	4	5	6	7	8	9
Management and Integration	436	363	431	357	323	327	327	318	318
Surface Facilities	3,576	2,858	3,511	2,789	2,592	2,464	2,487	2,442	2,460
Subsurface Facilities	2,340	2,581	2,341	2,581	2,441	2,582	2,582	2,330	2,330
Subtotal	6,352	5,802	6,283	5,727	5,356	5,373	5,396	5,090	5,108
Waste Containers	1,098	1,284	1,098	1,284	1,192	31	31	31	31
Total	7,450	7,086	7,381	7,011	6,548	5,404	5,427	5,121	5,139

TABLE 2-5

COST ESTIMATES BY LIFE-CYCLE PHASE
FOR THE LIFE OF THE REPOSITORY
(in Millions of 1988 Constant Dollars)

Life-Cycle Phase	Costs by Case 1	2	3	4	5	6	7	8	9
Construction and Design	1,479	1,212	1,465	1,192	1,075	1,085	1,085	1,064	1,064
Operations, Less Containers	4,469	4,156	4,417	4,101	3,887	3,868	3,891	3,643	3,662
Decommissioning	404	434	401	434	394	420	420	383	382
Subtotal	6,352	5,802	6,283	5,727	5,356	5,373	5,396	5,090	5,108
Waste Containers	1,098	1,284	1,098	1,284	1,192	31	31	31	31
Total	7,450	7,086	7,381	7,011	6,548	5,404	5,427	5,121	5,139

TABLE 2-6

REPOSITORY STAFFING DURING THE OPERATIONS PHASE

Case	Surface	Underground	Total
1	734	445	1,179
2	634	499	1,133
3	718	445	1,163
4	619	499	1,118
5	627	468	1,095
6	567	499	1,066
7	578	499	1,077
8	560	444	1,004
9	569	444	1,013

TABLE 2-7

REPOSITORY DESIGN, LICENSING, AND CONSTRUCTION ACTIVITIES SCHEDULE

Item	Duration (mo)	Start Date	Finish Date
Advanced Conceptual Design	27	Oct 89	Jan 92
License Application Design	30	Jan 92	Jul 94
Prepare License Application	6	Jul 94	Jan 95
Final Procurement and Construction Design	36	Jan 95	Jan 98
NRC License Review	36	Jan 95	Jan 98
Site Construction Facilities	6	Jan 98	Jul 98
Site Preparation - - Onsite	9	Feb 98	Nov 98
- - Offsite	37	Feb 98	Mar 01
Waste Handling			
Building #1 (Cases 1 and 3)[a]	39	Oct 98	Jan 02
Building #2 (Cases 1 and 3)[b]	54	Jan 99	Jul 03
Building #1 (Cases 2 and 4)[c]	48	Oct 98	Oct 02
Building #1 (Cases 5-9)[d]	43	Oct 98	May 02
Other Surface Facilities	45	Mar 98	Dec 01
Underground Facilities (All Cases)	60	Jan 98	Jan 03

a. Duration, including site preparation, is 48 mo.
b. Duration, including site preparation, is 66 mo.
c. Duration, including site preparation, is 57 mo.
d. Duration, including site preparation, is 52 mo.

3.0 GENERAL INFORMATION

This section contains criteria, assumptions, and descriptions that apply to all of the cases.

3.1 Design Descriptions

3.1.1 Criteria and Assumptions

The criteria and assumptions listed below pertain to all cases. Additional case-specific criteria and assumptions are included in the applicable subsection for each case in Sections 4 through 12.

3.1.1.1 Criteria

- The repository is designed to accommodate 70,000 metric tons of uranium (MTU) of waste consisting of 63,020 MTU of SNF in option-specific disposal containers (whose number varies for each option); 6,340 MTU of defense high-level waste (DHLW) in 12,680 disposal containers that are standard for all options; and 640 MTU of West Valley high-level waste (WVHLW) in 300 standard containers.

- The spent fuel receipt rate increases from 400 MTU/yr, in the years 2003-2005, to a maximum of 3,000 MTU/yr, beginning in 2008. DHLW and WVHLW are received at the constant (combined) rate of 400 MTU/yr, beginning in 2008. The actual year-by-year waste receipt rates and the corresponding number of high-level waste (DHLW and WVHLW) disposal containers are shown in Table 3-1.

- All DHLW and WVHLW disposal containers have a thermal power of 200 W at the time of emplacement.

- Each DHLW canister contains 0.5 MTU; each WVHLW canister contains 2.13 MTU.

TABLE 3-1

WASTE RECEIVED AT THE REPOSITORY

	MTU - - First Repository*			HLW Containers	
Year	SNF	HLW	Cum.	DHLW	WVHLW
2003	400	0	400	0	0
2004	400	0	800	0	0
2005	400	0	1,200	0	0
2006	900	0	2,100	0	0
2007	1,800	0	3,900	0	0
2008	3,000	400	7,300	800	0
2009	3,000	400	10,700	800	0
2010	3,000	400	14,100	800	0
2011	3,000	400	17,500	800	0
2012	3,000	400	20,900	800	0
2013	3,000	400	24,300	800	0
2014	3,000	400	27,700	800	0
2015	3,000	400	31,100	800	0
2016	3,000	400	34,500	800	0
2017	3,000	400	37,900	800	0
2018	3,000	400	41,300	800	0
2019	3,000	400	44,700	800	0
2020	3,000	400	48,100	800	0
2021	3,000	400	51,500	800	0
2022	3,000	400	54,900	800	0
2023	3,000	400	58,300	680	28
2024	3,000	400	61,700	0	188
2025	3,000	180	64,880	0	84
2026	2,700	0	67,580	0	0
2027	2,420	0	70,000	0	0
TOTALS	63,020	6,980	70,000	12,680	300

* Based on information contained in Table 2-2 of DOE (1988b).

- All DHLW and WVHLW is shipped to the repository in rail casks that hold five containers or canisters. (The design of the DHLW and WVHLW cask-unloading facilities, however, does not preclude acceptance of truck casks.)

- Measured on an MTU basis, 66.7% of the uranium received at the repository is from pressurized water reactors (PWRs) and 33.3% is from boiling water reactors (BWRs).

- PWR fuel uranium content is 0.43 MTU/assembly.

- BWR fuel uranium content is 0.18 MTU/assembly.

- In disposal scenarios featuring consolidation, only 95% of the fuel received at a facility (repository or MRS) is consolidated; the other 5% is containerized as intact fuel assemblies.

3.1.1.2 Assumptions

- Repository throughput is controlled by waste-receiving operations.

- The operational times used in this study are based on the calculations in Appendix A.

- There are 6 productive hours per 8-hr shift.

- Operations may be conducted on a 1-, 2-, or 3-shift/day basis.

- Operations may be conducted on a 5-, 10-, 15-, or 21-shift/wk basis.

- Operations will be conducted on a 50-wk/yr basis.

- Equipment availability factors corresponding to the number of shifts per week are

  - 5 shifts/wk -- 1.00,
  - 10 shifts/wk -- 0.90,
  - 15 shifts/wk -- 0.80, and
  - 21 shifts/wk -- 0.70.

- Cask unloading times are based on the assumption that material-handling equipment is available as required.

- The repository facility designs presented in the Site Characterization Plan Conceptual Design Report (SCP-CDR) (SNL, 1987) and in the Rod Consolidation Study (RCS) (O'Brien, 1988) are used as a basis in this analysis.

- The transport cask unloading times (as identified in Dennis, in preparation) are used as a basis for calculating the cask-unloading times for each case.

3.1.2 Waste Received

For all cases, 5,556 BWR assemblies per year containing 1,000 MTU and 4,652 PWR assemblies per year containing 2,000 MTU are received at the repository (when at full receipt capacity). The number and types of casks, whether these assemblies are received at the repository by truck or by rail, consolidated or intact, bare or in canisters, vary from case to case. These specifics are discussed in Sections 4 through 12.

For all cases, the annual quantity of DHLW received at the repository (when at full receipt capacity) is 400 MTU. The DHLW is packaged in 800 canisters, each containing 0.5 MTU. The canisters are transported in rail casks, each containing 5 canisters. Thus, the repository receives 160 rail casks of DHLW per year. WVHLW, which is packaged in canisters that contain 2.13 MTU each, is received at the repository during the years 2023-2025.

The expected annual receipt rates for SNF, DHLW, and WVHLW during the 25-yr waste receipt period of the repository are shown in Table 3-1. Also shown are the number of DHLW and WVHLW canisters received. These rates are the same for all cases.

3.1.3 Surface Facilities

For all cases, the overall repository (except the waste-handling buildings) design is based on the Yucca Mountain Project (YMP) SCP-CDR (SNL, 1987). The general arrangement of the surface facilities is as shown in Figure 3-1, which was taken from the SCP-CDR. The waste-handling building design in the SCP-CDR is specifically applicable to Cases 1 and 3 of this study. Waste-handling building designs for other cases are variations of the Case 2 and Case 3 designs of the RCS (O'Brien, 1988), with changes made as required for the different packaging and transportation scenarios.

Markups of the waste-handling building drawings, corresponding to the waste-handling building design for each case in this study, were prepared and are presented in the sections where the cases are discussed in more detail. The sole purpose of these markups is to show the portions of the building that have been eliminated for cost-estimating purposes. These should not be interpreted as a technical representation of how the design of the building with the reduced volume and areas would actually be developed.

For all cases, the central facilities area occupies about 82 acres. This area is divided by security fences into three functional areas dedicated to waste receipt and inspection, general repository support, and waste operations.

Rail or truck casks containing radioactive waste enter the repository through Gate 3, at the extreme northeast end of the central facilities area. Incoming casks are inspected, cleaned, and moved (by DOE-owned locomotives and tractors rather than by the commercial carriers used to deliver the casks to the

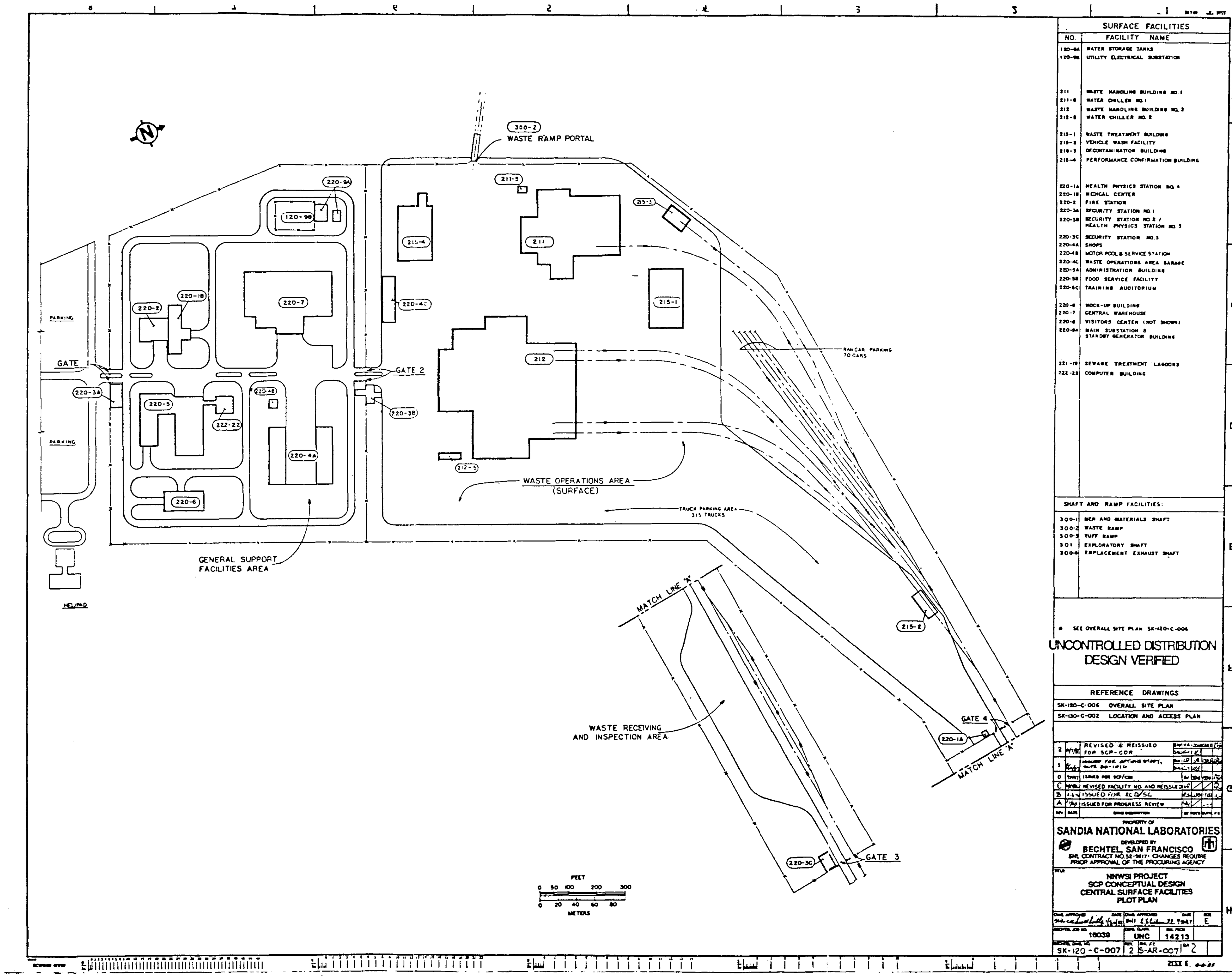

Figure 3-1. Surface Facilities General Arrangement

repository) into the waste operations area. Rail sidings and a paved parking lot are provided for the temporary storage of incoming casks and for empty casks awaiting return to the shippers.

The general support area consists of the administration building; medical, health physics, fire, and plant security facilities; the food service area; the central warehouse; the motor pool; and shops. Personnel and nonradioactive materials enter the area through Gate 1, which provides access from Drill Hole Wash Road, located south of the repository. The decision for or against consolidation and the presence or absence of an MRS facility will have little effect on the design of the general support area. Hence, this area is not discussed further in this report.

The waste operations area encompasses all the buildings associated with the handling of radioactive waste, including site-generated waste. Only the waste-handling buildings are discussed in this report because the designs of the other facilities in the area are assumed to be the same for all options.

3.1.4 Disposal Containers

Waste containers are transferred to the underground disposal area in radiation-shielded, rubber-tired, diesel/electric-powered transporters that are driven down the waste ramp. The repository design, therefore, imposes no critical limits as to the size or weight of the containers, such as might be dictated by the diameter of a shaft or the lifting capacity of a hoist. Waste form temperature does, to some extent, influence the design of the containers: the Yucca Mountain Site Characterization Plan (DOE, 1988a) sets 350°C (in an inert atmosphere) as the maximum permissible spent fuel cladding temperature. The SCP-CDR design value of 3,500 W keeps the fuel below this temperature. A container could be loaded with up to 7 (10-yr-old) PWR assemblies, or 21 BWR assemblies, or some combination of PWR and BWR fuel with a total thermal power of 3,500 W. Except in Case 5, where downloading of the consolidated PWR containers is required, the thermal power does not become limiting.

The spent fuel disposal containers for Cases 1, 3, 8, and 9 are the reference containers now under development by the YMP. The containers for Cases 2, 4, 6, and 7 are the so-called "hybrid" containers being considered for intact fuel disposal. The containers for Case 5 are used for intact and consolidated fuel that has been placed in canisters at the MRS.

For Cases 1, 3, 5, 8, and 9, in which spent fuel assemblies are consolidated, some of the hardware removed from the assemblies is placed in separate containers. These containers are described in the sections where the above cases are discussed.

A number of waste package materials are still under consideration. For this study, it is assumed that the container material for all cases is low-carbon austenitic stainless steel.

3.1.5 Underground Facility

The general layout of the underground facility adopted for this study is shown in Figure 3-2 and is identical in appearance, excavation method, and emplacement concept to what is described in the SCP-CDR (SNL, 1987).

Boundaries, as defined by the perimeter drift, are determined by the structural character of the rock mass. The disposal area is divided into discrete panels that are developed sequentially as waste emplacement proceeds during the operation of the repository. Each panel is 1,400 ft wide and 1,500-3,200 ft long, as determined by the irregularities of the boundary. Seventeen panels, encompassing a total area of about 1,200 acres, are required for the 70,000 MTU of waste for which the repository is designed. The total area of the underground facility workings, including shop areas, access drifts, etc., is about 1,400 acres.

The disposal panels are roughly rectangular in shape. For all options, single disposal containers are emplaced vertically in

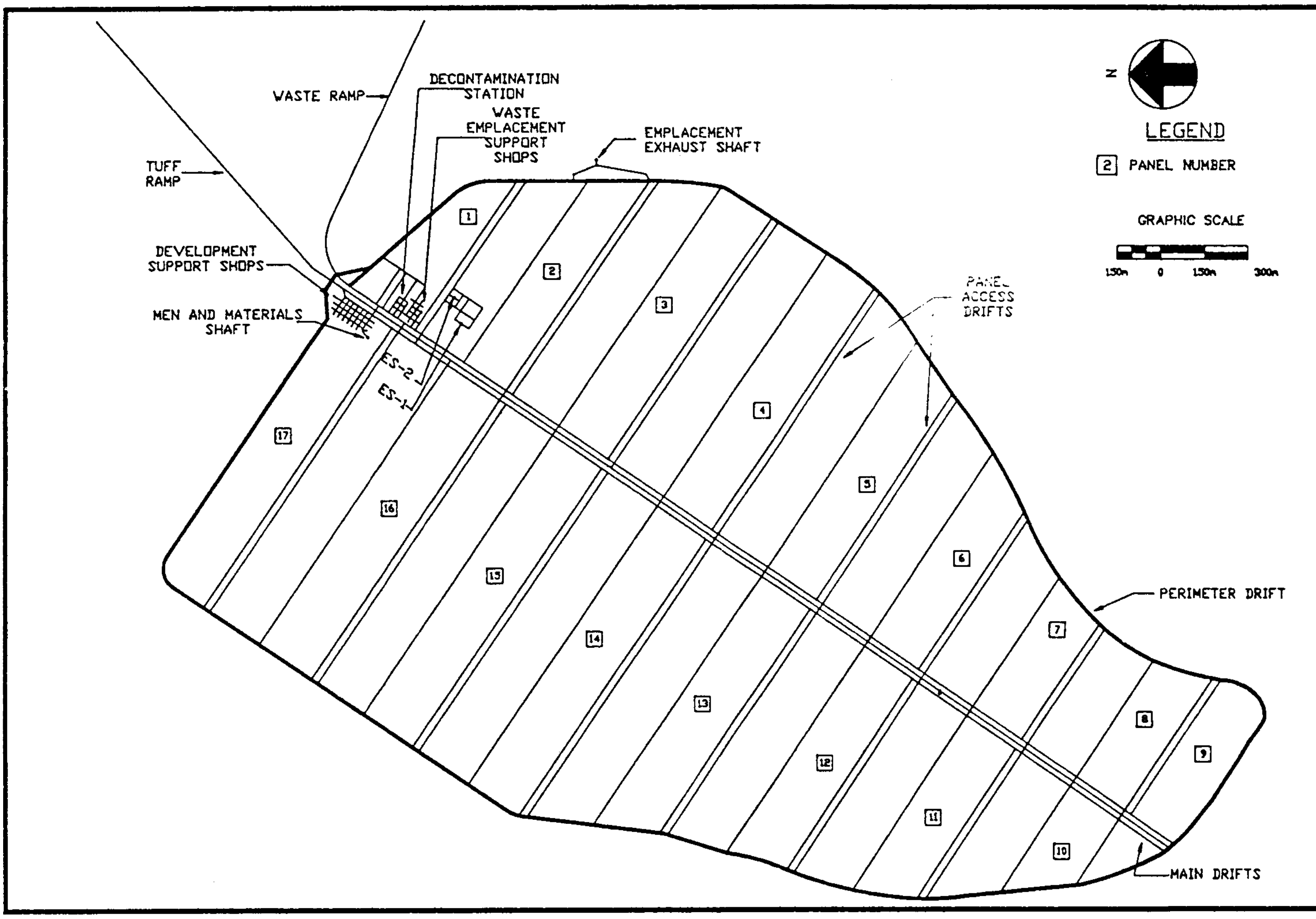

Figure 3-2. General Arrangement of the Underground Facility

partially lined boreholes with constant (for a given case) centerline spacing. In this study, the borehole spacing is uniform from panel to panel because the spent fuel is assumed to be of uniform age and burnup. In actual repository operation, however, the spacing may be varied periodically, depending on the characteristics of the waste received over the operational life of the repository.

Figure 3-3 shows the dimensional details of a typical emplacement drift. For all cases, the DHLW and WVHLW boreholes are 20 ft deep and 29 in. in diameter. Spent fuel boreholes are 25 ft deep; the diameter varies from case to case, depending on container diameter. The drawing illustrates the YMP concept of commingling, in which spent fuel hardware, DHLW, and WVHLW containers are alternated with spent fuel containers within the same emplacement drift.

Depending on the case, 1.3-2.4 times as many spent fuel containers as DHLW, WVHLW, and hardware containers will be emplaced over the life of the facility; therefore, not all drifts will contain commingled waste.

The bases for the emplacement panel layouts described in this study are Cases 1, 2, 3, and 4 of the RCS (O'Brien, 1988), hereinafter referred to as RCS Case 1, Case 2, Case 3, and Case 4. Slight differences in waste quantities and characteristics exist between this study and O'Brien (1988). Specific examples include the following:

- Spent fuel quantity: was 62,000 MTU
now 63,020 MTU
1.6% increase
- DHLW: was 7,360 MTU
now 6,340 MTU
14% decrease
- Average MTU per assembly: PWR was 0.4614 MTU/assembly
now 0.43 MTU/assembly

BWR was 0.1833 MTU/assembly
now 0.18 MTU/assembly

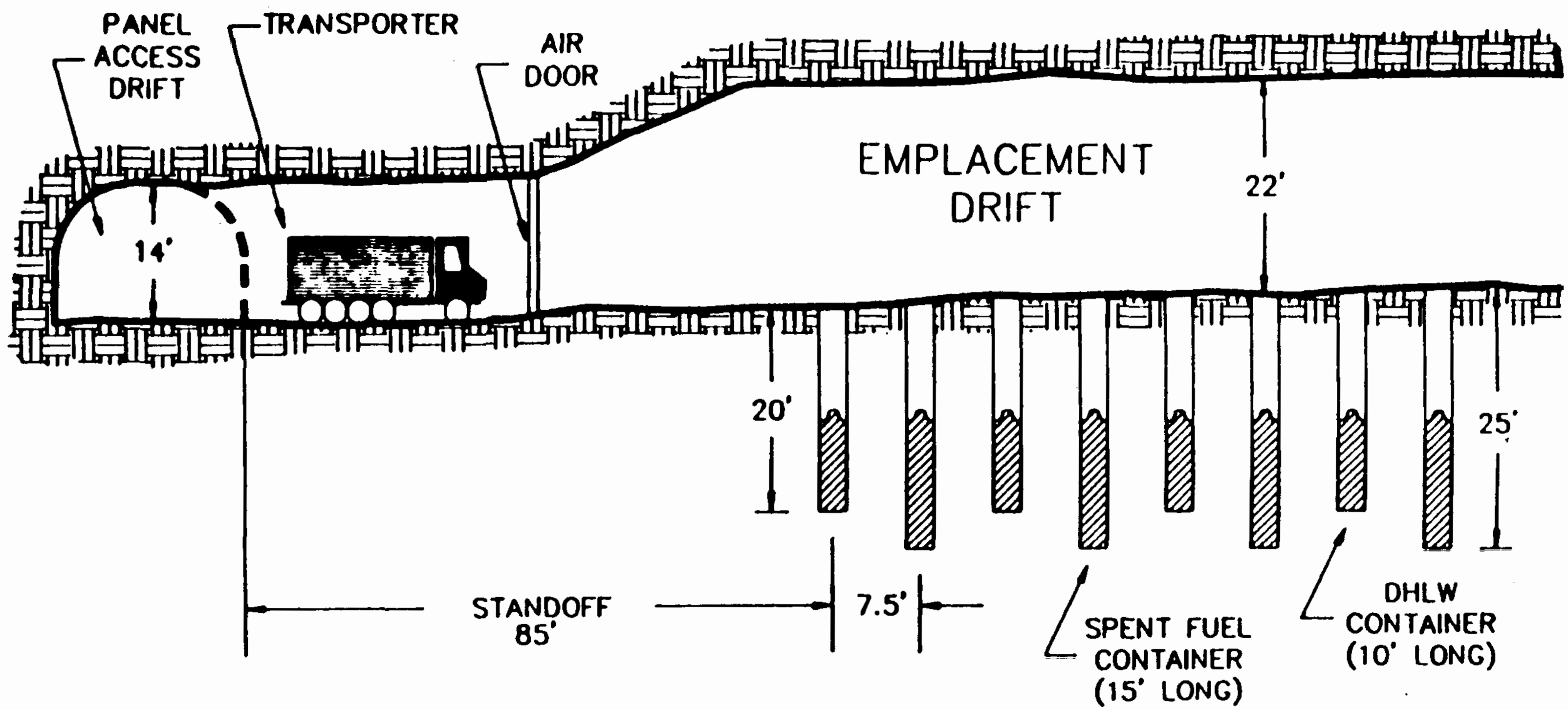

Figure 3-3. Emplacement Drift Dimensions

o	PWR/BWR split:	was 60% PWR, 40% BWR now 67% PWR, 33% BWR
o	Consolidated fraction:	was 90% now 95%

The above changes and the trend toward higher burnup fuels will affect the underground emplacement panel layout; however, the underground layouts developed for the RCS (O'Brien, 1988) are believed to be adequate for this study.

For all cases, the underground waste emplacement arrays are designed on the following basis:

- The areal power density will be chosen so that it does not exceed 55.6 kW/acre for 10-yr-old PWR fuel or 50.3 kW/acre for 10-yr-old BWR fuel. (The two values reflect differences in the decay characteristics of PWR and BWR fuel and were determined so that areal energy deposition over the first 2,000 yr after emplacement is the same for both fuel types.) This criterion determines the spacing of the emplacement drifts for vertical emplacement configurations.

- The borehole wall temperature may not exceed 235°C. This criterion is intended to ensure acceptably low fuel cladding temperatures; it can determine the minimum borehole spacing for vertical emplacement configurations.

- The rock temperature 1 m from the borehole wall may not exceed 200°C. This criterion limits thermal expansion of the rock around the borehole (but was found to be noncritical for all cases considered in this study).

- Fifty years after emplacement, the temperature in the panel access drifts may not significantly exceed 50°C. This criterion was established to facilitate drift maintenance and waste retrieval operations.

The waste disposal arrays described in this report were designed to minimize the total length (and cost) of the emplacement drifts. In all cases, except Case 5, the borehole wall temperature criterion was found to be nonlimiting, and the borehole spacing was determined by the physical properties of the rock around the holes. In Case 5, it was necessary to increase the spacing slightly in order to maintain acceptably low borehole wall temperatures. For all cases, the spacing of the emplacement drifts was adjusted to account for differences in the thermal power values of the option-specific disposal containers.

3.2 Cost Estimates

The basis and methodology for estimating each of the repository life-cycle phases are described by Gruer et al. (1987) and are applicable to all of the MRS study cases.

3.2.1 Surface Facility Costs

All cost estimates are modifications of prototypes prepared for earlier studies in the tuff repository program. The prototypes are:

Cases	Prototype	
1 and 3	SCP-CDR (RCS Case 1)	(SNL, 1987; Gruer et al., 1987)
2 and 4	RCS Case 2	(O'Brien, 1988)
5 through 9	RCS Case 3	(O'Brien, 1988)

In each case, the facility construction cost estimates were modified in two stages.

In the first stage, the cost data were updated from January 1986 to mid-1988, using the following indices:

- Labor 1.055
- Bulk material 1.069
- Equipment costs 1.056

In the second stage, the scope of the waste-handling building portion of the estimate was adjusted to reflect changes in the size of the building as developed for each case. These changes are shown on markups of the layouts of the prototypes. Building costs were modified pro rata by the square foot plan area or cubic foot volume change as appropriate for each cost element. Mechanical equipment lists were not modified for these changes in building size. However, the mechanical equipment cost was updated to 1988 costs. In all cases, site preparation and support facility scopes were not changed from the prototype, although the pricing was updated to 1988.

Similarly, operating cost estimates are modifications of the appropriate prototype estimates, adjusted first for cost update and second for scope of staffing.

The assumed annual cost of the average repository worker was increased from $50,000 to $52,700, in line with increases in craft wage rates. When the updated capital cost estimates were used as the measure of maintenance material costs, the two changes automatically updated the material costs.

Two key unit costs were not changed from previous estimates: the annual cost for bus transportation ($100,000) and the unit electricity cost ($0.05/kWh). Recent bidding experience by Bechtel at the Nevada Test Site (NTS) indicates that these do not require updating.

The staffing for each case was reviewed and adjusted vis-a-vis the prototypes. The number of personnel was a key scope adjustment for operating costs.

In each case, a new estimate was made of waste container costs, based on the number of containers calculated for each type of container and unit prices for container cost provided by Lawrence Livermore National Laboratory.

The AISI 304L/316L stainless steel container costs that were used are summarized as follows:

Container Type	Cases	Unit Cost ($1,000)
Fig. 2-1: A,B,C,D	1,3	29
Fig. 2-2: A,B,C	2,4	31
Fig. 2-3: A	5	31*
Fig. 2-4: DHLW, WVHLW	1,2,3,4,5	17
Hardware	1,3	26
Hardware	5	28
Performance confirmation	All cases	28

3.2.2 Underground Facility Costs

All costs have been escalated from 1986 dollars to mid-1988 constant dollars using published government cost indices (Producer Price Index) and current NTS craft labor contracts.

Materials cost escalation ranged from -0.1% to 23.8%, depending on commodity type, resulting in an overall average escalation of 6.8%. Equipment cost escalation ranged from 2.1% to 9.6%, depending on equipment type, with an average escalation of 4.2%.

The method used to evaluate labor costs has been changed from that used in earlier estimates. All previous estimates used a single wage rate that was based on the Reynolds Engineering and Electric Co. tunnel workers contract. A more detailed review of the current wage rates paid to other crafts that are likely to be present for underground construction suggests that additional labor categories and rates should be included. It is now assumed that labor rates currently paid to the electrician craft union are more appropriate for all tasks involving underground electrical power and instrumentation wiring. Similarly, it is assumed that

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* Container cost is based on intact fuel container (186.5 in. long) only.

current labor rates paid to the operating engineers union are applicable to underground mechanics and operators of waste-handling equipment. This change has the effect of increasing the labor costs for these estimates more than the 6.9% that is due to escalation alone.

The resulting underground labor rates in mid-1988 dollars range from $27.70/hr to $34.10/hr with an overall average of $30.40/hr, including benefits.

3.3 Construction Schedule

The existing schedules for each prototype are examined with a view to revise durations of appropriate activities as required by significant changes in quantities. It turns out that the variation from the prototype in all cases is so minor that it is not meaningful at this time to show a difference in duration between variations of the prototype. A more detailed study of the quantity and scope differences, beyond the scope of the present work, will be required to establish these minor duration differences. The total construction duration for Cases 1 through 9 is 60 mo.

The waste-handling building construction schedule for Cases 1 and 3 is based on the waste-handling building construction schedule for the SCP-CDR design (RCS Case 1); the waste-handling construction schedule for Cases 2 and 4 is based on the waste-handling construction schedule for RCS Case 2. The waste-handling construction schedule for Cases 5 through 9 is an assumed schedule. (Details are included in Subsection 3.4.2.)

The assumed dates for major milestones are the following:

- Begin advanced conceptual design — Oct 1989
- Begin license application design — Jan 1992
- Obtain construction authorization — Jan 1998
- Begin waste operations (not later than) — Jan 2003

3.4 Uncertainties in Cost and Schedule

Each of the nine cases is a modification of one of three prototypes. These prototypes were studied, estimated, scheduled, and reported on in previous tuff repository work (SNL, 1987; O'Brien, 1988). The uncertainties in the schedules are introduced by the following uncertainties:

- Long-lead-time items will be provided by DOE as government-furnished equipment to the contractor in a timely manner to support the construction schedule.

- There is no allowance for design changes after construction begins.

- There is no allowance for institutional delays.

- There is no allowance for labor stoppages or late delivery of materials.

3.4.1 Cost

These cost estimates do not include cost allowances for changes in scope or design criteria, changes in repository location, licensing delays, construction and/or operating labor problems, mandates relating to total retrieval activities, or cost escalation through the life of the project. Any of these uncertainties could have a significant impact on cost and/or schedule.

These estimates do not include the costs of sinking and developing exploratory shafts for site characterization, management by governmental agencies, any offsite nuclear waste preparation and transport, or any costs that occur before license application design.

In addition to the uncertainties applicable to the prototype studies, the modifications necessarily introduce further possible uncertainty because they are not rigorous reestimates of the exact scope of work of the cases in question.

3.4.2 Schedule

The construction schedules of the waste-handling buildings for Cases 1 and 3 were assumed to be the same as the construction schedules that were developed for the waste-handling buildings in RCS Case 1. If construction schedules were developed for the waste-handling buildings in Cases 1 and 3, which are slightly smaller than the waste-handling buildings in RCS Case 1, these schedules would be shorter than the 48-mo schedule for RCS Case 1 WHB-1 and the 66-mo schedule for RCS Case 1 WHB-2. Thus, the waste-handling building construction schedules used for Cases 1 and 3 in this study are probably conservative.

The construction schedule for the waste-handling building for Cases 2 and 4 was assumed to be the same as the construction schedule that was developed for the waste-handling building in RCS Case 2. If a construction schedule were developed for the waste-handling building in Cases 2 and 4, which is slightly smaller than the waste-handling building in RCS Case 2, this schedule would be shorter than the 57-mo schedule for the waste-handling building in RCS Case 2. Thus, the waste-handling building construction schedule used for Cases 2 and 4 in this study is probably conservative.

A detailed schedule for the construction of the waste-handling building was not developed for Cases 5, 6, 7, 8, and 9. Based on a review of the capital costs and the building takeoff quantities for the Case 1 WHB-1 and for the Case 2 waste-handling building, a schedule for the waste-handling building in Cases 5 through 9 would probably be longer than the 48 mo calculated for the Case 1 WHB-1 but shorter than the 57 mo calculated for the Case 2 waste-handling building. In this study, a 52-mo duration is assumed. This assumption creates an uncertainty which will be resolved when a construction schedule is developed.

4.0 CASE 1

For Case 1, there is no MRS. All SNF is shipped directly to the repository, where it is consolidated and containerized for emplacement. DHLW and WVHLW are received in canisters at the repository and then containerized for emplacement. Containerizing is in accordance with the SCP-CDR design.

Case 1 of this study is similar to the SCP-CDR design, except for the reduction in the hot cell volumes in the waste-handling building and the reduction of the floor areas due to the difference in the number of rail/truck shipments, the cask capacities, the ratio of BWR to PWR assemblies, and the assumed MTU per BWR and PWR assembly. For the SCP-CDR design, 30% of the SNF is shipped by rail and 70% by truck. The SCP-CDR BWR cask capacities are 36 assemblies per rail cask and 5 assemblies per truck cask, and the PWR cask capacities are 14 assemblies per rail cask and 2 assemblies per truck cask. In the SCP-CDR design, 40% of the fuel assemblies are BWR assemblies and 60% are PWR assemblies; BWR assemblies are assumed to contain 0.1833 MTU, and PWR assemblies are assumed to contain 0.4614 MTU.

The Case 1 rail/truck split and the cask capacities are as given in the assumptions below; the ratio of BWR assemblies to PWR assemblies is one-third to two-thirds; and the MTU per assembly is 0.18 MTU per BWR assembly and 0.43 MTU per PWR assembly.

4.1 Assumptions

In addition to the general assumptions stated in Section 3, the following specific assumptions apply to Case 1:

- The shipment of SNF from the reactors to the repository is 55% by rail and 45% by truck.

- There are 48 intact BWR SNF assemblies per rail cask shipped from the reactors to the repository.
- There are 7 intact BWR SNF assemblies per truck cask shipped from the reactors to the repository.
- There are 21 intact PWR SNF assemblies per rail cask shipped from the reactors to the repository.
- There are 3 intact PWR SNF assemblies per truck cask shipped from the reactors to the repository.
- There are 6 intact BWR SNF assemblies per container.
- There are 18 consolidated BWR SNF assemblies per container.
- There are 3 intact PWR SNF assemblies per container.
- There are 6 consolidated PWR SNF assemblies per container.
- There is one additional container for hardware generated per 108 BWR assemblies consolidated at the repository.

4.2 Waste Received

The annual and total quantities of SNF and high-level waste received at the repository during its 25 yr of operation are shown in Table 3-1. As can be seen from this figure, the maximum annual quantity of SNF received, when the repository is operating at full receipt capacity, is 3,000 MTU/yr. One-third, or 1,000 MTU, of this is BWR fuel; two-thirds, or 2,000 MTU, is PWR fuel. A total of 55% of the fuel is shipped to the repository by rail and 45% by truck. All of this SNF is shipped as intact fuel assemblies directly from the nuclear reactors to the repository.

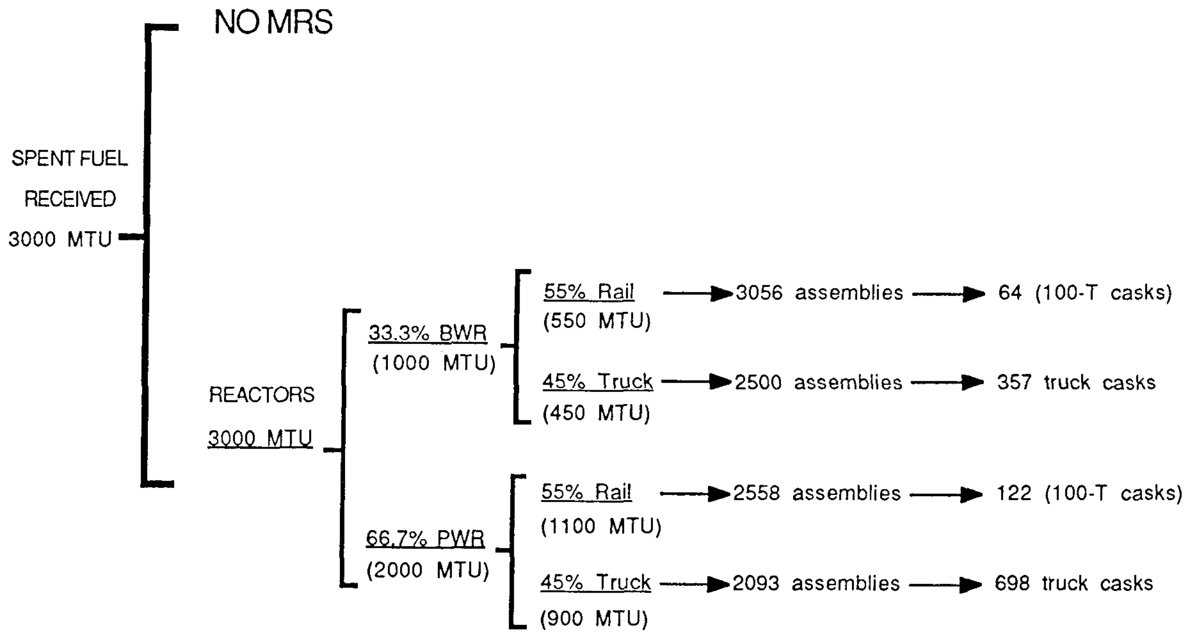
At 0.18 MTU per BWR assembly, 3,056 BWR assemblies per year are shipped to the repository by rail and 2,500 BWR assemblies per year are shipped by truck. Because the capacity of a BWR rail cask is 48 assemblies, 64 rail casks of BWR fuel are received at the repository per year. Because the capacity of a BWR truck cask is 7 assemblies, 357 truck casks of BWR fuel are received at the repository per year.

At 0.43 MTU per PWR assembly, 2,558 PWR assemblies per year are shipped to the repository by rail and 2,093 PWR assemblies per year are shipped by truck. Because the capacity of a PWR rail cask is 21 assemblies, 122 rail casks of PWR fuel are received at the repository per year. Because the capacity of a PWR truck cask is 3 assemblies, 698 truck casks of PWR fuel are received at the repository per year.

The annual throughputs (at full receipt capacity) for Case 1 are summarized in Figure 4-1. For comparison, the annual throughputs (at full receipt capacity) for the SCP-CDR design are summarized in Figure 4-2. The calculations for the quantities shown in these figures are provided in Appendix A.

4.3 Surface Facilities

The surface facilities for Case 1 are the same as the surface facilities in the SCP-CDR design, except that the waste-handling buildings for Case 1 are smaller than the waste-handling buildings in the SCP-CDR design. Owing primarily to the smaller number of casks received at the repository for Case 1, five fewer cask unloading bays are required in Case 1 than in the SCP-CDR design. The plot plan, which is essentially the same for both designs, is presented in Figure 4-3.

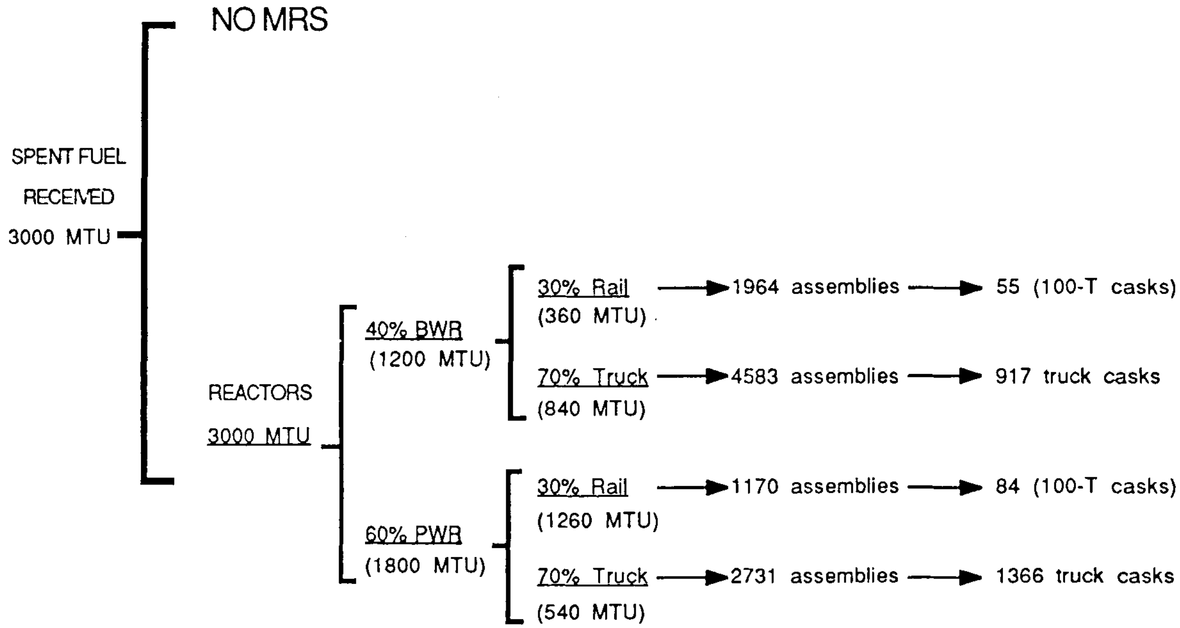


NON-SPENT FUEL RECEIVED		
DHLW :	MTU's	400
	Canisters	800
	Rail Casks	160
MRS Hardware :	Drums	0
	Canisters	0
	Rail Casks	0

CASK CAPACITIES (ASSEMBLIES)		
MRS ALL RAIL:	BWR intact	N/A
	BWR consol.	N/A
	PWR intact	N/A
	PWR consol.	N/A
REACTOR:	BWR rail	48
	BWR truck	7
	PWR rail	21
	PWR truck	3
HARDWARE:	rail	N/A
DHLW:	rail	5 canisters

EMPLACEMENT OPERATIONS	NO. CONTAINERS	NO. ASSEMBLIES/ CONTAINER
BWR (Intact)	46	6
BWR (Consolidated)	293	18
PWR (Intact)	78	3
PWR (Consolidated)	736	6
Hardware	49	108 BWR
DHLW	800	1 canister
TOTAL	2002	

Figure 4-1. Repository Annual Throughputs (Case 1)



NON-SPENT FUEL RECEIVED

DHLW :	MTU's	400
	Canisters	800
	Truck Casks	800
MRS Hardware :	Drums	0
	Canisters	0
	Rail Casks	0

CASK CAPACITIES (ASSEMBLIES)

MRS ALL RAIL:	BWR intact	N/A
	BWR consol.	N/A
	PWR intact	N/A
	PWR consol.	N/A
REACTOR:	BWR rail	36
	BWR truck	5
	PWR rail	14
	PWR truck	2
HARDWARE:	rail	N/A
DHLW:	truck	1 canisters

EMPLACEMENT OPERATIONS	NO. CONTAINERS	NO. ASSEMBLIES/ CONTAINER
BWR (Intact)	109	6
BWR (Consolidated)	327	18
PWR (Intact)	130	3
PWR (Consolidated)	585	6
Hardware	55	108 BWR
DHLW	800	1 canister
TOTAL	2006	

Figure 4-2. Repository Annual Throughputs (SCP-CDR)

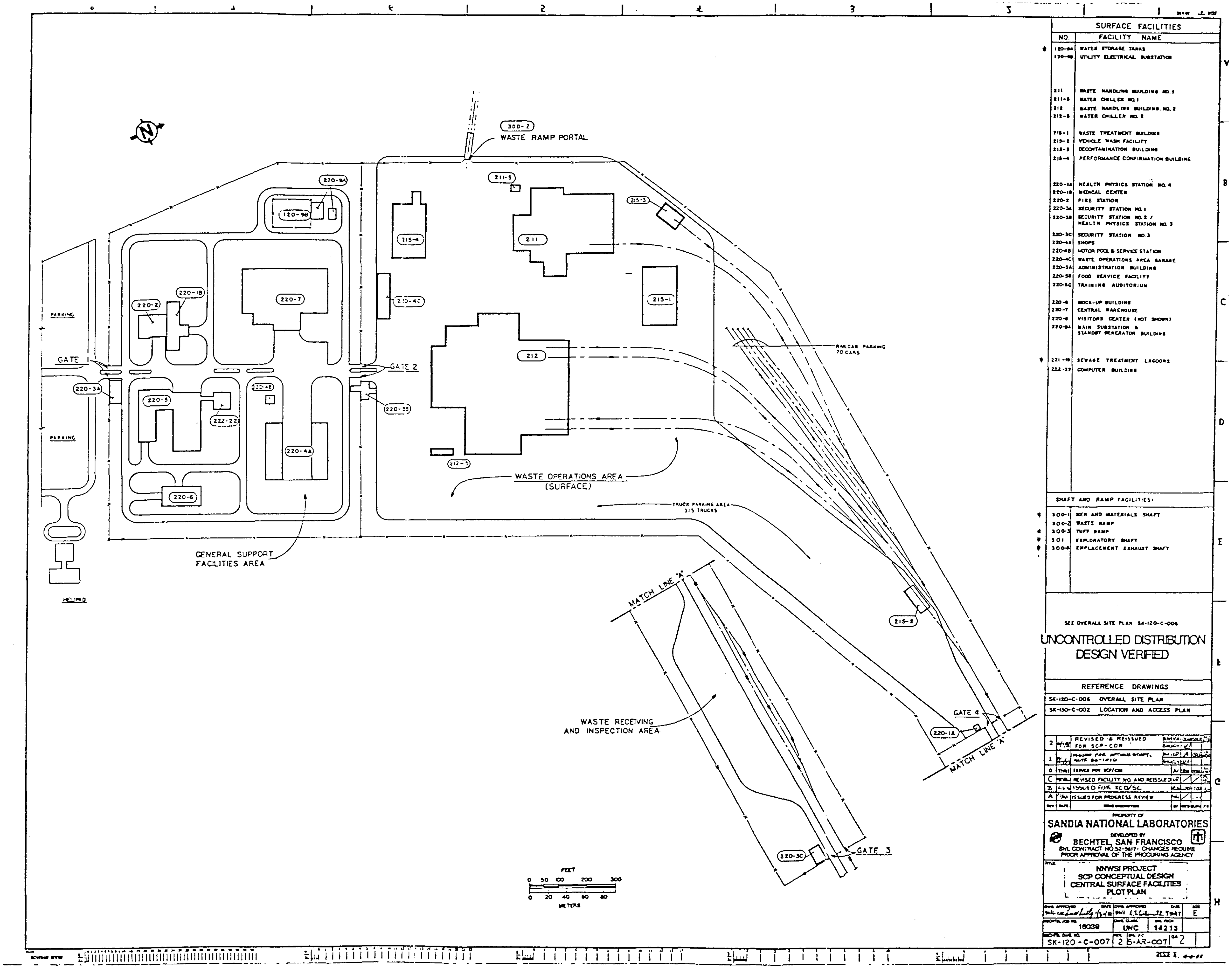


Figure 4-3. Repository Plot Plan (Case 1)

As in the SCP-CDR design, the surface waste-handling facilities for Case 1 include two structures, designated Waste-Handling Building 1 (WHB-1) and Waste-Handling Building 2 (WHB-2). WHB-1 has a throughput capacity of 400 MTU/yr. It becomes operational in 2003 and is used for containerizing spent fuel until 2008, when it becomes a containerizing facility for DHLW and WVHLW. WHB-2 is used exclusively for receiving spent fuel; it begins operation in 2006 and attains its design throughput of 3,000 MTU/yr in 2008.

Figure 4-4 is a markup of the design for the SCP-CDR WHB-1 with two cask unloading ports deleted to reflect the requirements for the Case 1 WHB-1. The sole purpose of this markup is to show deleted building volume for cost estimating purposes. This should not be interpreted as a technical representation of how the design of the building with the reduced volume and areas would actually be developed.

WHB-1, shown in Figure 4-4, has two cask receiving bays and one cask unloading cell with two floor ports, through which spent fuel assemblies or high-level waste canisters are removed from the shipping casks. Step-by-step details of the progress of a canister of DHLW or WVHLW through WHB-1 are shown in the material flow diagram in Figure 4-5. Figure 4-5 is a markup of the DHLW and WVHLW material flow diagram taken from the SCP-CDR. Four basic operations are performed:

- In the cask preparation area, the shipping cask is removed from a rail car or truck trailer and placed vertically on a cask transfer cart. At this point, the outer lid of the cask and the bolts securing the inner lid are removed and a hot cell adapter ring is added.

- The transfer cart moves the cask through a tunnel to a position under a floor port in the cask unloading cell and mates the adapter ring to the unloading port.

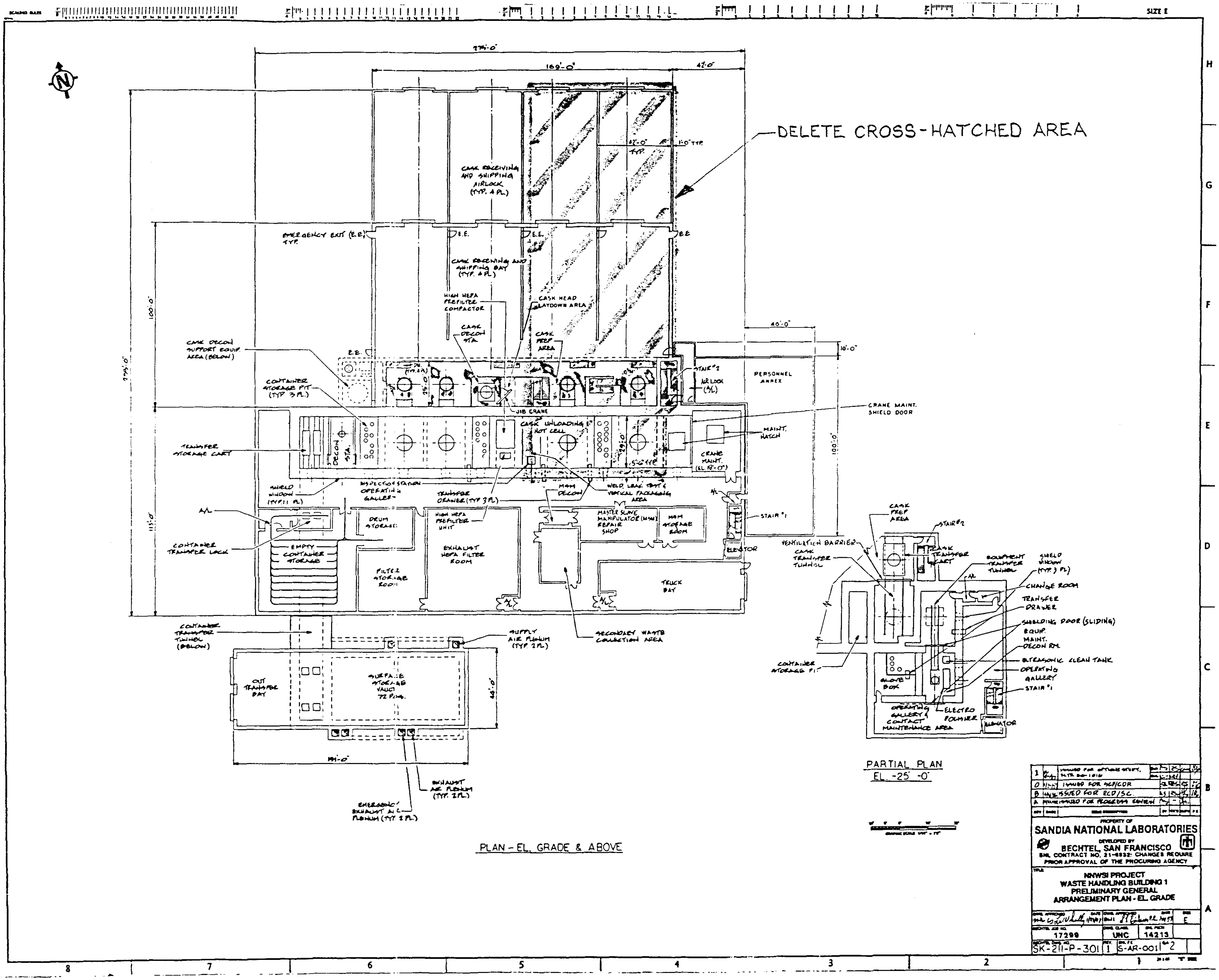


Figure 4-4. WHB-1 Layout (Case 1)

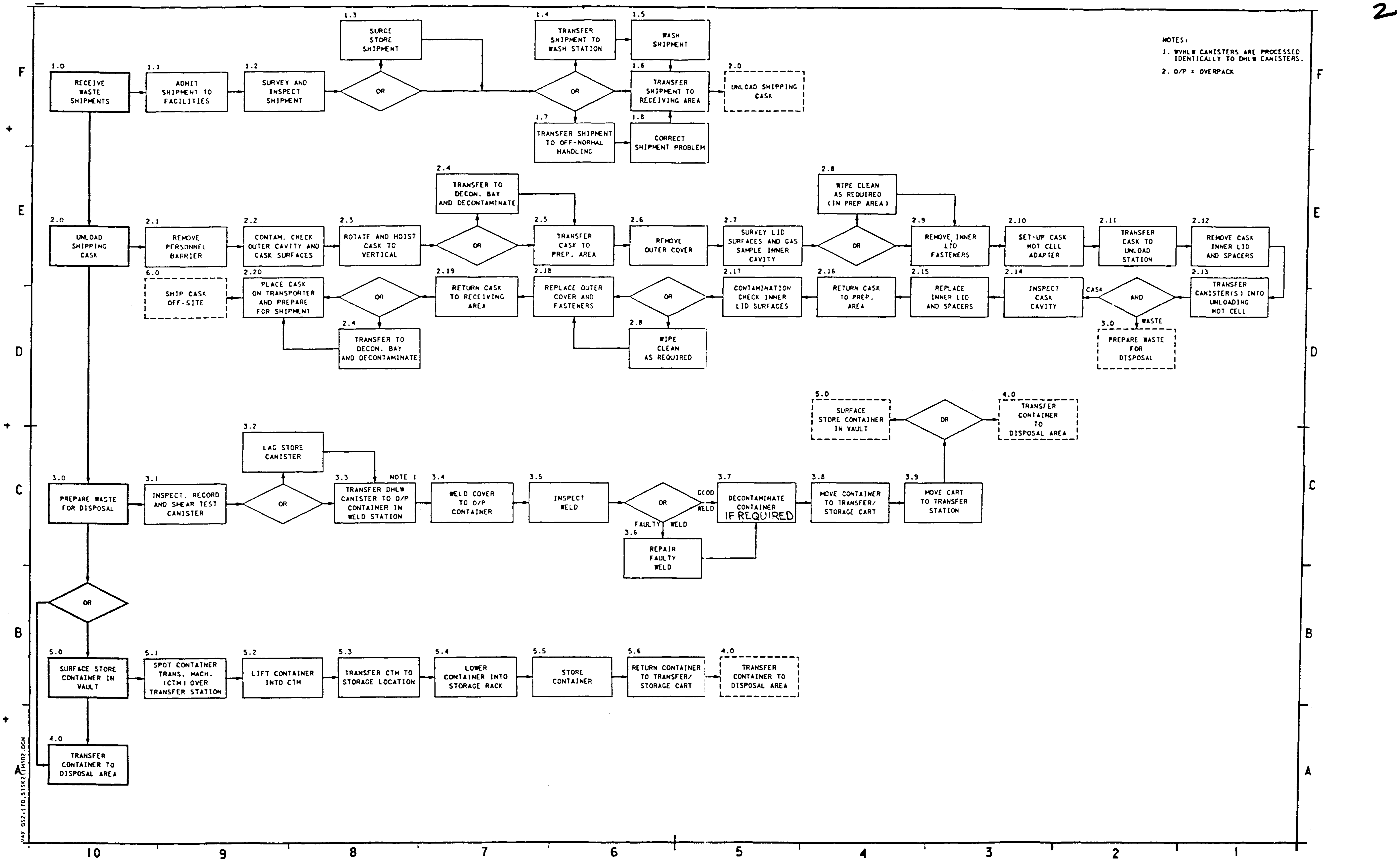


Figure 4-5. Material Flow Diagram for DHLW and WVHLW (Case 1)

- In the cask-unloading cell, the fuel assemblies (or DHLW or WVHLW canisters) are removed from the shipping cask, one at a time, and placed in a disposal container. When the container is fully loaded, the lid is welded to the container body, and the completed container is inspected, leak-tested, and decontaminated.

- The container is moved through a transfer tunnel to the surface storage vault area, where it is either transferred to the underground disposal area or put into the storage vault.

Figure 4-6 is a markup of the SCP-CDR WHB-2 with three cask-unloading ports deleted to reflect the requirements for the Case 1 WHB-2. The sole purpose of this markup is to show deleted building volume for cost-estimating purposes. This should not be interpreted as a technical representation of how the design of the building with the reduced volume and areas would actually be developed.

WHB-2, shown in Figure 4-6, has five cask-receiving bays, one cask-unloading cell with five floor ports, four large fuel consolidation cells (in mirror-image pairs), and two packaging cells. The procedures for receiving and unloading incoming shipping casks are the same as for WHB-1. Fuel assemblies that will not be consolidated (because of physical or thermal damage or because disassembly tooling will not be built for some low-production fuel types) are packaged in the cask-unloading cell. Following inspection, leak-testing, and decontamination, the containers are transferred directly to the surface storage vault.

After removal from the shipping casks, fuel assemblies that will be consolidated are placed on a transfer/storage rack and moved through a fuel transfer tunnel (different from, and not connected with, the cask transfer tunnel) to a position under a floor port in a consolidation cell. An overhead crane lifts the fuel assemblies, one at a time, from the transfer/storage rack through

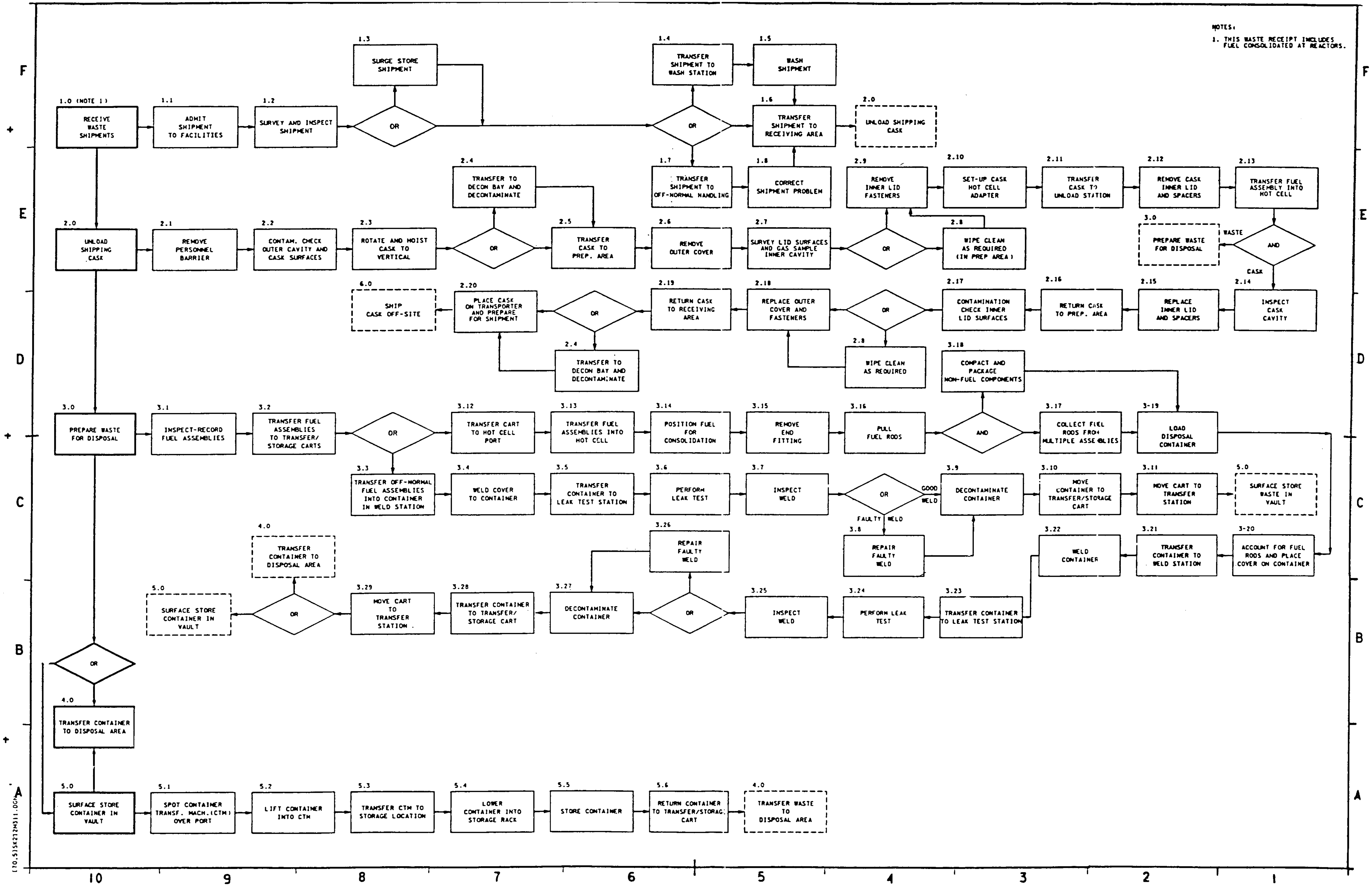


Figure 4-6. WHB-2 Layout (Case 1)

the floor port and into the consolidation cell. An automated consolidation machine, designed conceptually by BE Inc. (Townes et al., 1987) removes the end fittings from the fuel assemblies, extracts the fuel rods, and assembles them in a vertical collector. The collector is rotated to a horizontal position, and the consolidated fuel rods are pushed through a wall port into a disposal container in the adjacent packaging cell. The nonfuel-bearing hardware waste is collected and loaded through the wall port into the central cavity of the disposal container. After the container has been loaded, a lid is welded to the container body. Following inspection, leak-testing, and decontamination, the disposal container is transferred to the surface storage vault. Details of the spent fuel processing operation in WHB-2 are shown in the material flow diagram for SNF in Figure 4-7.

4.4 Disposal Containers

For Case 1, all the spent fuel, consolidated or intact, is packaged in the YMP reference containers shown in Figure 4-8. The 26-in.-diameter 187.5-in.-long container was designed specifically for a disposal scenario in which most of the fuel is consolidated at the repository. It features peripheral compartments for the heat-producing fuel rods (or intact assemblies) and provides a central cavity for the hardware waste produced in the consolidation operation. In its most common configuration, the container holds 6 consolidated PWR assemblies, or 6 intact or 18 consolidated BWR assemblies. All of the hardware waste from 6 PWR assemblies will fit into the central cavity.

The hardware waste includes the upper tie plate (including the handle), lower tie plate, spacers, springs, nuts, lock washers, and water rods.

Although the 6 outer compartments of the reference container can hold the fuel rods of 18 BWR assemblies, the center compartment can hold the hardware of only 8 BWR assemblies. Therefore, an

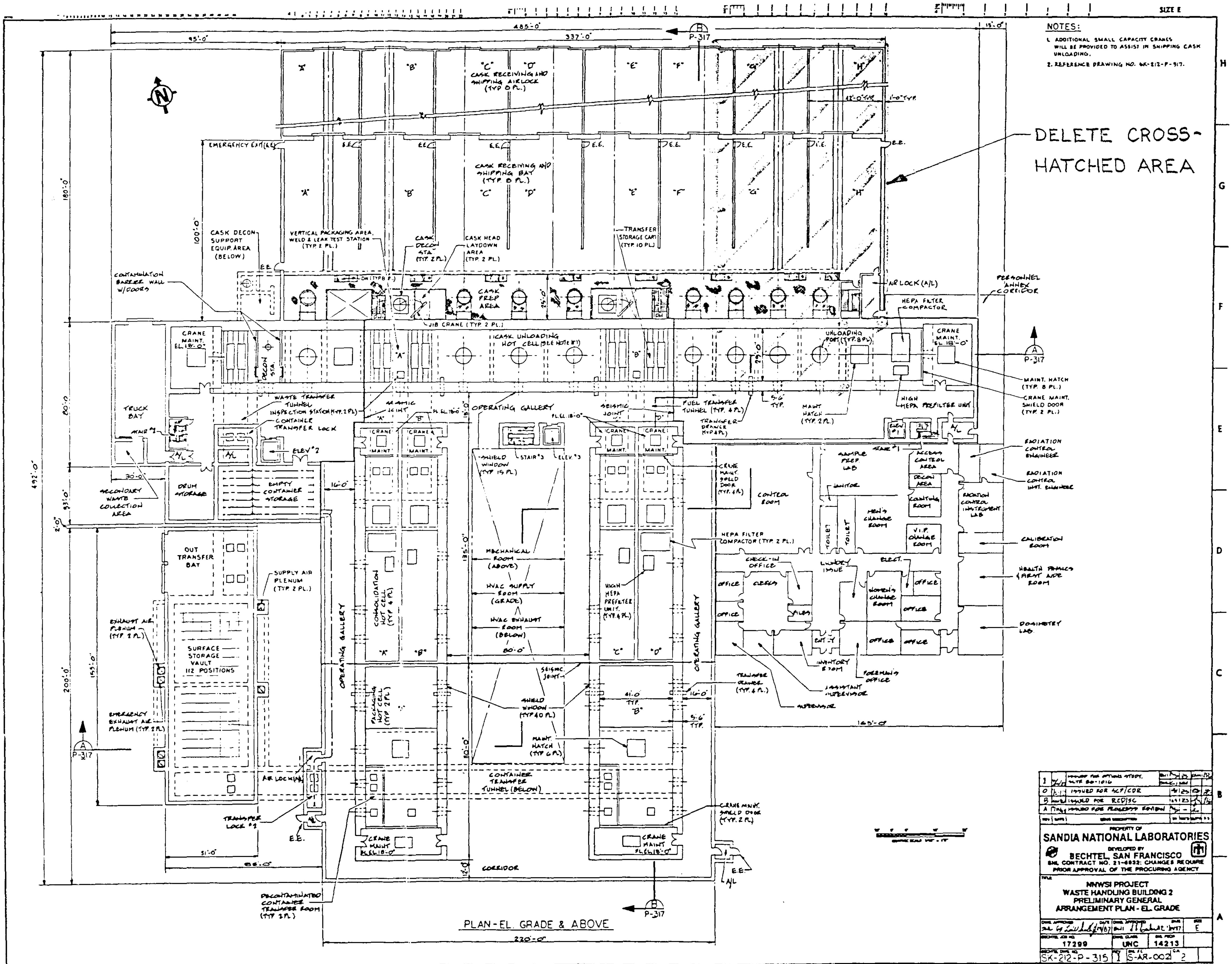


Figure 4.7. Material Flow Diagram for SNF

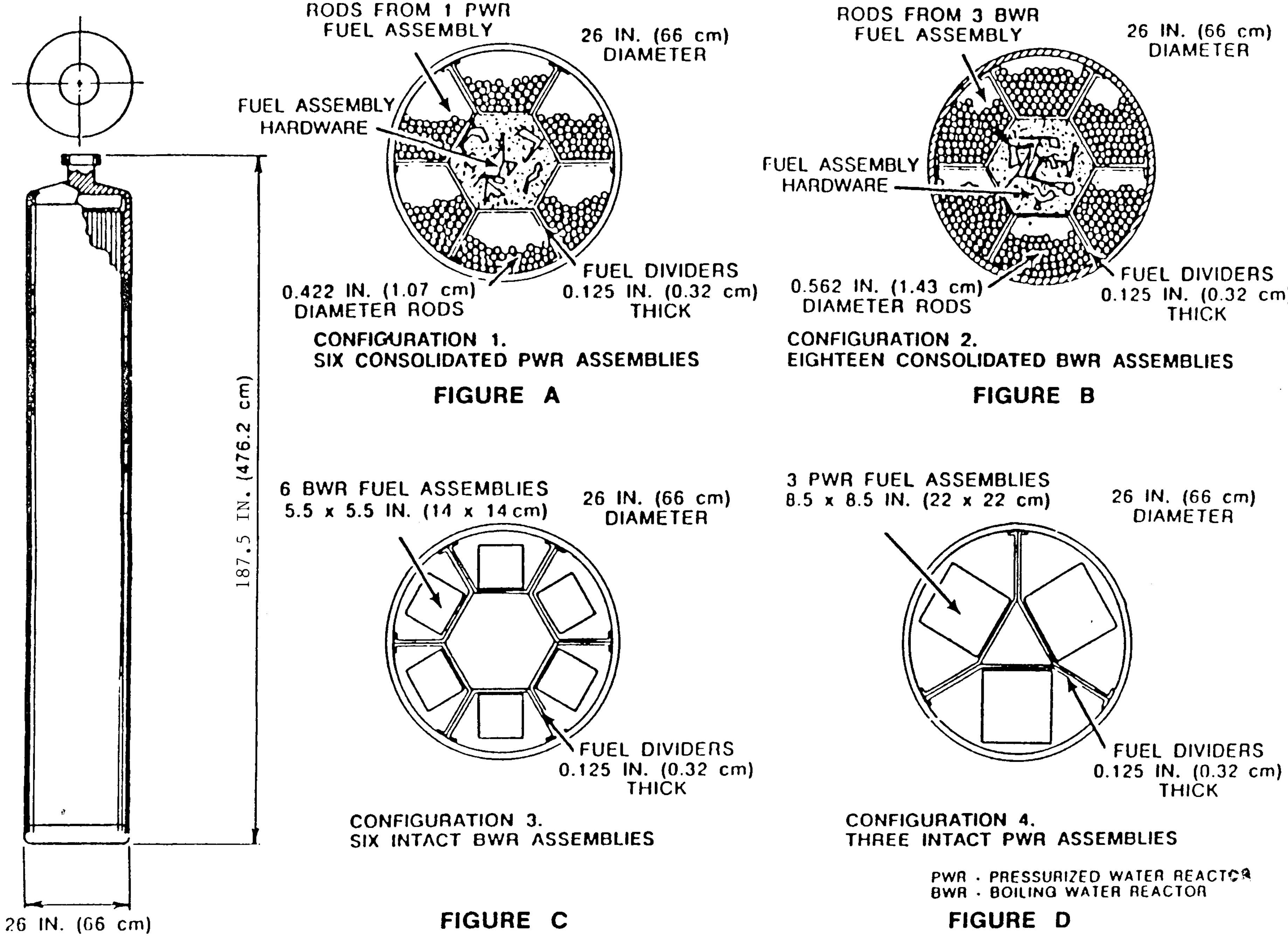


Figure 4-8. Reference Design Containers (Case 1)

overflow of hardware of 10 assemblies must be placed in an alternate, or special, container for every 18 assemblies. This special container will be the same size and shape and of the same material as the YMP reference container but will not have any compartments.

This packing is based on the General Electric (GE) 8 x 8 BWR fuel assembly characteristics, because this particular fuel assembly is by far the most common BWR fuel assembly in the U.S. It is assumed that the consolidation process will involve only the disassembly of each fuel assembly into its basic component parts and will not include any cutting of these parts into smaller pieces before their placement in the waste containers. It is also assumed that the water rods (2 per fuel assembly) will be placed in the outer compartments of the reference container, along with the fuel rods.

The hardware storage capacity of the reference container's center compartment was determined by preparing a scaled sketch of the disassembled parts stacked inside the compartment. It was assumed that all such parts from just one fuel assembly would be placed in the container, followed by all parts from the next fuel assembly, and so on.

The hardware storage capacity of the special container was also determined by the use of a scaled sketch. Unlike the assumed hardware packing of "one fuel assembly at a time" sequencing for the reference container, the special container would be packed in layers of 15 fuel assemblies' worth of one part, followed by a layer of 15 fuel assemblies' worth of another part, and so on. This approach makes efficient use of the special container's storage space, and requires the use of a pallet or expendable basket to place the layers of fuel assembly parts in the container. Essentially, there are three different types of layers of fuel assembly parts, placed in the following sequence:

- 108 spacers stacked in 12 layers of 9 spacers each in a 3 x 3 matrix (because the GE 8 x 8 BWR basis fuel assembly has 7 spacers each, the total of 108 spacers reflects the equivalent of 15.42 (i.e., 108/7) fuel assemblies);

- 15 upper tie plates (one per fuel assembly) in one layer of 9 in a 3 x 3 matrix, followed by 6 more placed upside down (handle side downwards) in a 2 x 3 matrix; and

- 15 lower tie plates (one per fuel assembly) arranged similarly to the upper tie plates.

Other remaining parts (springs, bolts, etc.) are assumed to fill in void spaces between the other pieces of hardware.

Each set of the above three layers takes up 40 in. of the total 160 in. of assumed useful storage height of the special container. Therefore, if one set of these three layers contains the hardware of 15 fuel assemblies, then one special container has a total storage capacity of

$$\frac{160}{40} \times 15 = 60 \text{ fuel assemblies' worth of miscellaneous hardware per special container.}$$

In summary, for every 18 fuel assemblies processed, one reference container plus 0.167 (10/60) special container is required. This means that one special container is required for every 108 (18/0.167) BWR fuel assemblies.

Table 4-1 shows the year-by-year spent fuel container emplacement schedule for Case 1 and the DHLW and WVHLW container emplacement schedule for all cases.

4.5 Underground Facility

Details of a typical container emplacement array for Case 1 (and Cases 3, 8, 9) are identical to what is described in the SCP-CDR (SNL, 1987) and are shown in Figure 4-9. The spacing between adjacent spent fuel and DHLW boreholes is 7.5 ft and is dictated by the mechanical properties of the tuff surrounding the holes. Because there are more spent fuel containers than DHLW and WVHLW containers, commingling is unnecessary in some of the emplacement drifts. In these drifts, alternative boreholes are omitted, and the spent fuel containers are emplaced on 15-ft centers.

The spacing between emplacement drifts and the standoff distance from the panel access drift to the first spent fuel emplacement hole were determined using thermal analyses.

Thermal power values for the Case 1 spent fuel container configurations are as follows:

• 3 intact PWR assemblies	1,578 W
• 6 consolidated PWR assemblies	3,156 W
• 6 intact BWR assemblies	1,002 W
• 18 consolidated BWR assemblies	3,006 W
• Hardware waste	insignificant

Drift spacings are based on average container heat output for the mix of wastes being emplaced within the panel. The maximum container heat output for the hottest container type is used to determine the minimum acceptable spacing between spent fuel boreholes.

TABLE 4-1

REPOSITORY THROUGHPUTS (CASE 1)

	MTU - First Repository			HLW Containers		Spent Fuel Containers												
							BWR						PWR					
	Spent							Assemblies		Disposal Containers				Assemblies		Disposal Containers		
Year	Fuel	HLW	Cum.	DHLW	WVHLW	MTU	MTU	Intact	Consol.	Intact	Consol.	Hdw.	MTU	Intact	Consol.	Intact	Consol.	Hdw.
2003	400	0	400	0	0	400	133	741	0	123	0	0	267	620	0	207	0	0
2004	400	0	800	0	0	400	133	741	0	123	0	0	267	620	0	207	0	0
2005	400	0	1200	0	0	400	133	741	0	123	0	0	267	620	0	207	0	0
2006	900	0	2100	0	0	900	300	787	880	131	49	8	600	659	736	220	123	0
2007	1800	0	3900	0	0	1800	600	870	2463	145	137	23	1200	729	2062	243	344	0
2008	3000	400	7300	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2009	3000	400	10700	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2010	3000	400	14100	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2011	3000	400	17500	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2012	3000	400	20900	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2013	3000	400	24300	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2014	3000	400	27700	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2015	3000	400	31100	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2016	3000	400	34500	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2017	3000	400	37900	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2018	3000	400	41300	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2019	3000	400	44700	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2020	3000	400	48100	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2021	3000	400	51500	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2022	3000	400	54900	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2023	3000	400	58300	680	28	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2024	3000	400	61700	0	188	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2025	3000	180	64880	0	84	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2026	2700	0	67580	0	0	2700	900	250	4750	42	264	44	1800	209	3977	70	663	0
2027	2420	0	70000	0	0	2420	807	224	4257	37	237	39	1613	188	3564	63	594	0
TOTALS	63020	6980	70000	12680	300	63020	21007	9354	107350	1559	5964	994	42013	7831	89874	2610	14979	0

Notes:

BWRs: 6 intact = 1 container
18 consolidated = 1 container

PWRs: 3 intact = 1 container
6 consolidated = 1 container

Hardware: 0 containers for each consolidated PWR fuel assembly
1 container for each 108 consolidated BWR fuel assembly

DHLW: 0.5 MTU = 1 container

WVHLW: 2.13 MTU = 1 container

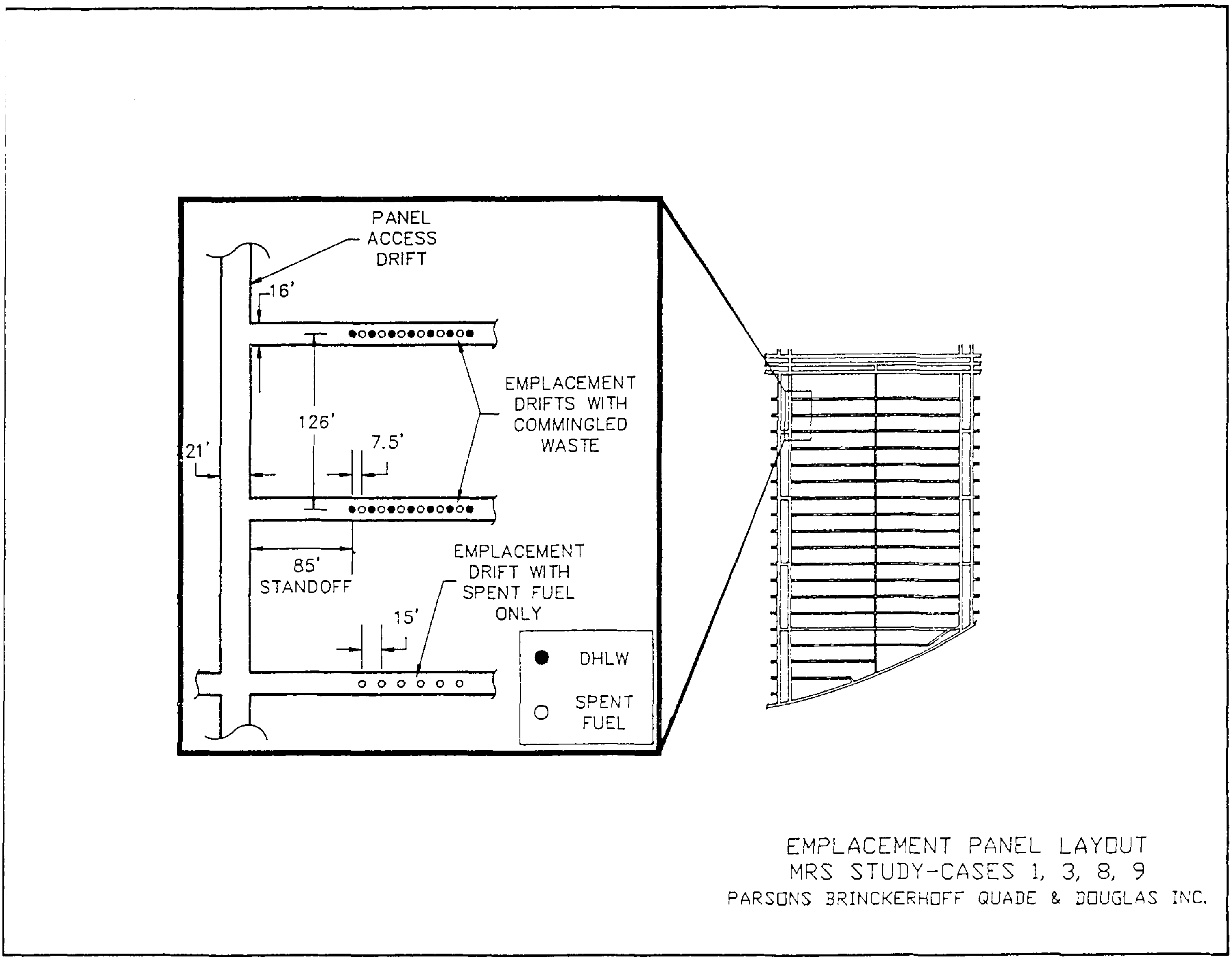


Figure 4-9. Emplacement Panel Layout (Case 1)

4.6 Cost and Schedule

4.6.1 Capital and Operating Costs

A summary of capital, operating, and decommissioning costs is given in Table 4-2.

Staffing requirements for the surface facilities for Case 1 are summarized in Table 4-3.

Staffing requirements for the underground facility for Case 1 are summarized in Table 4-4.

Further details of these estimates are included in Appendix B.

4.6.2 Construction Schedule

The construction schedule for Case 1 is the same as the construction schedule that was developed for the SCP-CDR. A summary bar chart covering the licensing, detailed design, and construction of the repository facilities for Case 1 is shown in Figure 4-10; the rationale for each activity of this schedule is explained in Table 4-5. Figure 4-11 shows a more detailed logic network for the construction of the waste-handling buildings; the rationale for each activity is explained in Table 4-6. A tabular presentation of the logic network is given in Table 4-7.

Assuming that licensing activities permit a construction authorization on January 31, 1998, the facilities will be ready to receive waste by January 2003.

As can be seen in Figure 4-10, the critical path after construction authorization is through the development of the underground facility, shown in Figure 4-12. In Cases 1 and 3, WHB-1 will be ready to accept waste 11 mo before the underground is ready. The WHB-1 construction schedule duration, including onsite and offsite preparation, is 48 mo. WHB-2 can be ready 6 mo after the underground is ready. The duration of the WHB-2 construction schedule is 66 mo, including onsite and offsite preparation. However, this second building is not needed to accept the rampup of waste receipt until 2006. As a practical matter, WHB-2 could be delayed for a period (to be determined later if necessary) without jeopardizing the repository operation.

On the other hand, in order to advance the date at which the initial waste can be received at the repository, the time for construction of the underground facility must be reduced.

The construction schedule for the underground facility, shown in Figure 4-12, covering the 60-mo period, from construction authorization to the first emplacement of waste, is the same for all nine cases. The schedule represents the most current design concepts.

For the underground facility, it is important to note that the schedules provided here differ in several respects from schedules published in earlier reports. Specific changes that affect the cost, effort, and duration of the construction include:

- adoption of a 2-shift/day, 250-day/yr work schedule versus the 3-shift/day schedule;

- use of mechanical mining methods (vertical mole) to excavate the men-and-material and emplacement exhaust shafts, as opposed to conventional drill and blast methods;

- use of exploratory drifts constructed during site characterization to provide early access to shaft sumps; and

- use of tunnel-boring machines to excavate the full length of each main drift during the construction phase as opposed to progressive development in sequence with adjacent emplacement panels.

The rationale behind each activity is given in Table 4-8.

TABLE 4-2

SUMMARY OF LIFE-CYCLE COSTS (CASE 1)
(in Millions of 1988 Constant Dollars[a])

Cost Category Description	Construction	Operations	Decommissioning	Total
Management and Integration				
Architect/Engineer	226	0	15	
Construction Management	77	0	3	
Other	57	54	4	
Subtotal	360	54	22	436
Surface Facilities				
Site	178	114	41	
High-Level Waste-Handling Facilities	449	1,240[b]	30	
Other Waste-Handling Facilities	46		4	
Balance of Plant	138	1,286	50	
Subtotal	811	2640	125	3576
Subsurface Facilities				
Shafts and Ramps	65	31	3	
Excavation and Emplacement	143	879	108	
Service Systems	100	865	146	
Subtotal	308	1,775	257	2,340
Total w/o Disposal Containers	1,479	4,469	404	6,352
Disposal Containers				
Spent Fuel	0	728	0	
DHLW	0	215	0	
Other	0	155	0	
Subtotal	0	1,098	0	1,098
Total	1,479	5,567	404	7,450

a. Unescalated for the life of the repository.
b. Includes cost of operations for all waste-handling facilities.

TABLE 4-3

STAFFING REQUIREMENTS: SURFACE FACILITIES (CASE 1)

Facility	Staff
Waste-Handling Building 1	19
Waste-Handling Building 2	179
Waste Treatment Building	9
Vehicle Wash Facility	0 *
Decontamination Building	0 *
Performance Confirmation Building	17
Health Physics Station 4	0 *
Medical Center	12
Fire Station/Emergency Center	15
Security Station 1	35
Security Station 2/Health Physics Station 3	19
Security Station 3	25
Men-and-Material Shaft Security Station	4
Shops	85
Motor Pool/Facilities Sewage Station	16
Transporter Garage	30
Administration Building	161
Food Services Facility	24
Mockup Building	6
Central Warehouse	17
Visitors Center	3
Change House	0
Computer Building	50
Concrete Batch Plant and Aggregate Storage	4
Tuff Pile	4
Total Full Time Personnel	734

* Assigned only as required.

TABLE 4-4

STAFFING REQUIREMENTS: UNDERGROUND FACILITY (CASE 1)

Category	Staff
Shafts and Ramps	12
Drift Excavation	110
Emplacement Borehole Drilling and Lining	68
Emplacement/Retrieval Operations	15
Support Services	240
Total, Subsurface	445

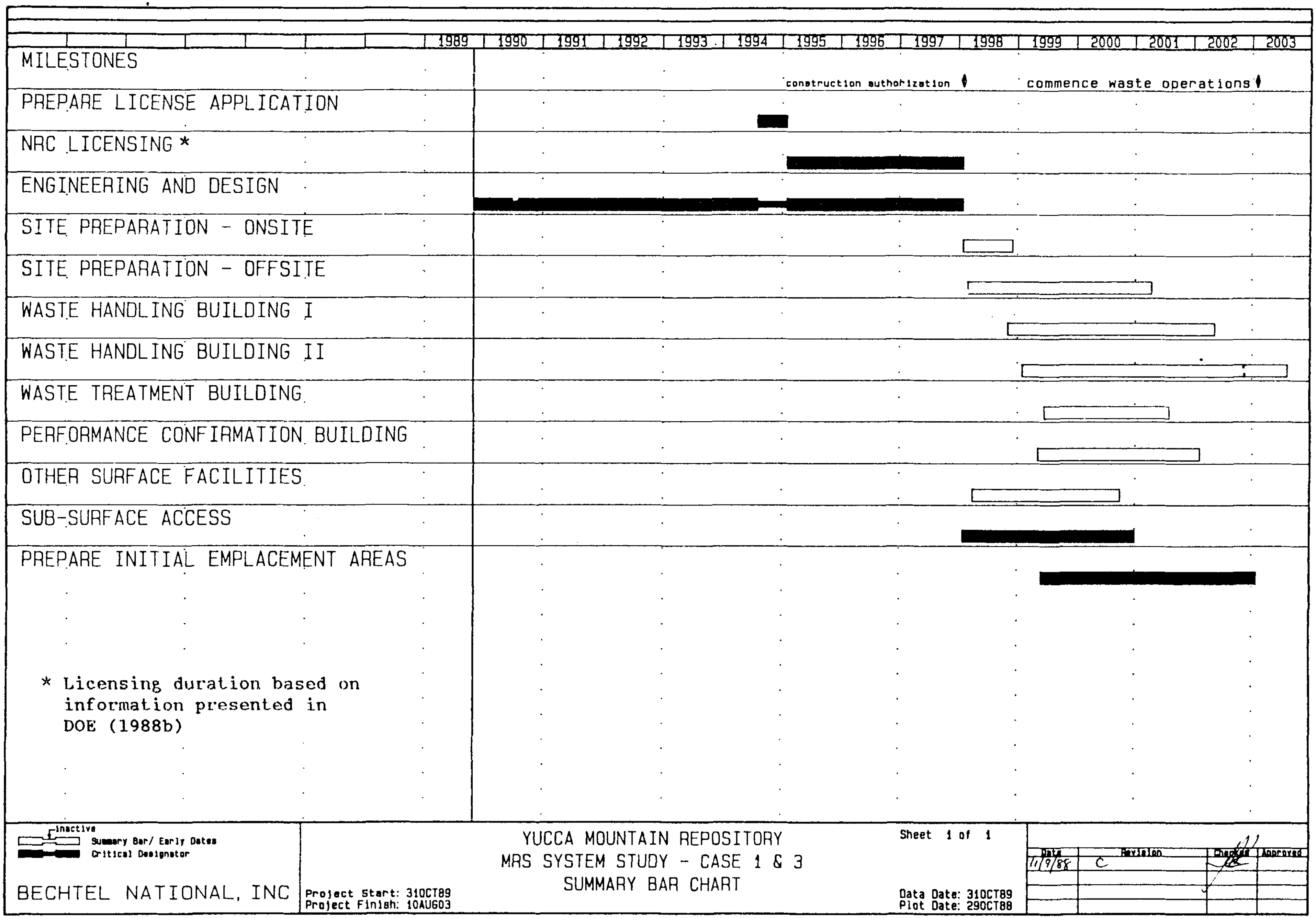


Figure 4-10. Construction Schedule Summary (Case 1)

TABLE 4-5

SUMMARY BAR CHART ACTIVITY DESCRIPTION--CASES 1 AND 3

Activity Number	Title	Duration Calendar Days	General Description	Constructed Quantity and Daily Rate	Other
None	Milestones	0	Shows timing of "Construction Authorization" and "Commence Waste Operations"	NA	These data are given as described in Subsection 3.3
None	Prepare License Application	184	Shows time required, after license application design phase, to prepare the NRC license application	6 mo	
None	NRC Licensing	1095	Period for NRC to review the repository license application	36 mo	Licensing duration based on information presented in DOE (1988b)
None	Engineering and Design	2829	Summary of engineering activities: - advanced conceptual design - license application design - final procurement and construction design	 822 days 912 days 1095 days	These engineering activities are consecutive, with an interruption of 184 days during preparation of license application
None	Site Preparation—Onsite	304	Summary of construction facility erection and site development	NA	Based on more detailed schedule
None	Site Preparation—Offsite	1140	Summary of offsite preparation activities: road, utilities, railroad, bridges	NA	Based on more detailed schedule
None	Waste-Handling Building 1	1200	Summary of WHB-1 activities	NA	See Table 4-6 for details of these activities
None	Waste-Handling Building 2	1653	Summary of WHB-2 activities	NA	See Table 4-6 for details of these activities
None	Waste Treatment Building	757	Summary of waste treatment building activities	NA	Based on more detailed schedule
None	Performance Confirmation Building	964	Summary of performance confirmation building activities	NA	Based on more detailed schedule
None	Other Surface Facilities	909	Summary of schedules for construction of other surface facilities	NA	Based on more detailed schedule
None	Subsurface Access	575	Summary of subsurface access activities	NA	Based on PBQ&D detailed schedule
None	Initial Emplacement Areas	1250	Summary of emplacement area excavation	NA	Based on PBQ&D detailed schedule

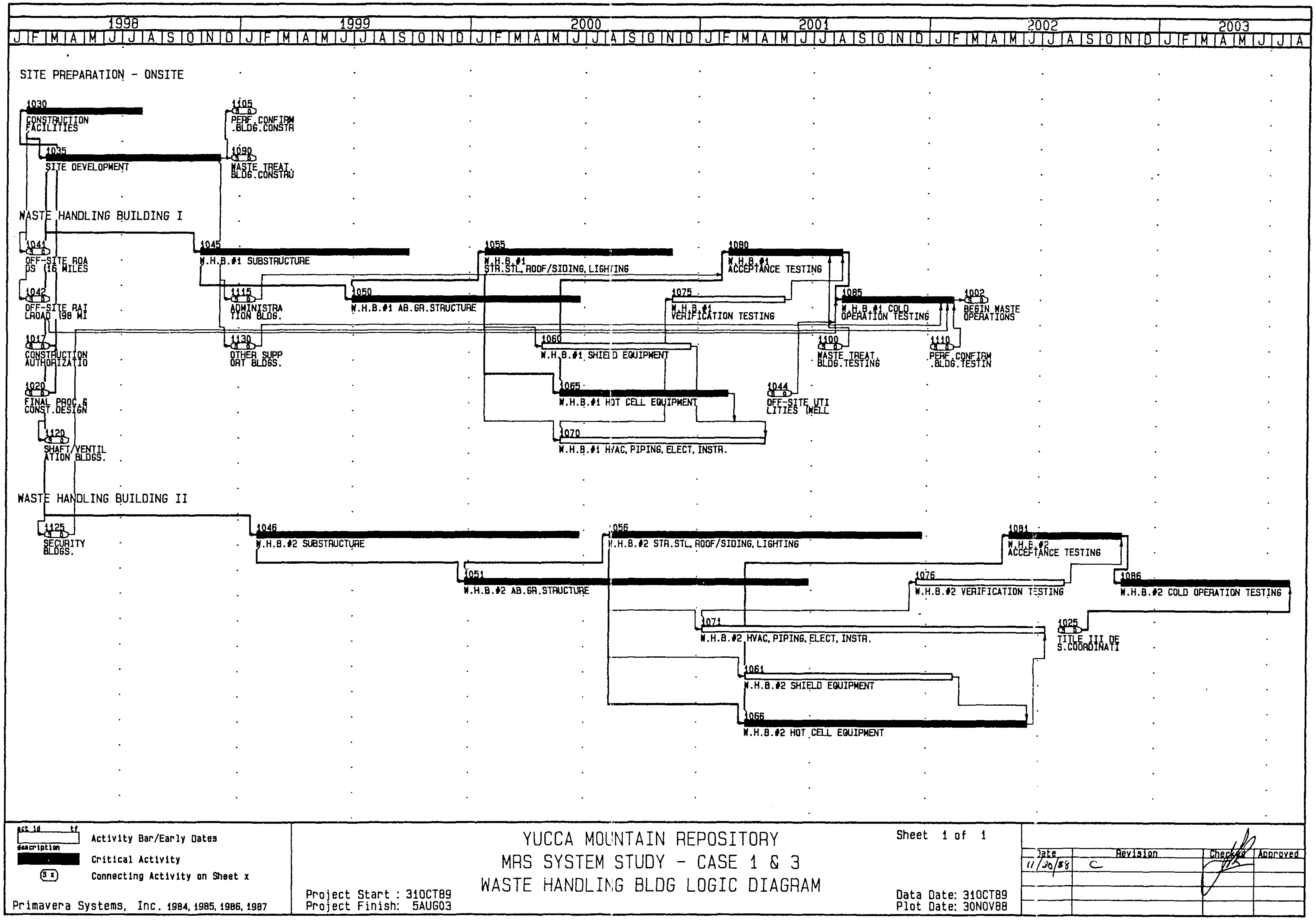


Figure 4-11. Logic Network for the Construction of the Waste-Handling Buildings

TABLE 4-6

WASTE-HANDLING BUILDING LOGIC DIAGRAM ACTIVITY DESCRIPTION--CASES 1 AND 3

Activity Number	Title	Duration Calendar Days	General Description	Constructed Quantity and Daily Rate	Other
1030	Construction Facilities	182	Period for erection of temporary facilities	Allowance	Based on similar historical experience
1035	Site Development	274	Period for rough grading, site roads, utilities	Allowance	Based on historical records, 1 mo after commencement of construction facilities
Waste-Handling Building 1					
1045	WHB-1 Substructure	330	Period for structure excavation and concrete work for foundations	Summary	Based on more detailed schedules
1050	WHB-1 Aboveground Structure	360	Period for construction of concrete structure above ground	Summary	Based on more detailed schedules
1055	Structured Steel, Roof, Siding, Lighting	300	Period for construction of steel structure, enclosure, and interior lighting	Summary	Based on more detailed schedules
1070	HVAC, Piping, Electrical, Instrumentation	330	Period for installation of mechanical, piping, and electrical power systems	Summary	Based on more detailed schedules
1060	Shield Equipment	240	Period for installation of shielded area penetrations, doors, windows, etc.	Summary	Based on more detailed schedules
1065	Hot Cell Equipment	270	Period for installation of equipment in hot-cell areas	Summary	Based on more detailed schedules
1075	Verification Testing	180	Period for contractor testing	6 mo	Allowance based on historical experience with similar facility
1080	Acceptance Testing	180	Period for DOE and NRC testing	6 mo	Allowance based on historical experience with similar facility
1085	Cold Operations	179	Period for training by operations staff	6 mo	Allowance based on historical experience with similar facility
1002	Begin Waste Operations	0	Milestone indicating completion of all construction and testing activities	--	WHB-1 begins operation

TABLE 4-6

WASTE-HANDLING BUILDING LOGIC DIAGRAM ACTIVITY DESCRIPTION--CASES 1 AND 3
(Concluded)

Activity Number	Title	Duration Calendar Days	General Description	Constructed Quantity and Daily Rate	Other
Waste-Handling Building 2					
1046	WHB-2 Substructure	510	Period for structure excavation and concrete work for foundations	Summary	Based on more detailed schedules
1051	WHB-2 Aboveground Structure	550	Period for construction of concrete structure above ground	Summary	Based on more detailed schedules
1056	Structured Steel, Roof, Siding, Lighting	499	Period for construction of steel structure, enclosure, and interior lighting	Summary	Based on more detailed schedules
1071	HVAC, Piping, Electrical, Instrumentation	549	Period for installation of mechanical, piping, and electrical power systems	Summary	Based on more detailed schedules
1061	Shield Equipment	330	Period for installation of shielded area penetrations, doors, windows, etc.	Summary	Based on more detailed schedules
1066	Hot Cell Equipment	450	Period for installation of equipment in hot cell areas	Summary	Based on more detailed schedules
1076	Verification Testing	240	Period for contractor testing	8 mo	Allowance based on historical experience with similar facility
1081	Acceptance Testing	180	Period for DOE and NRC testing	6 mo	Allowance based on historical experience with similar facility
1086	Cold Operations	269	Period for training by operations staff	9 mo	Allowance based on historical experience with similar facility
1002	Begin Waste Operations	0	Milestone indicating completion of all construction and testing activities	--	WHB-2 begins operation

TABLE 4-7

CONSTRUCTION SCHEDULE FOR THE WASTE-HANDLING BUILDING

Item	Duration (mo)	Cases 1 and 3 Start	Cases 1 and 3 Finish
Waste-Handling Building 1			
Substructure	11	Oct 98	Sep 99
Aboveground Structure	12	Jun 99	Jun 00
Steel, Roofing, Siding	10	Jan 00	Nov 00
Shield Equipment	8	Apr 00	Dec 00
HVAC, Piping, Electrical, Instrumentation	11	May 00	Apr 01
Hot Cell Equipment	9	May 00	Feb 01
Verification Testing	6	Nov 00	May 01
Acceptance Testing	6	Feb 01	Aug 01
Cold Operation	6	Aug 01	Feb 02
Ready to Accept Waste	-	Feb 02	
Waste-Handling Building 2			
Substructure	17	Jan 99	Jun 00
Aboveground Structure	18	Dec 99	Jun 01
Steel, Roofing, Siding	17	Jul 00	Dec 01
HVAC, Piping, Electrical, Instrumentation	19	Dec 00	Jul 02
Hot Cell Equipment	15	Mar 01	Jun 02
Shield Equipment	11	Mar 01	Feb 02
Verification Testing	9	Nov 01	Aug 02
Acceptance Testing	6	Apr 02	Oct 02
Cold Operation	9	Oct 02	Jul 03
Ready to Accept Waste	-	Aug 03	

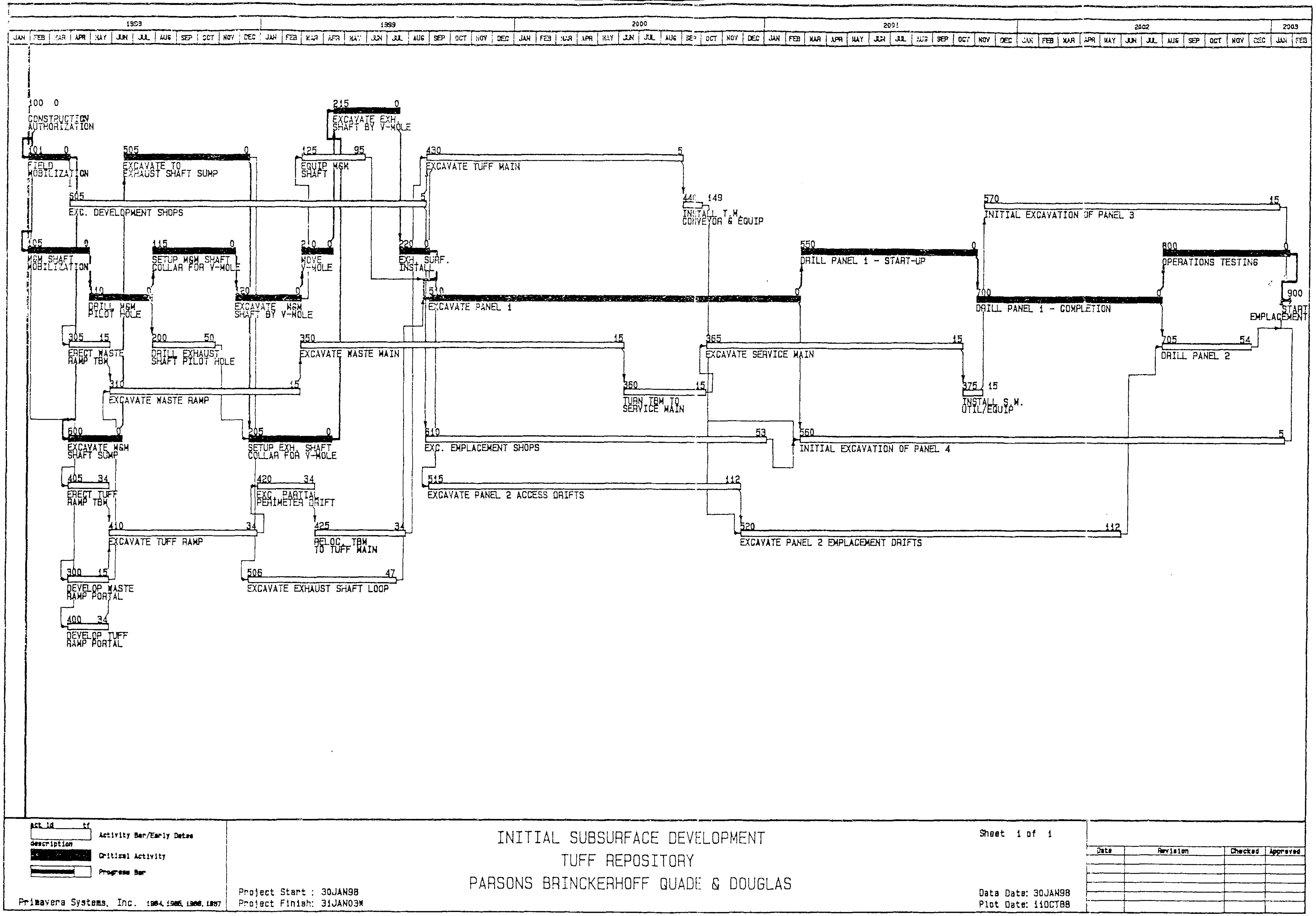


Figure 4-12. Construction Schedule for Underground Facility

TABLE 4-8

INITIAL UNDERGROUND CONSTRUCTION

Activity Number	Title	Duration Calendar Days	General Description	Constructed Quantity and Daily Rate	Other
100	Construction Authorization	1	Authorization to proceed with construction of underground facility		
101	Field Mobilization	60	General mobilization period to provide temporary power and water and establish field offices, shops, and change facilities; increase staff and provide necessary training.	Allowance	
105	M&M Shaft Mobilization	91	Mobilize men and equipment for pilot drill and V-Mole. Construct drill pad.	Allowance	
110	Drill M&M Pilot Hole	90	Drill pilot hole for V-Mole from collar to shaft sump	Allowance 1,090 ft	
115	Set Up M&M Shaft Collar for V-Mole	120	Preliminary excavation and equipment installation necessary for V-Mole operation.	Allowance	V-Mole concept is currently under investigation. Previous schedules have been based on conventional shaft-sinking methods.
120	Excavate M&M Shaft by V-Mole	95	Operate V-Mole	Allowance 1,090 ft	Cuttings are collected at sump and removed via ES-2.
125	Equip M&M Shaft	90	Install required shaft fixtures buntons, hoist guides, utility lines, etc.	Allowance	
200	Drill Exhaust Shaft Pilot Hole	90	Drill pilot hole for V-Mole from collar to sump.	Allowance 1,040 ft	

TABLE 4-8

INITIAL UNDERGROUND CONSTRUCTION
(Continued)

Activity Number	Title	Duration Calendar Days	General Description	Constructed Quantity and Daily Rate	Other
205	Set Up Exhaust Shaft Collar for V-Mole	120	Preliminary excavation and equipment installation necessary for V-Mole operation.	Allowance	
210	Move V-Mole	45	Move in V-Mole from men-and-materials shaft sump.	Allowance	
215	Excavate Exhaust Shaft by V-Mole	95	Operate V-Mole; excavate from collar to sump.	Allowance 1,060 ft	V-Mole concept is currently under investigation. Previous schedules have been based on conventional shaft-sinking methods.
220	Exhaust Shaft Surface Installation	45	Install equipment and fixtures at surface of exhaust shaft.	Allowance	
300	Develop Waste Ramp Portal	61	Preliminary excavation and construction of waste ramp portal.	Allowance	Drill and blast used to excavate areas to begin TBM.
305	Erect Waste Ramp TBM	61	TBM is erected, and the conveyor system and surface muck haulage facilities are installed.	Allowance	
310	Excavate Waste Ramp	274	Operate TBM	35 ft/day 6,603 ft	SCP-CDR has waste ramp at 23-ft diameter. This case assumes 25-ft diameter ramp.
350	Excavate Waste Main	468	Excavate waste main from base of waste ramp to south end of repository	35 ft/day 11,200 ft	SCP-CDR assumes only 4,900 ft is driven during construction phase and remainder during operations phase.

TABLE 4-8

INITIAL UNDERGROUND CONSTRUCTION
(Continued)

Activity Number	Title	Duration Calendar Days	General Description	Constructed Quantity and Daily Rate	Other
360	Turn TBM to Service Main	122	Excavate area required for reorientation of TBM to proceed up service main from south end of the repository to the north.	Allowance	Service main is excavated by drill-and-blast methods in SCP-CDR.
365	Excavate Service Main	372	Excavate service main from south end northward to development shops.	35 ft/day 8,920 ft	
375	Install Service Main Utilities/ Equipment	30	Install power, piping, water, and communication lines in service main.	Allowance	
400	Develop Tuff Ramp Portal	61	Perform preliminary excavation and construction of tuff ramp portal.	Allowance	Drill and blast used to develop
405	Erect Tuff Ramp TBM	61	TBM is erected, and the conveyor system and surface muck haulage facilities are installed.	Allowance	
410	Excavate Tuff Ramp	213	Operate TBM	35 ft/day 5,070 ft	
420	Excavation Partial Perimeter Drift	83	TBM from tuff ramp continues in perimeter drift to Panel 2 north panel access drift.	35 ft/day 2,000 ft	Great speed of TBM is used to provide early development of Panel 1.
425	Relocate TBM to Tuff Main	130	TBM in perimeter drift is relocated to tuff main.	Allowance	SCP-CDR design assumes that same TBM is used to drive entire perimeter drift.

TABLE 4-8

INITIAL UNDERGROUND CONSTRUCTION
(Continued)

Activity Number	Title	Duration Calendar Days	General Description	Constructed Quantity and Daily Rate	Other
430	Excavate Tuff Main	372	Excavate tuff main from Ghost Dance exploratory drift to south end of repository.	35 ft/day 8,920 ft	Tuff main is excavated by drill and blast in SCP-CDR.
440	Install Tuff Main Conveyor and Equipment	30	Install required equipment and conveyor in tuff main.	Allowance	
505	Excavate to Exhaust Shaft Sump	182	Drill and blast development of exhaust shaft sump.	10 ft/day	Cuttings from V-Mole are collected at sump.
506	Excavate Exhaust Shaft Loop	213	Drill and blast development of exhaust shaft loop	10 ft/day 2,700 ft	Connects exhaust shaft sump with perimeter drift.
510	Excavate Panel 1	541	Drill and blast development of Panel 1 panel access and emplacement drifts	10 ft/day/crew 6,370 ft	2 crews required
515	Excavate Panel 2 Access Drifts	456	Drill and blast development of Panel 2 panel access and emplacement drift stubs	10 ft/day/crew 10,050 ft	2 crews required
520	Excavate Panel 2 Emplacement Drift	552	Drill and blast development of Panel 2 emplacement drifts.	11.35 ft/day 12.09 ft/day 7,920 ft	Multiple heading development rates for 1 crew working in 3 emplacement drifts. Dual rates from Access Study (in progress) drift development module.
550	Drill Panel 1 -- Startup	255	Begin borehole drilling operations. Gradual increase in borehole drilling rate (holes/day)	Pilot: 4.5 hr/hole Reamer: 6.08 hr/hole 432 holes	Crew buildup: 2 crews to 6 crews. 0.5 hole/day to 4 holes/day

TABLE 4-8

INITIAL UNDERGROUND CONSTRUCTION
(Continued)

Activity Number	Title	Duration Calendar Days	General Description	Constructed Quantity and Daily Rate	Other
560	Initial Excavation of Panel 4	700	Begin drill and blast development of Panel 4 panel access drifts and emplacement drift stubs.	10 ft/day/crew	2 crews required
570	Initial Excavation of Panel 3	425	Begin drill and blast development of Panel 3 panel access drifts and emplacement drift stubs.	10 ft/day/crew	2 crews required
600	Excavate M&M Shaft Sump	79	Drill and blast excavation of men-and-materials shaft access ramp to sump.	10 ft/day/crew 550 ft	Cuttings from V-Mole are collected at sump. 1 crew required.
605	Excavate Development Shops	516	Drill and blast development of development shop areas.	10 ft/day/crew 3,140 ft	Treated as single heading. 1 crew required.
610	Excavate Emplacement Shops	498	Drill and blast development of emplacement shop areas.	10 ft/day/crew 3,265 ft	Treated as single heading. 1 crew required.
700	Drill Panel 1 -- Completion	270	Pilot and ream vertical emplacement boreholes.	Pilot: 4.5 hr/hole Reamer: 6.08 hr/hole 432 holes (cont)	6 crews, 4 holes/day
705	Drill Panel 2	126	Pilot drill and ream vertical emplacement boreholes.	Pilot: 4.5 hr/hole Reamer: 6.08 hr/hole 1,247 holes	Panel 2 is completed before first emplacement. 6 crews; 4 holes/day

TABLE 4-8

INITIAL UNDERGROUND CONSTRUCTION
(Concluded)

Activity Number	Title	Duration Calendar Days	General Description	Constructed Quantity and Daily Rate	Other
800	Operations Testing	180	Complete testing of emplacement operations in underground facility.		Dry runs are performed using inert containers.
900	Start Emplacement	0	Begin waste emplacement of Panel 1.		

5.0 CASE 2

For Case 2, there is no MRS. All SNF is shipped directly to the repository, where it is containerized intact for emplacement. There is no consolidation at the repository. DHLW and WVHLW are received in canisters at the repository and then containerized for emplacement.

Case 2 of this study is similar to the RCS Case 2 design, except that the number of cask unloading bays in the waste-handling building is reduced because of the difference in the number of rail/truck shipments, the cask capacities, the ratio of BWR to PWR assemblies, and the assumed MTU per BWR and PWR assembly. For the RCS Case 2 design, the number of rail/truck shipments, the cask capacities, the ratio of BWR to PWR assemblies, and the assumed MTU per BWR and PWR assembly are the same as those for the SCP-CDR design. For Case 2 of this study, these parameters are the same as those for Case 1 of this study.

5.1 Assumptions

In addition to the general assumptions stated in Section 3, the following specific assumptions apply to Case 2:

- The shipment of SNF from the reactors to the repository is 55% by rail and 45% by truck.
- There are 48 intact BWR SNF assemblies per rail cask shipped from the reactors to the repository.
- There are 7 intact BWR SNF assemblies per truck cask shipped from the reactors to the repository.
- There are 21 intact PWR SNF assemblies per rail cask shipped from the reactors to the repository.

- There are 3 intact PWR SNF assemblies per truck cask shipped from the reactors to the repository.

- There are 10 intact BWR SNF assemblies per BWR container.

- There are 4 intact PWR SNF assemblies per PWR container.

- There are 4 intact BWR SNF assemblies per hybrid container and 3 intact PWR SNF assemblies per hybrid container. (A hybrid container contains 4 BWR and 3 PWR assemblies.)

- Use of the hybrid container is preferred. After all of the BWR assemblies (along with the PWR assemblies) have been packaged in the hybrid containers, the remaining PWR assemblies are packaged in PWR containers (hybrid containers can accommodate all of the BWR assemblies, but not all of the PWR assemblies).

5.2 Waste Received

The annual and total quantities of SNF and other high-level waste received at the repository during its 25 yr of operation are shown in Table 3-1. As can be seen from this table, the maximum annual quantity of SNF received when the repository is operating at full receipt capacity is 3,000 MTU/yr. One-third, or 1,000 MTU, of this is BWR fuel; two-thirds, or 2,000 MTU, is PWR fuel. A total of 55% of the fuel is shipped to the repository by rail and 45% by truck. All of this SNF is shipped as intact fuel assemblies directly from the nuclear reactors to the repository.

At 0.18 MTU per BWR assembly, there are 3,056 BWR assemblies per year shipped to the repository by rail and 2,500 BWR assemblies per year shipped to the repository by truck.

The capacity of a BWR rail cask is 48 assemblies. Thus, there are 64 rail casks of BWR fuel received at the repository per year. The capacity of a BWR truck cask is 7 assemblies. Thus, there are 357 truck casks of BWR fuel received at the repository per year.

At 0.43 MTU per PWR assembly, there are 2,558 PWR assemblies per year shipped to the repository by rail, and 2,093 PWR assemblies per year shipped to the repository by truck.

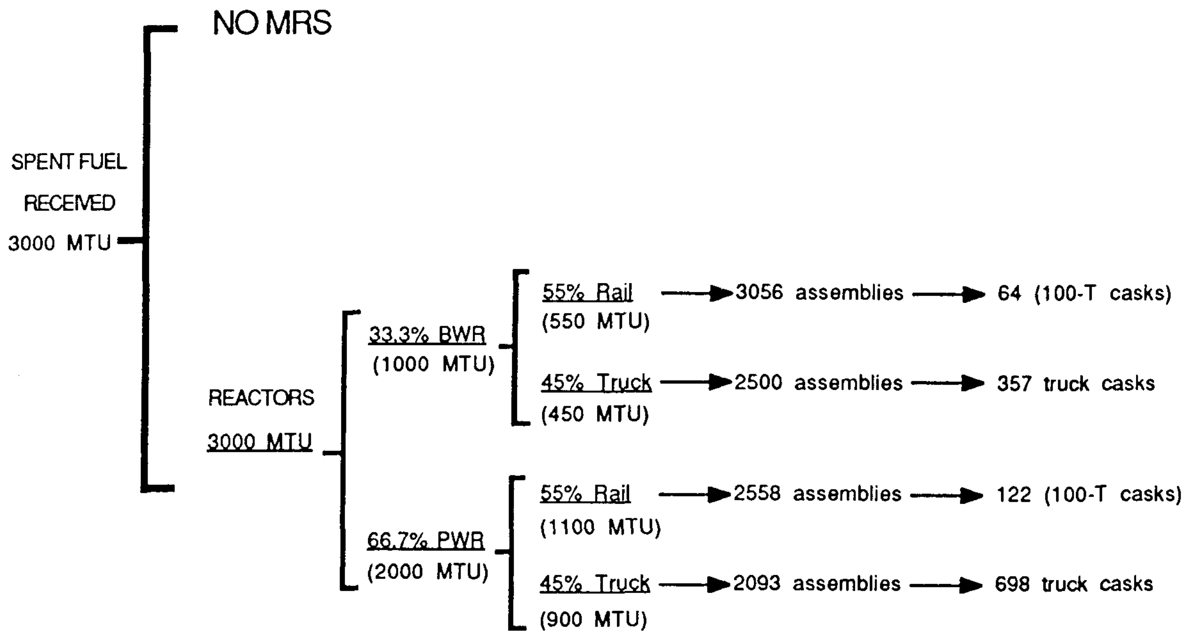
The capacity of a PWR rail cask is 21 assemblies. Thus, there are 122 rail casks of PWR fuel received at the repository per year. The capacity of a PWR truck cask is 3 assemblies. Thus, there are 698 truck casks of PWR fuel received at the repository per year.

The annual throughputs (at full receipt capacity) for Case 2 are summarized in Figure 5-1. The calculations for the quantities shown in this figure are provided in Appendix A.

5.3 Surface Facilities

The surface facilities for Case 2 of this study are similar to the surface facilities in the SCP-CDR design, except there is one waste-handling building for Case 2 of this study and two waste-handling buildings in the SCP-CDR design. The waste-handling building for Case 2 of this study is essentially the same as the waste-handling building in the RCS Case 2 design, except for a reduction in the number of required cask-unloading bays. The plot plan, which is essentially the same for both designs, is provided in Figure 5-2.

Figure 5-3 is a markup of the RCS Case 2 waste-handling building with three cask-unloading bays deleted to reflect the requirements for the Case 2 waste-handling building. The sole purpose of this markup is to show deleted building volume for cost-estimating purposes. This should not be interpreted as a technical representation of how the design of the building with the reduced volume and areas would actually be developed. The building has seven cask-receiving bays; one cask-unloading cell for spent fuel, with five floor ports, two welding and inspection stations, and two decontamination chambers; and a separate cask-unloading cell for DHLW and WVHLW, with two floor ports, one welding and



NON-SPENT FUEL RECEIVED

DHLW :	MTU's	400
	Canisters	800
	Rail Casks	160
MRS Hardware :	Drums	0
	Canisters	0
	Rail Casks	0

CASK CAPACITIES (ASSEMBLIES)

MRS ALL RAIL:	BWR intact	N/A
	BWR consol.	N/A
	PWR intact	N/A
	PWR consol.	N/A
REACTOR:	BWR rail	48
	BWR truck	7
	PWR rail	21
	PWR truck	3
HARDWARE:	rail	N/A
DHLW:	rail	5 canisters

EMPLACEMENT OPERATIONS	NO. CONTAINERS	NO. ASSEMBLIES/ CONTAINER
BWR/PWR-mixed (Intact)	1389	4/3
BWR (Intact)	0	N/A
PWR (Intact)	121	4
Hardware	0	N/A
DHLW	800	1 canister
TOTAL	2310	

Figure 5-1. Repository Annual Throughputs (Case 2)

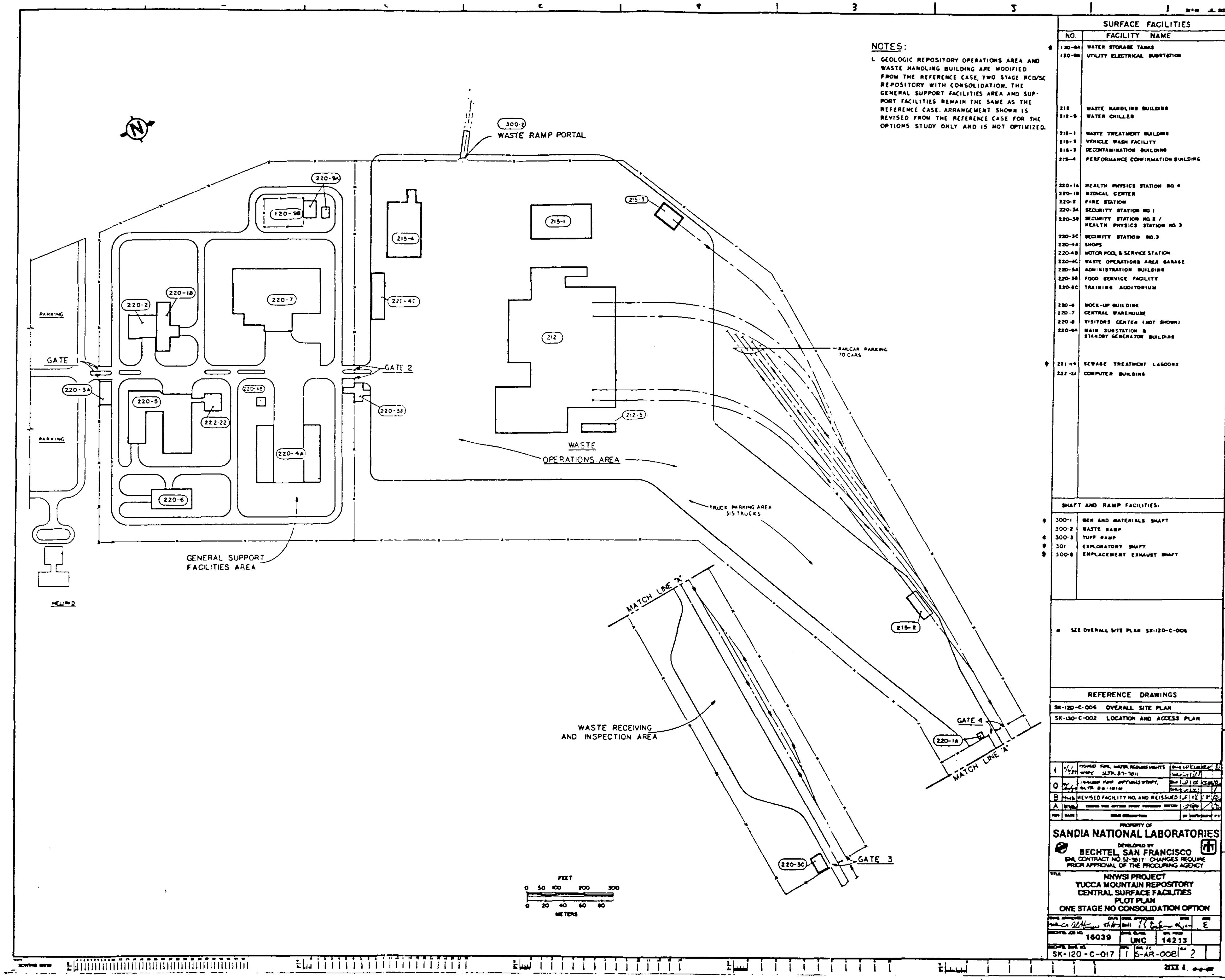


Figure 5-2. Repository Plot Plan (Case 2)

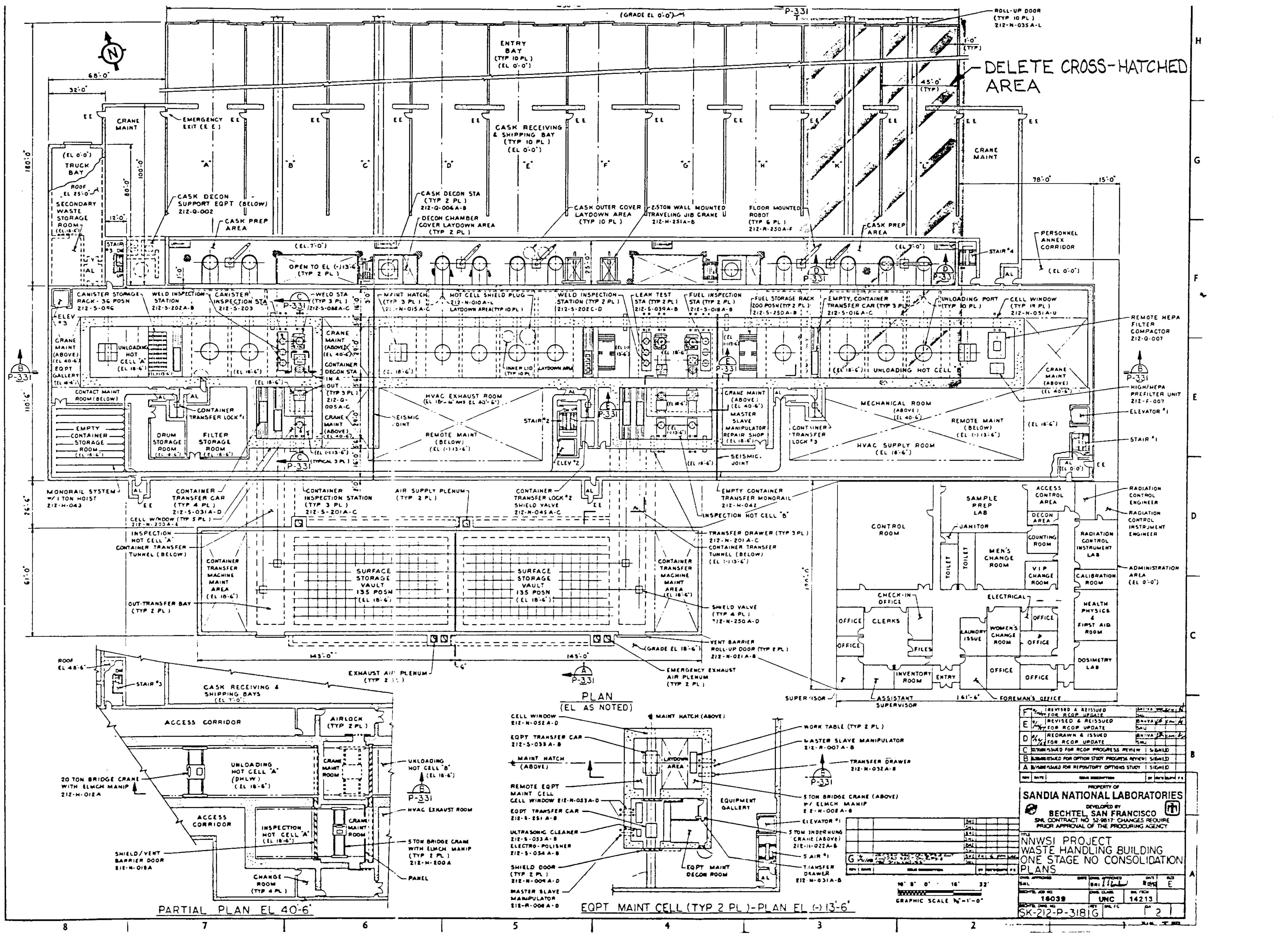


Figure 5-3. Waste Handling Building Layout (Case 2)

inspection station, and one decontamination chamber. Because the number of spent fuel containers is larger without consolidation, the Case 2 surface storage vault holds more waste containers than the combined capacities of the WHB-1 and WHB-2 storage vaults for Case 1.

Waste-handling building operational procedures are similar to those for the Case 1 WHB-2, but without consolidation. The DHLW and WVHLW material flow diagram for Case 2, shown in Figure 5-4, is the same as that for Case 1. The SNF material flow diagram for Case 2 is shown in Figure 5-5. This diagram is a markup of the WHB-2 material flow diagram taken from the SCP-CDR.

5.4 Disposal Containers

For Case 2, the YMP hybrid container shown in Figure 5-6 takes advantage of the relatively low thermal power density of the unconsolidated fuel through efficient packaging of mixed PWR and BWR assemblies. The 28-in.-diameter 187.5-in.-long container holds 3 intact PWR assemblies and 4 intact BWR assemblies.

Approximately 55% of the fuel assemblies are BWR assemblies. The packing ratio of 4 BWR assemblies to 3 PWR assemblies results in extra PWR assemblies. These are packaged in special PWR containers (of the same external dimensions) that hold 4 intact PWR assemblies. Without consolidation, of course, there is no hardware waste.

Under normal conditions, the waste-handling building has sufficient front-end storage capacity to ensure that PWR and BWR assemblies are always available for fully loading the hybrid containers. A container that holds 10 intact BWR assemblies or 4 intact PWR assemblies would be used only in the event that PWR or BWR assemblies are not available to fill a hybrid container.

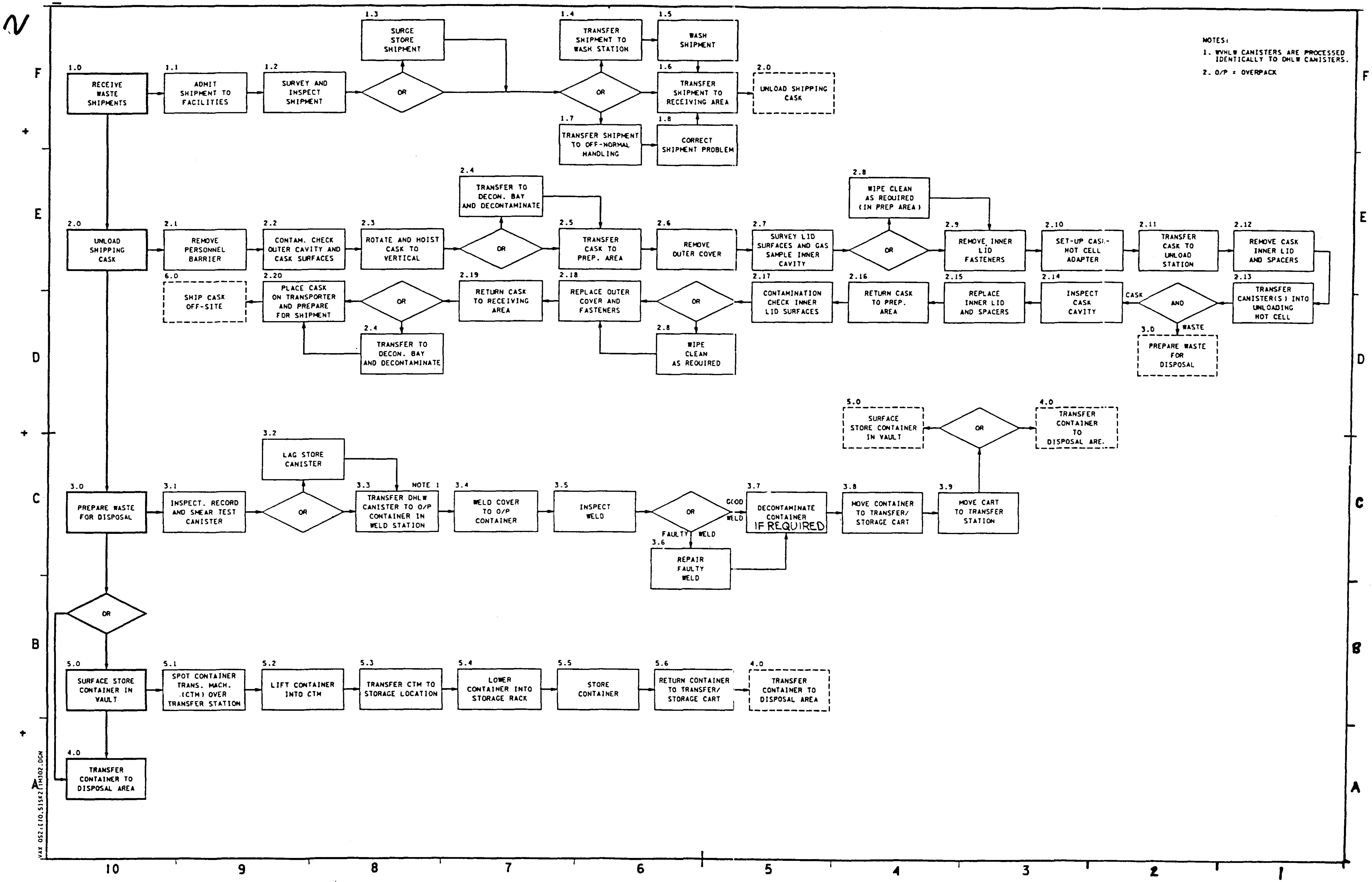


Figure 5-4. Material Flow Diagram for DHLW and WVHLW (Case 2)

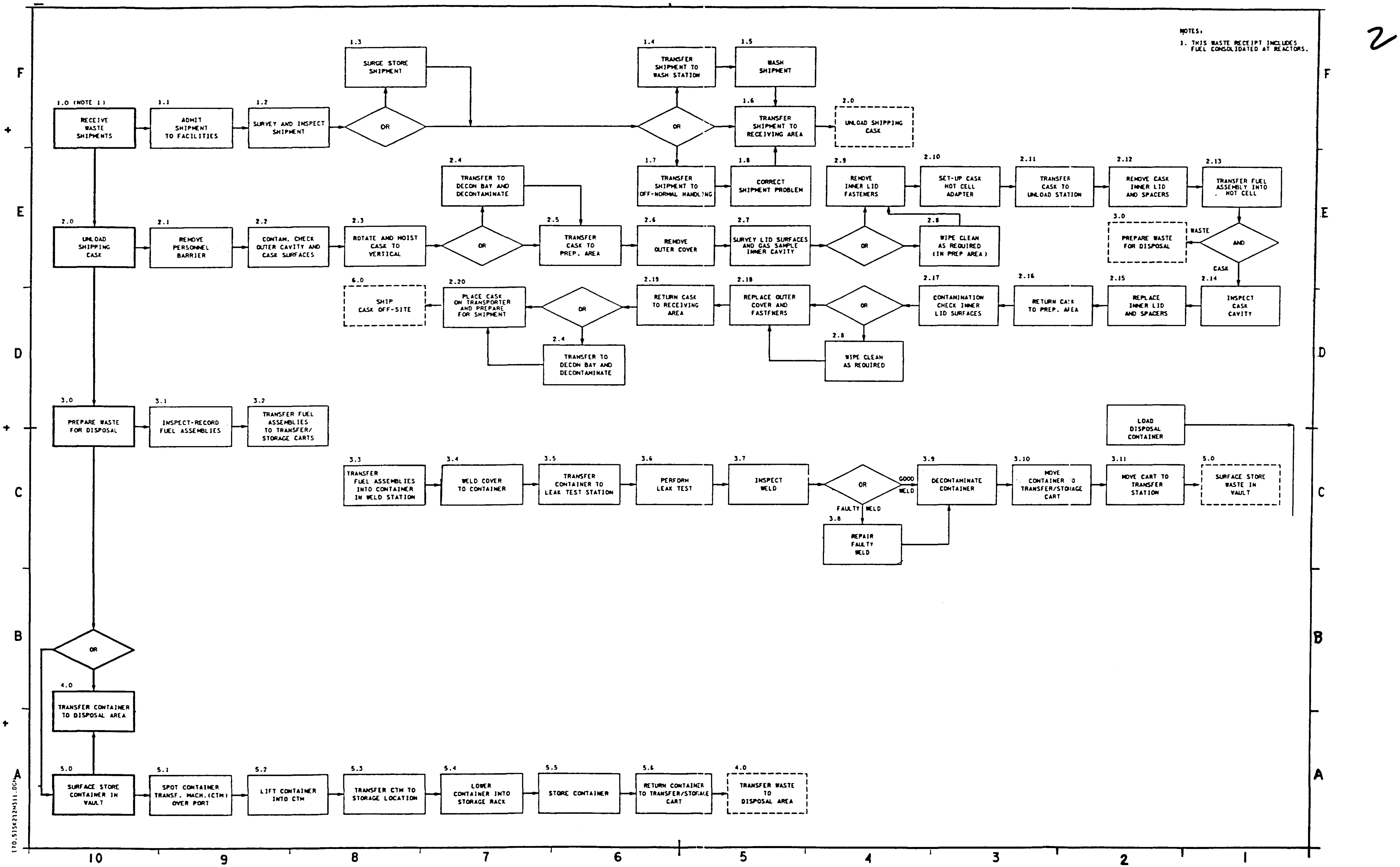


Figure 5-5. Material Flow Diagram for SNF (Case 2)

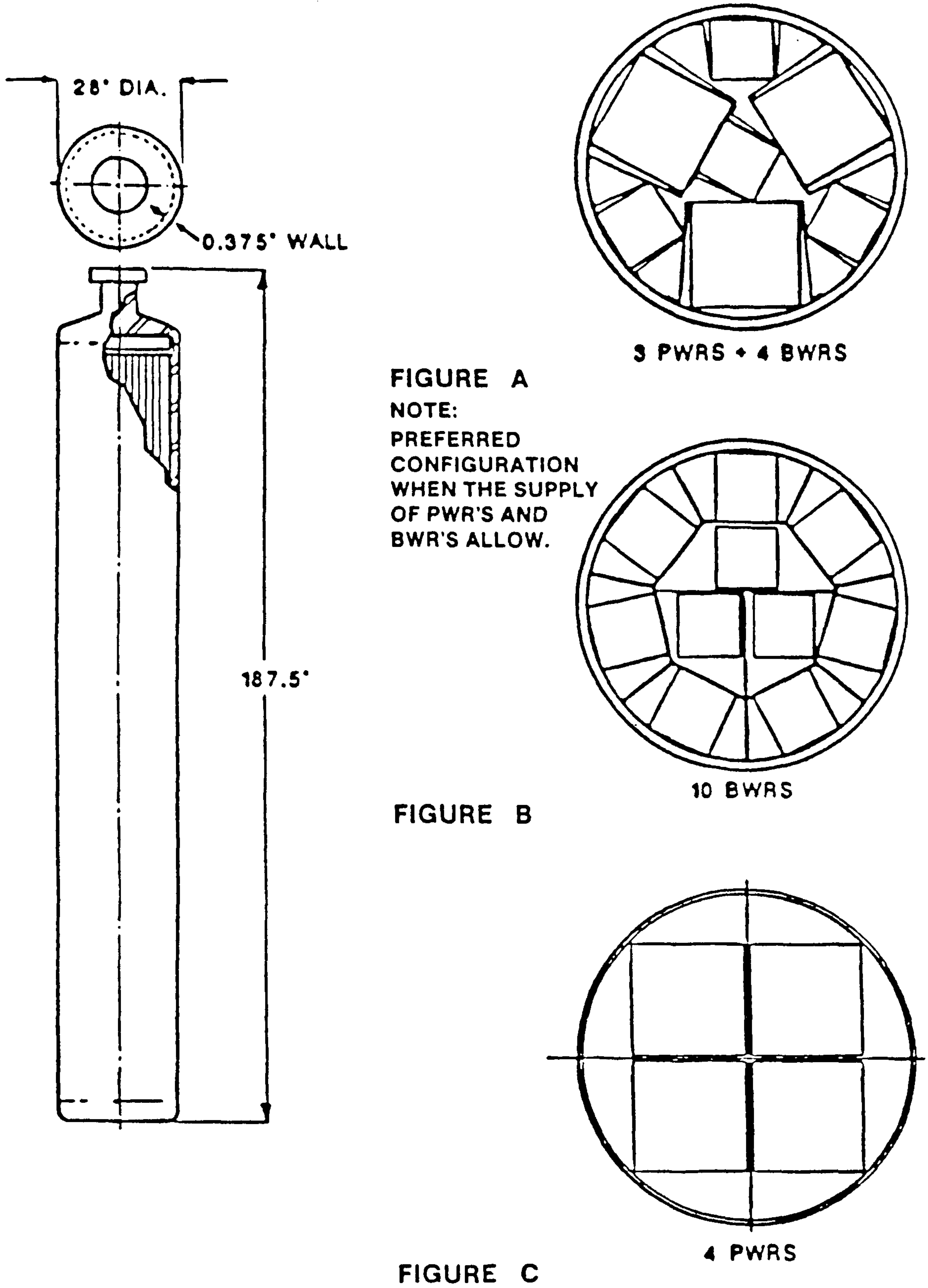


Figure 5-6. Intact Fuel Containers (Case 2)

A significant advantage of the hybrid containers over containers containing consolidated fuel assemblies is that, because of the low thermal power values, there is considerable margin for loading high-burnup fuel and fuel with short cooling times, without exceeding the 3,500 W limit assumed for this study. The higher thermal loadings would of course have to be considered in designing the underground disposal panels.

The spent fuel container emplacement schedule for Case 2 is shown in Table 5-1. Over the 25 yr period from 2003 through 2027, 31,720 spent fuel containers (and 12,980 DHLW and WVHLW containers) are emplaced.

5.5 Underground Facility

Dimensional details of the underground disposal array for Case 2 (and for Cases 4, 6, and 7) are shown in Figure 5-7. As in Case 1, spent fuel and DHLW containers are emplaced in alternate boreholes drilled on 7.5-ft centers. The number of spent fuel containers is larger for Case 2 than for Case 1; the number of DHLW and WVHLW containers is the same for all cases. For Case 2, therefore, there are more drifts in which the DHLW boreholes are omitted and in which spent fuel containers are emplaced, without commingling, on 15-ft centers.

The emplacement drift spacing for Case 2 is 100 ft, as compared with 126 ft for Case 1, because the thermal power per spent fuel container is smaller for Case 2. The total length of the emplacement drifts is greater for Case 2 than for Case 1, because of the larger number of spent fuel containers.

Thermal power values for the Case 2 spent fuel containers are as follows:

- 3 intact PWR assemblies + 4 intact BWRs assemblies 2,246 W
- 4 intact PWR assemblies 2,104 W

TABLE 5-1

REPOSITORY THROUGHPUTS (CASE 2)

	MTU - First Repository			HLW Containers		Spent Fuel						
							BWR		PWR		Disposal Containers	
	Spent							Assemblies		Asemblies		
Year	Fuel	HLW	Cum.	DHLW	WVHLW	MTU	MTU	Intact	MTU	Intact	Hybrid	PWR Only
2003	400	0	400	0	0	400	133	741	267	620	185	16
2004	400	0	800	0	0	400	133	741	267	620	185	16
2005	400	0	1200	0	0	400	133	741	267	620	185	16
2006	900	0	2100	0	0	900	300	1667	600	1395	417	36
2007	1800	0	3900	0	0	1800	600	3333	1200	2791	833	73
2008	3000	400	7300	800	0	3000	1000	5556	2000	4651	1389	121
2009	3000	400	10700	800	0	3000	1000	5556	2000	4651	1389	121
2010	3000	400	14100	800	0	3000	1000	5556	2000	4651	1389	121
2011	3000	400	17500	800	0	3000	1000	5556	2000	4651	1389	121
2012	3000	400	20900	800	0	3000	1000	5556	2000	4651	1389	121
2013	3000	400	24300	800	0	3000	1000	5556	2000	4651	1389	121
2014	3000	400	27700	800	0	3000	1000	5556	2000	4651	1389	121
2015	3000	400	31100	800	0	3000	1000	5556	2000	4651	1389	121
2016	3000	400	34500	800	0	3000	1000	5556	2000	4651	1389	121
2017	3000	400	37900	800	0	3000	1000	5556	2000	4651	1389	121
2018	3000	400	41300	800	0	3000	1000	5556	2000	4651	1389	121
2019	3000	400	44700	800	0	3000	1000	5556	2000	4651	1389	121
2020	3000	400	48100	800	0	3000	1000	5556	2000	4651	1389	121
2021	3000	400	51500	800	0	3000	1000	5556	2000	4651	1389	121
2022	3000	400	54900	800	0	3000	1000	5556	2000	4651	1389	121
2023	3000	400	58300	680	28	3000	1000	5556	2000	4651	1389	121
2024	3000	400	61700	0	188	3000	1000	5556	2000	4651	1389	121
2025	3000	180	64880	0	84	3000	1000	5556	2000	4651	1389	121
2026	2700	0	67580	0	0	2700	900	5000	1800	4186	1250	109
2027	2420	0	70000	0	0	2420	807	4481	1613	3752	1120	98
TOTALS	63020	6980	70000	12680	300	63020	21007	116704	42013	97705	29176	2544

Notes: Hybrid: 4 BWR = 1 container
3 PWR = 1 container

PWR only: 4 PWR = 1 container

DHLW: 0.5 MTU = 1 container

WVHLW: 2.13 MTU = 1 container

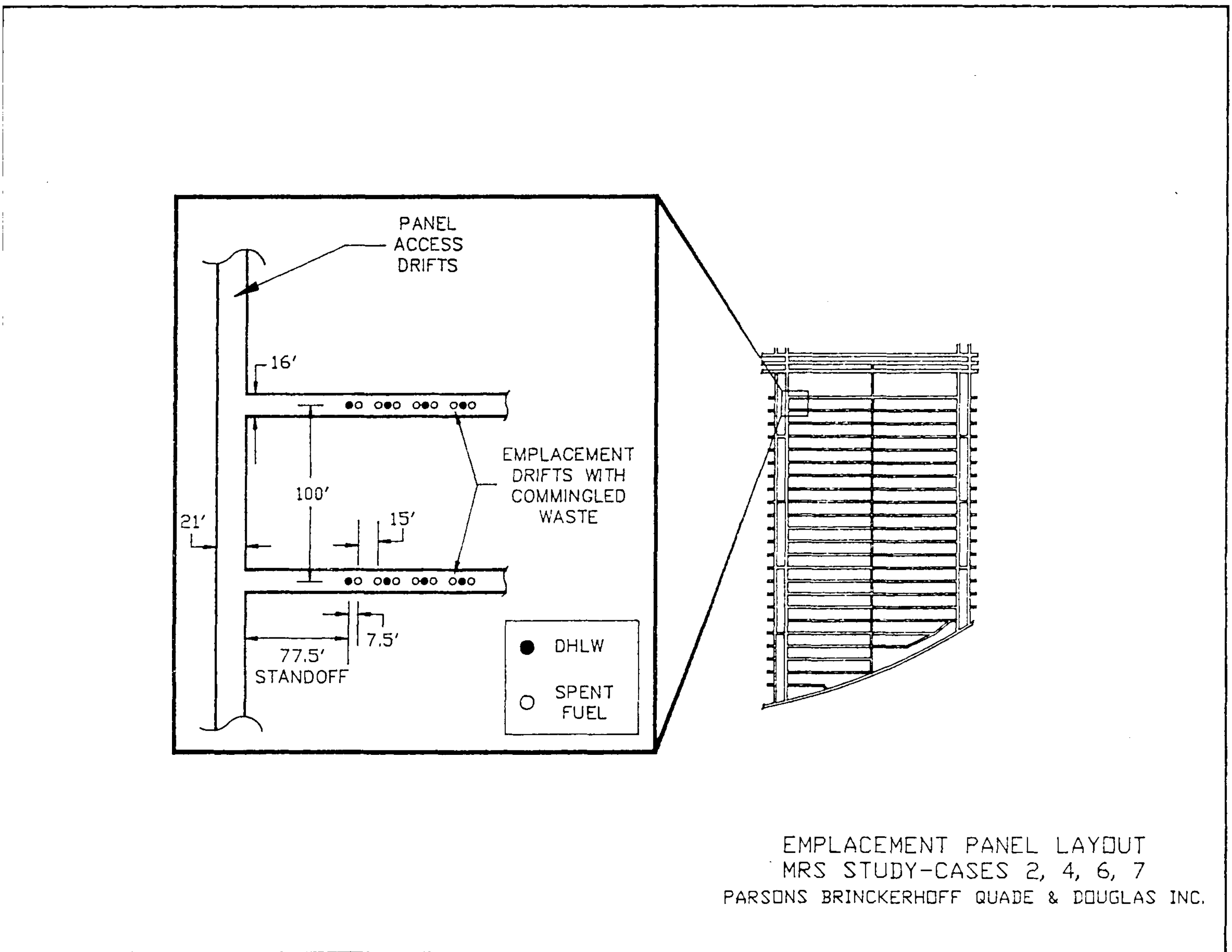


Figure 5-7. Emplacement Panel Layout (Case 2)

5.6 Cost and Schedule

5.6.1 Capital and Operating Costs

A summary of capital, operating, and decommissioning costs is given in Table 5-2.

Staffing requirements for the surface facilities for Case 2 are summarized in Table 5-3.

Staffing requirements for the underground facility for Case 2 are summarized in Table 5-4.

Further details of these estimates are included in Appendix B.

5.6.2 Construction Schedule

The construction schedule for Case 2 is the same as the construction schedule that was developed for RCS Case 2. A summary bar chart covering the licensing, detailed design, and construction of the repository facilities for Case 2 is shown in Figure 5-8. The rationale for each activity of the summary schedule is given in Table 5-5. Figure 5-9 shows a more detailed logic network for the construction of the waste-handling building. The rationale for each activity in this logic network is given in Table 5-6. A tabular presentation of the logic network is provided in Table 5-7. The scheduled duration of the waste-handling building construction, including onsite and offsite preparation, is 57 mo. The logic network for the construction of the underground facility is presented in Figure 4-12.

Assuming that licensing activities permit a construction authorization on January 31, 1998, the facilities will be ready to receive waste by January 2003. As shown in Figure 5-8, the critical path after construction authorization is through the construction of the underground facility.

TABLE 5-2

SUMMARY OF LIFE-CYCLE COSTS (CASE 2)
(in Millions of 1988 Constant Dollars[a])

Cost Category Description	Construction	Operations	Decommissioning	Total
Management and Integration				
Architect/Engineer	176	0	17	
Construction Management	64	0	2	
Other	46	54	4	
Subtotal	286	54	23	363
Surface Facilities				
Site	178	113	43	
High-Level Waste-Handling Facilities	243	810[b]	22	
Other Waste-Handling Facilities	47		5	
Balance of Plant	137	1,211	49	
Subtotal	605	2,134	119	2,858
Subsurface Facilities				
Shafts and Ramps	65	31	4	
Excavation and Emplacement	151	1,011	123	
Service Systems	105	926	165	
Subtotal	321	1,968	292	2,581
Total w/o Disposal Containers	1,212	4,156	434	5,802
Disposal Containers				
Spent Fuel	0	983	0	
DHLW	0	216	0	
Other	0	85	0	
Subtotal	0	1,284	0	1,284
Total	1,212	5,440	434	7,086

a. Unescalated for the life of the repository.
b. Includes cost of operations for all waste-handling facilities.

TABLE 5-3

STAFFING REQUIREMENTS: SURFACE FACILITIES (CASE 2)

Facility	Staff
Waste-Handling Building 1	0
Waste-Handling Building 2	139
Waste Treatment Building	8
Vehicle Wash Facility	0 *
Decontamination Building	0 *
Performance Confirmation Building	17
Health Physics Station 4	0 *
Medical Center	11
Fire Station/Emergency Center	15
Security Station 1	35
Security Station 2/Health Physics Station 3	19
Security Station 3	25
Men-and-Material Shaft Security Station	4
Shops	70
Motor Pool/Facilities Sewage Station	16
Transporter Garage	30
Administration Building	143
Food Services Facility	22
Mockup Building	6
Central Warehouse	17
Visitors Center	3
Change House	0 *
Computer Building	46
Concrete Batch Plant and Aggregate Storage	4
Tuff Pile	4
Total Full Time Personnel	634

* Assigned only as required.

TABLE 5-4

STAFFING REQUIREMENTS:
UNDERGROUND FACILITY (CASE 2)

Category	Staff
Shafts and Ramps	12
Drift Excavation	130
Emplacement Borehole Drilling and Lining	77
Emplacement/Retrieval Operations	17
Support Services	263
Total, Subsurface	499

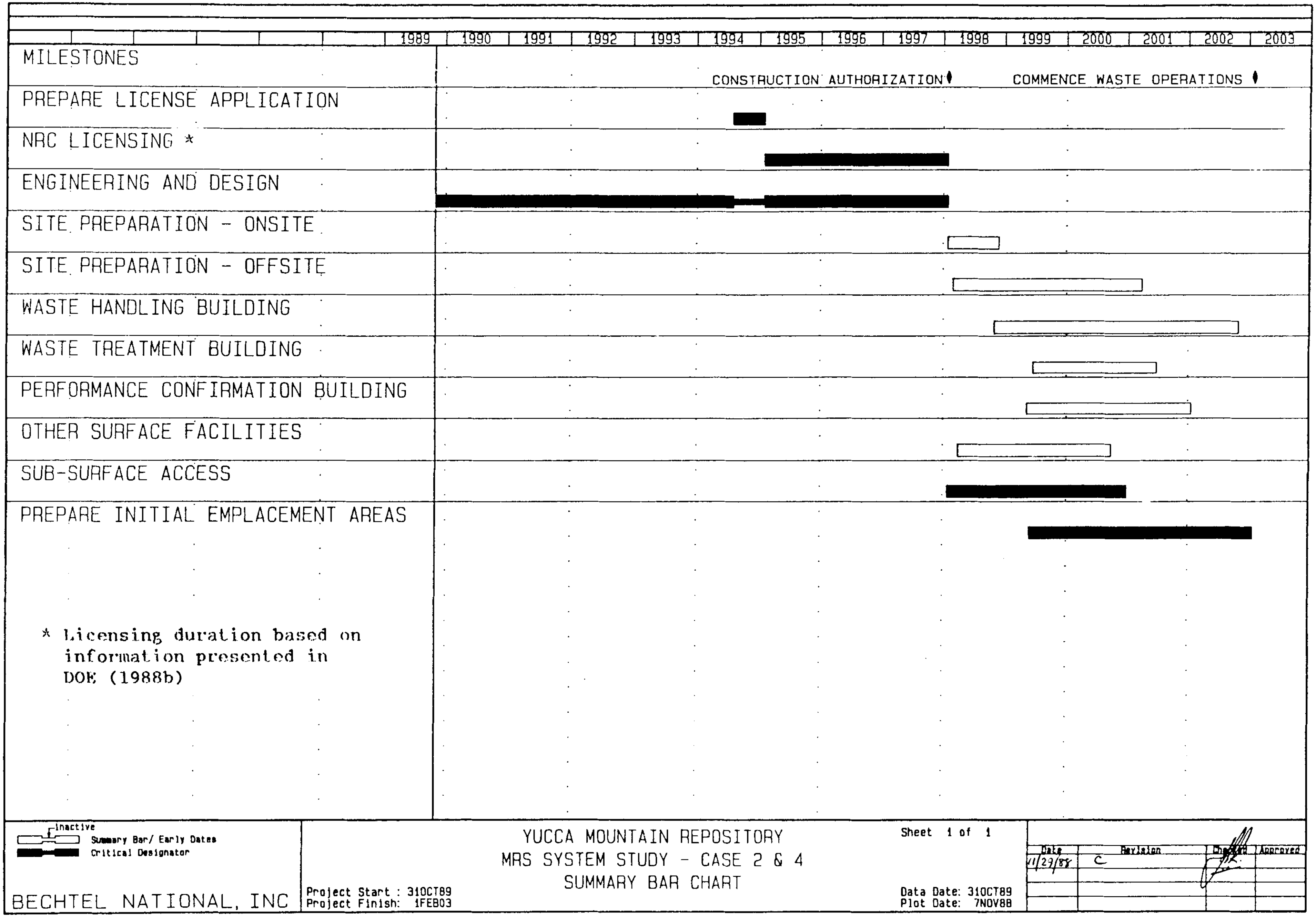


Figure 5-8. Construction Schedule Summary (Case 2)

TABLE 5-5

SUMMARY BAR CHART ACTIVITY DESCRIPTION--CASES 2 AND 4

Activity Number	Title	Duration Calendar Days	General Description	Constructed Quantity and Daily Rate	Other
None	Milestones	0	Shows timing of "Construction Authorization" and "Commence Waste Operations"	NA	These data are given as described in Subsection 3.3
None	Prepare License Application	184	Shows time required, after license application design phase, to prepare the NRC license application	6 mo	
None	NRC Licensing	1095	Period for NRC to review the repository license application	36 mo	Licensing duration based on information presented in DOE (1988b)
None	Engineering and Design	2829	Summary of engineering activities: - advanced conceptual design - license application design - final procurement and construction design	 822 days 912 days 1,095 days	These engineering activities are consecutive, with an interruption of 184 days during preparation of license application
None	Site Preparation--Onsite	304	Summary of construction facility erection and site development	NA	Based on more detailed schedule
None	Site Preparation--Offsite	1140	Summary of offsite preparation activities: road, utilities, railroad, bridges	NA	Based on more detailed schedule
None	Waste-Handling Building	1460	Summary of WHB activities	NA	See Table 5-6 for details of these activities
None	Waste Treatment Building	757	Summary of waste treatment building activities	NA	Based on more detailed schedule
None	Performance Confirmation Building	964	Summary of performance confirmation building activities	NA	Based on more detailed schedule
None	Other Surface Facilities	909	Summary of schedules for construction of other surface facilities	NA	Based on more detailed schedule
None	Subsurface Access	575	Summary of subsurface access activities	NA	Based on PBQ&D detailed schedule
None	Initial Emplacement Areas	1250	Summary of emplacement area excavation	NA	Based on PBQ&D detailed schedule

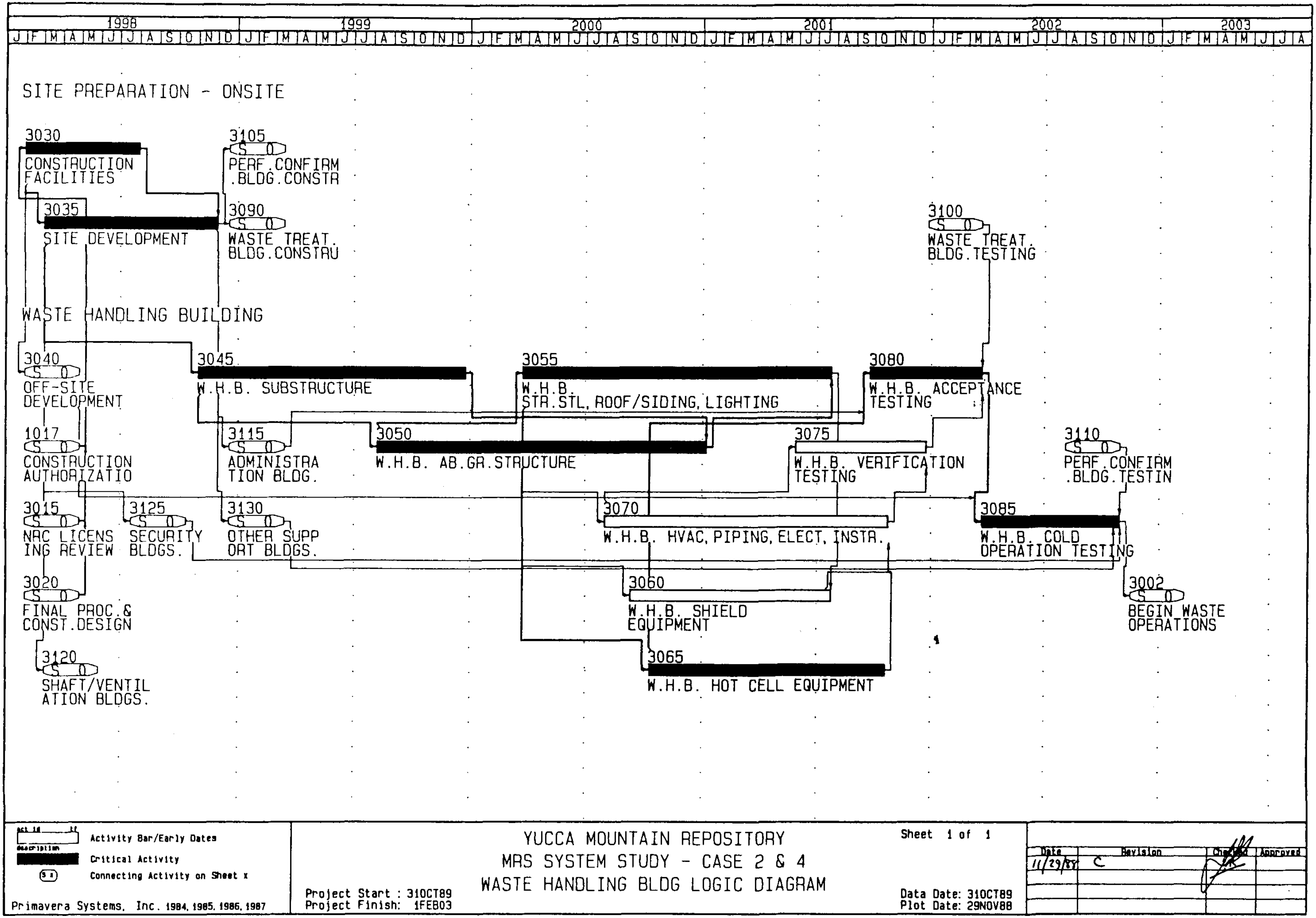


Figure 5-9. Logic Network for the Construction of the Waste Handling Building

TABLE 5-6

WASTE-HANDLING BUILDING LOGIC DIAGRAM ACTIVITY DESCRIPTION--CASES 2 AND 4

Activity Number	Title	Duration Calendar Days	General Description	Constructed Quantity and Daily Rate	Other
2030	Construction Facilities	182	Period for erection of temporary facilities	Allowance	Based on similar historical experience
2035	Site Development	274	Period for rough grading, site roads, utilities	Allowance	Based on historical records, 1 mo after commencement of construction facilities
2045	WHB-1 Substructure	420	Period for structure excavation and concrete work for foundations	Summary	Based on more detailed schedules
2050	WHB-1 Aboveground Structure	519	Period for construction of concrete structure above ground	Summary	Based on more detailed schedules
2055	Structured Steel, Roof, Siding, Lighting	488	Period for construction of steel structure, enclosure, and interior lighting	Summary	Based on more detailed schedules
2070	HVAC, Piping, Electrical, Instrumentation	450	Period for installation of mechanical, piping, and electrical power systems	Summary	Based on more detailed schedules
2060	Shield Equipment	318	Period for installation of shielded area penetrations, doors, windows, etc.	Summary	Based on more detailed schedules
2065	Hot Cell Equipment	375	Period for installation of equipment in hot cell areas	Summary	Based on more detailed schedules
2075	Verification Testing	210	Period for contractor testing	6 mo	Allowance based on historical experience with similar facility
2080	Acceptance Testing	180	Period for DOE and NRC testing	6 mo	Allowance based on historical experience with similar facility
2085	Cold Operations	220	Period for training by operations staff	6 mo	Allowance based on historical experience with similar facility
2002	Begin Waste Operations	0	Milestone indicating completion of all construction and testing activities	--	Waste-handling building begins operation

TABLE 5-7

CONSTRUCTION SCHEDULE FOR THE WASTE-HANDLING BUILDING

Item	Duration (mo)	Start Date	Finish Date
Substructure	14	Oct 98	Dec 99
Aboveground Structure	17	Jul 99	Dec 00
Steel, Roofing, Siding	17	Feb 00	Jul 01
Shield Equipment	11	Aug 00	Jul 01
HVAC, Piping, Electrical, Instrumentation	17	Jul 00	Oct 01
Hot Cell Equipment	13	Sep 00	Oct 01
Verification Testing	8	May 01	Dec 01
Acceptance Testing	6	Sep 01	Mar 02
Cold Operation	7	Mar 02	Oct 02
Ready to Accept Waste		Nov 02	

6.0 CASE 3

For Case 3, bare SNF assemblies are stored at the MRS and shipped to the repository, where they are consolidated and containerized for emplacement. DHLW and WVHLW are received in canisters at the repository and then containerized for emplacement.

Case 3 is similar to Case 1 of this study, except for further reduction of the WHB-2 volume, due to the difference in rail/truck shipments. For Case 3, 95.5% of the SNF is received at the repository by rail; in Case 1, 55% is received at the repository by rail and 45% is received by truck.

6.1 Assumptions

In addition to the general assumptions stated in Section 3, the following specific assumptions apply to Case 3:

- Ninety percent of the SNF received at the repository is in the form of bare intact assemblies shipped from the MRS; the remaining 10% is in the form of bare intact assemblies shipped from western reactors.
- All of the SNF from the MRS is shipped to the repository by rail.
- The shipment of SNF from western reactors to the repository is 55% by rail and 45% by truck.
- There are 48 intact BWR SNF assemblies per rail cask.
- There are 7 intact BWR SNF assemblies per truck cask.
- There are 21 intact PWR SNF assemblies per rail cask.
- There are 3 intact PWR SNF assemblies per truck cask.

- There are 6 intact BWR SNF assemblies per container.
- There are 18 consolidated BWR SNF assemblies per container.
- There are 3 intact PWR SNF assemblies per container.
- There are 6 consolidated PWR SNF assemblies per container.
- There is one additional container of hardware generated per 108 BWR assemblies consolidated.

6.2 Waste Received

The annual and total quantities of SNF and high-level waste received at the repository during its 25 yr of operation are shown in Table 3-1. As can be seen from this table, the maximum annual quantity of SNF received when the repository is operating at full receipt capacity is 3,000 MTU/yr.

Ninety percent, or 2,700 MTU, is in the form of bare assemblies, stored at the MRS and shipped to the repository by rail, in the same casks that were used to ship the fuel from eastern reactors to the MRS. One third, or 900 MTU, of this is BWR fuel; two-thirds, or 1,800 MTU, is PWR fuel. At 0.18 MTU per BWR assembly, there are 5,000 BWR assemblies, and at 0.43 MTU per PWR assembly, there are 4,186 PWR assemblies per year shipped to the repository from the MRS.

With a BWR rail cask capacity of 48 assemblies, there are 104 rail casks of BWR fuel received at the repository per year from the MRS. With a PWR rail cask capacity of 21 assemblies, there are 199 rail casks of PWR fuel received at the repository per year from the MRS.

Ten percent of the SNF, or 300 MTU, is in the form of intact assemblies, shipped directly to the repository from western reactors. One-third, or 100 MTU, of this is BWR fuel;

two-thirds, or 200 MTU, is PWR fuel. A total of 55% of this fuel is shipped to the repository by rail and 45% by truck.

This corresponds to 306 BWR assemblies in 6 rail casks (48 assemblies per BWR rail cask), 250 BWR assemblies in 36 truck casks (7 assemblies per BWR truck cask), 256 PWR assemblies in 12 rail casks (21 assemblies per BWR rail cask), and 209 PWR assemblies in 70 truck casks (3 assemblies per BWR truck cask) shipped to the repository from western reactors.

DHLW and WVHLW are received at the repository directly from the applicable facilities (not from the MRS).

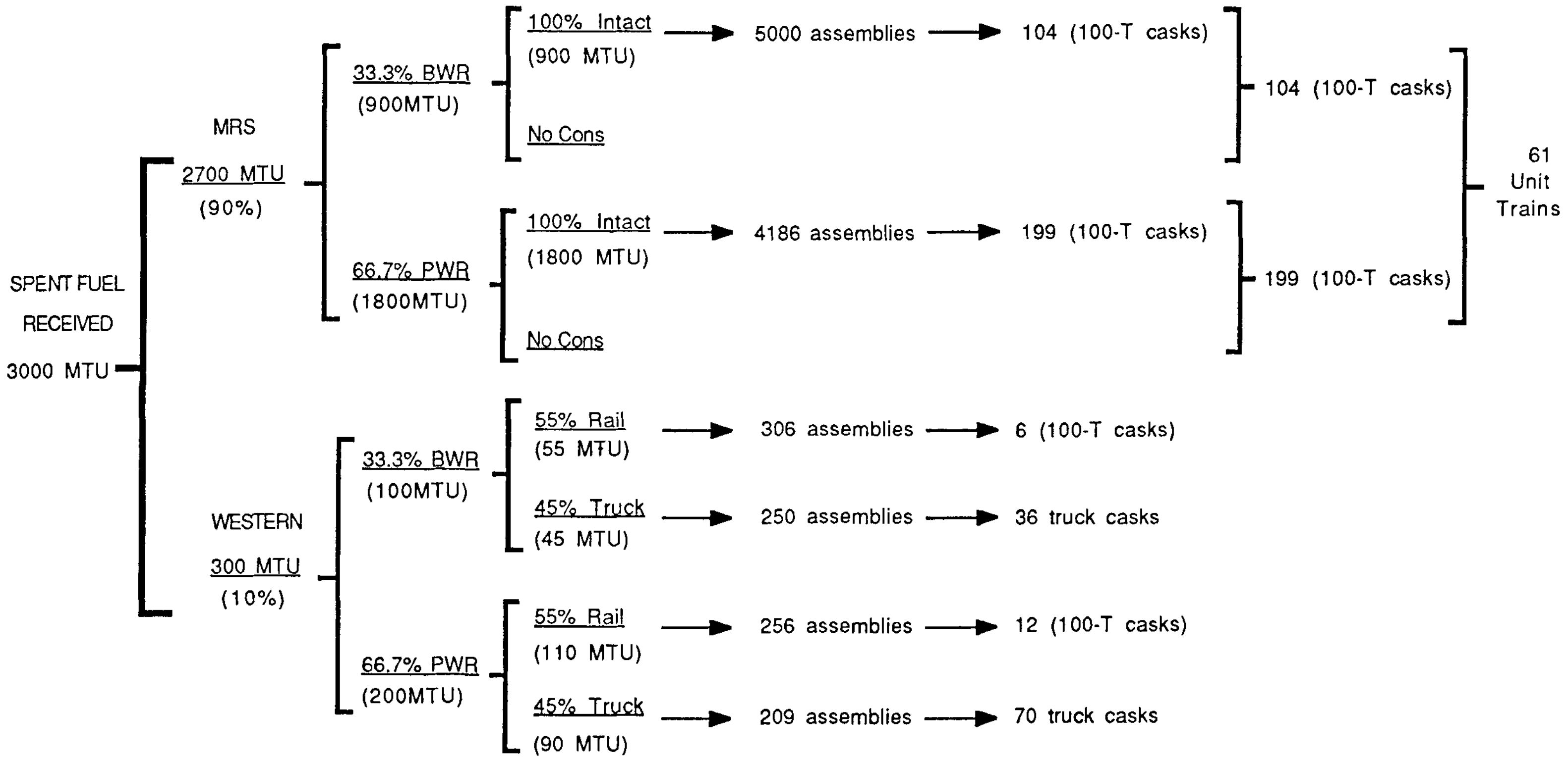
The annual throughputs (at full receipt capacity) for Case 3 are summarized in Figure 6-1. The calculations for the quantities shown in this figure are provided in Appendix A.

6.3 Surface Facilities

As in Case 1 of this study, the Case 3 surface facilities include two waste-handling buildings. The surface facilities for Case 3 are similar to the surface facilities for Case 1, except that WHB-2 for Case 3 has two fewer cask-unloading ports than does WHB-2 for Case 1. This is due to the greater number of higher capacity rail casks (from the MRS) that require less unloading time. The plot plan, which is essentially the same for both designs, is provided in Figure 6-2.

The layout and functional requirements of WHB-1 for Case 3 are exactly the same as those of WHB-1 for Case 1. Figure 6-3, which is a markup of the WHB-1 layout for Case 3, is exactly the same as the markup provided for WHB-1 in Case 1.

Figure 6-4 is a markup of the SCP-CDR WHB-2 with five receiving bays deleted (two more than are deleted in WHB-2 for Case 1), leaving three remaining bays to reflect the requirements for Case 3. Other than the unloading requirements, the remaining



NON-SPENT FUEL RECEIVED

DHLW:	MTU's	400
	Canisters	800
	Rail Casks	160
MRS Hardware:	Drums	0
	Canisters	0
	Rail Casks	0

CASK CAPACITIES (ASSEMBLIES)

MRS ALL RAIL:	BWR intact	48
	BWR consol.	N/A
	PWR intact	21
	PWR consol.	N/A
REACTOR:	BWR rail	48
	BWR truck	7
	PWR rail	21
	PWR truck	3
HARDWARE:	rail	N/A
DHLW:	rail	5 canisters

EMPLACEMENT OPERATIONS	NO. CONTAINERS	NO. ASSEMBLIES/ CONTAINER
BWR (Intact)	46	6
BWR (Consolidated)	293	18
PWR (Intact)	78	3
PWR (Consolidated)	736	6
Hardware	49	108 BWR
DHLW	800	1 canister
Total	2002	

Figure 6-1. Repository Annual Throughputs (Case 3)

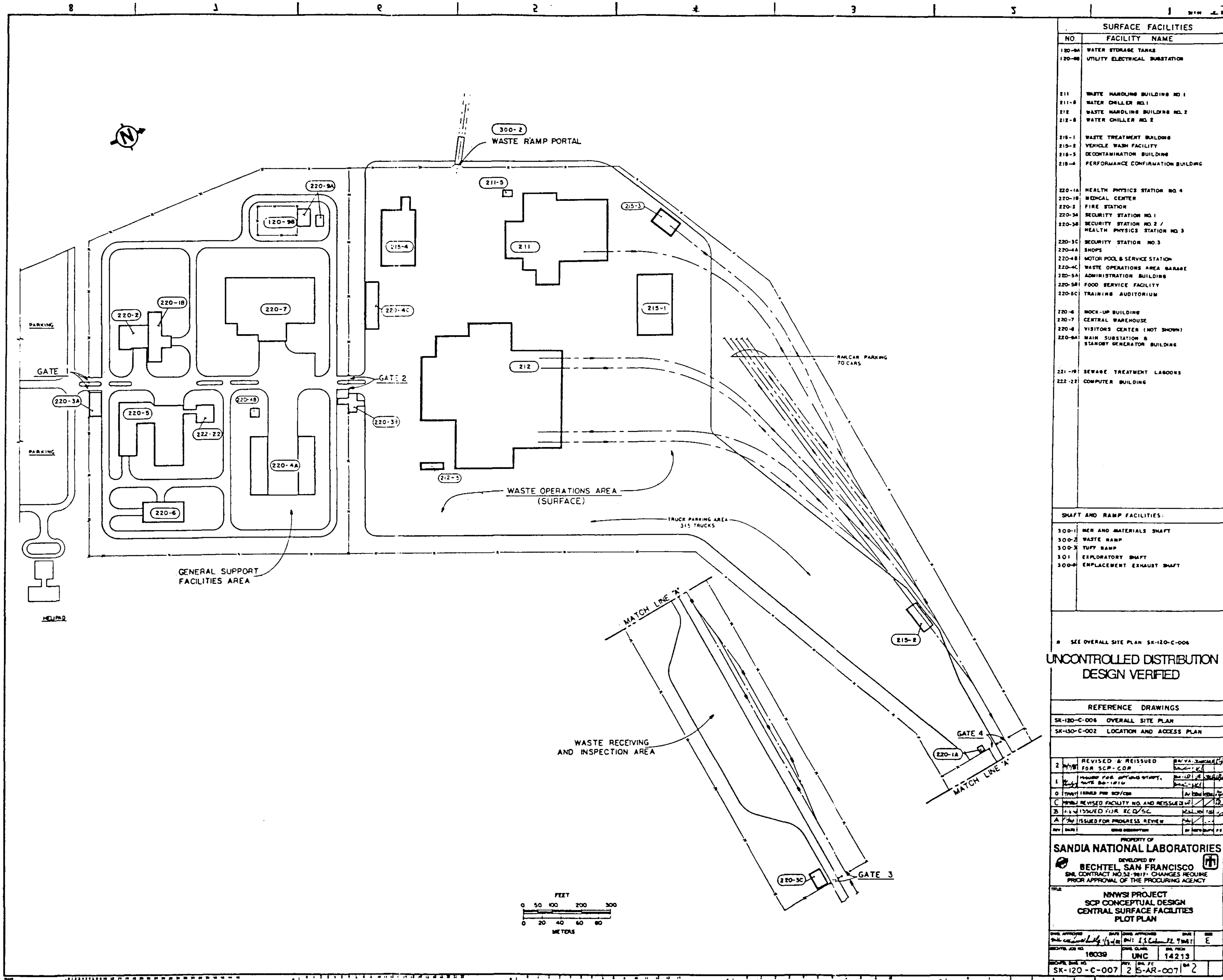


Figure 6-2. Repository Plot Plan (Case 3)

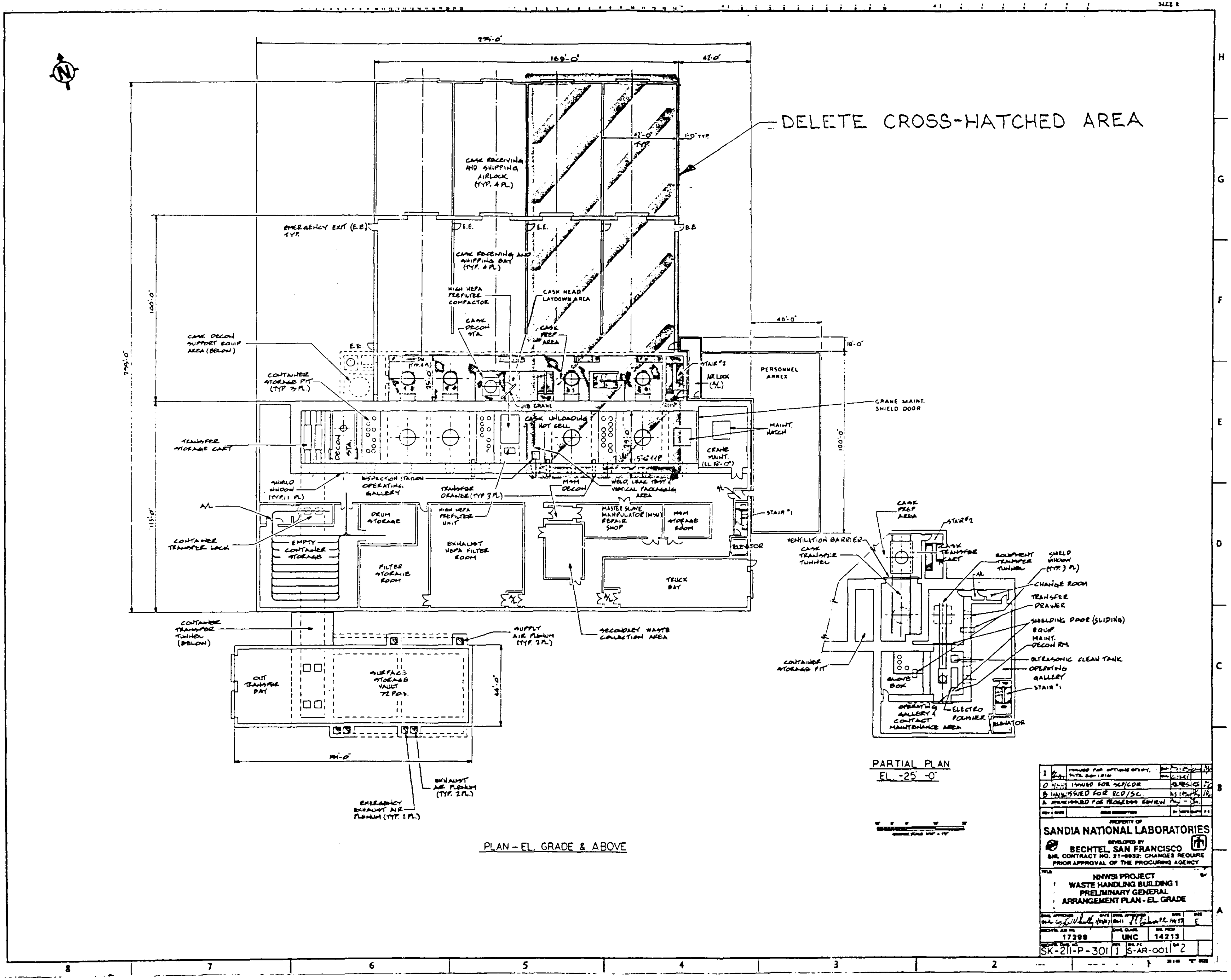


Figure 6-3. WHB-1 Layout (Case 3)

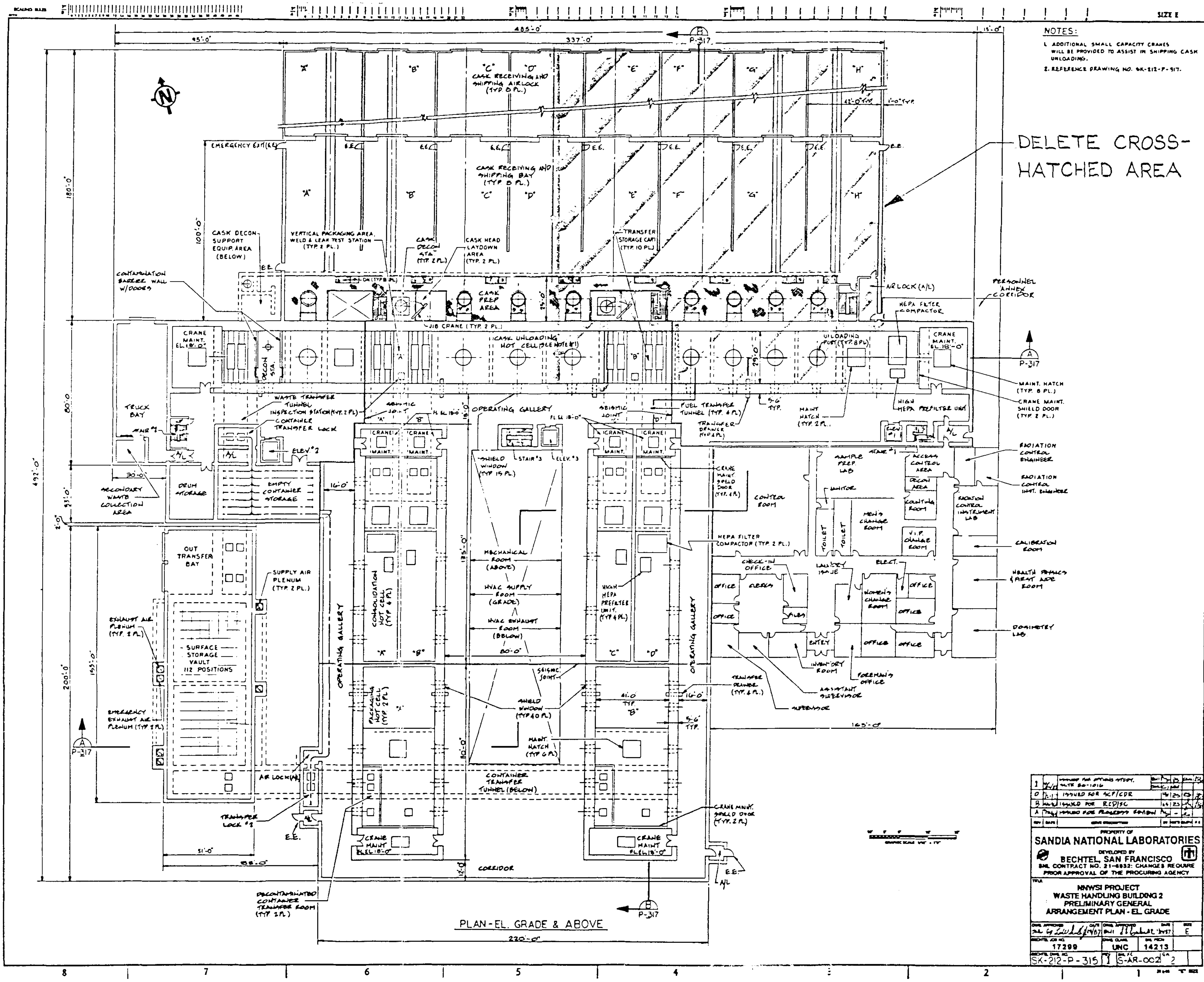


Figure 6-4. WHB-2 Layout (Case 3)

functional requirements, throughputs, and descriptions pertaining to WHB-2 for Case 3 are exactly the same as those for WHB-2 in Case 1.

The material flow diagrams for Case 3, shown in Figures 6-5 and 6-6, are the same as those for Case 1.

6.4 Disposal Containers

For Case 3, the YMP container shown in Figure 6-7 is the same container used in Case 1 of this study. The container descriptions, contents, and throughputs are the same as provided in Subsection 4.4 (Case 1) of this report. The year-by-year container emplacement schedule shown in Table 6-1 is the same as that for Case 1.

6.5 Underground Facility

The quantity and characteristics of containers required for Case 3 are identical to Case 1 as described in Subsection 4.5. Hence, the layout of a typical emplacement panel for Case 3, which is shown in Figure 6-8, is also identical.

6.6 Cost and Schedule

6.6.1 Capital and Operating Costs

A summary of capital, operating, and decommissioning costs is given in Table 6-2.

Staffing requirements for the surface facilities for Case 3 are summarized in Table 6-3.

Staffing requirements for the underground facility for Case 3 are summarized in Table 6-4.

Further details of these estimates are included in Appendix B.

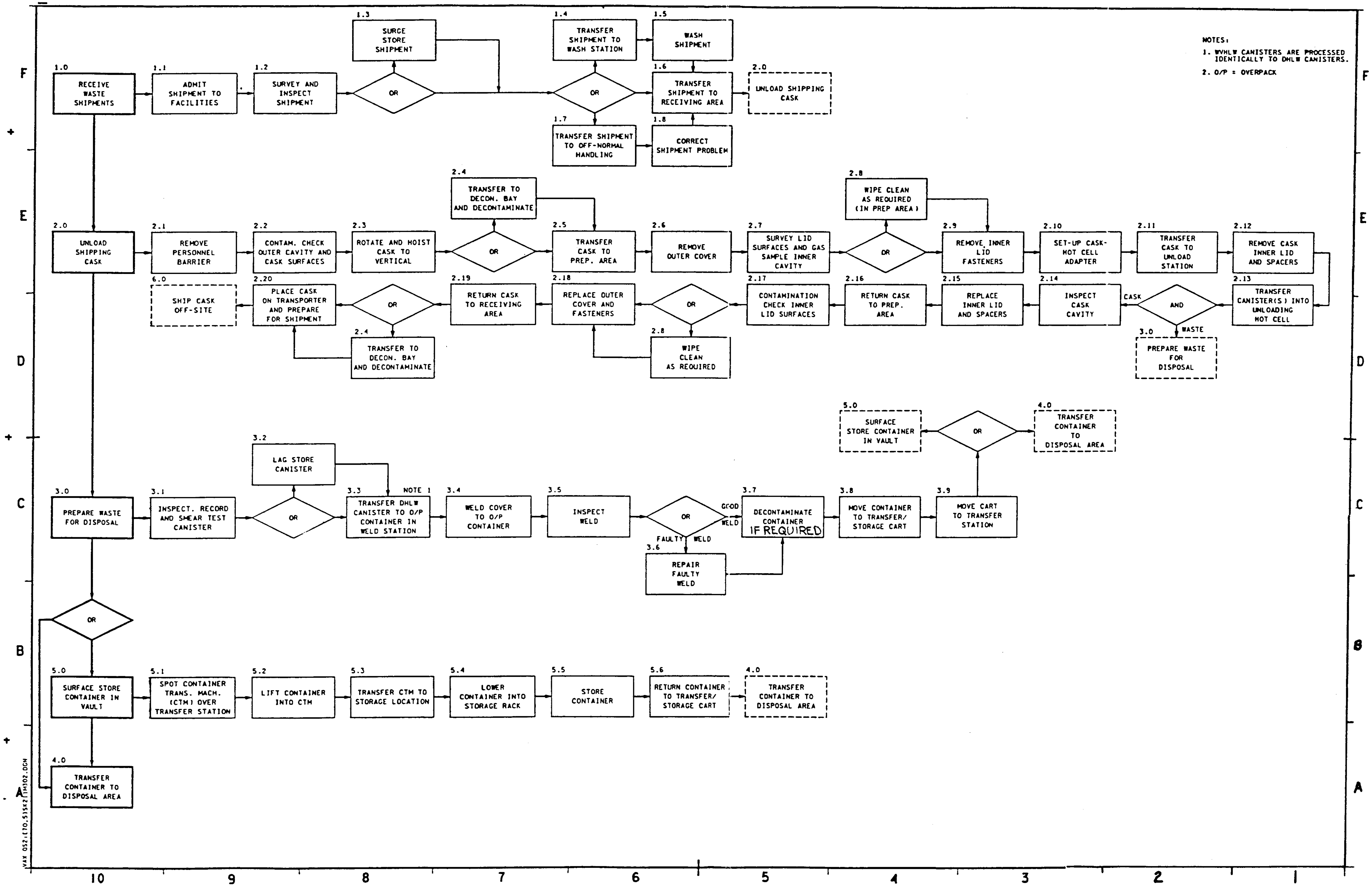


Figure 6-5. Material Flow Diagram for DHLW and WVHLW (Case 3)

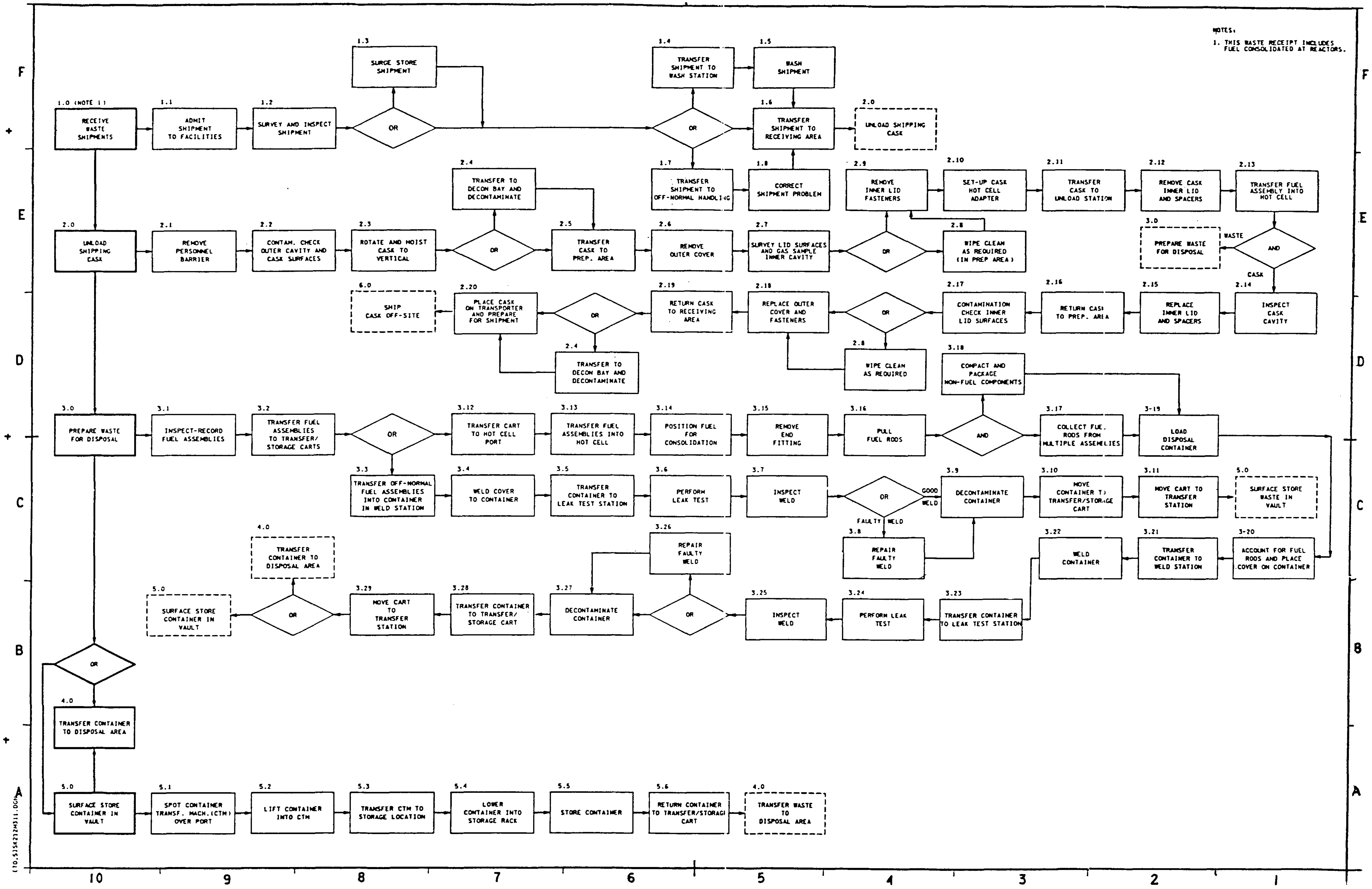


Figure 6-6. Material Flow Diagram for SNF (Case 3)

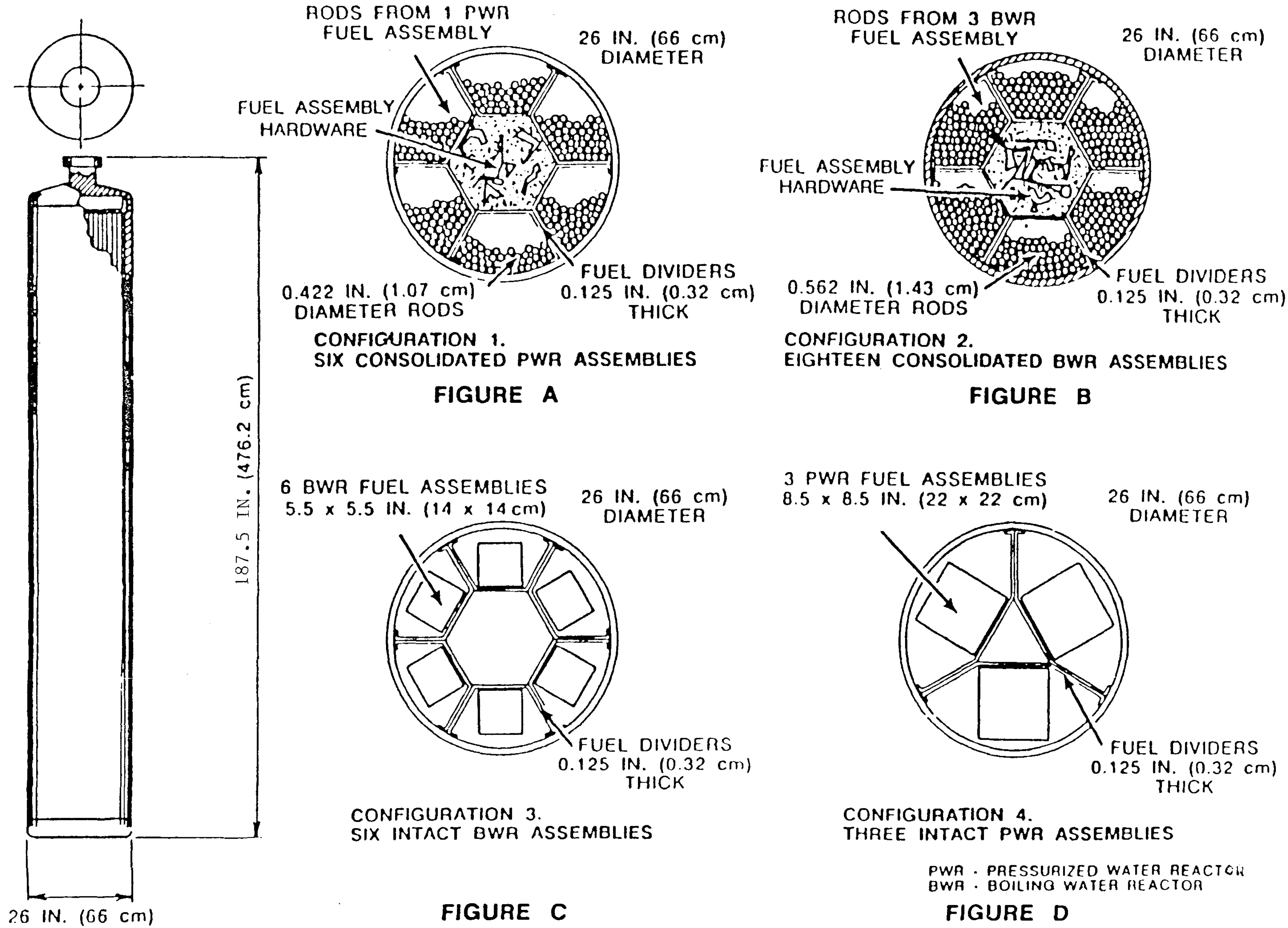


Figure 6-7. Reference Design Containers (Case 3)

TABLE 6-1

REPOSITORY THOUGHPUTS (CASE 3)

	MTU - First Repository			HLW Containers		Spent Fuel Containers												
							BWR						PWR					
								Assemblies		Disposal Containers				Assemblies		Disposal Containers		
Year	Spent Fuel	HLW	Cum.	DHLW	WVHLW	MTU	MTU	Intact	Consol.	Intact	Consol.	Hdw.	MTU	Intact	Consol.	Intact	Consol.	Hdw.
2003	400	0	400	0	0	400	133	741	0	123	0	0	267	620	0	207	0	0
2004	400	0	800	0	0	400	133	741	0	123	0	0	267	620	0	207	0	0
2005	400	0	1200	0	0	400	133	741	0	123	0	0	267	620	0	207	0	0
2006	900	0	2100	0	0	900	300	787	880	131	49	8	600	659	736	220	123	0
2007	1800	0	3900	0	0	1800	600	870	2463	145	137	23	1200	729	2062	243	344	0
2008	3000	400	7300	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2009	3000	400	10700	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2010	3000	400	14100	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2011	3000	400	17500	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2012	3000	400	20900	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2013	3000	400	24300	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2014	3000	400	27700	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2015	3000	400	31100	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2016	3000	400	34500	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2017	3000	400	37900	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2018	3000	400	41300	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2019	3000	400	44700	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2020	3000	400	48100	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2021	3000	400	51500	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2022	3000	400	54900	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2023	3000	400	58300	680	28	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2024	3000	400	61700	0	188	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2025	3000	180	64880	0	84	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2026	2700	0	67580	0	0	2700	900	250	4750	42	264	44	1800	209	3977	70	663	0
2027	2420	0	70000	0	0	2420	807	224	4257	37	237	39	1613	188	3564	63	594	0
TOTALS	63020	6980	70000	12680	300	63020	21007	9354	107350	1559	5964	994	42013	7831	89874	2610	14979	0

Notes:

BWRs: 6 intact = 1 container
18 consolidated = 1 container

PWRs: 3 intact = 1 container
6 consolidated = 1 container

Hardware: 0 containers for each consolidated PWR fuel assembly
1 container for each 108 consolidated BWR fuel assembly

DHLW: 0.5 MTU = 1 container

WVHLW: 2.13 MTU = 1 container

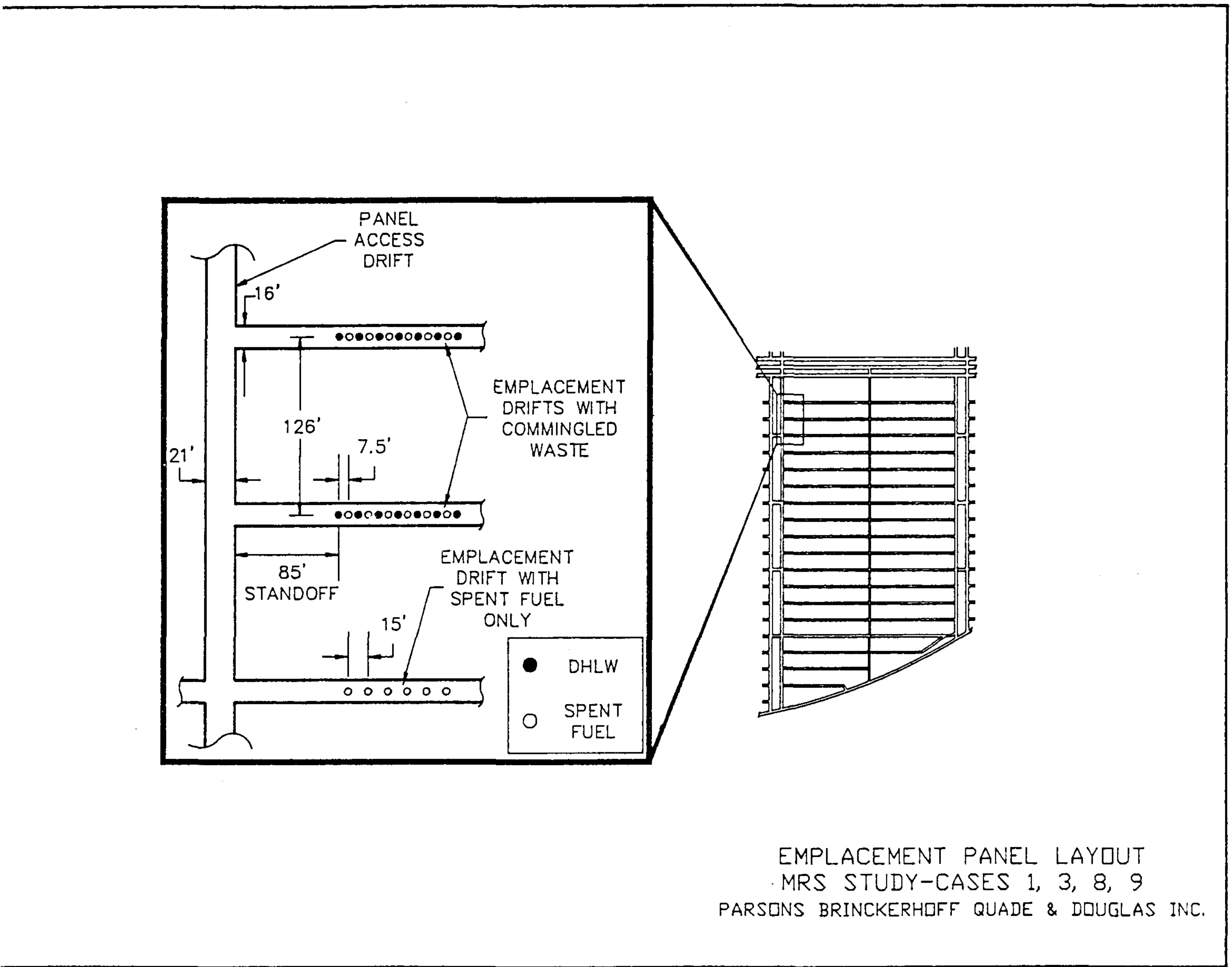


Figure 6-8. Emplacement Panel Layout (Case 3)

TABLE 6-2

SUMMARY OF LIFE-CYCLE COSTS (CASE 3)
(in Millions of 1988 Constant Dollars[a])

Cost Category Description	Construction	Operations	Decommissioning	Total
Management and Integration				
Architect/Engineer	223	0	15	
Construction Management	76	0	2	
Other	57	54	4	
Subtotal	356	54	21	431
Surface Facilities				
Site	178	109	41	
High-Level Waste-Handling Facilities	438	1,192[b]	28	
Other Waste-Handling Facilities	46		4	
Balance of Plant	138	1,287	50	
Subtotal	800	2,588	123	3,511
Subsurface Facilities				
Shafts and Ramps	66	31	3	
Excavation and Emplacement	143	879	108	
Service Systems	100	865	146	
Subtotal	309	1,775	257	2,341
Total w/o Disposal Containers	1,465	4,417	401	6,283
Disposal Containers				
Spent Fuel	0	728	0	
DHLW	0	216	0	
Other	0	154	0	
Subtotal	0	1,098	0	1,098
Total	1,465	5,515	401	7,381

a. Unescalated for the life of the repository.
b. Includes cost of operations for all waste-handling facilities.

TABLE 6-3

STAFFING REQUIREMENTS: SURFACE FACILITIES (CASE 3)

Facility	Staff
Waste-Handling Building 1	19
Waste-Handling Building 2	163
Waste Treatment Building	9
Vehicle Wash Facility	0 *
Decontamination Building	0 *
Performance Confirmation Building	17
Health Physics Station 4	0 *
Medical Center	12
Fire Station/Emergency Center	15
Security Station 1	35
Security Station 2/Health Physics Station 3	19
Security Station 3	25
Men-and-Material Shaft Security Station	4
Shops	85
Motor Pool/Facilities Sewage Station	16
Transporter Garage	30
Administration Building	161
Food Services Facility	24
Mockup Building	6
Central Warehouse	17
Visitors Center	3
Change House	0 *
Computer Building	50
Concrete Batch Plant and Aggregate Storage	4
Tuff Pile	4
Total Full Time Personnel	718

* Assigned only as required.

TABLE 6-4

STAFFING REQUIREMENTS:
UNDERGROUND FACILITY (CASE 3)

Category	Staff
Shafts and Ramps	12
Drift Excavation	110
Emplacement Borehole Drilling and Lining	68
Emplacement/Retrieval Operations	15
Support Services	240
Total, Subsurface	445

6.6.2 Construction Schedule

The construction schedule for Case 3 is the same as the construction schedule that was developed for the SCP-CDR. A summary bar chart covering the licensing, detailed design, and construction of the repository facilities for Case 3 is shown in Figure 6-9. Figure 6-10 shows a more detailed logic network for the construction of the waste-handling buildings. Details of the construction schedules for the surface and underground facilities for this case, which are identical to those for Case 1, are presented in Subsection 4.6.2.

Assuming that licensing activities permit a construction authorization on January 31, 1998, the facilities will be ready to receive waste by January 2003.

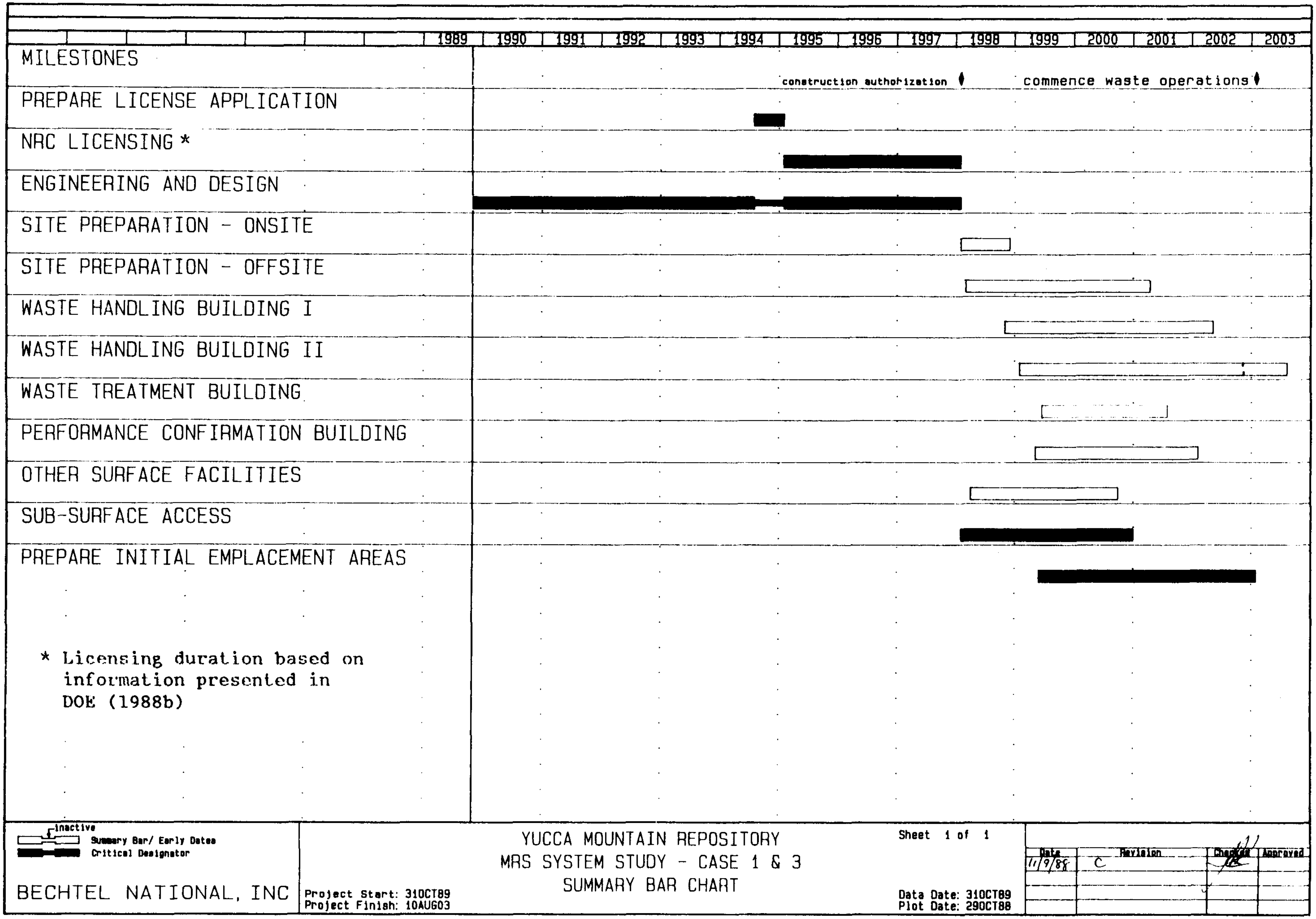


Figure 6-9. Construction Schedule Summary (Case 3)

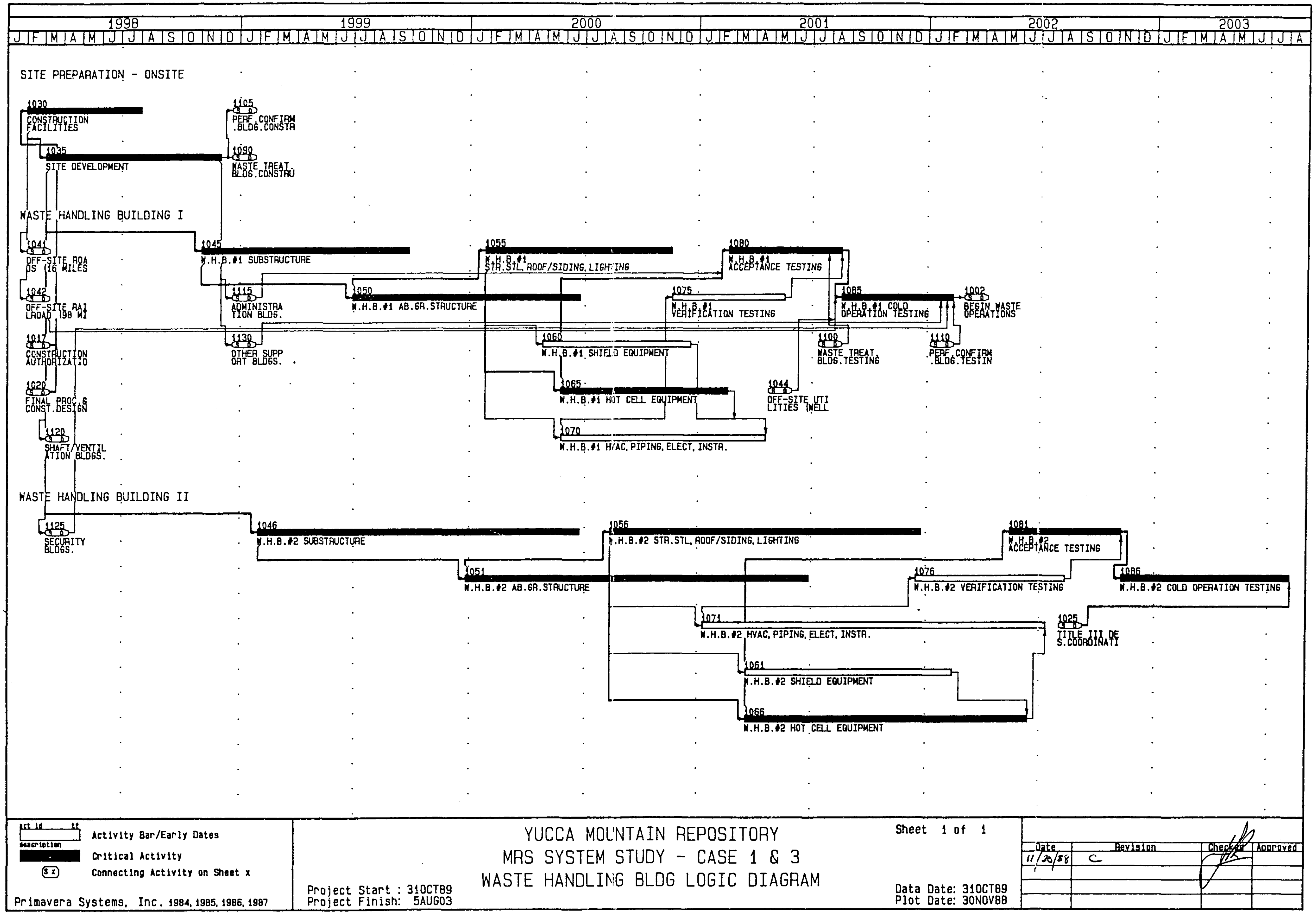


Figure 6-10. Logic Network for the Construction of the Waste-Handling Building

7.0 CASE 4

For Case 4, bare SNF assemblies are stored at the MRS and shipped to the repository, where they are containerized for emplacement. There is no consolidation at the repository. DHLW and WVHLW are received in canisters at the repository and then containerized for emplacement.

Case 4 is similar to Case 2 of this study, except that the WHB volume is further reduced because of the difference in rail/truck shipments. For Case 4, 95.5% of the SNF is received at the repository by rail; in Case 2, 55% is received at the repository by rail and 45% is received by truck.

7.1 Assumptions

In addition to the general assumptions stated in Section 3, the following specific assumptions apply to Case 4:

- Ninety percent of the SNF received at the repository is in the form of bare intact assemblies shipped from the MRS; the remaining 10% is in the form of bare intact assemblies shipped from western reactors.
- All of the SNF from the MRS is shipped to the repository by rail.
- The shipment of SNF from western reactors to the repository is 55% by rail and 45% by truck.
- There are 48 intact BWR SNF assemblies per rail cask.
- There are 7 intact BWR SNF assemblies per truck cask.
- There are 21 intact PWR SNF assemblies per rail cask.

- There are 3 intact PWR SNF assemblies per truck cask.

- There are 10 BWR SNF assemblies per BWR container.

- There are 4 PWR SNF assemblies per PWR container.

- There are 4 BWR SNF assemblies per hybrid container and 3 PWR SNF assemblies per hybrid container. (A hybrid container contains 4 BWR and 3 PWR assemblies.)

- Use of the hybrid container is preferred. After all of the BWR assemblies (along with the PWR assemblies) have been packaged in the hybrid containers, the remaining PWR assemblies are packaged in PWR containers. (Hybrid containers can accommodate all of the BWR assemblies but not all of the PWR assemblies.)

7.2 Waste Received

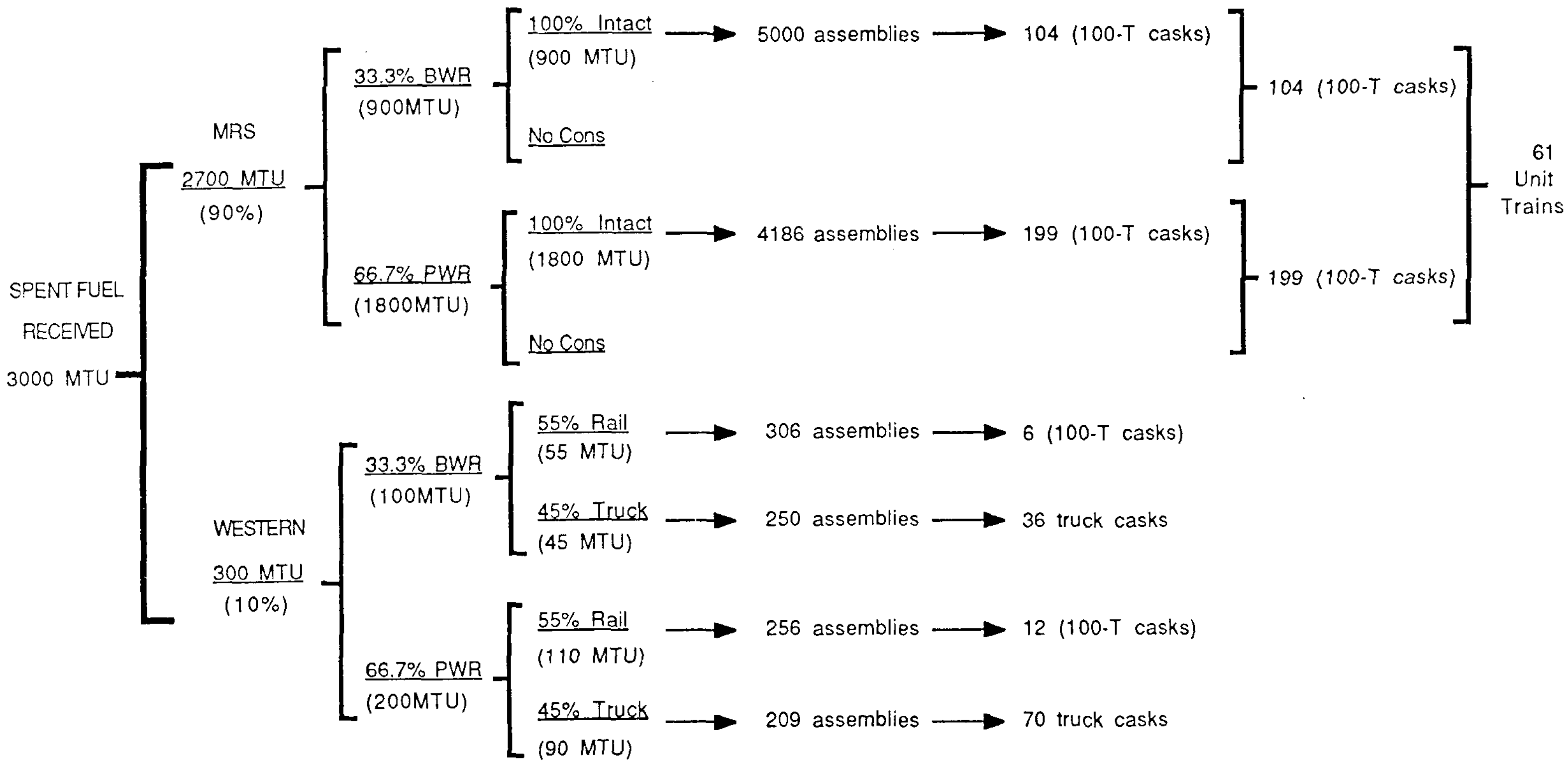
For Case 4, the number and type of assemblies per cask and the number and type of casks received at the repository are exactly the same as those received at the repository for Case 3, which is described in Subsection 6.2.

DHLW and WVHLW are received at the repository directly from the applicable facilities (not from the MRS).

The annual throughputs (at full receipt capacity) for Case 4 are summarized in Figure 7-1. The calculations for the quantities shown in this figure are provided in Appendix A.

7.3 Surface Facilities

As in Case 2 of this study, the Case 4 surface facilities include only one waste-handling building. The waste-handling building for Case 4 is similar to the waste-handling building for Case 2, except that the waste-handling building for Case 4 has two fewer cask-unloading bays than does the waste-handling building for



NON-SPENT FUEL RECEIVED

DHLW :	MTU's	400
	Canisters	800
	Rail Casks	160
MRS Hardware :	Drums	0
	Canisters	0
	Rail Casks	0

CASK CAPACITIES (ASSEMBLIES)

MRS ALL RAIL:	BWR intact	48
	BWR consol.	N/A
	PWR intact	21
	PWR consol.	N/A
REACTOR:	BWR rail	48
	BWR truck	7
	PWR rail	21
	PWR truck	3
HARDWARE:	rail	N/A
DHLW:	rail	5 canisters

EMPLACEMENT OPERATIONS	NO. CONTAINERS	NO. ASSEMBLIES/ CONTAINER
BWR/PWR-mixed (Intact)	1389	4/3
BWR (Intact)	0	N/A
PWR (Intact)	121	4
Hardware	0	N/A
DHLW	800	1 canister
Total	2310	

Figure 7.1. Repository Annual Throughputs (Case 4)

Case 2. This is due to the greater number of higher capacity rail casks (from the MRS) that require less unloading time. The plot plan, which is essentially the same for both designs, is provided in Figure 7-2.

Figure 7-3 is a markup of the RCS Case 2 waste-handling building layout with five receiving bays deleted (two more than are deleted for WHB-2 in Case 2 of this study), leaving five remaining bays to satisfy the requirements for Case 4. Other than the unloading requirements, the remaining functional requirements, throughputs, and descriptions pertaining to the waste-handling building for Case 4 are the same as those for the waste-handling building in Case 2, as described in Subsection 5.3.

The DHLW and WVHLW material flow diagram for Case 4, shown in Figure 7-4, is the same as that for Case 1 and Case 2. The SNF material flow diagram for Case 4, shown in Figure 7-5, is the same as that for Case 2.

7.4 Disposal Containers

For Case 4, the container shown in Figure 7-6 is the same container used in Case 2 of this study. The container descriptions, contents, and throughputs are the same as those provided in Subsection 5.4 (Case 2) of this report. The year-by-year container emplacement schedule shown in Table 7-1 i the same as that for Case 2.

7.5 Underground Facility

The emplacement panel layout for Case 4 is identical to what is described for Case 2 in Subsection 5.5. Figure 7-7 shows detail: of a typical emplacement drift for Case 4.

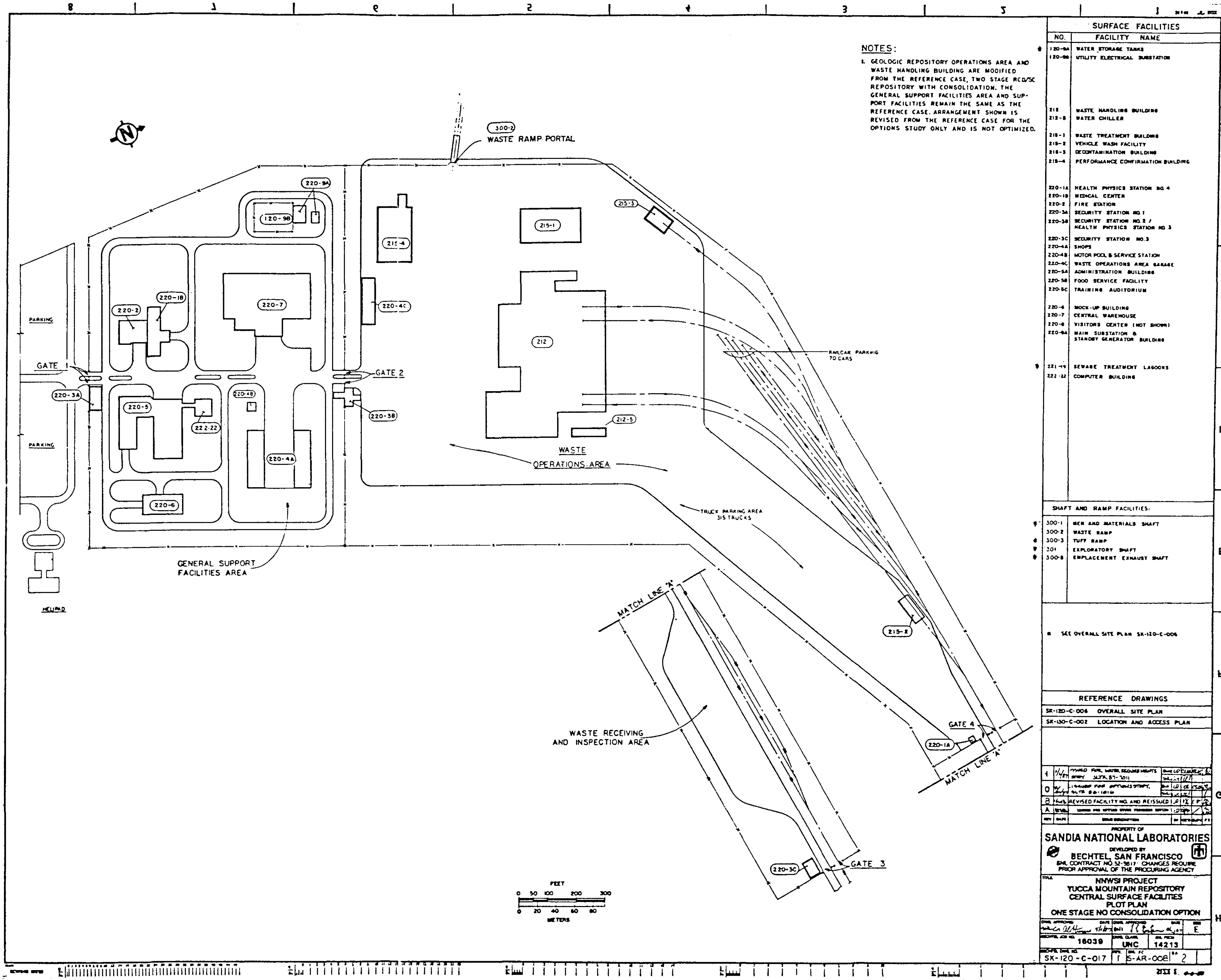


Figure 7-2. Repository Plot Plan (Case 4)

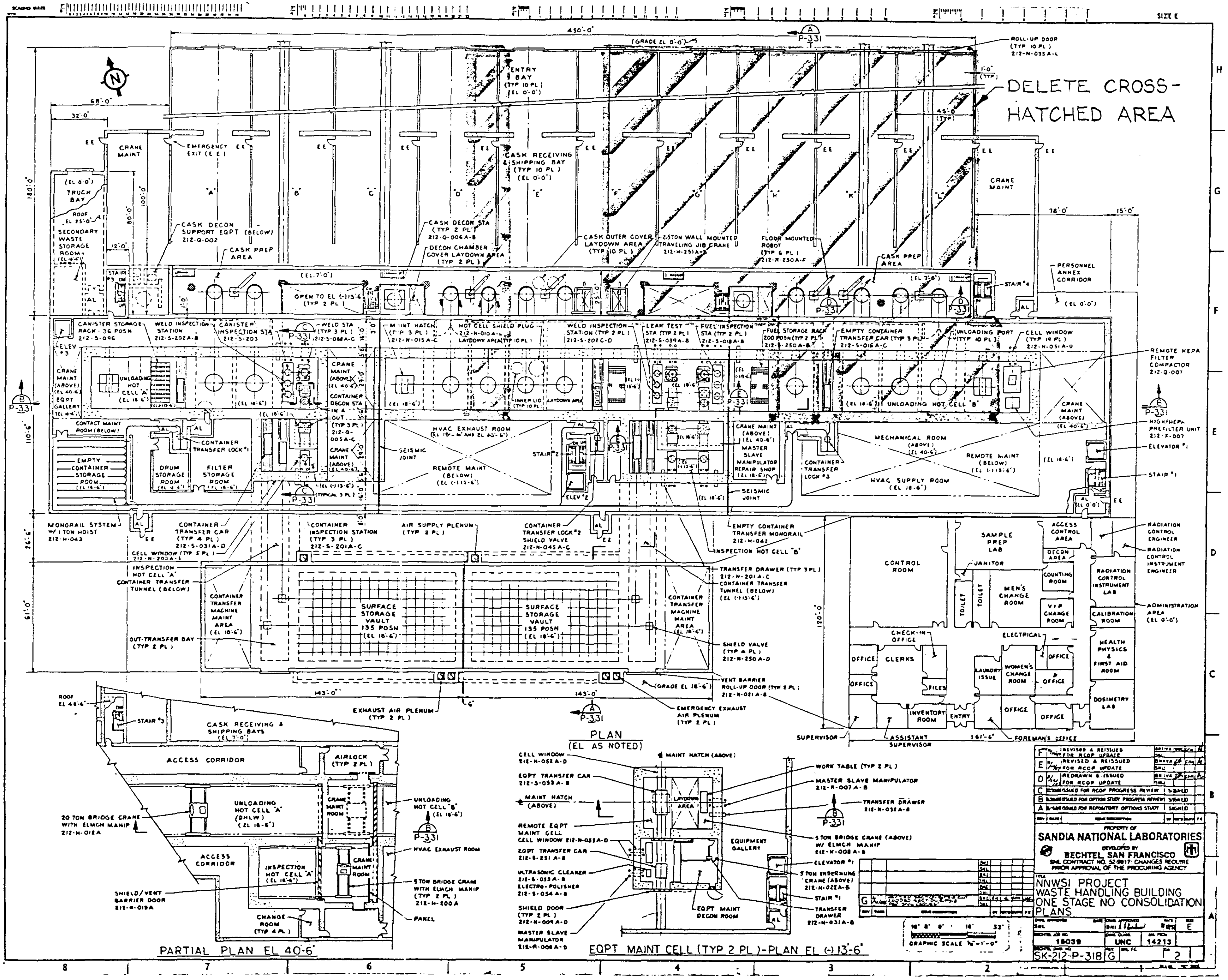


Figure 7-3. Waste-Handling Building Layout (Case 4)

2

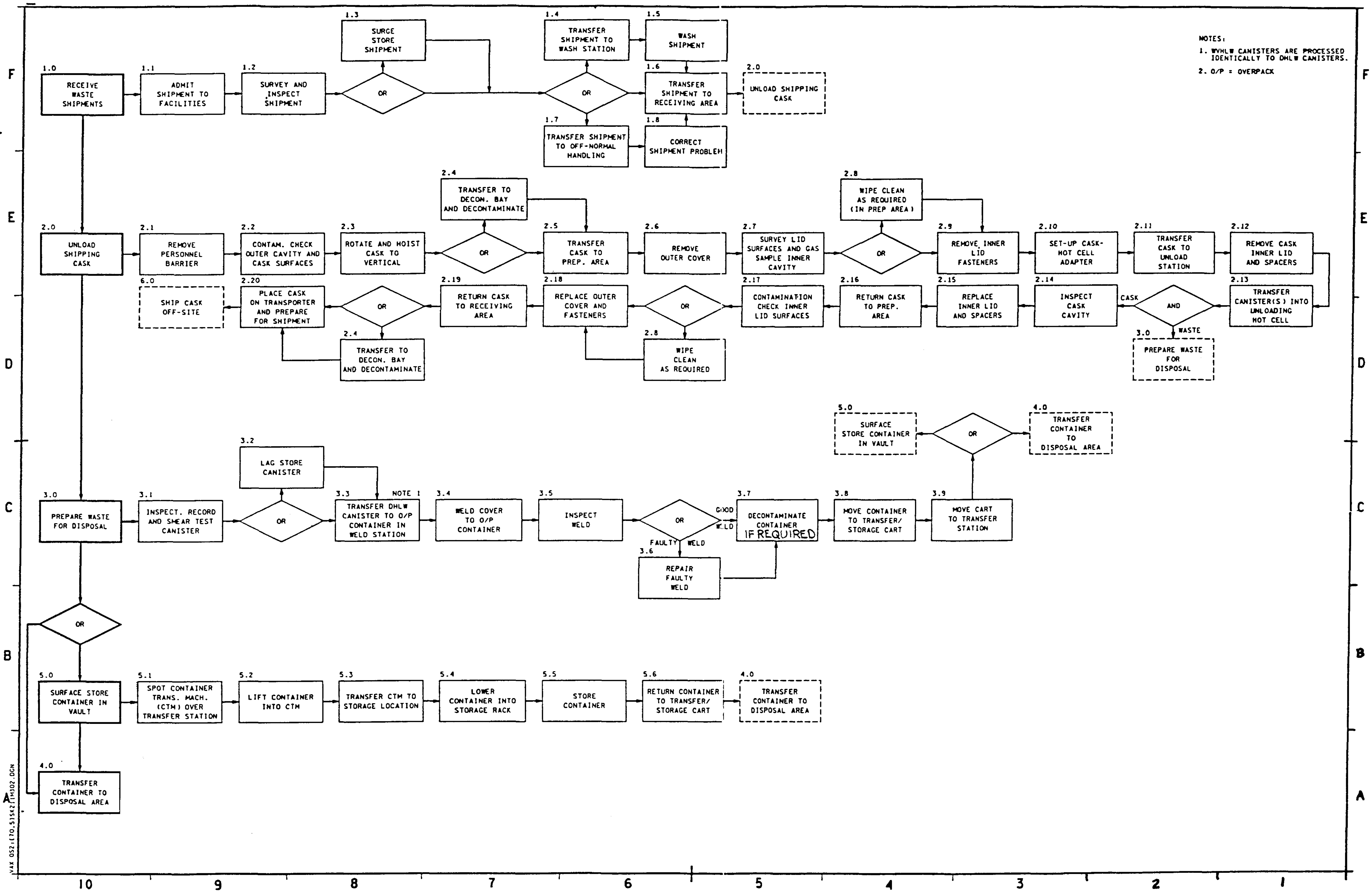


Figure 7-4. Material Flow Diagram for DHLW and WVHLW (Case 4)

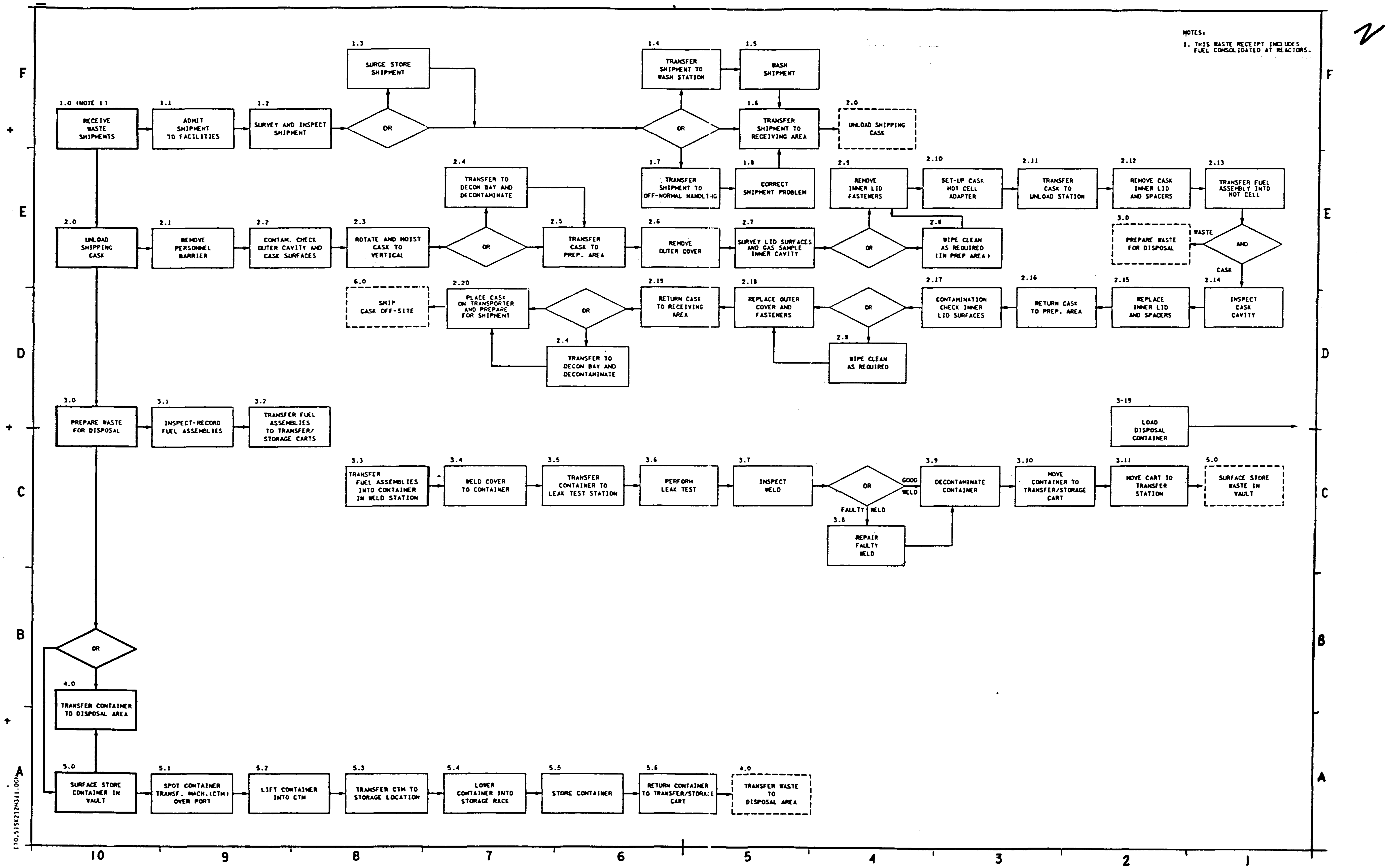


Figure 7-5. Material Flow Diagram for SNF (Case 4)

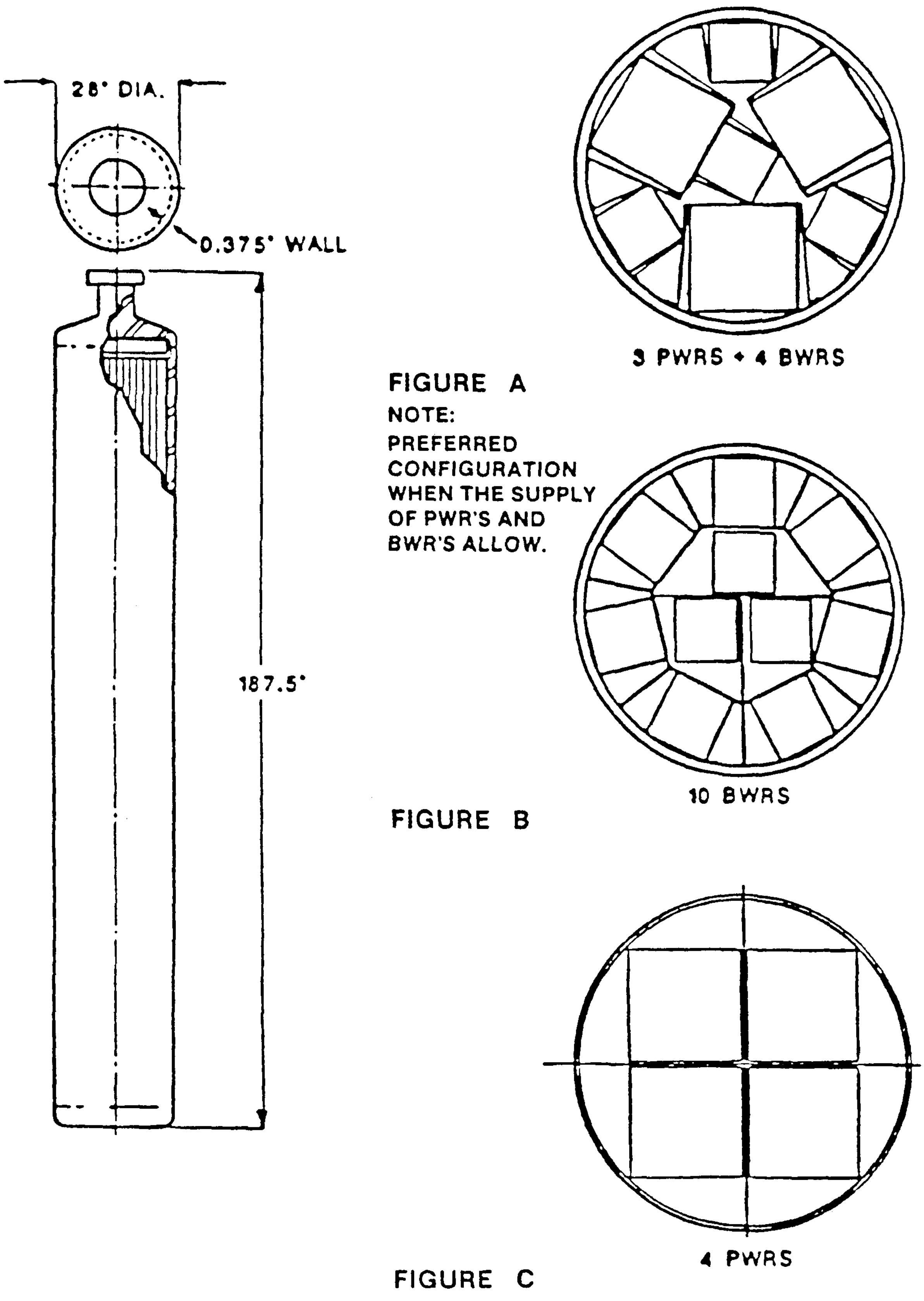


Figure 7-6. Intact Fuel Containers (Case 4)

<u>TABLE 7-1</u>

REPOSITORY THROUGHPUTS (CASE 4)

Year	MTU - First Repository: Spent Fuel	MTU - First Repository: HLW	MTU - First Repository: Cum.	HLW Containers: DHLW	HLW Containers: WVHLW	Spent Fuel: MTU	Spent Fuel: BWR MTU	Spent Fuel: BWR Assemblies Intact	Spent Fuel: PWR MTU	Spent Fuel: PWR Asemblies Intact	Disposal Containers: Hybrid	Disposal Containers: PWR Only
2003	400	0	400	0	0	400	133	741	267	620	185	16
2004	400	0	800	0	0	400	133	741	267	620	185	16
2005	400	0	1200	0	0	400	133	741	267	620	185	16
2006	900	0	2100	0	0	900	300	1667	600	1395	417	36
2007	1800	0	3900	0	0	1800	600	3333	1200	2791	833	73
2008	3000	400	7300	800	0	3000	1000	5556	2000	4651	1389	121
2009	3000	400	10700	800	0	3000	1000	5556	2000	4651	1389	121
2010	3000	400	14100	800	0	3000	1000	5556	2000	4651	1389	121
2011	3000	400	17500	800	0	3000	1000	5556	2000	4651	1389	121
2012	3000	400	20900	800	0	3000	1000	5556	2000	4651	1389	121
2013	3000	400	24300	800	0	3000	1000	5556	2000	4651	1389	121
2014	3000	400	27700	800	0	3000	1000	5556	2000	4651	1389	121
2015	3000	400	31100	800	0	3000	1000	5556	2000	4651	1389	121
2016	3000	400	34500	800	0	3000	1000	5556	2000	4651	1389	121
2017	3000	400	37900	800	0	3000	1000	5556	2000	4651	1389	121
2018	3000	400	41300	800	0	3000	1000	5556	2000	4651	1389	121
2019	3000	400	44700	800	0	3000	1000	5556	2000	4651	1389	121
2020	3000	400	48100	800	0	3000	1000	5556	2000	4651	1389	121
2021	3000	400	51500	800	0	3000	1000	5556	2000	4651	1389	121
2022	3000	400	54900	800	0	3000	1000	5556	2000	4651	1389	121
2023	3000	400	58300	680	28	3000	1000	5556	2000	4651	1389	121
2024	3000	400	61700	0	188	3000	1000	5556	2000	4651	1389	121
2025	3000	180	64880	0	84	3000	1000	5556	2000	4651	1389	121
2026	2700	0	67580	0	0	2700	900	5000	1800	4186	1250	109
2027	2420	0	70000	0	0	2420	807	4481	1613	3752	1120	98
TOTALS	63020	6980	70000	12680	300	63020	21007	116704	42013	97705	29176	2544

Notes: **Hybrid:** 4 BWR = 1 container
3 PWR = 1 container

PWR only: 4 PWR = 1 container

DHLW: 0.5 MTU = 1 container

WVHLW: 2.13 MTU = 1 container

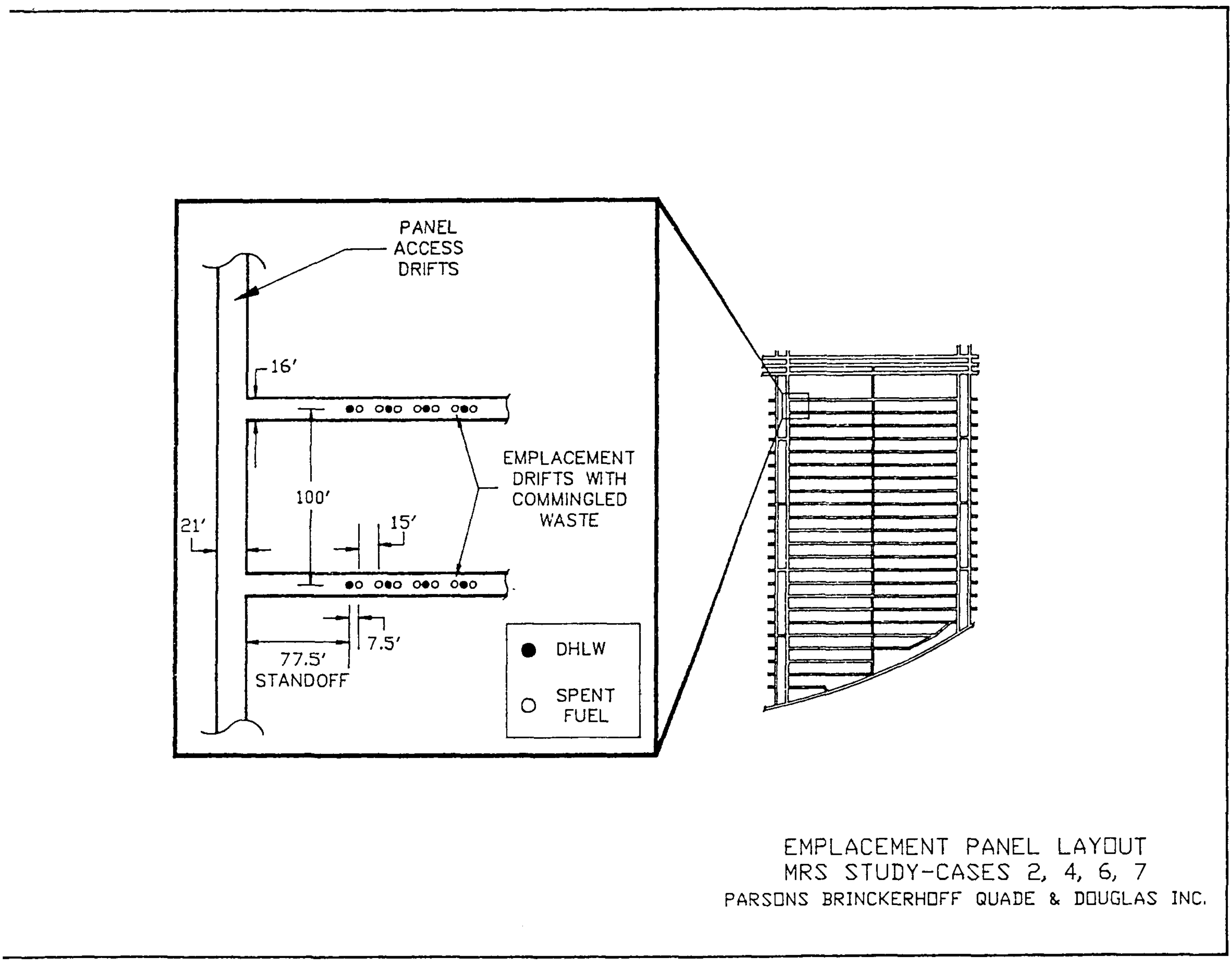


Figure 7-7. Emplacement Panel Layout (Case 4)

7.6 Cost and Schedule

7.6.1 Capital and Operating Costs

A summary of capital, operating, and decommissioning costs is given in Table 7-2.

Staffing requirements for the surface facilities for Case 4 are summarized in Table 7-3.

Staffing requirements for the underground facilities for Case 4 are summarized in Table 7-4.

Further details of these estimates are included in Appendix B.

7.6.2 Construction Schedule

The construction schedule for Case 4 is the same as the construction schedule that was developed for RCS Case 2. A summary bar chart covering the licensing, detailed design, and construction of the repository facilities for Case 4 is shown in Figure 7-8. Figure 7-9 shows a more detailed logic network for the construction of the waste-handling building.

Assuming that licensing activities permit a construction authorization on January 31, 1998, the facilities will be ready to receive waste by January 2003.

Details of the construction schedules for the surface and underground facilities for this case, which are identical to those for Case 2, are presented in Subsection 5.6.2.

TABLE 7-2

SUMMARY OF LIFE-CYCLE COSTS (CASE 4)
(in Millions of 1988 Constant Dollars[a])

Cost Category Description	Construction	Operations	Decommissioning	Total
Management and Integration				
Architect/Engineer	173	0	17	
Construction Management	63	0	2	
Other	44	54	4	
Subtotal	280	54	23	357
Surface Facilities				
Site	178	109	41	
High-Level Waste-Handling Facilities	230	759[b]	22	
Other Waste-Handling Facilities	46		5	
Balance of Plant	137	1,211	51	
Subtotal	591	2,079	119	2,789
Subsurface Facilities				
Shafts and Ramps	65	31	4	
Excavation and Emplacement	151	1,011	123	
Service Systems	105	926	165	
Subtotal	321	1,968	292	2,581
Total w/o Disposal Containers	1,192	4,101	434	5,727
Disposal Containers				
Spent Fuel	0	983	0	
DHLW	0	216	0	
Other	0	85	0	
Subtotal	0	1,284	0	1,284
Total	1,192	5,385	434	7,011

a. Unescalated for the life of the repository.
b. Includes cost of operations for all waste-handling facilities.

TABLE 7-3

STAFFING REQUIREMENTS: SURFACE FACILITIES (CASE 4)

Facility	Staff
Waste-Handling Building 1	0
Waste-Handling Building 2	124
Waste Treatment Building	8
Vehicle Wash Facility	0 *
Decontamination Building	0 *
Performance Confirmation Building	17
Health Physics Station 4	0 *
Medical Center	11
Fire Station/Emergency Center	15
Security Station 1	35
Security Station 2/Health Physics Station 3	19
Security Station 3	25
Men-and-Material Shaft Security Station	4
Shops	70
Motor Pool/Facilities Sewage Station	16
Transporter Garage	30
Administration Building	143
Food Services Facility	22
Mockup Building	6
Central Warehouse	17
Visitors Center	3
Change House	0 *
Computer Building	46
Concrete Batch Plant and Aggregate Storage	4
Tuff Pile	4
Total Full Time Personnel	619

* Assigned only as required.

TABLE 7-4

STAFFING REQUIREMENTS: UNDERGROUND FACILITY (CASE 4)

Category	Staff
Shafts and Ramps	12
Drift Excavation	130
Emplacement Borehole Drilling and Lining	77
Emplacement/Retrieval Operations	17
Support Services	263
Total, Subsurface	499

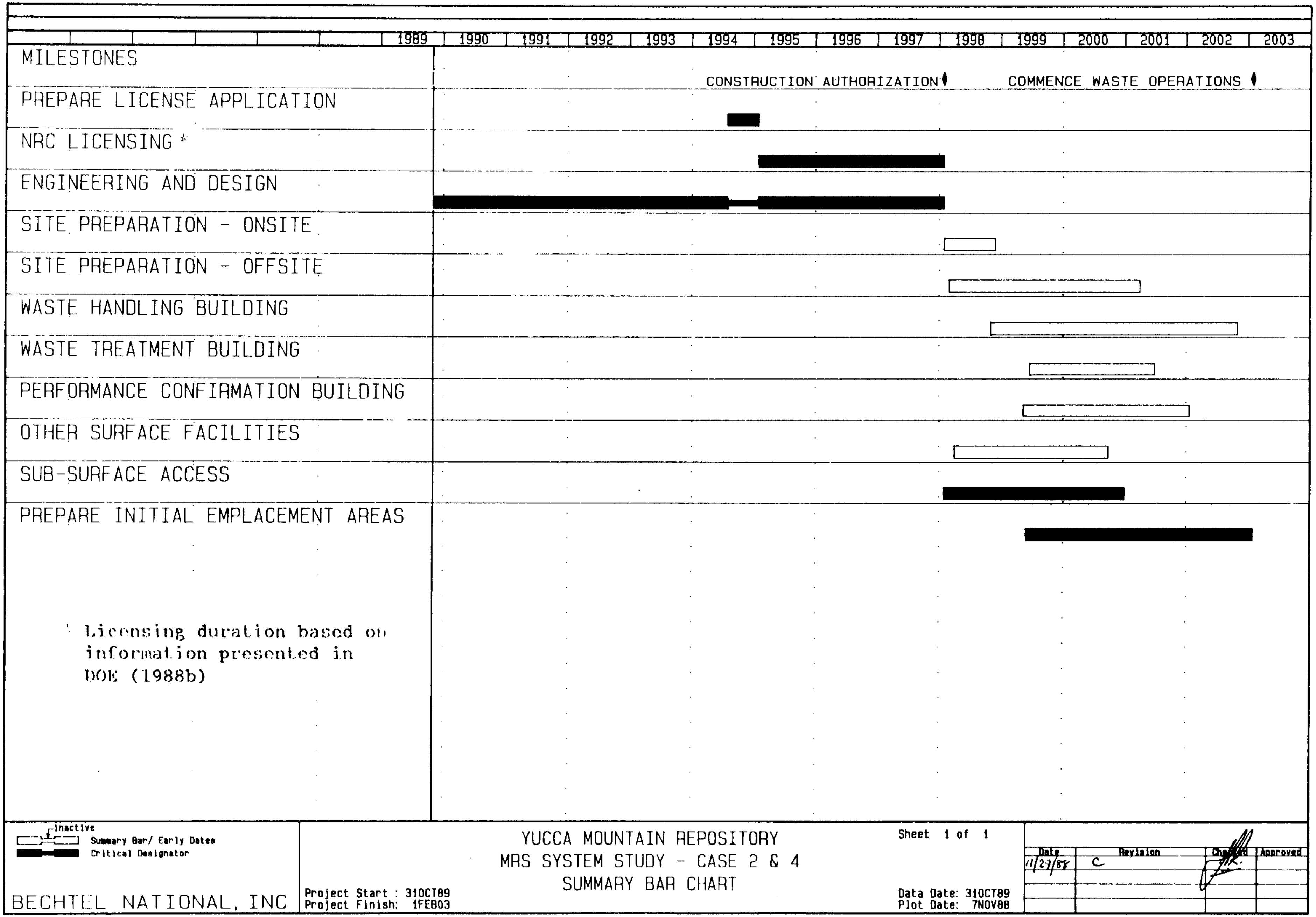


Figure 7-8. Construction Schedule Summary (Case 4)

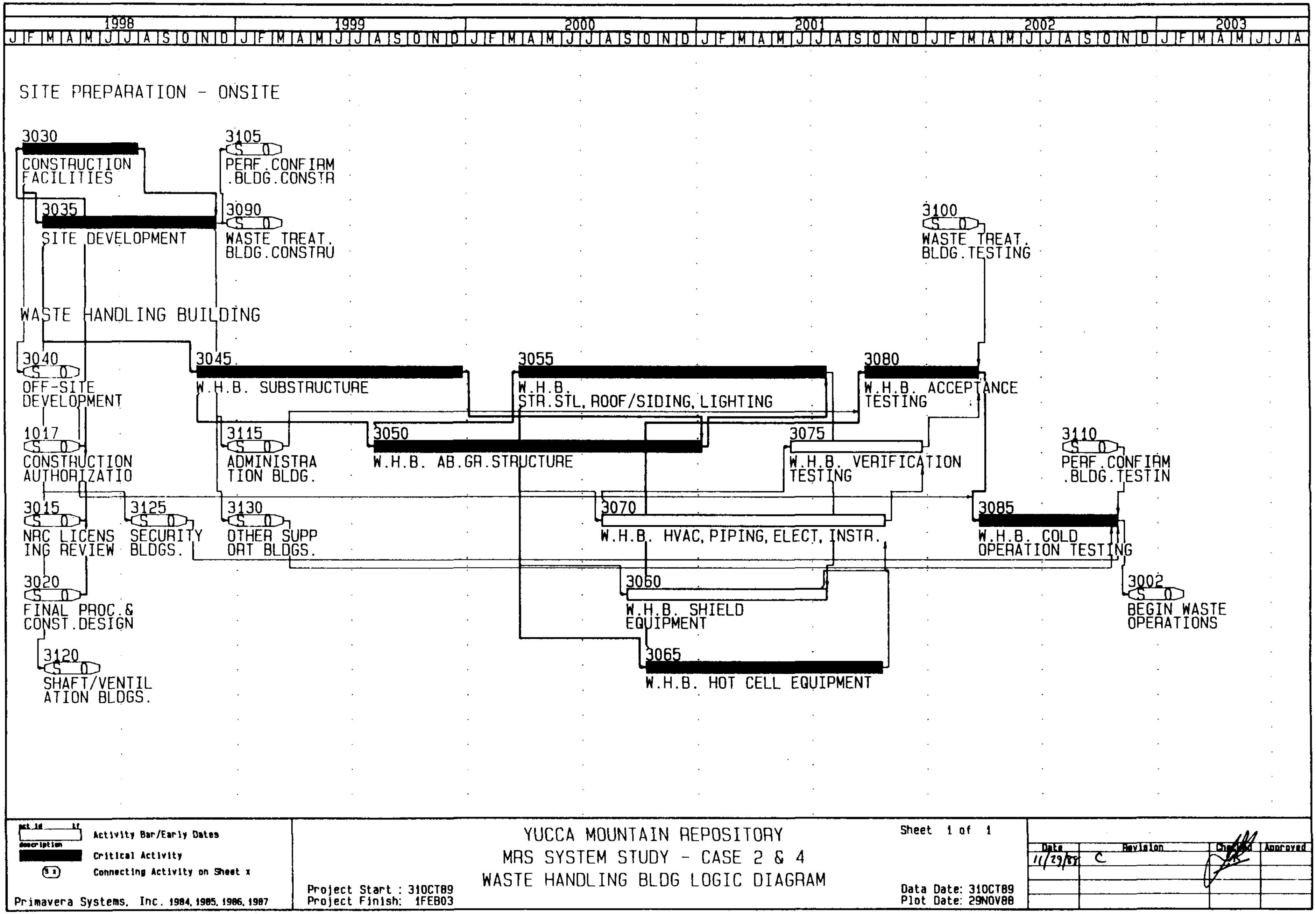


Figure 7-9. Logic Network for the Construction of the Waste-Handling Buildings

8.0 CASE 5

For Case 5, SNF assemblies are consolidated and placed in canisters at the MRS and then shipped to the repository, where the canisters are overpacked (containerized) for emplacement. There is no consolidation at the repository. DHLW and WVHLW are received in canisters at the repository and then containerized for emplacement.

8.1 Assumptions

In addition to the general assumptions stated in Section 3, the following specific assumptions apply to Case 5:

- Ninety percent of the SNF received at the repository is in canisters shipped from the MRS; the remaining 10% is in the form of bare intact assemblies shipped from western reactors.

- At the MRS, 95% of the SNF is consolidated and 5 percent is left intact.

- At the MRS, all (intact and consolidated) SNF is placed in square canisters before being shipped to the repository. As shown in Figure 8-1, there are two types of square canisters used for intact and consolidated BWR and PWR assemblies: 9.1 in. x 9.1 in. for packaging 1 intact PWR assembly, 2 consolidated PWR assemblies, or 5 consolidated BWR assemblies; and 6.0 in. x 6.0 in. for packaging 1 intact BWR assembly.

- For BWR assemblies, 1 intact assembly is placed in each square canister, and 61 canisters (61 intact assemblies) are loaded into each shipping cask; 5 consolidated assemblies are placed in each square canister and 28 canisters (140 consolidated assemblies) are loaded into each shipping cask.

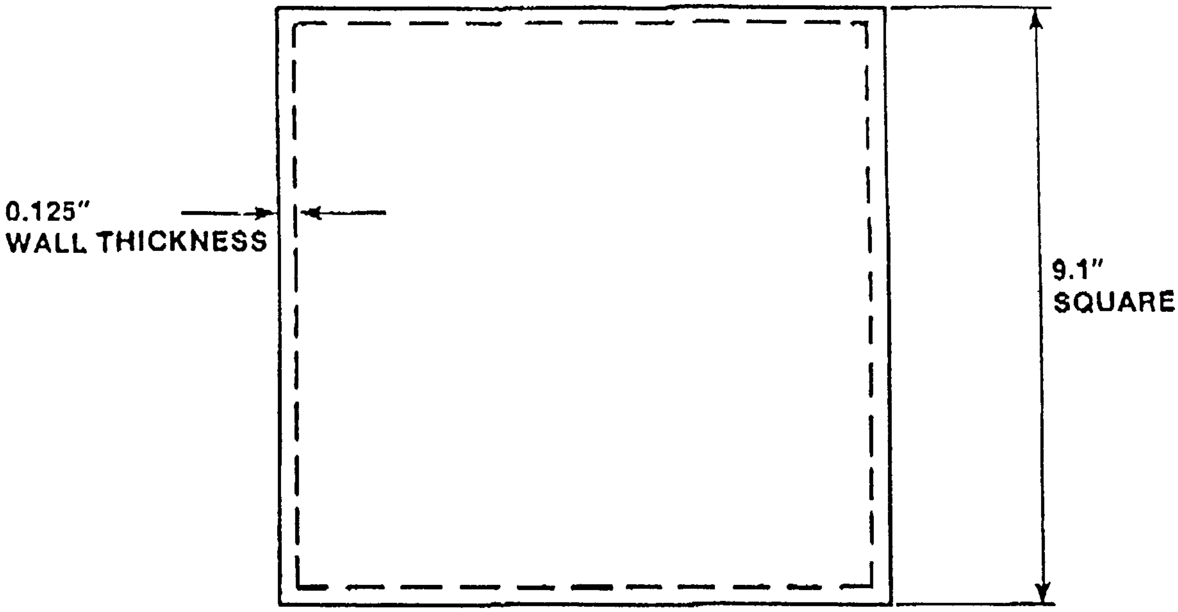


FIGURE A - PWR - INTACT & CONSOLIDATED, AND BWR - CONSOLIDATED

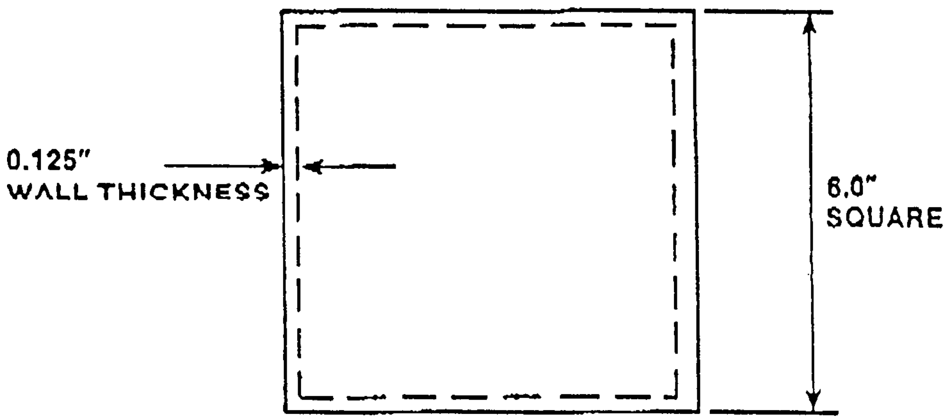


FIGURE B - BWR INTACT

Figure 8-1. MRS Canisters (Case 5)

- For PWR assemblies, 1 intact assembly is placed in each square canister, and 28 canisters (28 intact assemblies) are loaded into each shipping cask; 2 consolidated assemblies are placed in each square canister, and 28 canisters (56 consolidated assemblies) are loaded into each shipping cask.

- The hardware from the consolidation of 7 BWR and/or PWR assemblies at the MRS is collected in a 55-gal drum. Five drums of hardware are loaded into a hardware cage, and 4 hardware cages are placed in a cask for shipment to the repository.

- All the SNF from the MRS is shipped to the repository by rail.

- The shipment of SNF from western reactors to the repository is 55% by rail and 45% by truck.

- There are 48 intact BWR SNF assemblies per rail cask shipped from the western reactors to the repository.

- There are 7 intact BWR SNF assemblies per truck cask shipped from western reactors to the repository.

- There are 21 intact PWR SNF assemblies per rail cask shipped from western reactors to the repository.

- There are 3 intact PWR SNF assemblies per truck cask shipped from western reactors to the repository.

- At the repository, 9 intact BWR assemblies (bare from western reactors and canistered from the MRS) are placed in a container for emplacement. A total of 20 consolidated BWR assemblies (4 canisters) are placed in a container for emplacement.

- At the repository, 4 intact PWR assemblies (bare from western reactors and canistered from the MRS) are placed into a container for emplacement. Six consolidated PWR assemblies (3 canisters) are placed in a container for emplacement.

- At the repository, each hardware canister is overpacked in a 28-in.-diameter x 188-in.-long container for emplacement.

8.2 Waste Received

The annual and total quantities of SNF and high-level waste received at the repository during its 25 yr of operation are shown in Table 3-1. As can be seen from this table, the maximum annual quantity of SNF received, when the repository is operating at full receipt capacity, is 3,000 MTU/yr.

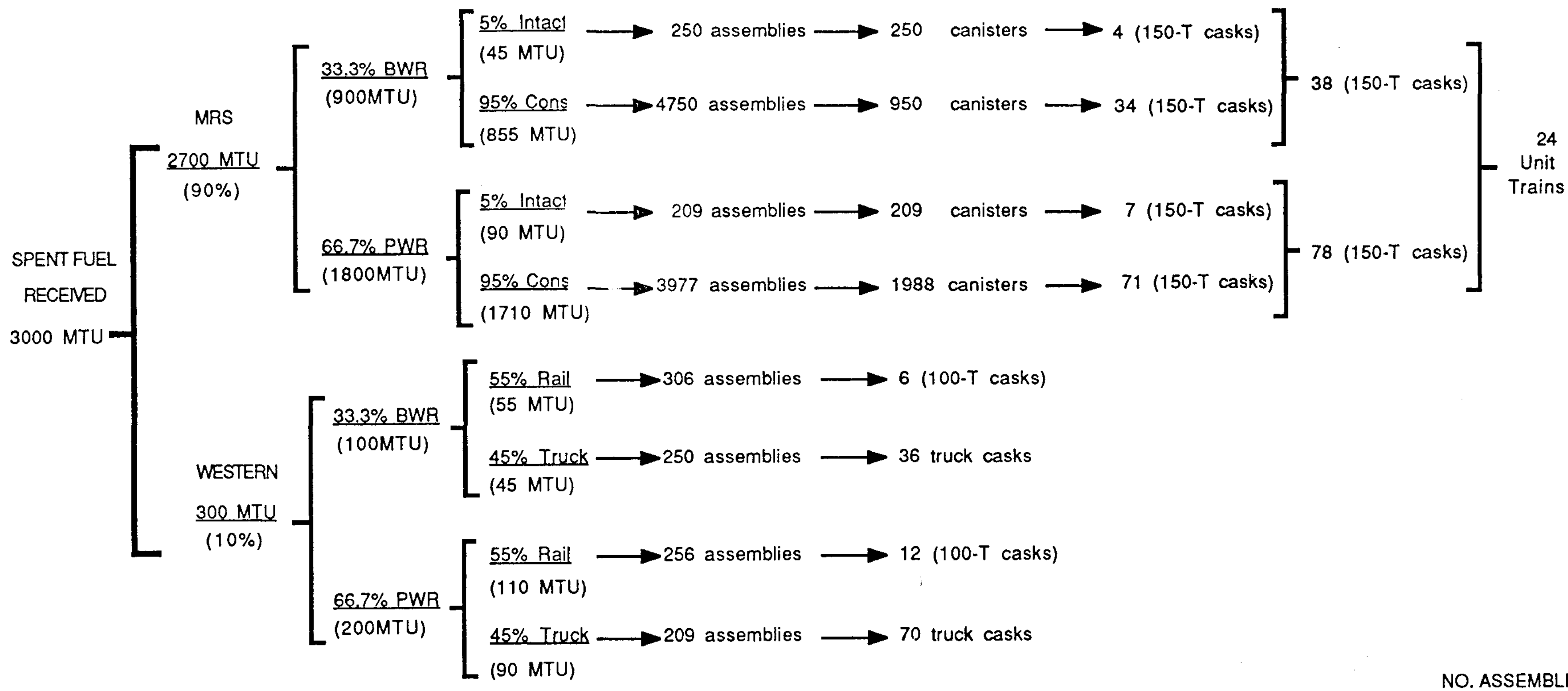
DHLW and WVHLW are received at the repository directly from the applicable facilities (not from the MRS).

The annual throughputs (at full receipt capacity) for Case 5 are summarized in Figure 8-2. The calculations for the quantities shown in this figure are provided in Appendix A.

8.2.1 SNF from the MRS

Ninety percent, or 2,700 MTU, is received in canisters, stored at the MRS, and shipped to the repository by rail in 150-ton casks that are unique for this case. One-third, or 900 MTU, of this is BWR fuel; two-thirds, or 1,800 MTU, is PWR fuel. At 0.18 MTU per BWR assembly, there are 5,000 BWR assemblies; at 0.43 MTU per PWR assembly, there are 4,186 PWR assemblies per year shipped to the repository from the MRS.

A total of 95% of the assemblies (4,750 BWR assemblies and 3,977 PWR assemblies) are consolidated assemblies, and 5% (250 BWR assemblies and 209 PWR assemblies) are intact assemblies.



NON-SPENT FUEL RECEIVED

DHLW:	MTU's	400
	Canisters	800
	Rail Casks	160
MRS Hardware:	Drums	1247
	Cages	250
	Rail Casks	63

CASK CAPACITIES (ASSEMBLIES)

MRS ALL RAIL:	BWR intact	61
	BWR consol.	140
	PWR intact	28
	PWR consol.	56
REACTOR:	BWR rail	48
	BWR truck	7
	PWR rail	21
	PWR truck	3
HARDWARE:	rail	4 cages
DHLW:	rail	5 canisters

EMPLACEMENT OPERATIONS	NO. CONTAINERS	NO. ASSEMBLIES/ CONTAINER
BWR (Intact)	90	9
BWR (Consolidated)	237	20
PWR (Intact)	168	4
PWR (Consolidated)	663	6
Hardware	250	35
DHLW	800	1 canister
Total	2208	

Figure 8-2. Repository Annual Throughputs (Case 5)

With a BWR rail cask capacity of 140 consolidated assemblies (28 canisters), there are 34 rail casks of BWR consolidated fuel received at the repository per year from the MRS. With a BWR rail cask capacity of 61 intact assemblies (61 canisters), there are 4 rail casks of BWR intact fuel received at the repository per year from the MRS.

With a PWR rail cask capacity of 56 consolidated assemblies (28 canisters), there are 71 rail casks of PWR consolidated fuel received at the repository per year from the MRS. With a PWR rail cask capacity of 28 intact assemblies (28 canisters), there are 7 rail casks of PWR intact fuel received at the repository per year from the MRS.

With five casks of SNF per train, 24 unit trains per year transport SNF from the MRS to the repository.

For every 7 BWR or PWR assemblies, one drum of hardware is collected. Five drums are placed in a cage, and 4 cages are loaded into a shipping cask for transport to the repository for emplacement. Extra cars are added to the SNF rail shipments, as required, to transport hardware from the MRS to the repository. This averages to 2-3 cars per unit train.

8.2.2 SNF from Western Reactors

Every year, western reactors ship 300 MTU of bare assemblies directly to the repository. One-third, or 100 MTU, of this is BWR fuel; two-thirds, or 200 MTU, is PWR fuel. A total of 55% of this fuel is shipped to the repository by rail and 45% by truck.

This corresponds to 306 BWR assemblies in 6 rail casks (48 assemblies per BWR rail cask), 250 BWR assemblies in 36 truck casks (and 7 assemblies per BWR truck cask), 256 PWR assemblies in 12 rail casks (21 assemblies per BWR rail cask), and 209 PWR assemblies in 70 truck casks (3 assemblies per BWR truck cask) shipped to the repository from western reactors.

8.3 Surface Facilities

The surface facilities for Case 5 of this study are similar to the surface facilities in the SCP-CDR design, except that there is one waste-handling building for Case 5 and two waste-handling buildings in the SCP-CDR design. The Case 5 waste-handling building is the same as the waste-handling building in the RCS Case 3 design. The plot plan, which is essentially the same for both designs, is provided in Figure 8-3.

For Case 5, the use of the 150-ton rail cask for SNF shipments from the MRS necessitates major changes in both the configuration and orientation of the waste-handling building. These changes are related to the exclusive use of rail casks for shipments from the MRS and to the practical limit for the span of the 200-ton bridge crane used to unload the casks from the railcars. As seen in Figure 8-3, the waste-handling building is rotated about 45°, and a single rail line passes through a cask-receiving bay that accommodates three railcars in tandem.

The waste-handling building, shown in Figure 8-4, is considerably smaller and simpler than the waste-handling building shown in Case 2, primarily because most of the waste (all but 135 MTU/yr of the spent fuel from the western utilities) is received in rail casks. Two cask-unloading cells, with a total of three floor ports, accommodate the entire 3,400 MTU/yr throughput of spent fuel, DHLW, and WVHLW. The fact that most of the waste is received prepackaged in decontaminated canisters simplifies the waste-handling operation and contributes to a relatively uncomplicated facility design.

The DHLW and WVHLW material flow diagram for Case 5, as shown in Figure 8-5, is the same as that for Cases 1 through 4. The SNF material flow diagram for Case 5 is shown in Figure 8-6.

8.4 Disposal Containers

The spent fuel containers are unique for Case 5. The design is based on the DOE square/small square canister concept. The

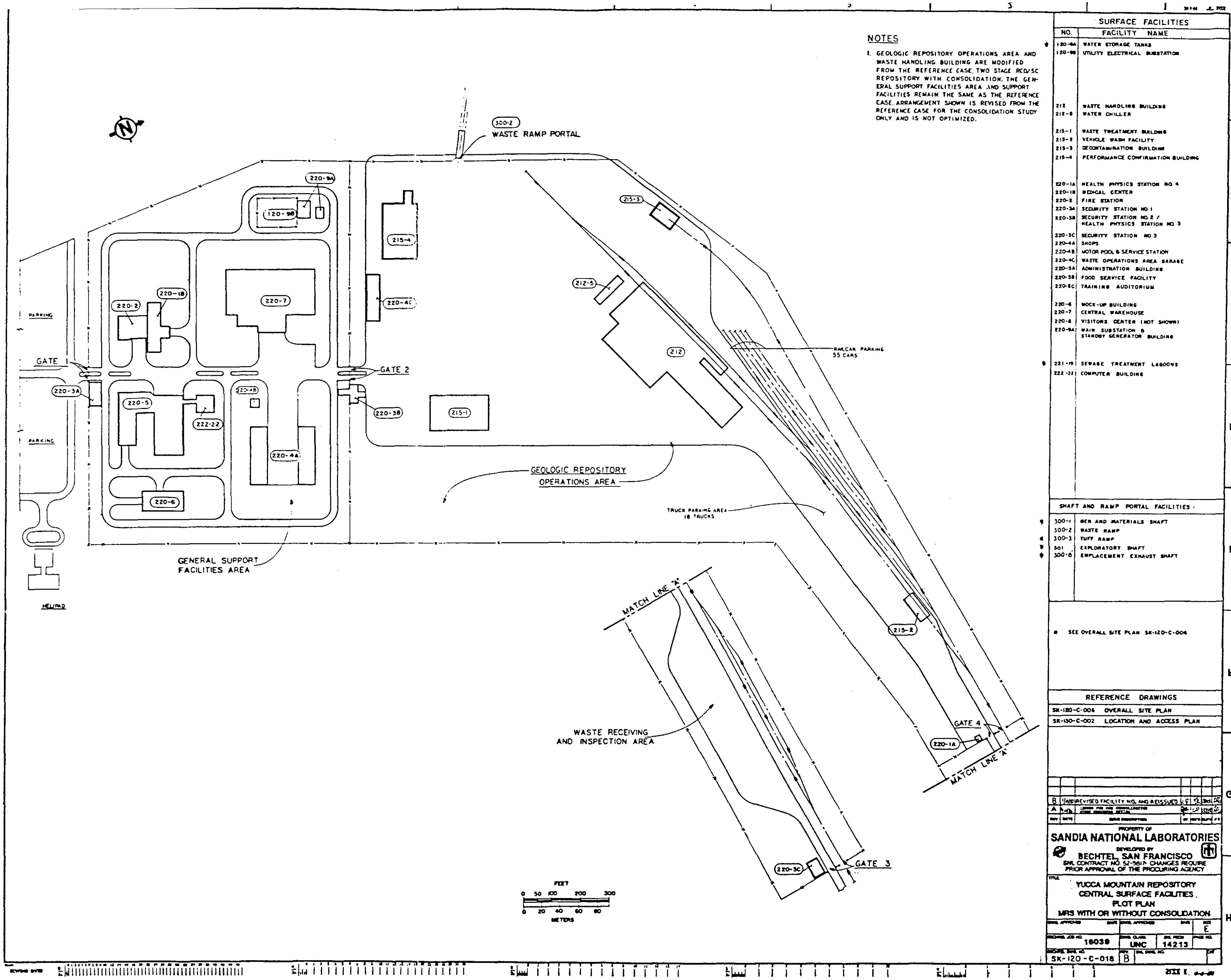


Figure 8-3. Repository Plot Plan (Case 5)

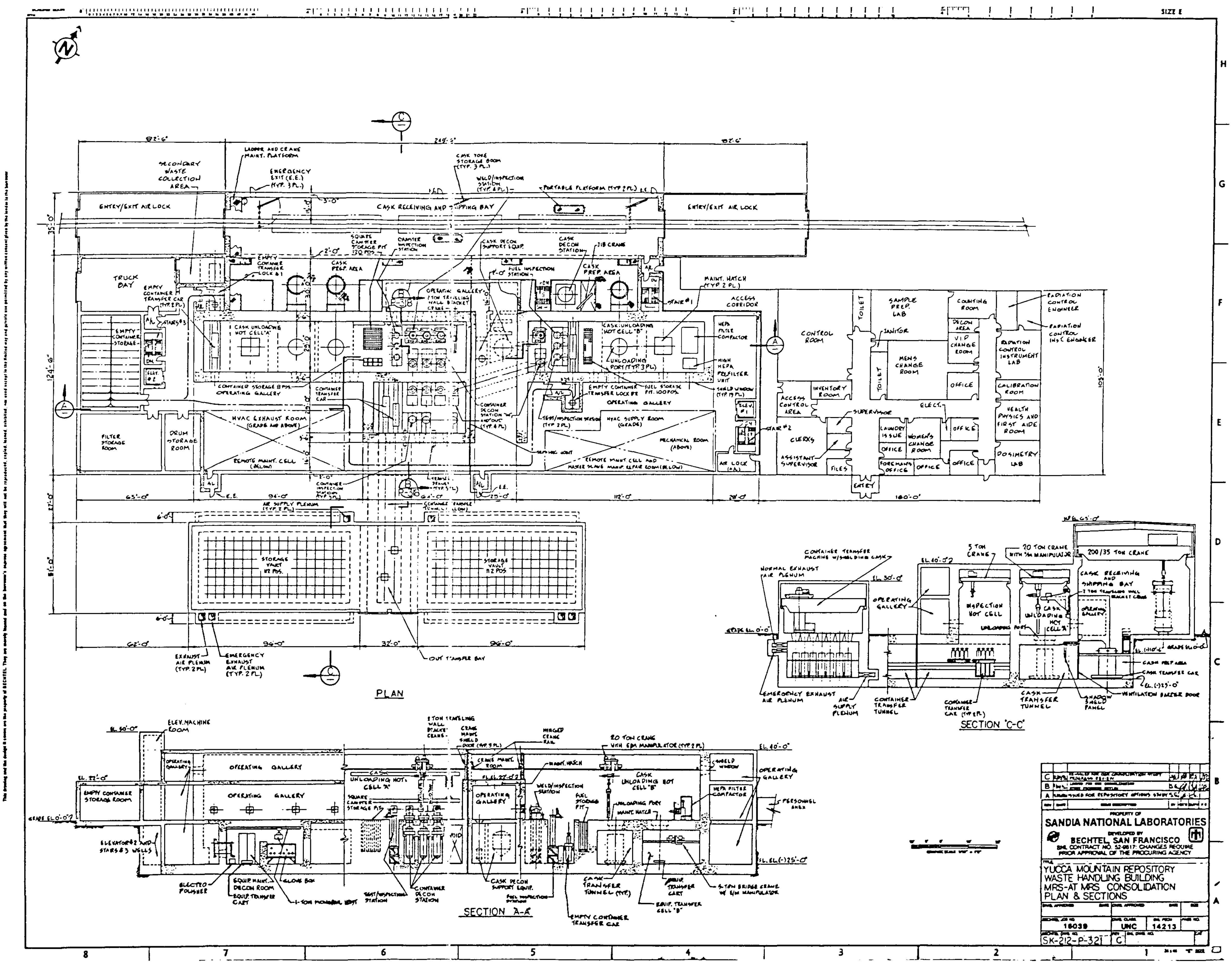


Figure 8-4. Waste-Handling Building Layout (Case 5)

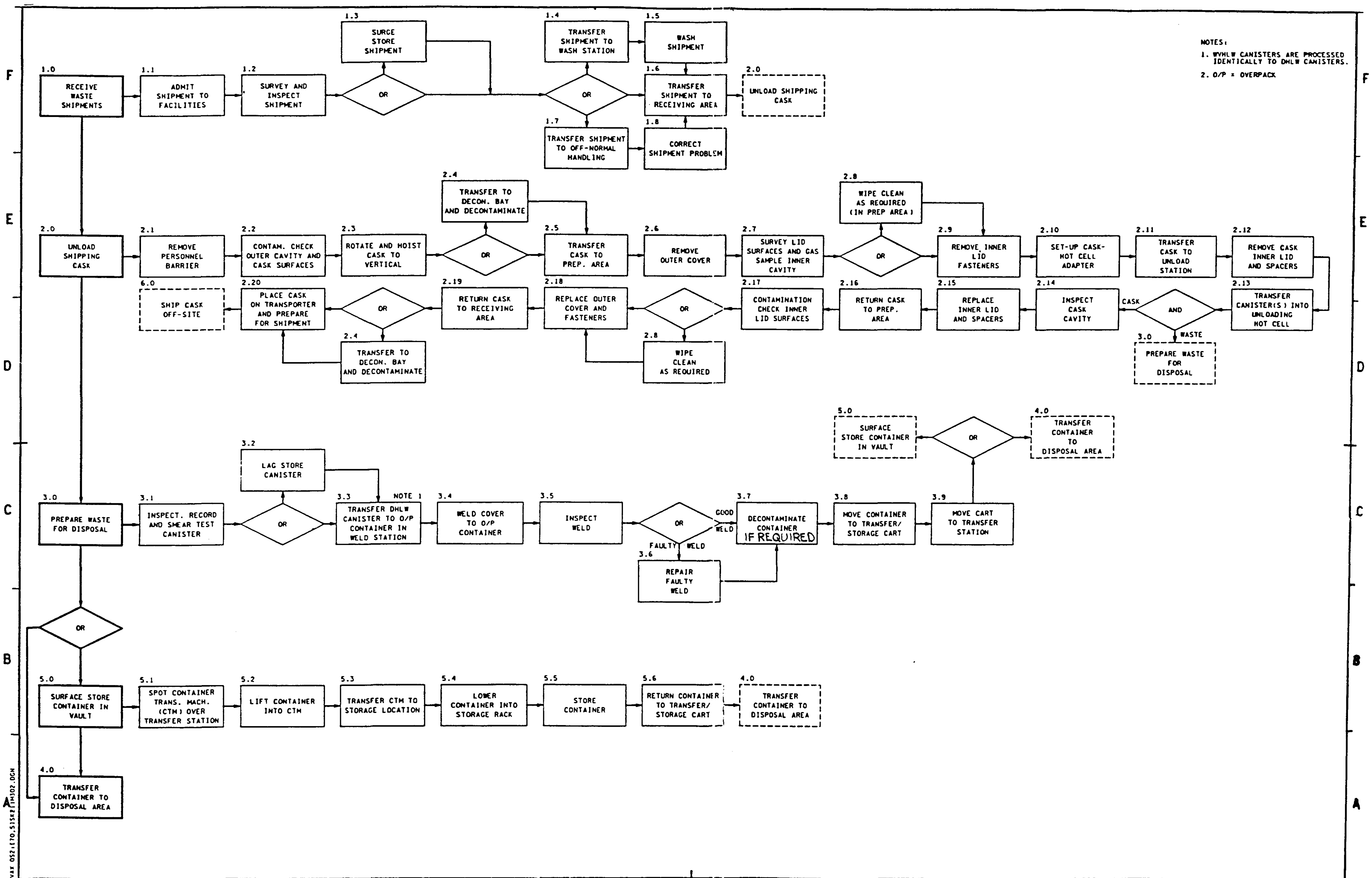


Figure 8-5. Materia Flow Diagram for DHLW and WVHLW (Case 5)

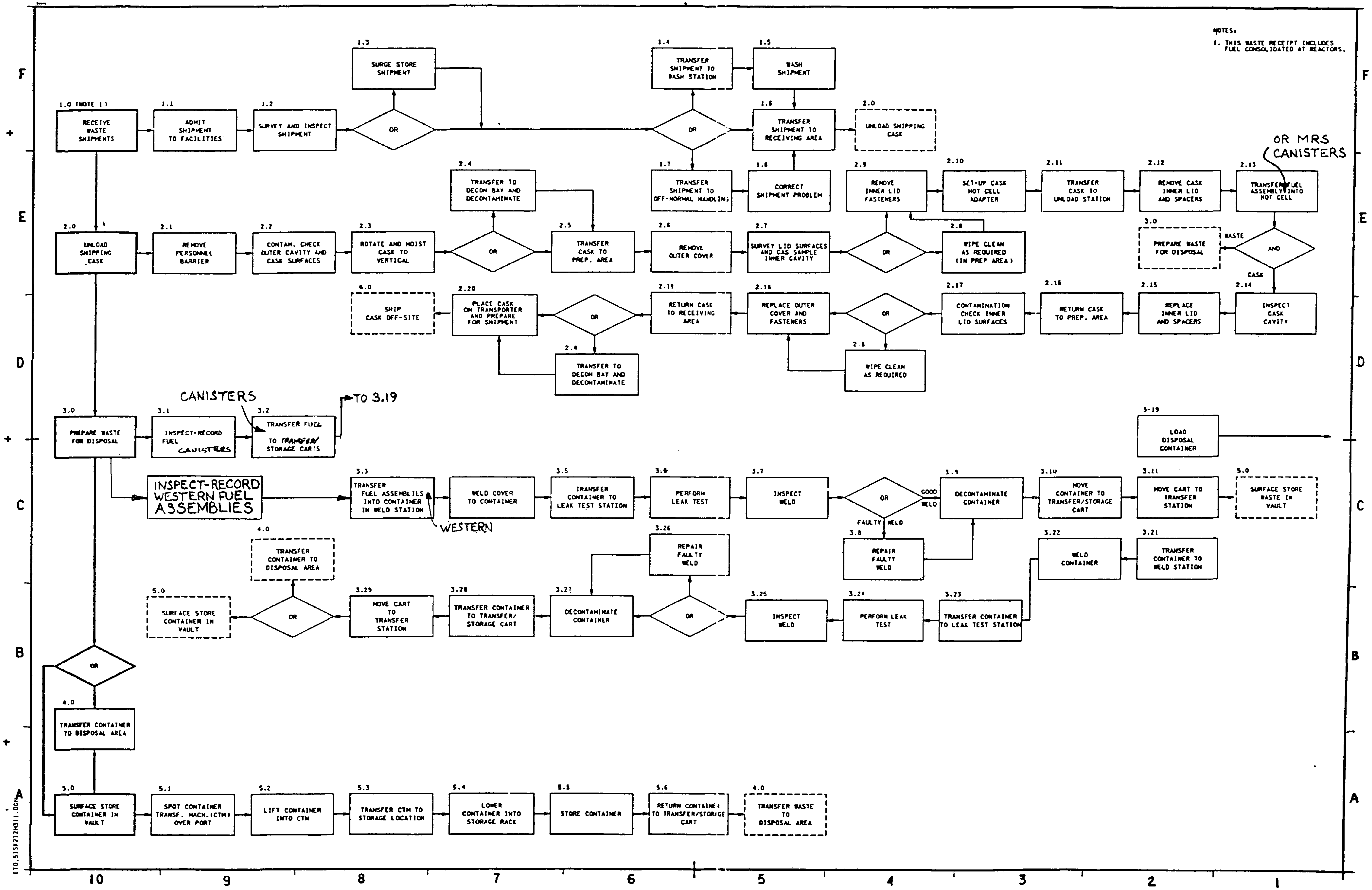


Figure 8-6. Material Flow Diagram for SNF (Case 5)

disposal container, shown in Figure 8-7, is 28 in. in diameter and is 179.5 in. long when configured for consolidated fuel and 186.5 in. long when configured for intact fuel assemblies. It accommodates 9 small square canisters (6 in. x 6 in.) or up to 4 square canisters (9 in. x 9 in.). (The 3,500-W thermal power limit necessitates downloading to 3 square canisters of consolidated PWR fuel.) Alternatively, the container holds 4 intact PWR assemblies or 9 intact BWR assemblies, either as bare fuel assemblies (for fuel shipped from the western utilities) or in canisters (for fuel shipped from the MRS). Hardware waste is shipped from the MRS in generic cages (each containing five 55-gal drums) assumed to be 26 in. in diameter and 180 in. long and is overpacked at the repository in 28-in.-diameter x 188-in.-long disposal containers.

The spent fuel container emplacement schedule for Case 5 is shown in Table 8-1. During the 25-yr operating history of the repository, 24,345 spent fuel containers, 5,238 hardware containers, and 12,980 DHLW and WVHLW containers are emplaced.

8.5 Underground Facility

Figure 8-8 shows the dimensional details of the Case 5 emplacement panel. In this case, the 235°C limit for borehole wall temperature (Criterion 2, Subsection 3.1.5) is limiting, and the borehole spacing is 8.0 ft (as compared with 7.5 ft for Cases 2, 3, and 4). The emplacement drift spacing is 121 ft.

The thermal power values for the Case 5 spent fuel container configurations are as follows:

• 4 intact PWR assemblies	2,104 W
• 6 consolidated PWR assemblies	3,156 W
• 9 intact BWR assemblies	1,503 W
• 20 consolidated BWR assemblies	3,340 W
• Hardware waste	insignificant

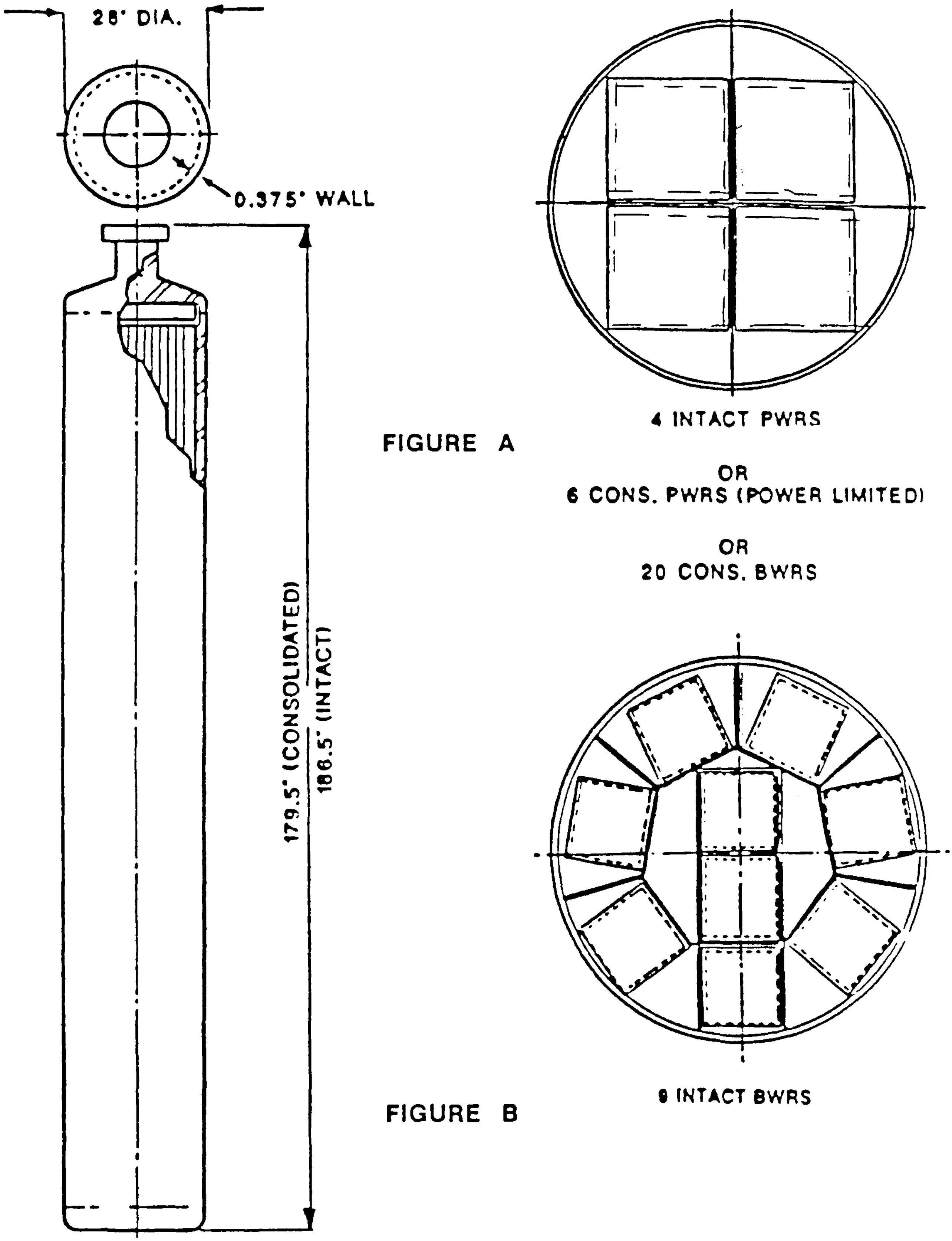


Figure 8-7. Canistered Fuel Containers (Case 5)

TABLE 8-1

REPOSITORY THROUGHPUTS (CASE 5)

	MTU - First Repository			HLW Containers		Spent Fuel from MRS													Spent Fuel from Western Reactors						
							BWR						PWR							BWR			PWR		
								Assemblies		Disposal Containers				Assemblies		Disposal Containers									
Year	Spent Fuel	HLW	Cum.	DHLW	WVHLW	MTU	MTU	Intact	Consol.	Intact	Consol.	Hdw.	MTU	Intact	Consol.	Intact	Consol.	Hdw.	MTU	MTU	Assys.	Cont.	MTU	Assys.	Cont.
2003	400	0	400	0	0	360	120	33	633	4	32	18	240	28	530	7	88	15	40	13	74	8	27	62	16
2004	400	0	800	0	0	360	120	33	633	4	32	18	240	28	530	7	88	15	40	13	74	8	27	62	16
2005	400	0	1200	0	0	360	120	33	633	4	32	18	240	28	530	7	88	15	40	13	74	8	27	62	16
2006	900	0	2100	0	0	810	270	75	1425	8	71	41	540	63	1193	16	199	34	90	30	167	19	60	140	35
2007	1800	0	3900	0	0	1620	540	150	2850	17	142	81	1080	126	2386	31	398	68	180	60	333	37	120	279	70
2008	3000	400	7300	800	0	2700	900	250	4750	28	237	136	1800	209	3977	52	663	114	300	100	556	62	200	465	116
2009	3000	400	10700	800	0	2700	900	250	4750	28	237	136	1800	209	3977	52	663	114	300	100	556	62	200	465	116
2010	3000	400	14100	800	0	2700	900	250	4750	28	237	136	1800	209	3977	52	663	114	300	100	556	62	200	465	116
2011	3000	400	17500	800	0	2700	900	250	4750	28	237	136	1800	209	3977	52	663	114	300	100	556	62	200	465	116
2012	3000	400	20900	800	0	2700	900	250	4750	28	237	136	1800	209	3977	52	663	114	300	100	556	62	200	465	116
2013	3000	400	24300	800	0	2700	900	250	4750	28	237	136	1800	209	3977	52	663	114	300	100	556	62	200	465	116
2014	3000	400	27700	800	0	2700	900	250	4750	28	237	136	1800	209	3977	52	663	114	300	100	556	62	200	465	116
2015	3000	400	31100	800	0	2700	900	250	4750	28	237	136	1800	209	3977	52	663	114	300	100	556	62	200	465	116
2016	3000	400	34500	800	0	2700	900	250	4750	28	237	136	1800	209	3977	52	663	114	300	100	556	62	200	465	116
2017	3000	400	37900	800	0	2700	900	250	4750	28	237	136	1800	209	3977	52	663	114	300	100	556	62	200	465	116
2018	3000	400	41300	800	0	2700	900	250	4750	28	237	136	1800	209	3977	52	663	114	300	100	556	62	200	465	116
2019	3000	400	44700	800	0	2700	900	250	4750	28	237	136	1800	209	3977	52	663	114	300	100	556	62	200	465	116
2020	3000	400	48100	800	0	2700	900	250	4750	28	237	136	1800	209	3977	52	663	114	300	100	556	62	200	465	116
2021	3000	400	51500	800	0	2700	900	250	4750	28	237	136	1800	209	3977	52	663	114	300	100	556	62	200	465	116
2022	3000	400	54900	800	0	2700	900	250	4750	28	237	136	1800	209	3977	52	663	114	300	100	556	62	200	465	116
2023	3000	400	58300	680	28	2700	900	250	4750	28	237	136	1800	209	3977	52	663	114	300	100	556	62	200	465	116
2024	3000	400	61700	0	188	2700	900	250	4750	28	237	136	1800	209	3977	52	663	114	300	100	556	62	200	465	116
2025	3000	180	64880	0	84	2700	900	250	4750	28	237	136	1800	209	3977	52	663	114	300	100	556	62	200	465	116
2026	2700	0	67580	0	0	2430	810	225	4275	25	214	122	1620	188	3579	47	597	102	270	90	500	56	180	419	105
2027	2420	0	70000	0	0	2178	726	202	3832	22	192	109	1452	169	3208	42	535	92	242	81	448	50	161	375	94
TOTALS	63020	6980	70000	12680	300	56718	18906	5252	99782	584	4989	2851	37812	4397	83538	1099	13923	2387	6302	2101	11670	1297	4201	9771	2443

Notes:

BWRs: 9 intact = 1 container
20 consolidated = 1 container

PWRs: 4 intact = 1 container
6 consolidated = 1 container

Hardware: 7 assemblies = 1 drum
5 drums = 1 container

DHLW: 0.5 MTU = 1 container

WVHLW: 2.13 MTU = 1 container

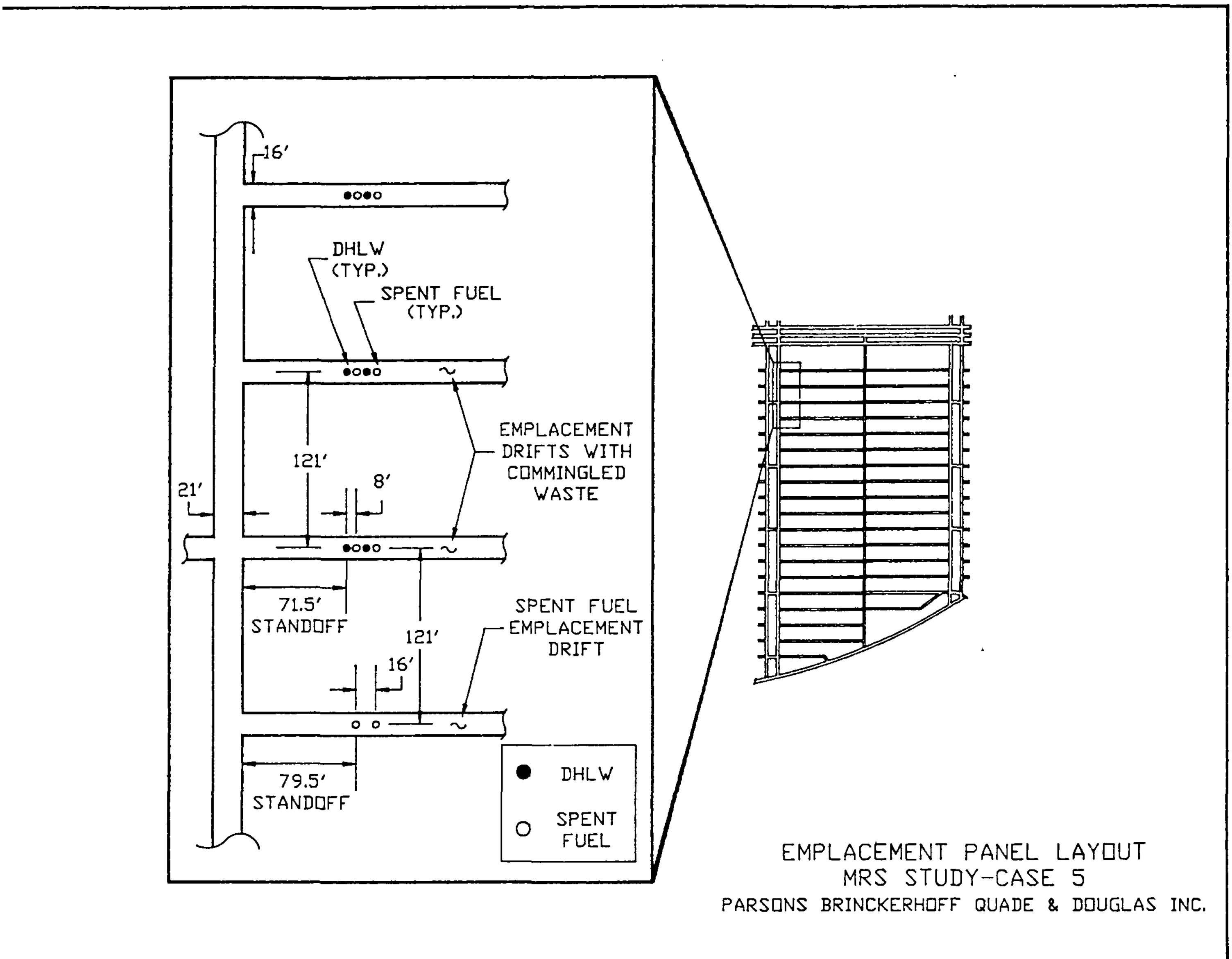


Figure 8-8. Emplacement Panel Layout (Case 5)

8.6 Cost and Schedule

8.6.1 Capital and Operating Costs

A summary of capital, operating, and decommissioning costs is given in Table 8-2.

Staffing requirements for the surface facilities for Case 5 are summarized in Table 8-3.

Staffing requirements for the underground facility for Case 5 are summarized in Table 8-4.

Further details of these estimates are included in Appendix B.

8.6.2 Construction Schedule

A detailed schedule for the waste-handling building was not developed for Cases 5, 6, 7, 8, and 9. Based on a review of the capital costs and the building takeoff quantities for the Case 1 WHB-1 and for the Case 2 waste-handling building, a schedule for the construction of the waste-handling building in Cases 5 through 9 would probably be longer than the 48 mo calculated for the Case 1 WHB-1 but shorter than the 57 mo calculated for the Case 2 waste-handling building. In this study, a 52-mo duration is assumed. A summary bar chart showing the licensing, detailed design, and construction of the repository facilities for Case 5 is shown in Figure 8-9. The rationale for each activity of the summary schedule is given in Table 8-5. The logic network for the construction of the underground facility is presented in Figure 4-12.

Assuming that licensing activities permit a construction authorization on January 31, 1998, the facilities will be ready to receive waste by January 2003.

TABLE 8-2

SUMMARY OF LIFE-CYCLE COSTS (CASE 5)
(In Millions of 1988 Constant Dollars[a])

Cost Category Description	Construction	Operations	Decommissioning	Total
Management and Integration				
Architect/Engineer	151	0	16	
Construction Management	57	0	2	
Other	39	54	4	
Subtotal	247	54	22	323
Surface Facilities				
Site	178	107	41	
High-Level Waste-Handling Facilities	156	687[b]	11	
Other Waste-Handling Facilities	46		4	
Balance of Plant	136	1,176	50	
Subtotal	516	1,970	106	2,592
Subsurface Facilities				
Shafts and Ramps	66	31	3	
Excavation and Emplacement	146	943	112	
Service Systems	100	889	151	
Subtotal	312	1,863	266	2,441
Total w/o Disposal Containers	1,075	3,887	394	5,356
Disposal Containers				
Spent Fuel	0	754	0	
DHLW	0	215	0	
Other	0	223	0	
Subtotal	0	1,192	0	1,192
Total	1,075	5,079	394	6,548

a. Unescalated for the life of the repository.
b. Includes cost of operations for all waste-handling facilities.

TABLE 8-3

STAFFING REQUIREMENTS: SURFACE FACILITIES (CASE 5)

Facility	Staff
Waste-Handling Building 1	0
Waste-Handling Building 2	150
Waste Treatment Building	8
Vehicle Wash Facility	0 *
Decontamination Building	0 *
Performance Confirmation Building	17
Health Physics Station 4	0 *
Medical Center	10
Fire Station/Emergency Center	15
Security Station 1	35
Security Station 2/Health Physics Station 3	18
Security Station 3	22
Men-and-Material Shaft Security Station	4
Shops	68
Motor Pool/Facilities Sewage Station	15
Transporter Garage	28
Administration Building	142
Food Services Facility	20
Mockup Building	5
Central Warehouse	17
Visitors Center	3
Change House	0 *
Computer Building	44
Concrete Batch Plant and Aggregate Storage	4
Tuff Pile	4
Total Full Time Personnel	627

* Assigned only as required.

TABLE 8-4

STAFFING REQUIREMENTS:
UNDERGROUND FACILITY (CASE 5)

Category	Staff
Shafts and Ramps	12
Drift Excavation	117
Emplacement Borehole Drilling and Lining	74
Emplacement/Retrieval erations	16
Support Services	249
Total, Subsurface	468

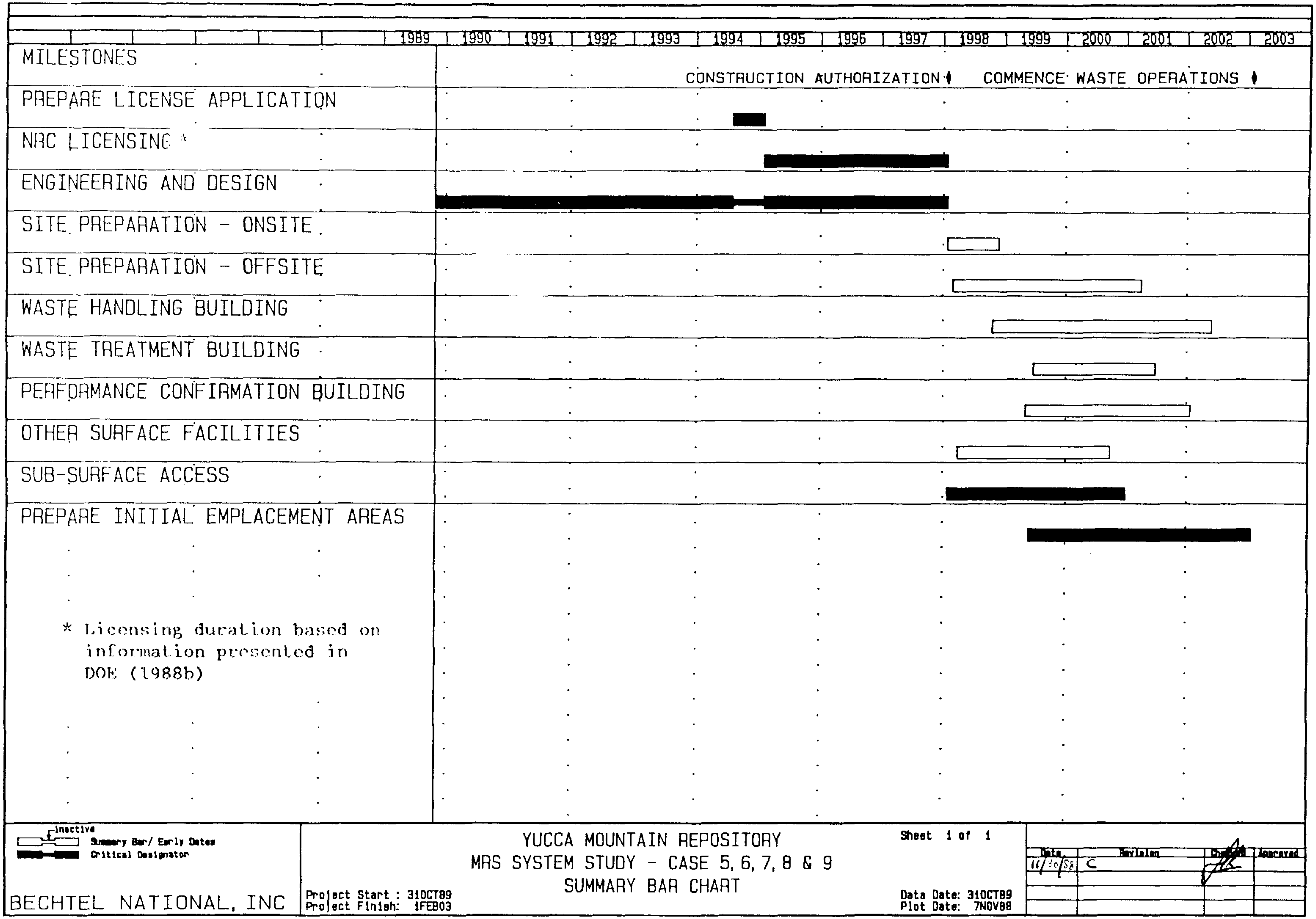


Figure 8.9. Construction Schedule Summary (Case 5)

TABLE 8-5

SUMMARY BAR CHART ACTIVITY DESCRIPTION--CASES 5, 6, 7, 8, AND 9

Activity Number	Title	Duration Calendar Days	General Description	Constructed Quantity and Daily Rate	Other
None	Milestones	0	Shows timing of "Construction Authorization" and "Commence Waste Operations"	NA	These data are given as described in Subsection 3.3
None	Prepare License Application	184	Shows time required, after license application design phase, to prepare the NRC license application	6 mo	
None	NRC Licensing	1095	Period for NRC to review the repository license application	36 mo	Licensing duration based on information presented in DOE (1988b)
None	Engineering and Design	2829	Summary of engineering activities: - advanced conceptual design - license application design - final procurement and construction design	 822 days 912 days 1,095 days	These engineering activities are consecutive, with an interruption of 184 days during preparation of license application
None	Site Preparation--Onsite	304	Summary of construction facility erection and site development	NA	Based on more detailed schedule
None	Site Preparation--Offsite	1140	Summary of offsite preparation activities: road, utilities, railroad, bridges	NA	Based on more detailed schedule
None	Waste-Handling Building	1320	Summary of WHB activities	NA	Assumed duration
None	Waste Treatment Building	757	Summary of waste treatment building activities	NA	Based on more detailed schedule
None	Performance Confirmation Building	964	Summary of performance confirmation building activities	NA	Based on more detailed schedule
None	Other Surface Facilities	909	Summary of schedules for construction of other surface facilities	NA	Based on more detailed schedule
None	Subsurface Access	575	Summary of subsurface access activities	NA	Based on PBQ&D detailed schedule
None	Initial Emplacement Areas	1250	Summary of emplacement area excavation	NA	Based on PBQ&D detailed schedule

9.0 CASE 6

For Case 6, SNF assemblies from all reactors are placed, without consolidation, in containers at the MRS and then shipped to the repository for inspection and emplacement. Defective containers found during inspection at the repository are returned to the MRS. DHLW and WVHLW canisters are containerized at the MRS and then shipped to the repository for emplacement. There is no consolidation or containerizing at the repository.

9.1 Assumptions

In addition to the general assumptions stated in Section 3, the following specific assumptions apply to Case 6:

- All the SNF (from eastern and western reactors) is shipped by rail from the MRS to the repository.
- All SNF is containerized intact at the MRS.
- There are 10 BWR SNF assemblies per BWR container.
- There are 4 PWR SNF assemblies per PWR container.
- There are 4 BWR SNF assemblies per hybrid container and 3 PWR SNF assemblies per hybrid container. (A hybrid container contains 4 BWR and 3 PWR assemblies.)
- There are 4 containers (BWR, PWR, or hybrid) per cask.
- The use of the hybrid container is preferred. After all of the BWR assemblies (along with the PWR assemblies) have been packaged in the hybrid containers, the remaining PWR assemblies are packaged in PWR containers (hybrid containers can accommodate all of the BWR assemblies, but not all of the PWR assemblies).

- DHLW is containerized at the MRS and is shipped to the repository in casks that have a capacity of 5 containers.

- All containerized waste received at the repository from the MRS is inspected, and defective containers are returned to the MRS. If necessary, the containers are repaired sufficiently to allow shipment back to the MRS.

- It is assumed that 1% of the containers are defective.

- The time required to load and unload casks with returned containers is not included.

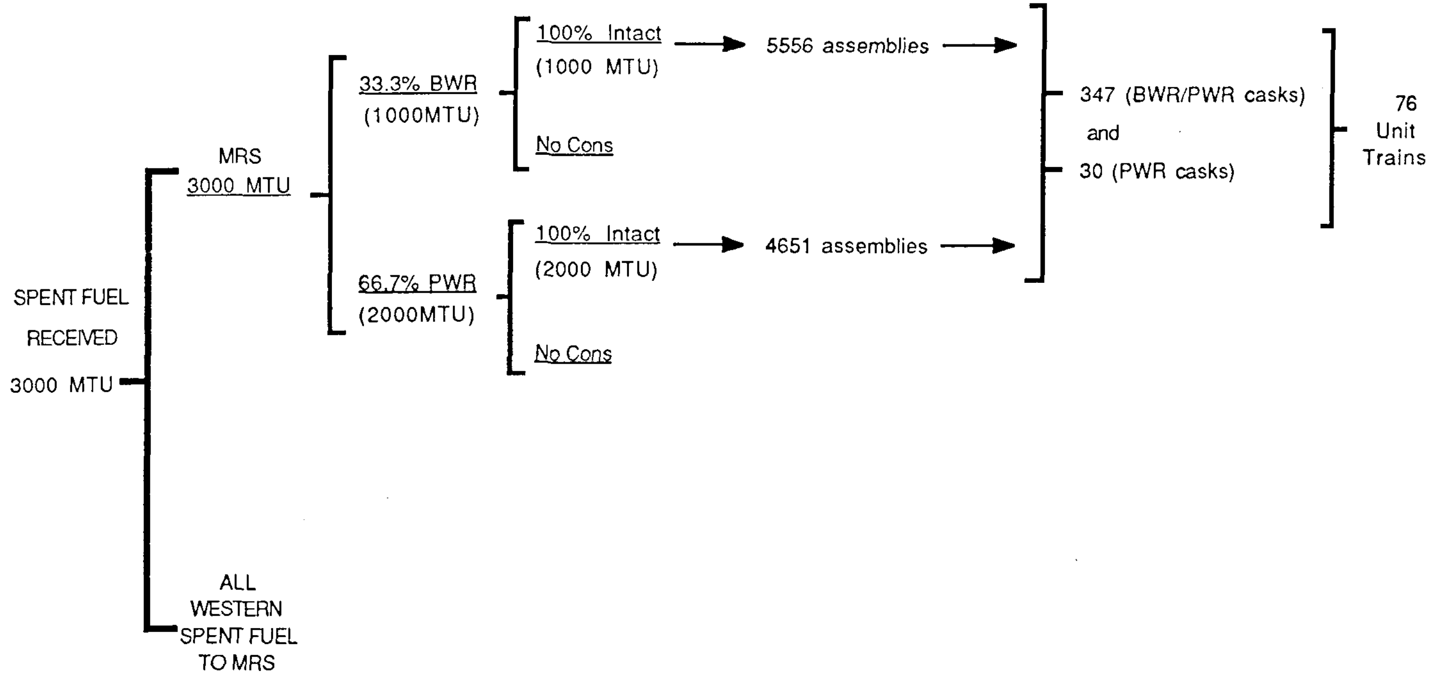
9.2 Waste Received

For Case 6, all of the SNF (3,000 MTU), including SNF from western reactors, received at the repository is received as intact assemblies that have been containerized at the MRS in the same BWR, PWR, and hybrid containers described in Subsection 5.4 (Case 2). One-third, or 1,000 MTU (5,556 assemblies), is received as BWR assemblies; two-thirds, or 2,000 MTU (4,651 assemblies), is received as PWR assemblies.

With 4 BWR and 3 PWR assemblies per hybrid container, 1,389 hybrid containers will accommodate all BWR assemblies and all but 484 PWR assemblies, which are packaged in 121 PWR containers that have a capacity of 4 PWR assemblies per container. At 4 containers per cask, 347 casks are required for the hybrid containers and 30 casks are required for the PWR containers. A total of 76 trains (5 casks per train) are used to transport the casks from the MRS to the repository.

All DHLW and WVHLW is containerized at the MRS and shipped to the repository in casks that have a capacity of 5 containers.

The annual throughputs (at full receipt capacity) for Case 6 are summarized in Figure 9-1. The calculations for the quantities shown in this figure are provided in Appendix A.



NON-SPENT FUEL RECEIVED

DHLW:	MTU's	400
	Canisters	800
	Rail Casks	160
MRS Hardware:	Drums	0
	Canisters	0
	Rail Casks	0

CASK CAPACITIES (ASSEMBLIES)

MRS ALL RAIL:	BWR/PWR intact	16/12
	BWR intact	40
	PWR intact	16
REACTOR:	BWR rail	N/A
	BWR truck	N/A
	PWR rail	N/A
	PWR truck	N/A
HARDWARE:	rail	N/A
DHLW:	rail	5 canisters

EMPLACEMENT OPERATIONS	NO. CONTAINERS	NO. ASSEMBLIES/ CONTAINERS
BWR/PWR-mixed (Intact)	1389	4/3
BWR (Intact)	0	N/A
PWR (Intact)	121	4
Hardware	0	N/A
DHLW	800	1 canister
Total	2310	

Figure 9-1. Repository Annual Throughputs (Case 6)

9.3 Surface Facilities

Only one waste-handling building is required for Case 6. The waste-handling building for Case 6 is similar to the waste-handling building for Case 5, except that areas required for containerizing SNF in the waste-handling building for Case 5 have been eliminated because packaging in containers is not performed in the waste-handling building for Case 6. The plot plan, which is essentially the same for both designs, is provided in Figure 9-2.

Figure 9-3 is a markup of the RCS Case 3 (also Case 5) waste-handling building layout showing the space for equipment required for containerizing deleted to reflect the requirements for Case 6. The sole purpose of this markup is to show deleted building volume for cost-estimating purposes. This should not be interpreted as a technical representation of how the design of the building with the reduced volume and areas would actually be developed. Other than the containerizing requirements, the remaining functional requirements, throughputs, and descriptions pertaining to the waste-handling building for Case 6 are the same as those for the waste-handling building in Case 5, as described in Subsection 8.3.

The DHLW and WVHLW material flow diagram for Case 6 is shown in Figure 9-4. The SNF material flow diagram for Case 6 is shown in Figure 9-5.

9.4 Disposal Containers

The container for Case 6, shown in Figure 9-6, is the same container used in Cases 2 and 4 of this study. The container descriptions, contents, and throughputs are the same as those provided in Subsection 5.4 (Case 2) of this report. The year-by-year container emplacement schedule shown in Table 9-1 is the same as that for Case 2.

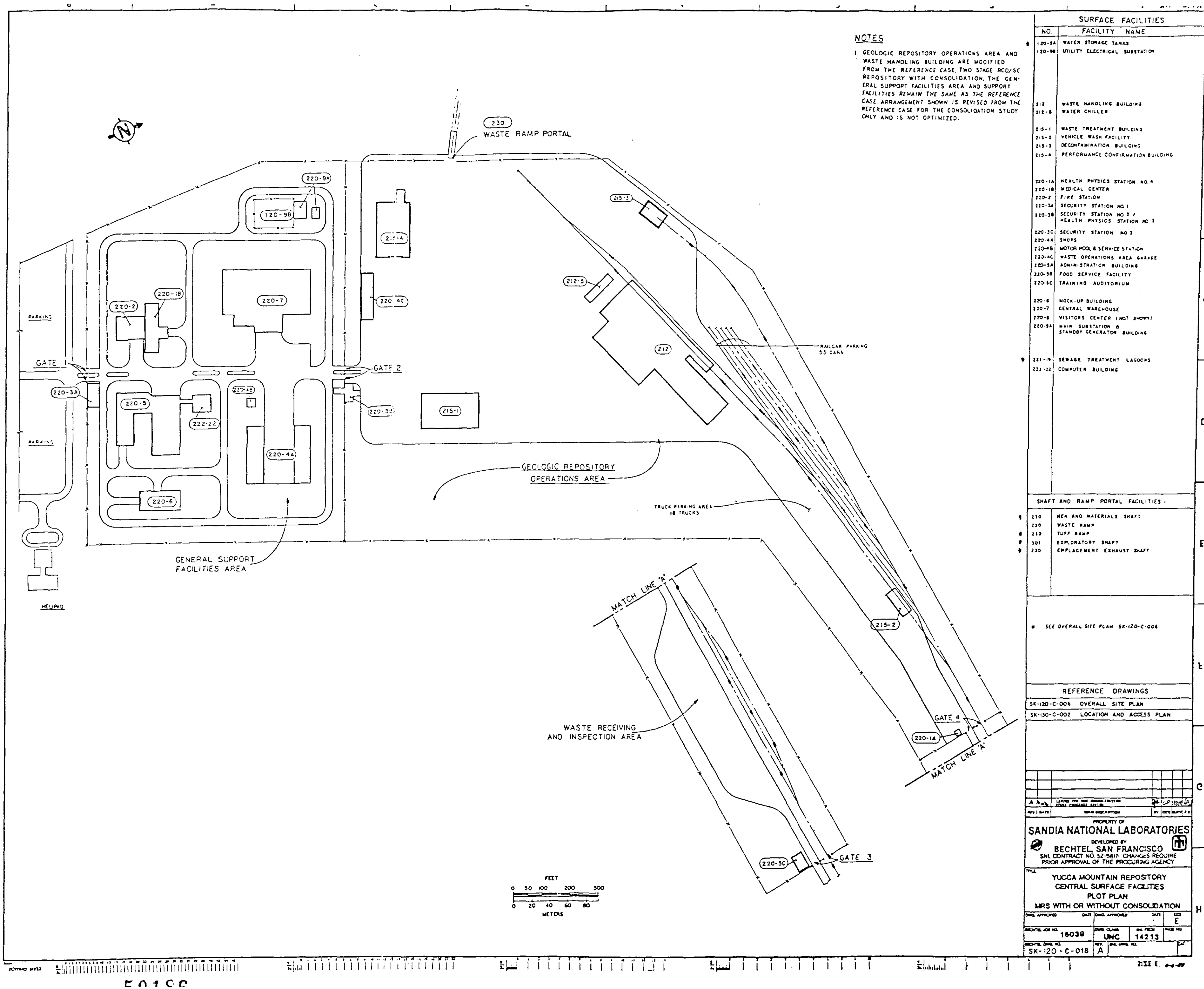


Figure 9-2. Repository Plot Plan (Case 6)

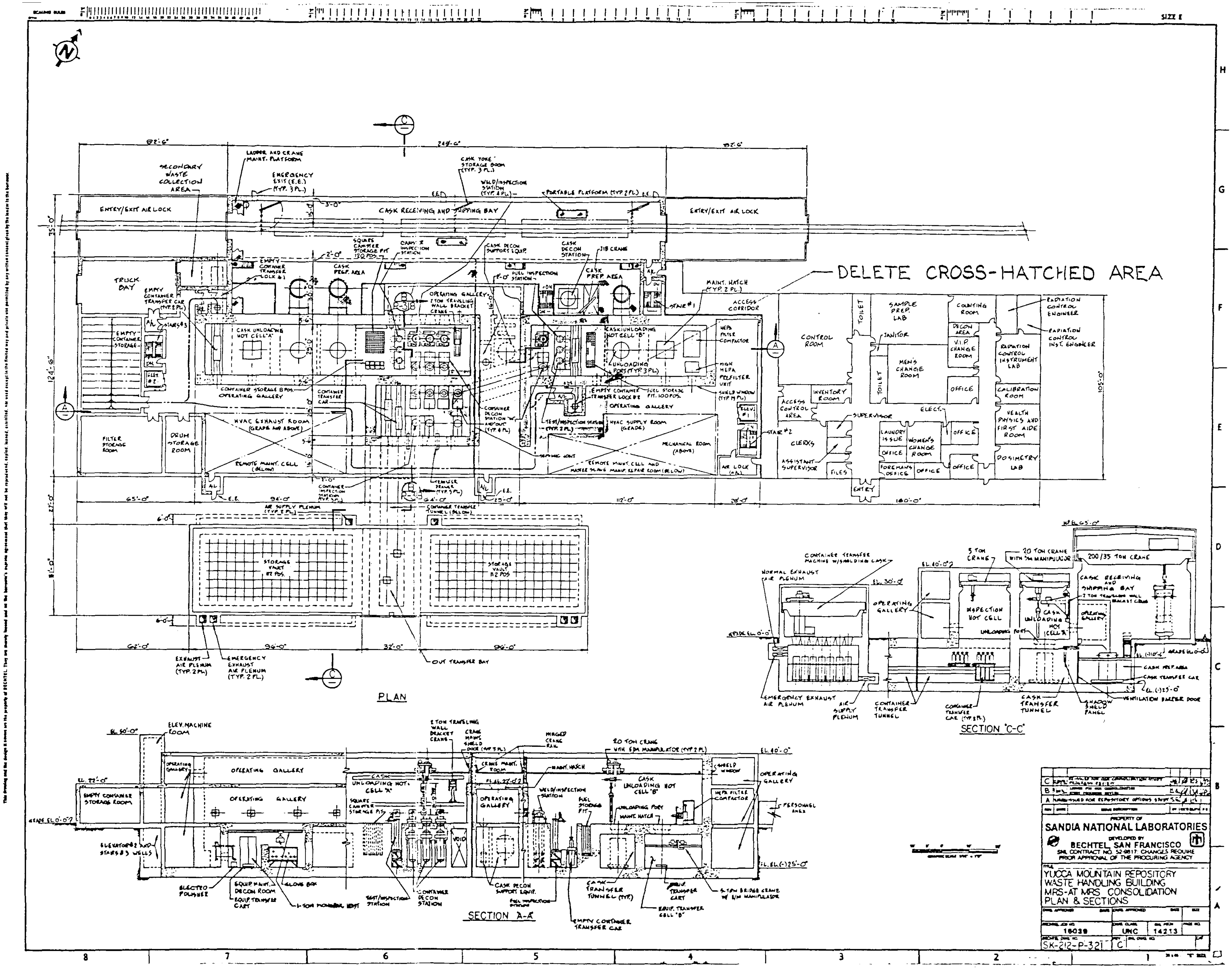


Figure 9-3. Waste Handling Building Layout (Case 6)

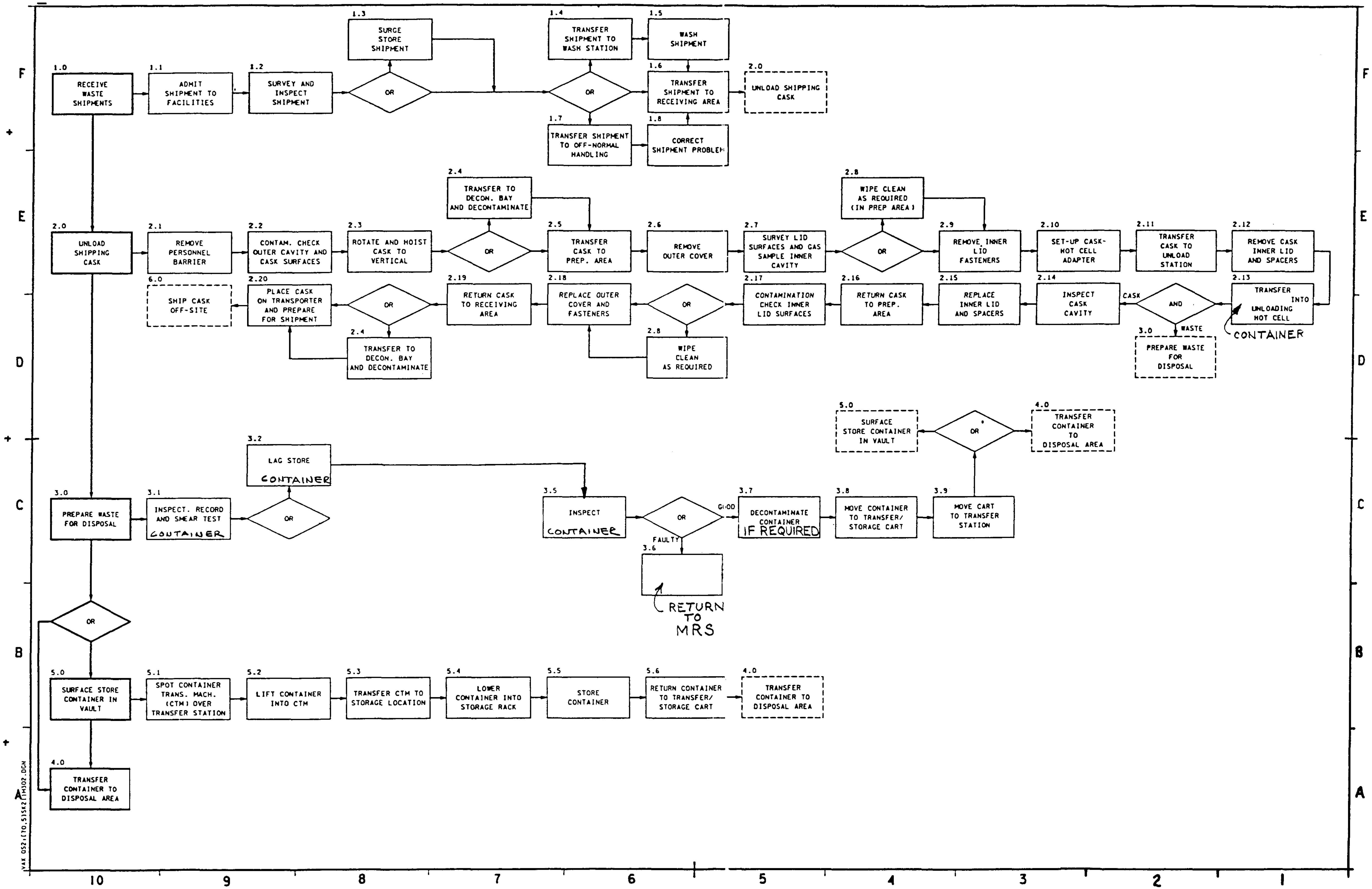


Figure 9-4. Material Flow Diagram for DHLW and WVHLW (Case 6)

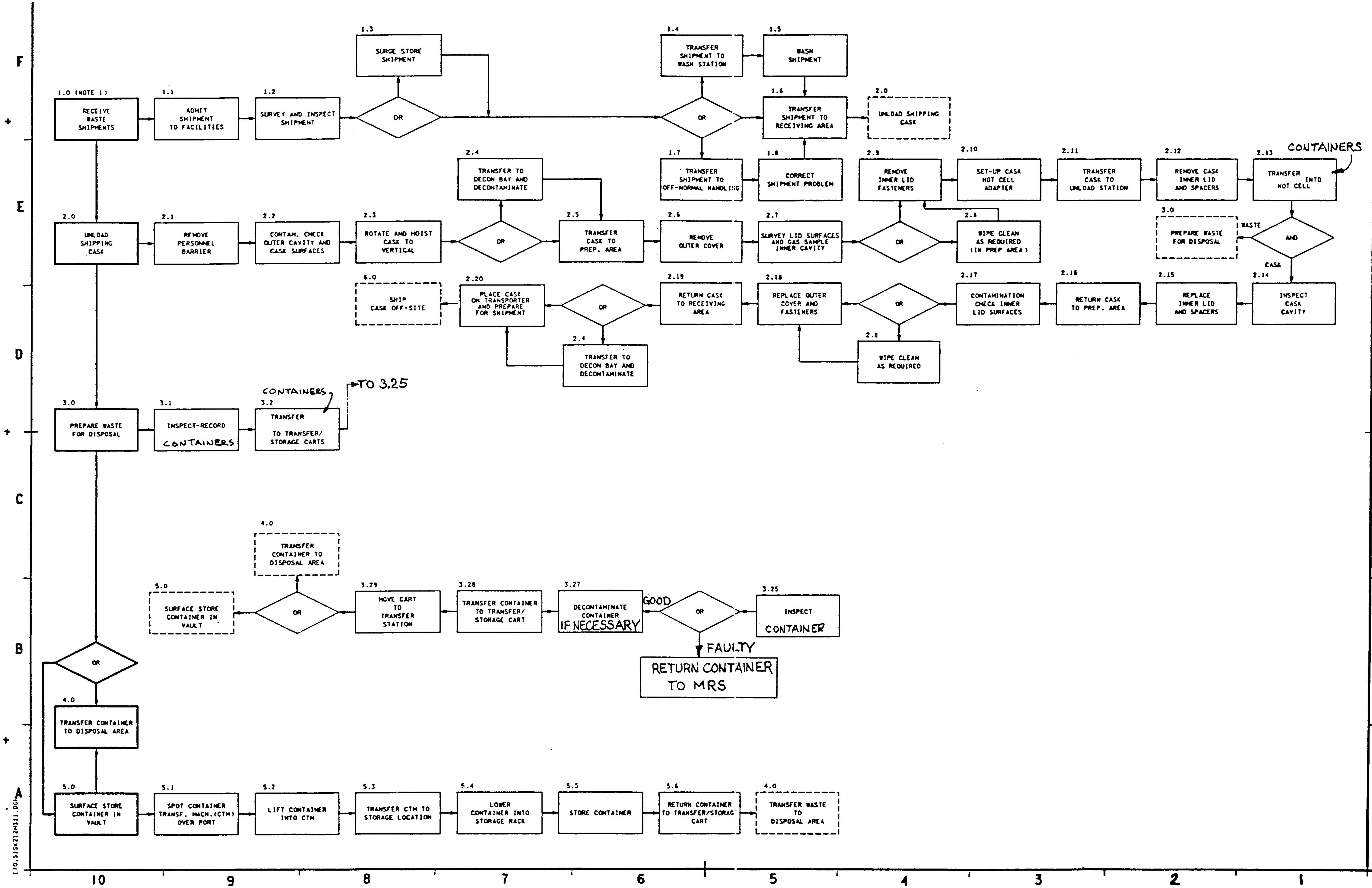


Figure 9-5. Material Flow Diagram for SNF (Case 6)

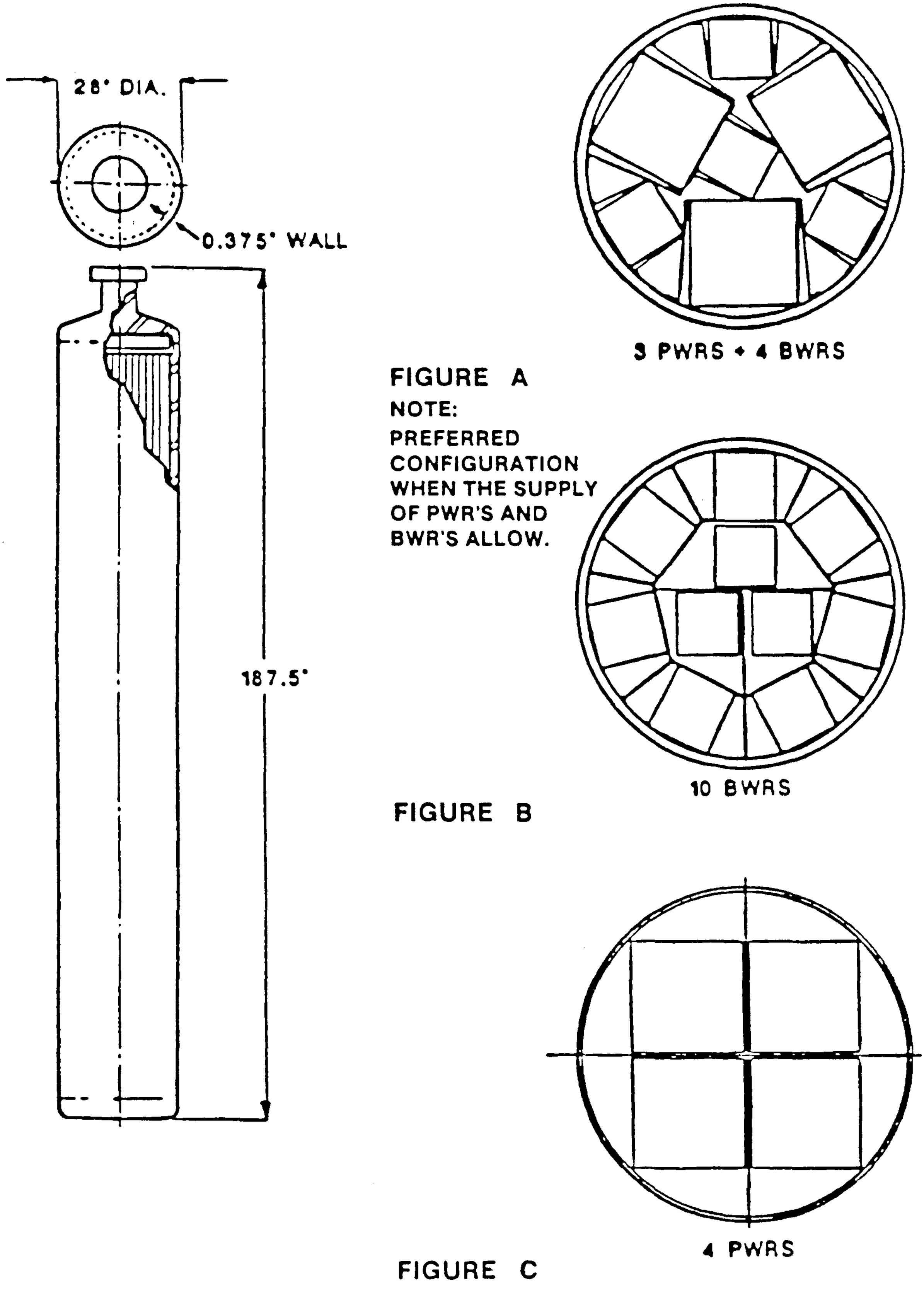


Figure 9-6. Intact Fuel Containers (Case 6)

TABLE 9-1

REPOSITORY THROUGHPUTS (CASE 6)

Year	MTU - First Repository			HLW Containers		Spent Fuel						
							BWR		PWR		Disposal Containers	
	Spent Fuel	HLW	Cum.	DHLW	WVHLW	MTU	MTU	Assemblies Intact	MTU	Asemblies Intact	Hybrid	PWR Only
2003	400	0	400	0	0	400	133	741	267	620	185	16
2004	400	0	800	0	0	400	133	741	267	620	185	16
2005	400	0	1200	0	0	400	133	741	267	620	185	16
2006	900	0	2100	0	0	900	300	1667	600	1395	417	36
2007	1800	0	3900	0	0	1800	600	3333	1200	2791	833	73
2008	3000	400	7300	800	0	3000	1000	5556	2000	4651	1389	121
2009	3000	400	10700	800	0	3000	1000	5556	2000	4651	1389	121
2010	3000	400	14100	800	0	3000	1000	5556	2000	4651	1389	121
2011	3000	400	17500	800	0	3000	1000	5556	2000	4651	1389	121
2012	3000	400	20900	800	0	3000	1000	5556	2000	4651	1389	121
2013	3000	400	24300	800	0	3000	1000	5556	2000	4651	1389	121
2014	3000	400	27700	800	0	3000	1000	5556	2000	4651	1389	121
2015	3000	400	31100	800	0	3000	1000	5556	2000	4651	1389	121
2016	3000	400	34500	800	0	3000	1000	5556	2000	4651	1389	121
2017	3000	400	37900	800	0	3000	1000	5556	2000	4651	1389	121
2018	3000	400	41300	800	0	3000	1000	5556	2000	4651	1389	121
2019	3000	400	44700	800	0	3000	1000	5556	2000	4651	1389	121
2020	3000	400	48100	800	0	3000	1000	5556	2000	4651	1389	121
2021	3000	400	51500	800	0	3000	1000	5556	2000	4651	1389	121
2022	3000	400	54900	800	0	3000	1000	5556	2000	4651	1389	121
2023	3000	400	58300	680	28	3000	1000	5556	2000	4651	1389	121
2024	3000	400	61700	0	188	3000	1000	5556	2000	4651	1389	121
2025	3000	180	64880	0	84	3000	1000	5556	2000	4651	1389	121
2026	2700	0	67580	0	0	2700	900	5000	1800	4186	1250	109
2027	2420	0	70000	0	0	2420	807	4481	1613	3752	1120	98
TOTALS	63020	6980	70000	12680	300	63020	21007	116704	42013	97705	29176	2544

Notes: Hybrid: 4 BWR = 1 container
3 PWR = 1 container

PWR only: 4 PWR = 1 container

DHLW: 0.5 MTU = 1 container

WVHLW: 2.13 MTU = 1 container

9.5 Underground Facility

The emplacement panel layout for Case 6 is identical to what is described for Case 2 in Subsection 5.5. Figure 9-7 shows details of a typical emplacement drift for Case 6.

9.6 Cost and Schedule

9.6.1 Capital and Operating Costs

A summary of capital, operating, and decommissioning costs is given in Table 9-2.

Staffing requirements for the surface facilities for Case 6 are summarized in Table 9-3.

Staffing requirements for the underground facility for Case 6 are summarized in Table 9-4.

Further detail of these estimates is included in Appendix B.

9.6.2 Construction Schedule

The construction schedules for the underground facility and surface facilities (including the waste-handling building) for Case 6 are the same as those for Cases 5, 7, 8, and 9. For details, see Subsection 8.6.2.

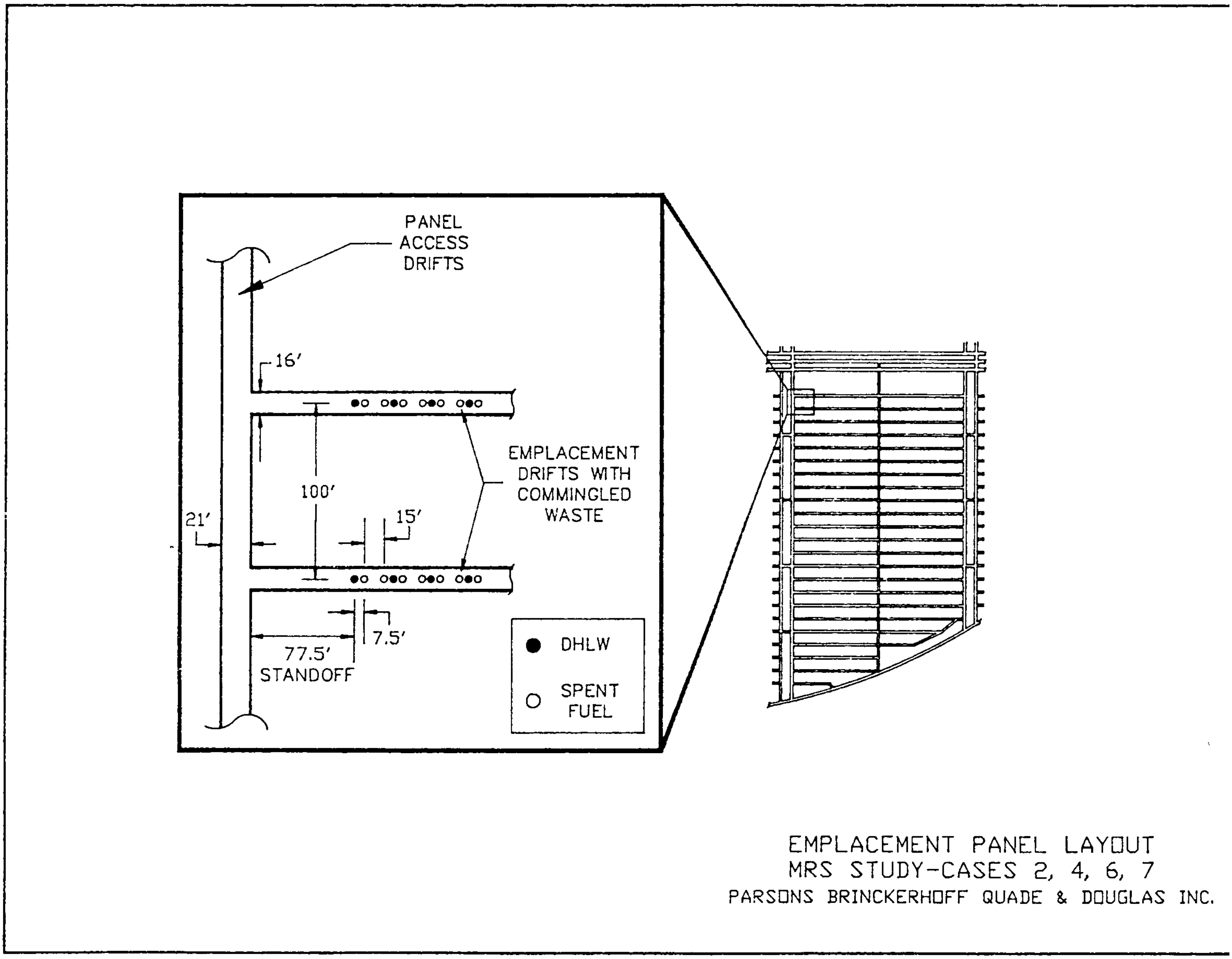


Figure 9-7. Emplacement Panel Layout (Case 6)

TABLE 9-2

SUMMARY OF LIFE-CYCLE COSTS (CASE 6)
(in Millions of 1988 Constant Dollars[a])

Cost Category Description	Construction	Operations	Decommissioning	Total
Management and Integration				
Architect/Engineer	153	0	17	
Construction Management	58	0	2	
Other	39	54	4	
Subtotal	250	54	23	327
Surface Facilities				
Site	178	105	41	
High-Level Waste-Handling Facilities	154	564[b]	9	
Other Waste-Handling Facilities	45		4	
Balance of Plant	136	1,177	51	
Subtotal	513	1,846	105	2,464
Subsurface Facilities				
Shafts and Ramps	66	31	4	
Excavation and Emplacement	151	1,011	123	
Service Systems	105	926	165	
Subtotal	322	1,968	292	2,582
Total w/o Disposal Containers	1,085	3,868	420	5,373
Disposal Containers				
Spent Fuel	0	0	0	
DHLW	0	0	0	
Other	0	31	0	
Subtotal	0	31	0	31
Total	1,085	3,899	420	5,404

a. Unescalated for the life of the repository.
b. Includes cost of operations for all waste-handling facilities.

TABLE 9-3

STAFFING REQUIREMENTS: SURFACE FACILITIES (CASE 6)

Facility	Staff
Waste Handling Building 1	0
Waste Handling Building 2	90
Waste Treatment Building	8
Vehicle Wash Facility	0 *
Decontamination Building	0 *
Performance Confirmation Building	17
Health Physics Station 4	0 *
Medical Center	10
Fire Station/Emergency Center	15
Security Station 1	35
Security Station 2/Health Physics Station 3	18
Security Station 3	22
Men-and-Material Shaft Security Station	4
Shops	68
Motor Pool/Facilities Sewage Station	15
Transporter Garage	28
Administration Building	142
Food Services Facility	20
Mockup Building	5
Central Warehouse	17
Visitors Center	3
Change House	0 *
Computer Building	44
Concrete Batch Plant and Aggregate Storage	4
Tuff Pile	4
Total Full Time Personnel	567

* Assigned only as required.

TABLE 9-4

STAFFING REQUIREMENTS:
UNDERGROUND FACILITY (CASE 6)

Category	Staff
Shafts and Ramps	12
Drift Excavation	130
Emplacement Borehole Drilling and Lining	77
Emplacement/Retrieval Operations	17
Support Services	263
Total, Subsurface	499

10.0 CASE 7

For Case 7, SNF assemblies are placed, without consolidation, in containers at the MRS and then shipped to the repository for inspection and emplacement. Defective containers found during inspection at the repository are repaired at the repository. DHLW and WVHLW canisters are containerized at the MRS and then shipped to the repository for emplacement. There is no consolidation or containerizing at the repository.

10.1 Assumptions

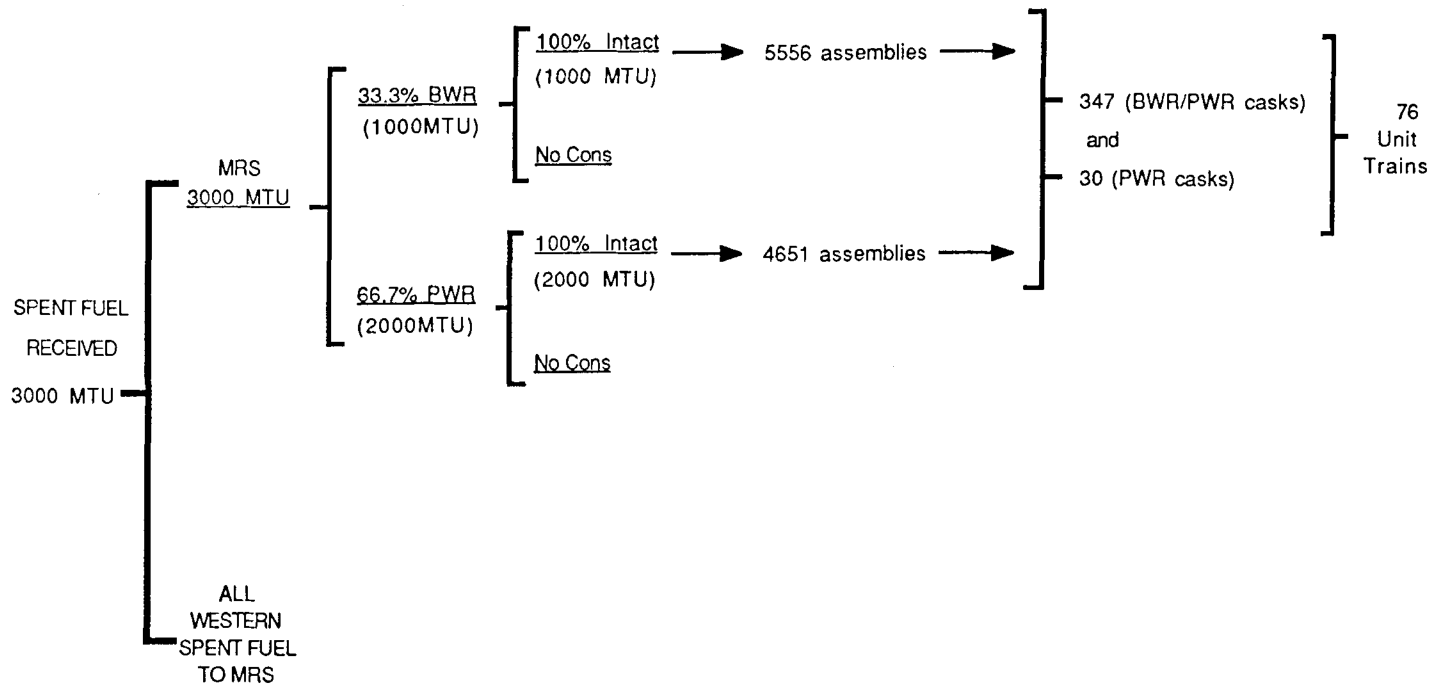
All of the assumptions for Case 7 are exactly the same as those for Case 6, except that in Case 7, defective containers received at the repository from the MRS are repaired at the repository, whereas in Case 6 defective containers are shipped back to the MRS for repair.

10.2 Waste Received

As in Case 6, all of the SNF (3,000 MTU), including SNF from western reactors, is received at the repository as intact assemblies that have been containerized at the MRS in the same BWR, PWR, and hybrid containers, described in Subsection 5.4 (Case 2). The same type and number of casks are also used for Cases 6 and 7.

As in Case 6, all DHLW and WVLHW is containerized at the MRS and shipped to the repository in casks that have a capacity of 5 containers.

The annual throughputs (at full receipt capacity) for Case 7 are summarized in Figure 10-1. The calculations for the quantities shown in this figure are provided in Appendix A.



NON-SPENT FUEL RECEIVED

DHLW :	MTU's	400
	Canisters	800
	Rail Casks	160
MRS Hardware :	Drums	0
	Canisters	0
	Rail Casks	0

CASK CAPACITIES (ASSEMBLIES)

MRS ALL RAIL:	BWR/PWR intact	16/12
	BWR intact	40
	PWR intact	16
REACTOR:	BWR rail	N/A
	BWR truck	N/A
	PWR rail	N/A
	PWR truck	N/A
HARDWARE:	rail	N/A
DHLW:	rail	5 canisters

EMPLACEMENT OPERATIONS	NO. CONTAINERS	NO. ASSEMBLIES/ CONTAINERS
BWR/PWR-mixed (Intact)	1389	4/3
BWR (Intact)	0	N/A
PWR (Intact)	121	4
Hardware	0	N/A
DHLW	800	1 canister
Total	2310	

Figure 10-1. Repository Annual Throughputs (Case 7)

10.3 Surface Facilities

Only one waste-handling building is required for Case 7. The waste-handling building for Case 7 is the same as the waste-handling building for Case 6, because the space required for container repair in Case 7 is considered to be insignificant. The plot plan, which is the same for both designs, is provided in Figure 10-2.

Figure 10-3, which is the same as Figure 9-3 (Case 6), is a markup of the RCS Case 3 (also Case 5) waste-handling building layout showing the space for equipment required for containerizing deleted to satisfy the requirements for Case 7. Other than the containerizing and container repair requirements, the remaining functional requirements, throughputs, and descriptions pertaining to the waste-handling building for Case 7 are the same as those for the waste-handling building in Case 5, as described in Subsection 8.3.

The DHLW and WVHLW material flow diagram for Case 7 is shown in Figure 10-4. The SNF material flow diagram for Case 7 is shown in Figure 10-5.

10.4 Disposal Containers

For Case 7, the YMP container shown in Figure 10-6 is the same container used in Cases 2, 4, and 6 of this study. The container descriptions, contents, and throughputs are the same as those provided in Subsection 5.4 (Case 2) of this report. The year-by-year container emplacement schedule shown in Table 10-1 is the same as that for Cases 2, 4, and 6.

10.5 Underground Facility

The emplacement panel layout for Case 7 is identical to what is described for Case 2 in Subsection 5.5. Figure 10-7 shows details of a typical emplacement drift for Case 7.

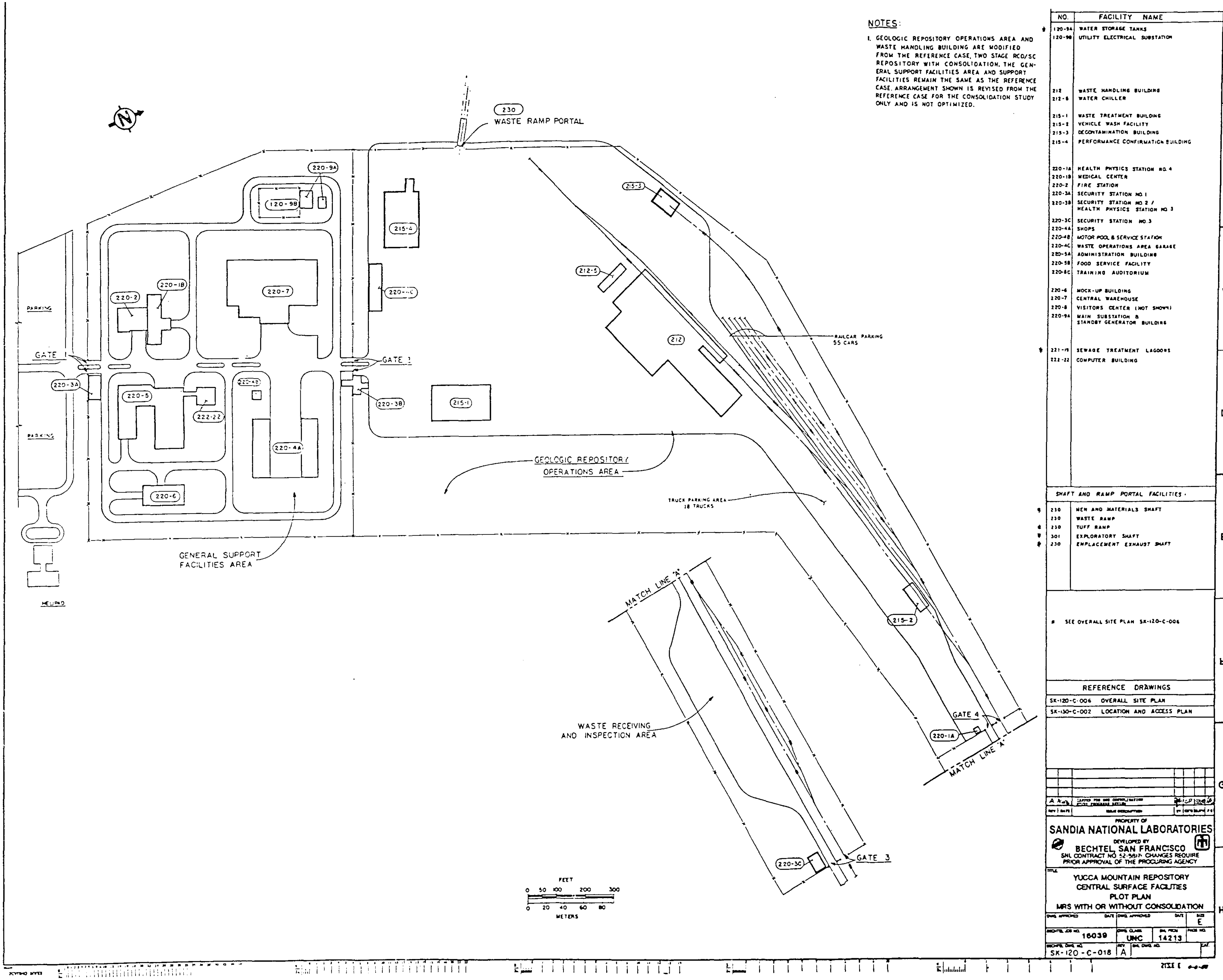


Figure 10-2. Repository Plot Plan (Case 7)

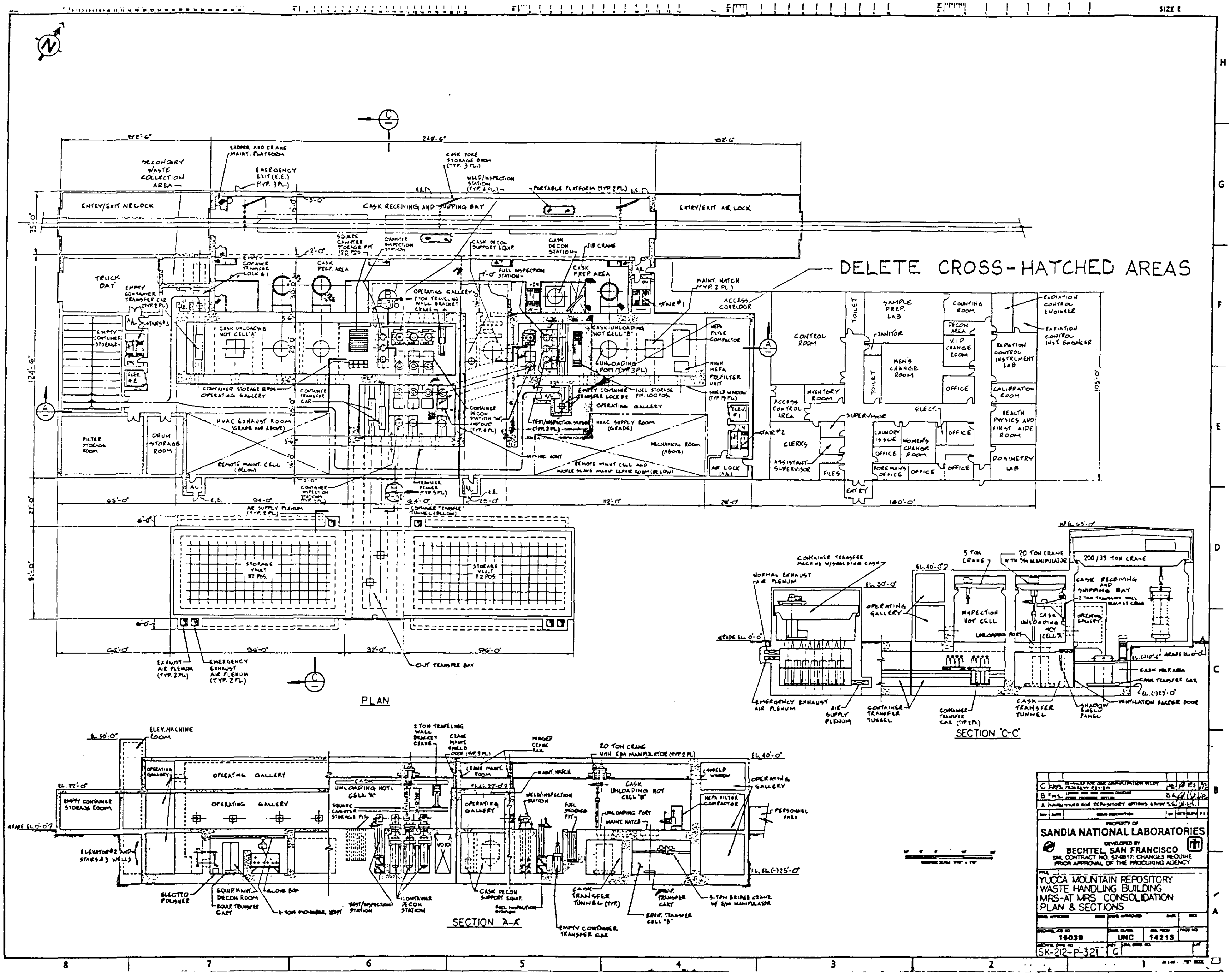


Figure 10-3. Waste-Handling Building Layout (Case 7)

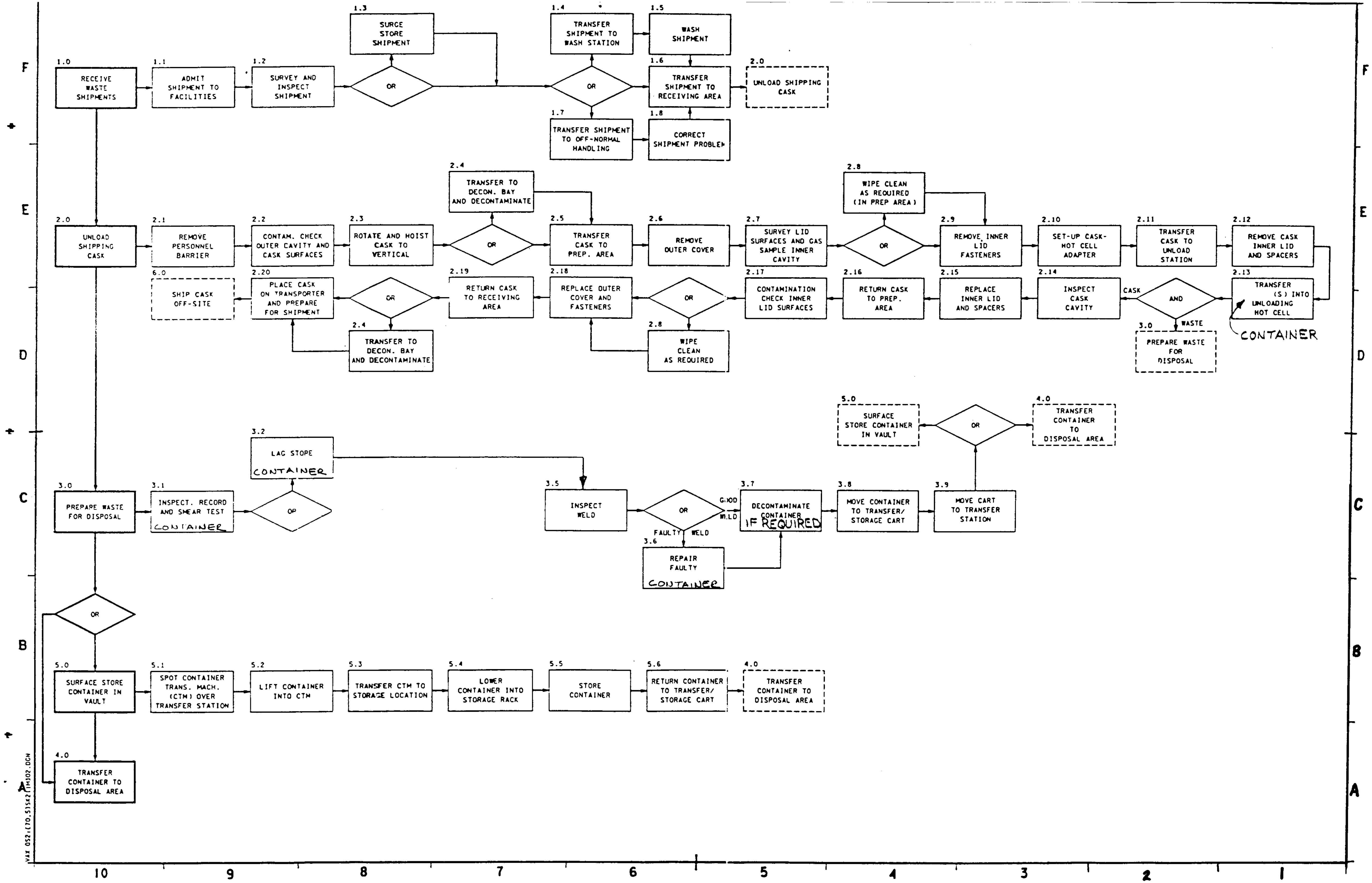


Figure 10-4. Material Flow Diagram for DHLW and WVHLW (Case 7)

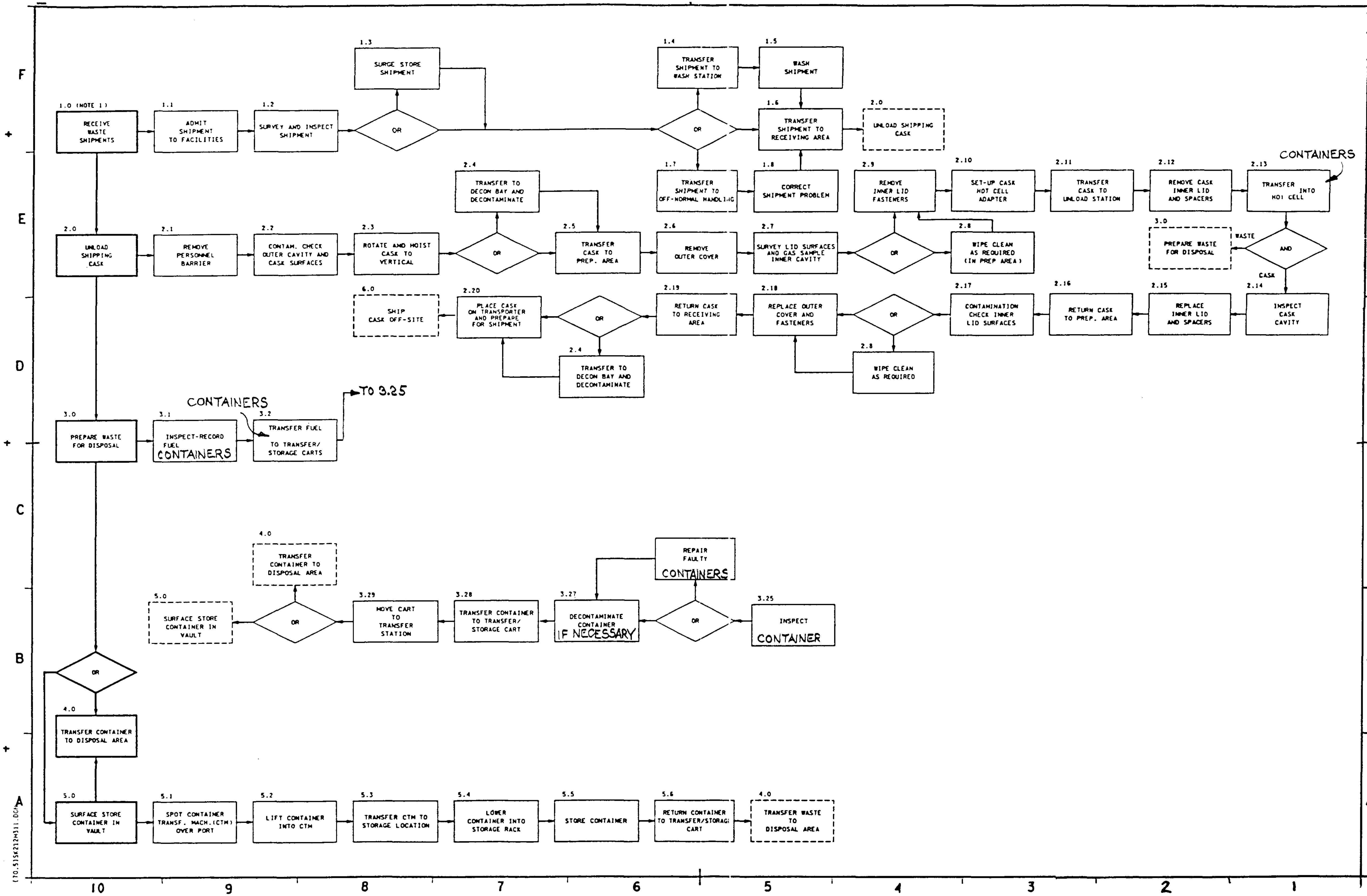


Figure 10.5. Material Flow Diagram for SNF (Case 7)

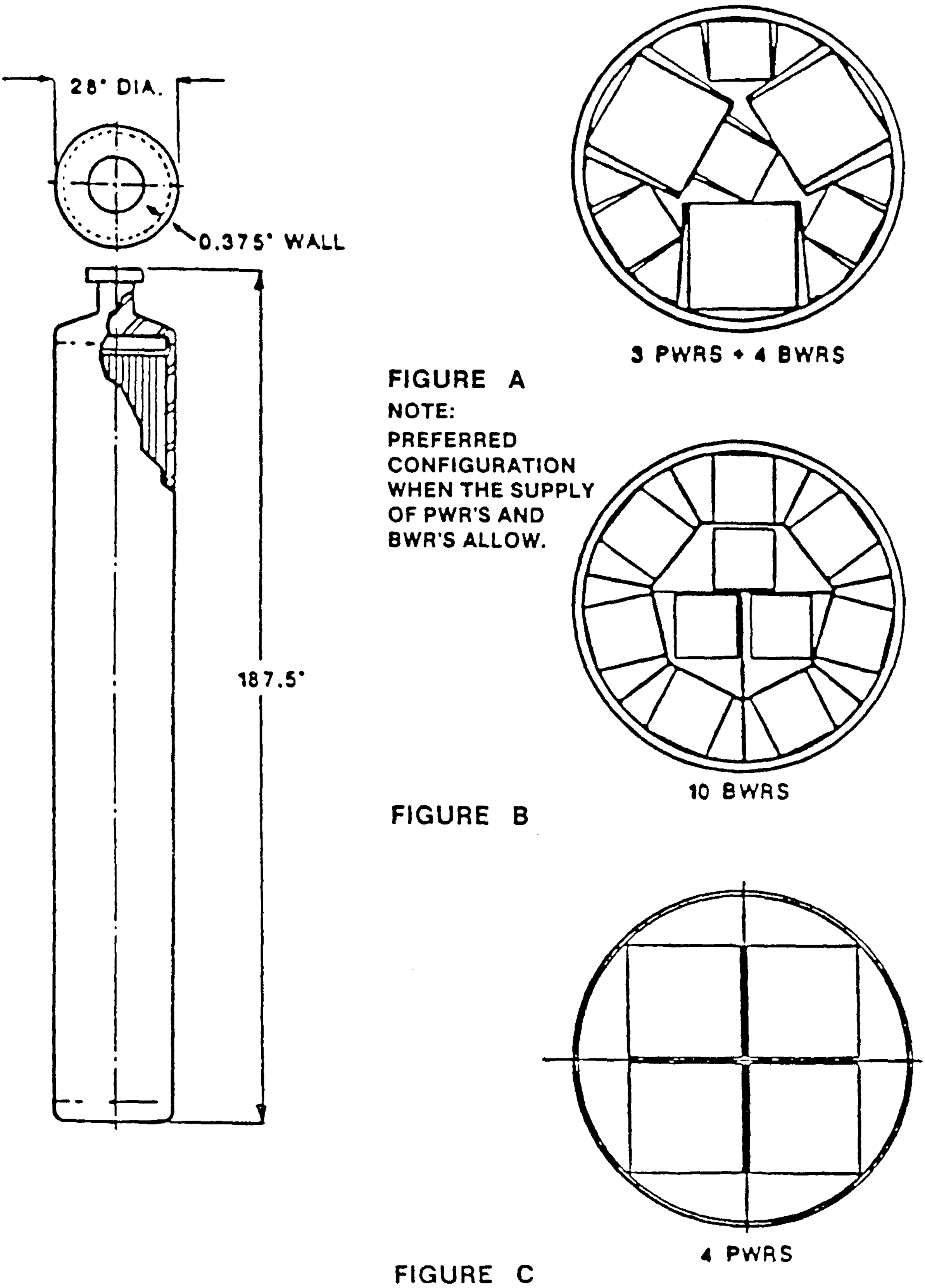


Figure 10-6. Intact Fuel Containers (Case 7)

TABLE 10-1

REPOSITORY THROUGHPUTS (CASE 7)

Year	MTU - First Repository			HLW Containers		Spent Fuel							
							BWR		PWR		Disposal Containers	
	Spent Fuel	HLW	Cum.	DHLW	WVHLW	MTU	MTU	Assemblies Intact	MTU	Asemblies Intact	Hybrid	PWR Only
2003	400	0	400	0	0	400	133	741	267	620	185	16
2004	400	0	800	0	0	400	133	741	267	620	185	16
2005	400	0	1200	0	0	400	133	741	267	620	185	16
2006	900	0	2100	0	0	900	300	1667	600	1395	417	36
2007	1800	0	3900	0	0	1800	600	3333	1200	2791	833	73
2008	3000	400	7300	800	0	3000	1000	5556	2000	4651	1389	121
2009	3000	400	10700	800	0	3000	1000	5556	2000	4651	1389	121
2010	3000	400	14100	800	0	3000	1000	5556	2000	4651	1389	121
2011	3000	400	17500	800	0	3000	1000	5556	2000	4651	1389	121
2012	3000	400	20900	800	0	3000	1000	5556	2000	4651	1389	121
2013	3000	400	24300	800	0	3000	1000	5556	2000	4651	1389	121
2014	3000	400	27700	800	0	3000	1000	5556	2000	4651	1389	121
2015	3000	400	31100	800	0	3000	1000	5556	2000	4651	1389	121
2016	3000	400	34500	800	0	3000	1000	5556	2000	4651	1389	121
2017	3000	400	37900	800	0	3000	1000	5556	2000	4651	1389	121
2018	3000	400	41300	800	0	3000	1000	5556	2000	4651	1389	121
2019	3000	400	44700	800	0	3000	1000	5556	2000	4651	1389	121
2020	3000	400	48100	800	0	3000	1000	5556	2000	4651	1389	121
2021	3000	400	51500	800	0	3000	1000	5556	2000	4651	1389	121
2022	3000	400	54900	800	0	3000	1000	5556	2000	4651	1389	121
2023	3000	400	58300	680	28	3000	1000	5556	2000	4651	1389	121
2024	3000	400	61700	0	188	3000	1000	5556	2000	4651	1389	121
2025	3000	180	64880	0	84	3000	1000	5556	2000	4651	1389	121
2026	2700	0	67580	0	0	2700	900	5000	1800	4186	1250	109
2027	2420	0	70000	0	0	2420	807	4481	1613	3752	1120	98
TOTALS	63020	6980	70000	12680	300	63020	21007	116704	42013	97705	29176	2544

Notes: Hybrid: 4 BWR = 1 container
3 PWR = 1 container

PWR only: 4 PWR = 1 container

DHLW: 0.5 MTU = 1 container

WVHLW: 2.13 MTU = 1 container

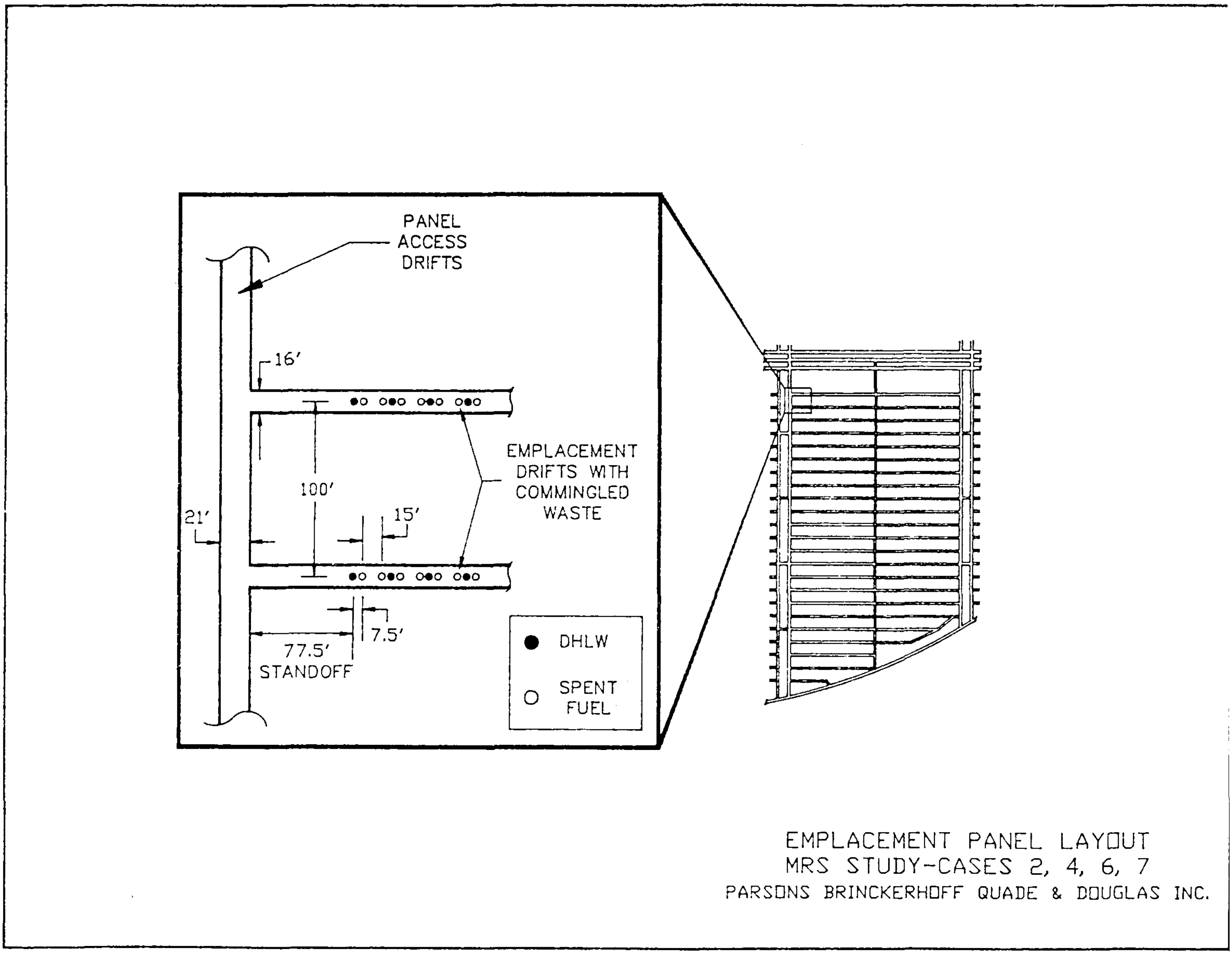


Figure 10-7. Emplacement Panel Layout (Case 7)

10.6 Cost and Schedule

10.6.1 Capital and Operating Costs

A summary of capital, operating, and decommissioning costs is given in Table 10-2.

Staffing requirements for the surface facilities for Case 7 are summarized in Table 10-3.

Staffing requirements for the underground facilities for Case 7 are summarized in Table 10-4.

Further detail of these estimates is included in Appendix B.

10.6.2 Construction Schedule

The construction schedules for the underground and surface facilities (including the waste-handling building) for Case 7 are the same as those for Cases 5, 6, 8, and 9. For details, see Subsection 8.6.2.

TABLE 10-2

SUMMARY OF LIFE-CYCLE COSTS (CASE 7)
(in Millions of 1988 Constant Dollars[a])

Cost Category Description	Construction	Operations	Decommissioning	Total
Management and Integration				
Architect/Engineer	153	0	17	
Construction Management	58	0	2	
Other	39	54	4	
Subtotal	250	54	23	327
Surface Facilities				
Site	178	106	41	
High-Level Waste-Handling Facilities	154	586[b]	9	
Other Waste-Handling Facilities	45		4	
Balance of Plant	136	1,177	51	
Subtotal	513	1,869	105	2,487
Subsurface Facilities				
Shafts and Ramps	66	31	4	
Excavation and Emplacement	151	1,011	123	
Service Systems	105	926	165	
Subtotal	322	1,968	292	2,582
Total w/o Disposal Containers	1,085	3,891	420	5,396
Disposal Containers				
Spent Fuel	0	0	0	
DHLW	0	0	0	
Other	0	31	0	
Subtotal	0	31	0	31
Total	1,085	3,922	420	5,427

a. Unescalated for the life of the repository.
b. Includes cost of operations for all waste-handling facilities.

TABLE 10-3

STAFFING REQUIREMENTS: SURFACE FACILITIES (CASE 7)

Facility	Staff
Waste-Handling Building 1	0
Waste-Handling Building 2	101
Waste Treatment Building	8
Vehicle Wash Facility	0 *
Decontamination Building	0 *
Performance Confirmation Building	17
Health Physics Station 4	0 *
Medical Center	10
Fire Station/Emergency Center	15
Security Station 1	35
Security Station 2/Health Physics Station 3	18
Security Station 3	22
Men-and-Material Shaft Security Station	4
Shops	68
Motor Pool/Facilities Sewage Station	15
Transporter Garage	28
Administration Building	142
Food Services Facility	20
Mockup Building	5
Central Warehouse	17
Visitors Center	3
Change House	0 *
Computer Building	44
Concrete Batch Plant and Aggregate Storage	4
Tuff Pile	4
Total Full Time Personnel	578

* Assigned only as required.

TABLE 10-4

STAFFING REQUIREMENTS: UNDERGROUND FACILITY (CASE 7)

Category	Staff
Shafts and Ramps	12
Drift Excavation	130
Emplacement Borehole Drilling and Lining	77
Emplacement/Retrieval Operations	17
Support Services	263
Total, Subsurface	499

11.0 CASE 8

For Case 8, SNF assemblies (from eastern and western reactors) are consolidated and placed in containers at the MRS and then shipped to the repository for inspection and emplacement. Defective containers found during inspection at the repository are returned to the MRS. DHLW and WVHLW canisters are containerized at the MRS and then shipped to the repository for emplacement. There is no consolidation or containerizing at the repository.

11.1 Assumptions

In addition to the general assumptions stated in Section 3, the following specific assumptions apply to Case 8:

- All of the SNF (3,000 MTU) is shipped by rail from the MRS to the repository.
- Ninety-five percent of the SNF is consolidated and containerized at the MRS.
- Five percent of the SNF is containerized intact at the MRS.
- There are 6 intact BWR SNF assemblies per container.
- There are 18 consolidated BWR SNF assemblies per container.
- There are 3 intact PWR SNF assemblies per container.
- There are 6 consolidated PWR SNF assemblies per container.
- There is 1 container of hardware per 108 BWR assemblies consolidated at the MRS.
- The SNF and hardware are shipped to the repository in casks that have a capacity of 4 containers.

- DHLW and WVHLW are containerized at the MRS and shipped to the repository in casks that have a capacity of 5 containers.

- All containerized waste received at the repository from the MRS is inspected, and any defective containers found during inspection are returned to the MRS. If necessary, the containers are repaired sufficiently to allow shipment back to the MRS.

- It is assumed that 1% of the containers are defective.

- The time required to load and unload casks with returned containers is not included.

11.2 Waste Received

All SNF (3,000 MTU), including SNF from western reactors, is received at the repository from the MRS in the same BWR and PWR containers used in Cases 1 and 3 and described in Subsection 4.4 (Case 1). A total of 95% of the SNF is consolidated at the MRS and 5% is left intact. Thus, 5,278 BWR assemblies (950 MTU) and 4,419 PWR assemblies (1,900 MTU) are consolidated, and 278 BWR assemblies (50 MTU) and 233 PWR assemblies (100 MTU) are left intact.

With 6 intact BWR assemblies per container, 46 intact BWR containers in 12 casks are received at the repository per year. With 18 consolidated BWR assemblies per container, 293 consolidated BWR containers in 73 casks are received at the repository per year. With 3 intact PWR assemblies per container, 78 intact PWR containers in 19 casks are received at the repository per year. With six consolidated PWR assemblies per container, 736 consolidated PWR containers in 184 casks are received at the repository per year. A total of 58 trains (5 casks per train) are used to transport the casks from the MRS to the repository.

As in Cases 6 and 7, all DHLW and WVHLW is containerized at the MRS and shipped to the repository in casks that have a capacity of 5 containers.

The annual throughputs (at full receipt capacity) for Case 8 are summarized in Figure 11-1. The calculations for the quantities shown in this figure are provided in Appendix A.

11.3 Surface Facilities

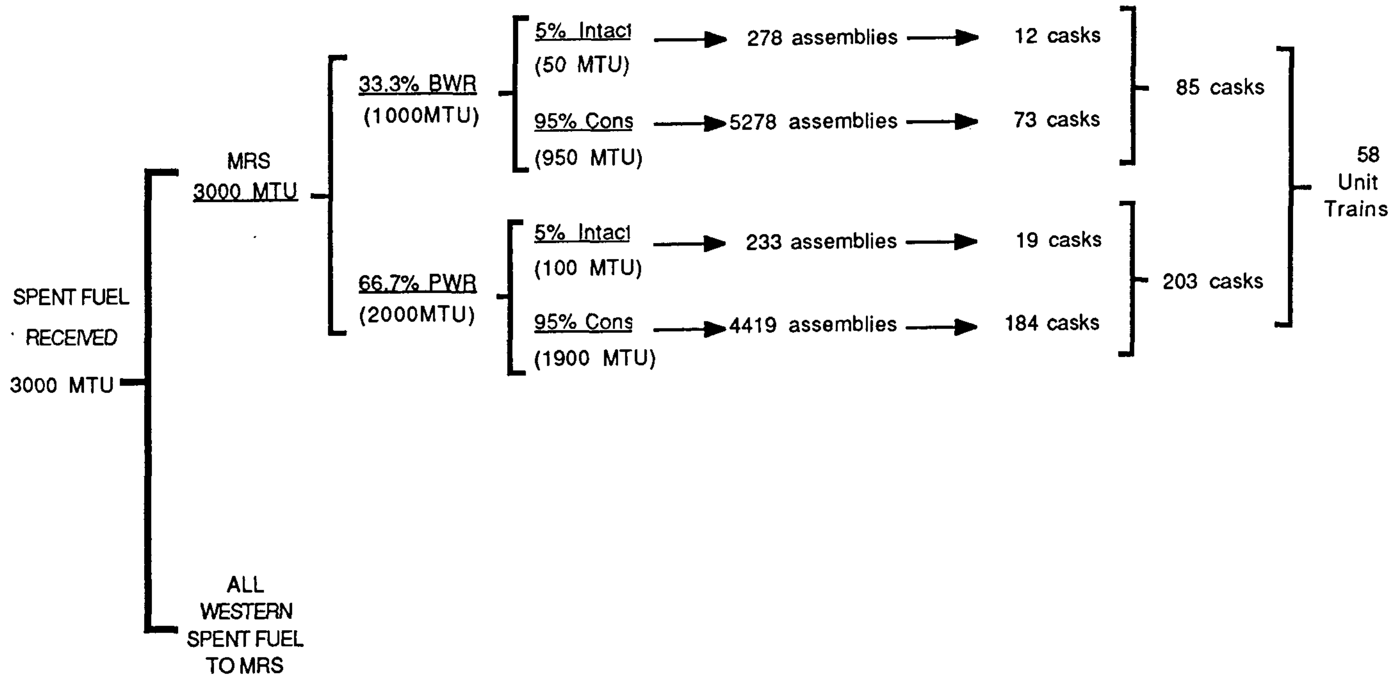
Only one waste-handling building is required for Case 8. The waste-handling building for Case 8 is similar to the waste-handling building for Cases 6 and 7, except one less unloading bay is required for Case 8 because there are fewer casks to unload and fewer containers to handle because of the consolidation of the fuel at the MRS. The plot plan, which is the same as for Cases 6, 7, and 8, is provided in Figure 11-2.

Figure 11-3 is a markup of the RCS Case 3 (also Case 5) waste-handling building layout showing the space for equipment required for containerizing and an unloading bay deleted to reflect the requirements for Case 8. Other than the cask unloading and containerizing requirements, the remaining functional requirements, throughputs, and descriptions pertaining to the waste-handling building for Case 8 are the same as those for the waste-handling building in Case 5, as described in Subsection 8.3.

The DHLW and WVHLW material flow diagram for Case 8 shown in Figure 11-4 is the same as that for Case 6. The SNF material flow diagram for Case 8, shown in Figure 11-5, is the same as that for Case 6.

11.4 Disposal Containers

For Case 8, the YMP container shown in Figure 11-6 is the same container used in Cases 1 and 3 of this study. The container descriptions, contents, and throughputs are the same as those



NON-SPENT FUEL RECEIVED

DHLW:	MTU's	400
	Canisters	800
	Rail Casks	160
MRS Hardware:	Drums	N/A
	Canisters	49
	Rail Casks	12

CASK CAPACITIES (ASSEMBLIES)

MRS ALL RAIL:	BWR intact	24
	BWR consol.	72
	PWR intact	12
	PWR consol.	24
REACTOR:	BWR rail	N/A
	BWR truck	N/A
	PWR rail	N/A
	PWR truck	N/A
HARDWARE:	rail	4
DHLW:	rail	5 canisters

EMPLACEMENT OPERATIONS	NO. CONTAINERS	NO. ASSEMBLIES/ CONTAINER
BWR (Intact)	46	6
BWR (Consolidated)	293	18
PWR (Intact)	78	3
PWR (Consolidated)	736	6
Hardware	49	108 BWR
DHLW	800	1 canister
Total	2002	

Figure 11-1. Repository Annual Throughputs (Case 8)

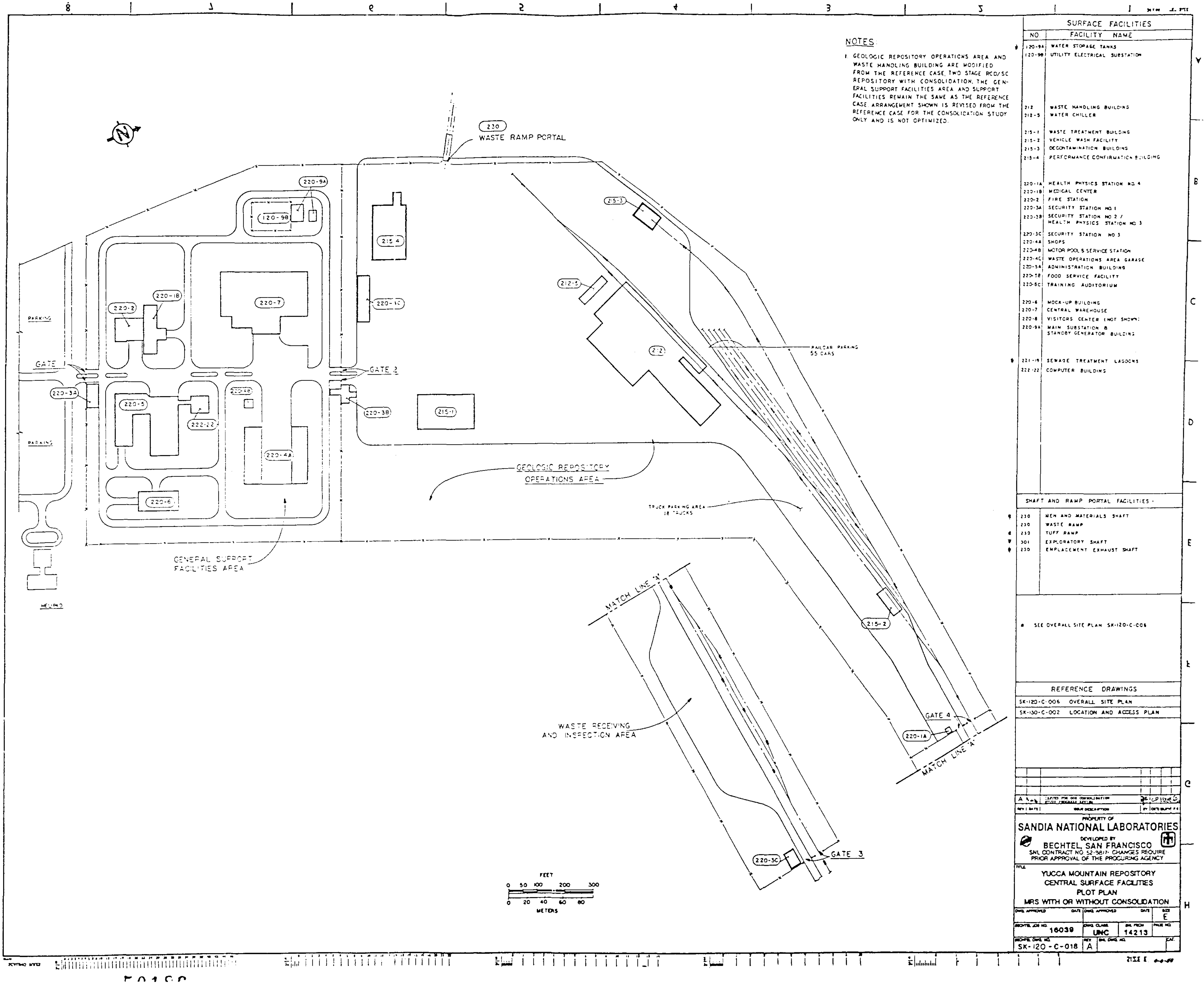


Figure 11-2. Repository Plot Plan (Case 8)

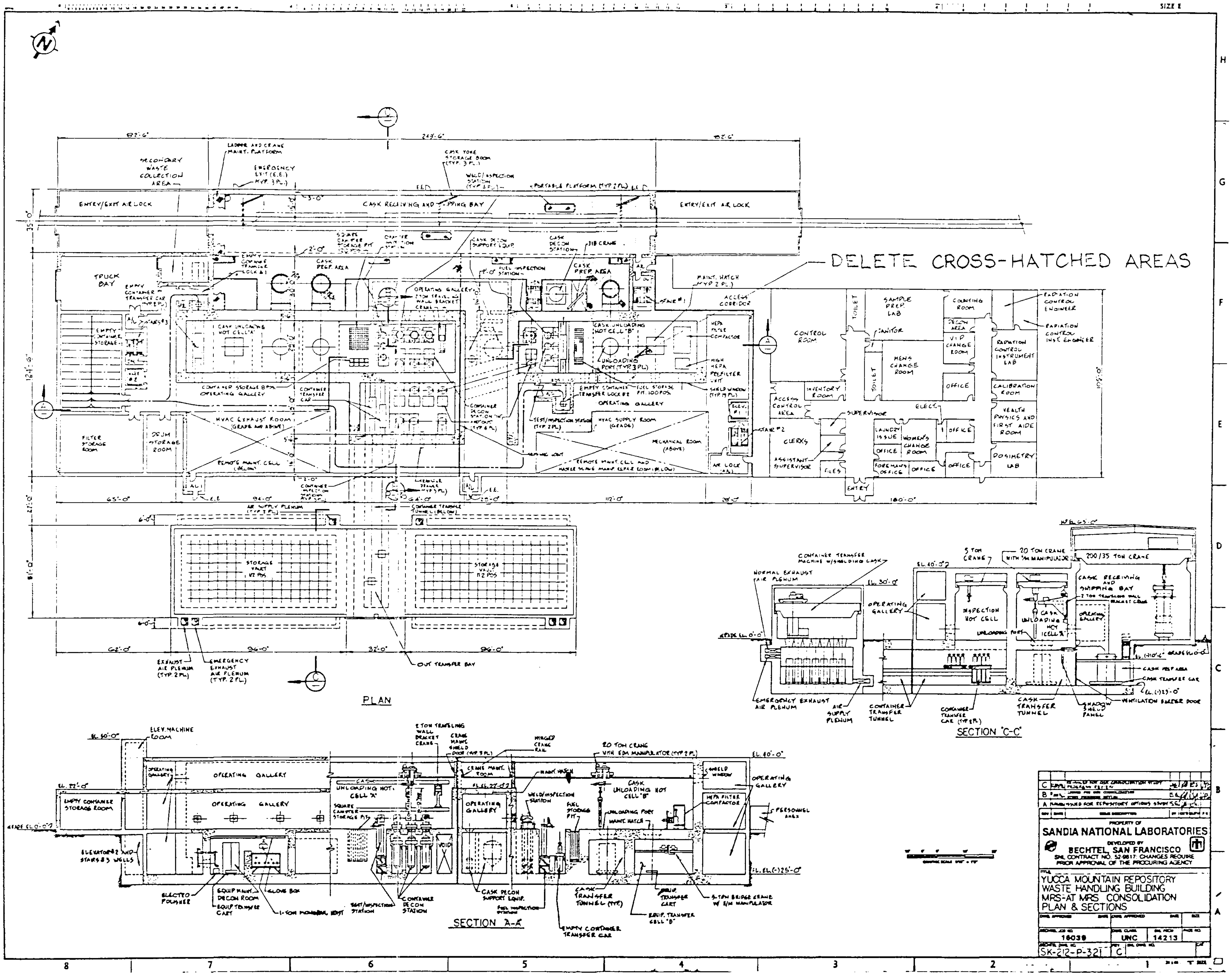


Figure 11-3. Waste-Handling Building Layout (Case 8)

2

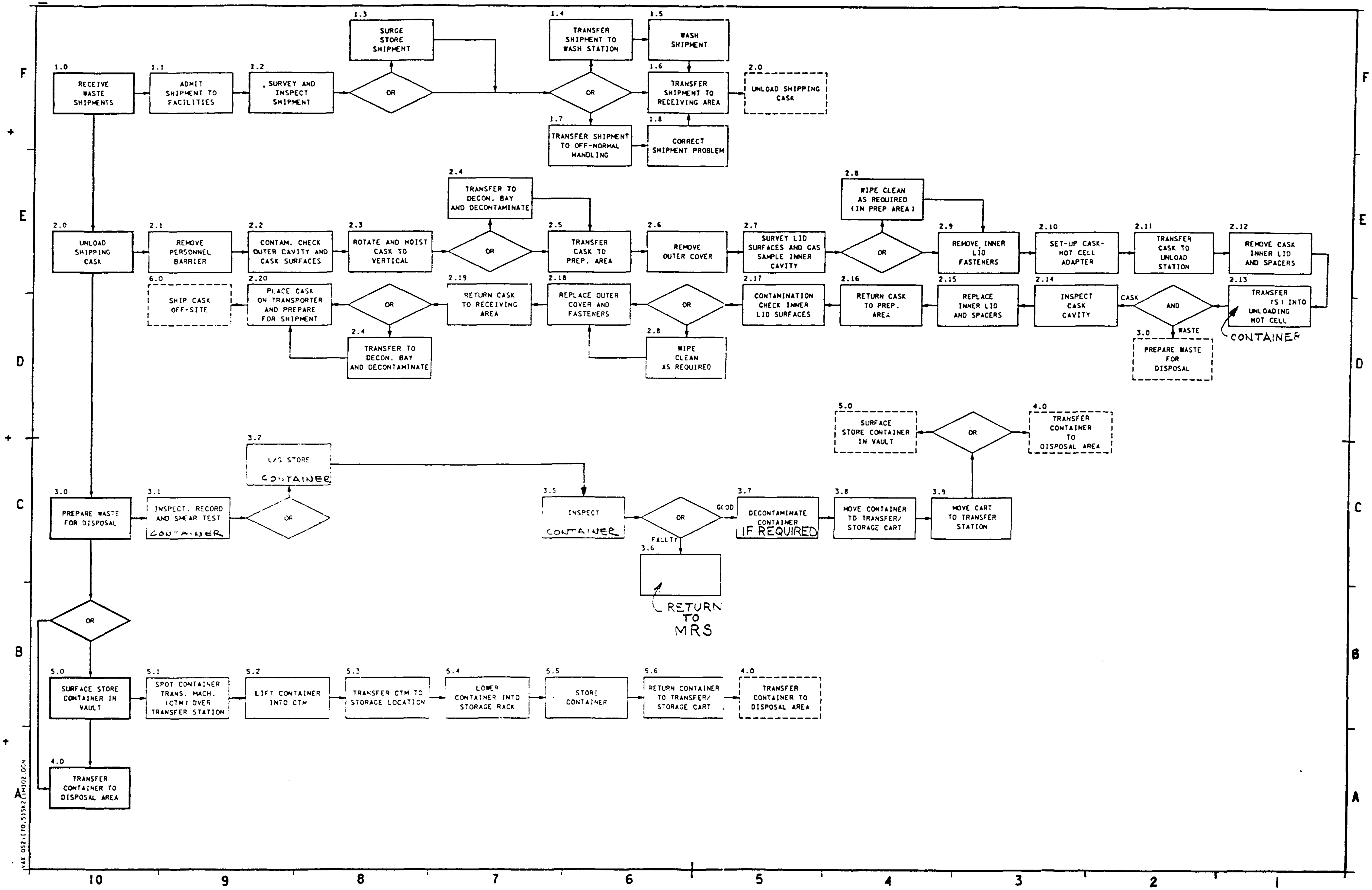


Figure 11-4. Material Flow Diagram for DHLW and WVHLW (Case 8)

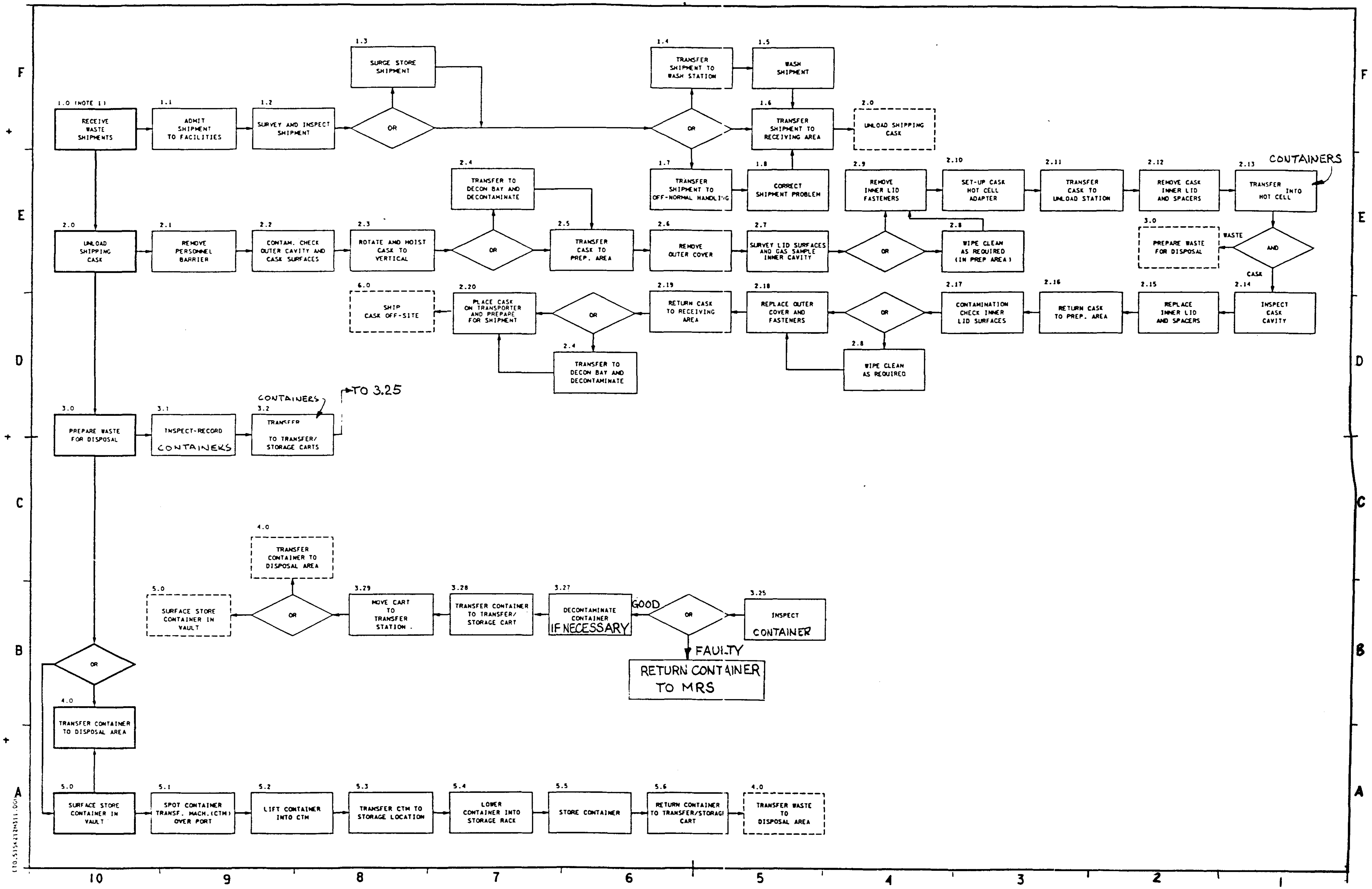


Figure 11-5. Material Flow Diagram for SNF (Case 8)

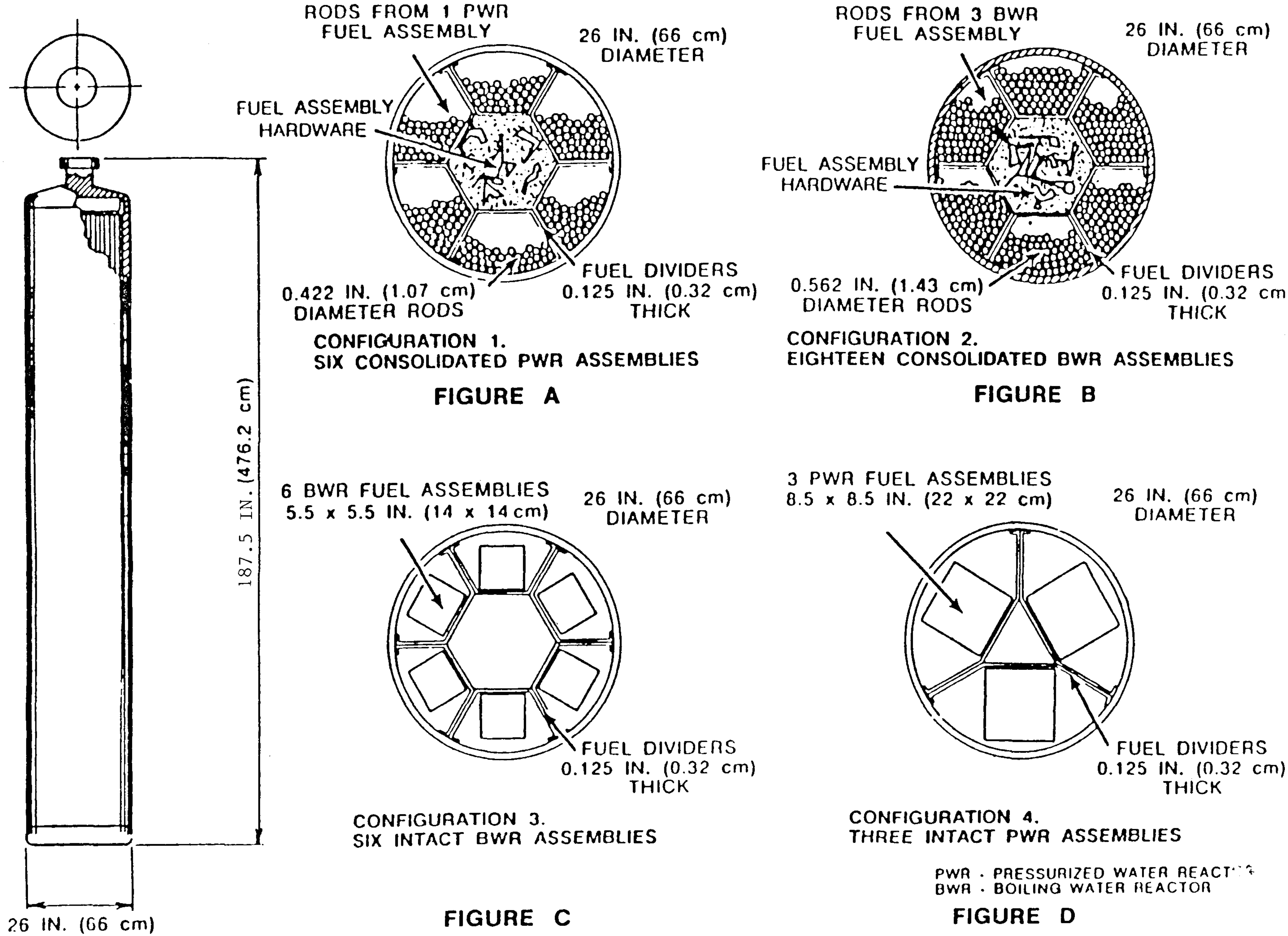


Figure 11 6. Intact Fuel Containers (Case 8) provided in Subsection 4.4 (Case 1) of this report. The year-by-year container emplacement schedule shown in Table 11-1 is the same as that for Cases 1 and 3.

11.5 Underground Facility

The emplacement panel layout for Case 8 is identical to what is described for Case 1 in Subsection 4.5. Figure 11-7 shows details of a typical emplacement drift for Case 8.

11.6 Cost and Schedule

11.6.1 Capital and Operating Costs

A summary of capital, operating, and decommissioning costs is given in Table 11-2.

Staffing requirements for the surface facilities for Case 8 are summarized in Table 11-3.

Staffing requirements for the underground facility for Case 8 are summarized in Table 11-4.

Further detail of these estimates is included in Appendix B.

11.6.2 Construction Schedule

The construction schedules for the underground and surface facilities (including the waste-handling building) for Case 8 are the same as those for Cases 5, 6, 7, and 9. For details, see Subsection 8.6.2.

TABLE 11-1

REPOSITORY THROUGHPUTS (CASE 8)

	MTU - First Repository			HLW Containers			Spent Fuel Containers											
							BWR						PWR					
								Assemblies		Disposal Containers				Assemblies		Disposal Containers		
Year	Spent Fuel	HLW	Cum.	DHLW	WVHLW	MTU	MTU	Intact	Consol.	Intact	Consol.	Hdw.	MTU	Intact	Consol.	Intact	Consol.	Hdw.
2003	400	0	400	0	0	400	133	37	704	6	39	7	267	31	589	10	98	0
2004	400	0	800	0	0	400	133	37	704	6	39	7	267	31	589	10	98	0
2005	400	0	1200	0	0	400	133	37	704	6	39	7	267	31	589	10	98	0
2006	900	0	2100	0	0	900	300	83	1583	14	88	15	600	70	1326	23	221	0
2007	1800	0	3900	0	0	1800	600	167	3167	28	176	29	1200	140	2651	47	442	0
2008	3000	400	7300	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2009	3000	400	10700	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2010	3000	400	14100	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2011	3000	400	17500	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2012	3000	400	20900	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2013	3000	400	24300	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2014	3000	400	27700	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2015	3000	400	31100	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2016	3000	400	34500	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2017	3000	400	37900	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2018	3000	400	41300	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2019	3000	400	44700	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2020	3000	400	48100	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2021	3000	400	51500	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2022	3000	400	54900	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2023	3000	400	58300	680	28	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2024	3000	400	61700	0	188	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2025	3000	180	64880	0	84	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2026	2700	0	67580	0	0	2700	900	250	4750	42	264	44	1800	209	3977	70	663	0
2027	2420	0	70000	0	0	2420	807	224	4257	37	237	39	1613	188	3564	63	594	0
TOTALS	63020	6980	70000	12680	300	63020	21007	5835	110868	973	6159	1027	42013	4885	92820	1628	15470	0

Notes: BWRs: 6 intact = 1 container
18 consolidated = 1 container

PWRs: 3 intact = 1 container
6 consolidated = 1 container

Hardware: 0 containers for each consolidated PWR fuel assembly
1 container for each 108 consolidated BWR fuel assembly

DHLW: 0.5 MTU = 1 container

WVHLW: 2.13 MTU = 1 container

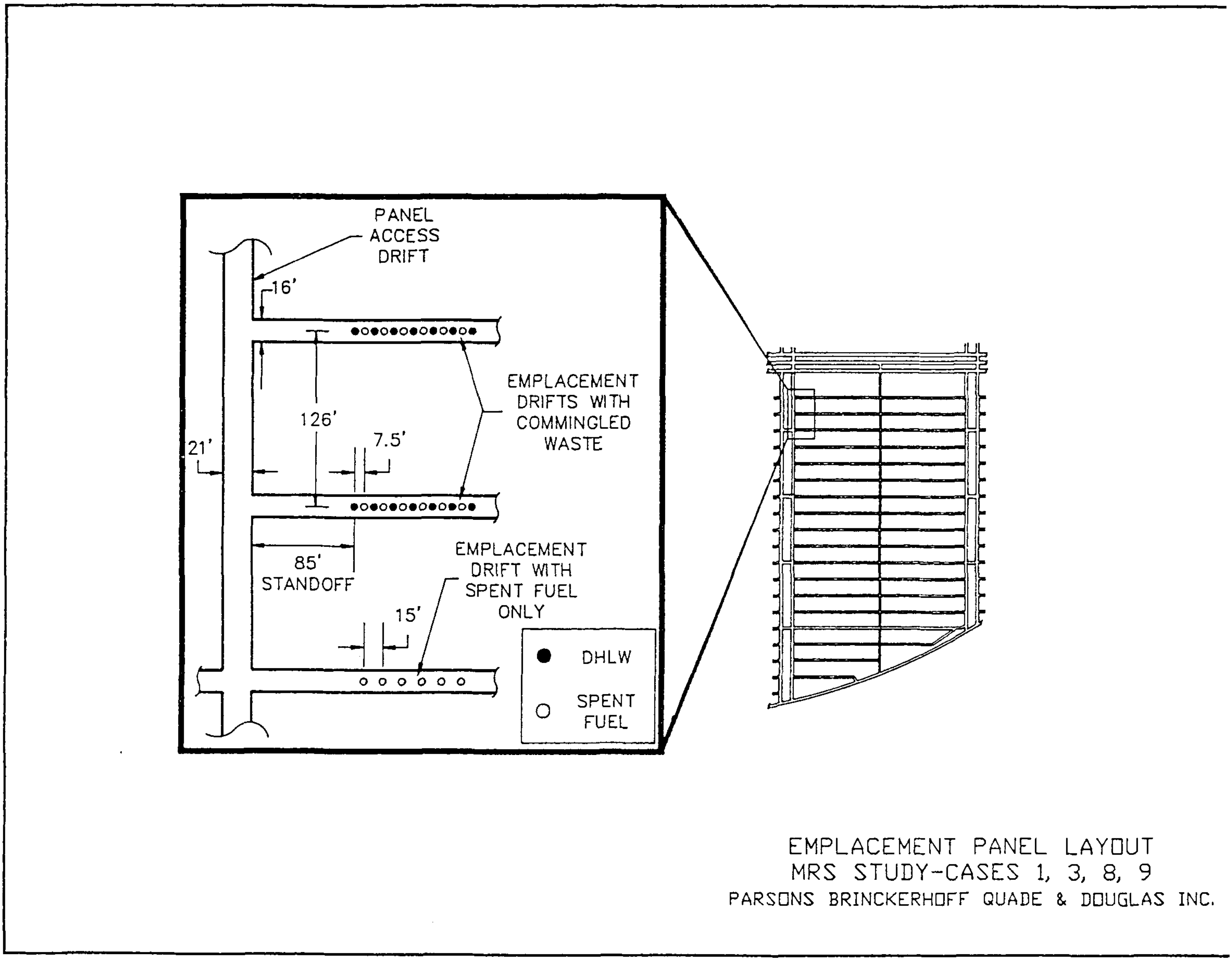


Figure 11-7. Emplacement Panel Layout (Case 8)

TABLE 11-2

SUMMARY OF LIFE-CYCLE COSTS (CASE 8)
(in Millions of 1988 Constant Dollars[a])

Cost Category Description	Construction	Operations	Decommissioning	Total
Management and Integration				
Architect/Engineer	148	0	15	
Construction Management	57	0	2	
Other	38	54	4	
Subtotal	243	54	21	318
Surface Facilities				
Site	178	101	41	
High-Level Waste-Handling Facilities	153	547[b]	9	
Other Waste-Handling Facilities	45		4	
Balance of Plant	136	1,177	51	
Subtotal	512	1,825	105	2,442
Subsurface Facilities				
Shafts and Ramps	66	31	3	
Excavation and Emplacement	143	868	108	
Service Systems	100	865	146	
Subtotal	309	1,764	257	2,330
Total w/o Disposal Container	1,064	3,643	383	5,090
Disposal Containers				
Spent Fuel	0	0	0	
DHLW	0	0	0	
Other	0	31	0	
Subtotal	0	31	0	31
Total	1,064	3,674	383	5,121

a. Unescalated for the life of the repository.
b. Includes cost of operations for all waste-handling facilities.

TABLE 11-3

STAFFING REQUIREMENTS: SURFACE FACILITIES (CASE 8)

Facility	Staff
Waste-Handling Building 1	0
Waste-Handling Building 2	83
Waste Treatment Building	8
Vehicle Wash Facility	0 *
Decontamination Building	0 *
Performance Confirmation Building	17
Health Physics Station 4	0 *
Medical Center	10
Fire Station/Emergency Center	15
Security Station 1	35
Security Station 2/Health Physics Station 3	18
Security Station 3	22
Men-and-Material Shaft Security Station	4
Shops	68
Motor Pool/Facilities Sewage Station	15
Transporter Garage	28
Administration Building	142
Food Services Facility	20
Mockup Building	5
Central Warehouse	17
Visitors Center	3
Change House	0 *
Computer Building	44
Concrete Batch Plant and Aggregate Storage	4
Tuff Pile	4
Total Full Time Personnel	560

* Assigned only as required.

TABLE 11-4

STAFFING REQUIREMENTS: UNDERGROUND FACILITY (CASE 8)

Category	Staff
Shafts and Ramps	12
Drift Excavation	110
Emplacement Borehole Drilling and Lining	67
Emplacement/Retrieval Operations	15
Support Services	240
Total, Subsurface	444

12.0 CASE 9

For Case 9, SNF assemblies (from eastern and western reactors) are consolidated and placed in containers at the MRS and then shipped to the repository for inspection and emplacement. Defective containers found during inspection at the repository are repaired at the repository. DHLW and WVHLW canisters are containerized at the MRS and then shipped to the repository for emplacement. There is no consolidation or containerizing at the repository.

12.1 Assumptions

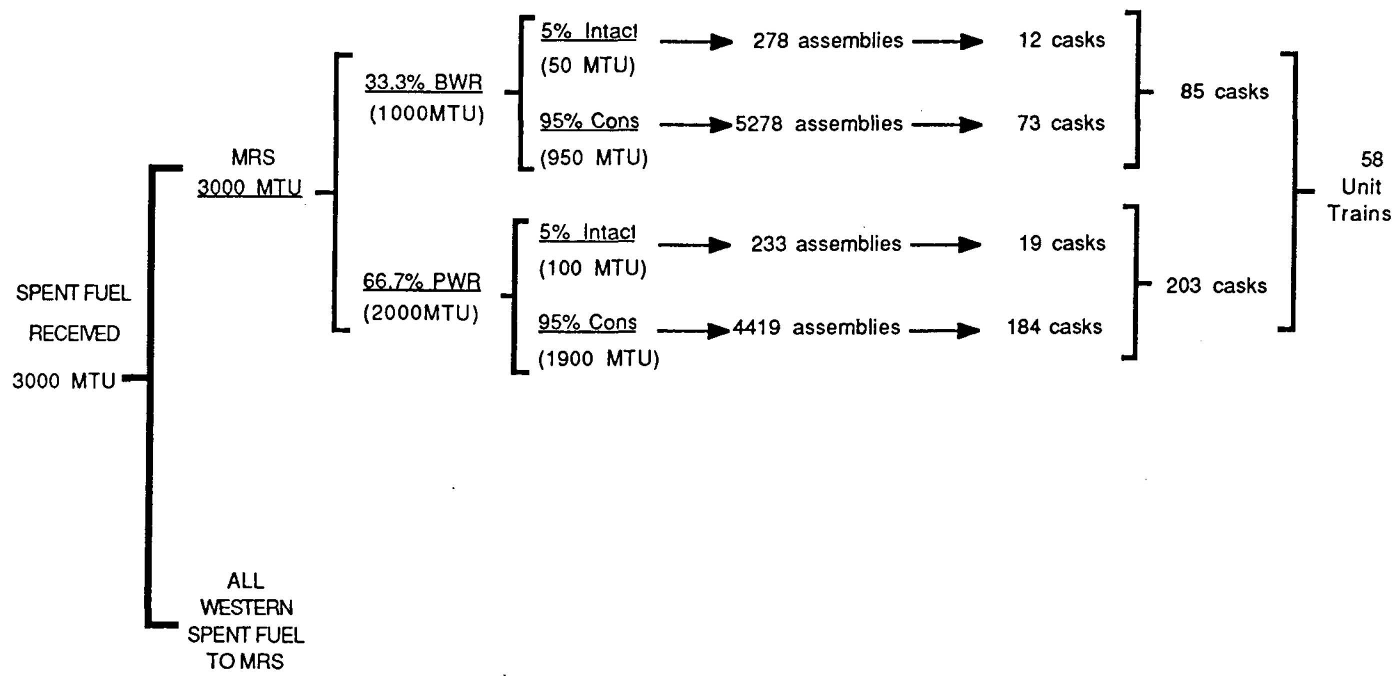
All of the assumptions for Case 9 are exactly the same as those for Case 8, except that in Case 9, defective containers received at the repository from the MRS are repaired at the repository, whereas in Case 8 defective containers are shipped back to the MRS for repair.

12.2 Waste Received

As in Case 8, all SNF (3,000 MTU), including SNF from western reactors, is received at the repository from the MRS in the same BWR and PWR containers used in Cases 1 and 3 and described in Subsection 4.4 (Case 1). The same type and number of casks are also used for Cases 8 and 9.

As in Case 6, 7, and 8, all DHLW and WVHLW is containerized in containers at the MRS and shipped to the repository in casks that have a capacity of 5 containers.

The annual throughputs (at full receipt capacity) for Case 9 are summarized in Figure 12-1. The calculations for the quantities shown in this figure are provided in Appendix A.



NON-SPENT FUEL RECEIVED

DHLW:	MTU's	400
	Canisters	800
	Rail Casks	160
MRS Hardware:	Drums	N/A
	Canisters	49
	Rail Casks	12

CASK CAPACITIES (ASSEMBLIES)

MRS ALL RAIL:	BWR intact	24
	BWR consol.	72
	PWR intact	12
	PWR consol.	24
REACTOR:	BWR rail	N/A
	BWR truck	N/A
	PWR rail	N/A
	PWR truck	N/A
HARDWARE:	rail	4
DHLW:	rail	5 canisters

EMPLACEMENT OPERATIONS	NO. CONTAINERS	NO. ASSEMBLIES/ CONTAINERS
BWR (Intact)	46	6
BWR (Consolidated)	293	18
PWR (Intact)	78	3
PWR (Consolidated)	736	6
Hardware	49	108 BWR
DHLW	800	1 canister
Total	2002	

Figure 12-1. Repository Annual Throughputs (Case 9)

12.3 Surface Facilities

Only one waste-handling building is required for Case 9. The waste-handling building for Case 9 is the same as the waste-handling building for Case 8, because the space required for container repair in Case 9 is considered to be insignificant. The plot plan, which is the same for both designs, is provided in Figure 12-2.

Figure 12-3, which is the same as Figure 11-3 (Case 8), is a markup of the RCS Case 3 (also Case 5) waste-handling building layout showing the space for equipment required for containerizing and a cask-unloading bay deleted to reflect the requirements for Case 9. Other than the cask unloading, containerizing, and container repair requirements, the remaining functional requirements, throughputs, and descriptions pertaining to the waste-handling building for Case 9 are the same as those for the waste-handling building in Case 5, as described in Subsection 8.3.

The DHLW and WVHLW material flow diagram for Case 9, shown in Figure 12-4, is the same as that for Case 7. The SNF material flow diagram for Case 9, shown in Figure 12-5, is the same as that for Case 7.

12.4 Disposal Containers

For Case 9, the YMP container shown in Figure 12-6 is the same container used in Cases 1, 3, and 8 of this study. The container descriptions, contents, and throughputs are the same as those provided in Subsection 4.4 (Case 1) of this report. The year-by-year container emplacement schedule shown in Table 12-1 is the same as that for Cases 1, 3, and 8.

12.5 Underground Facility

The emplacement panel layout for Case 9 is identical to what is described for Case 1 in Subsection 4.5. Figure 12-7 shows details of a typical emplacement drift for Case 9.

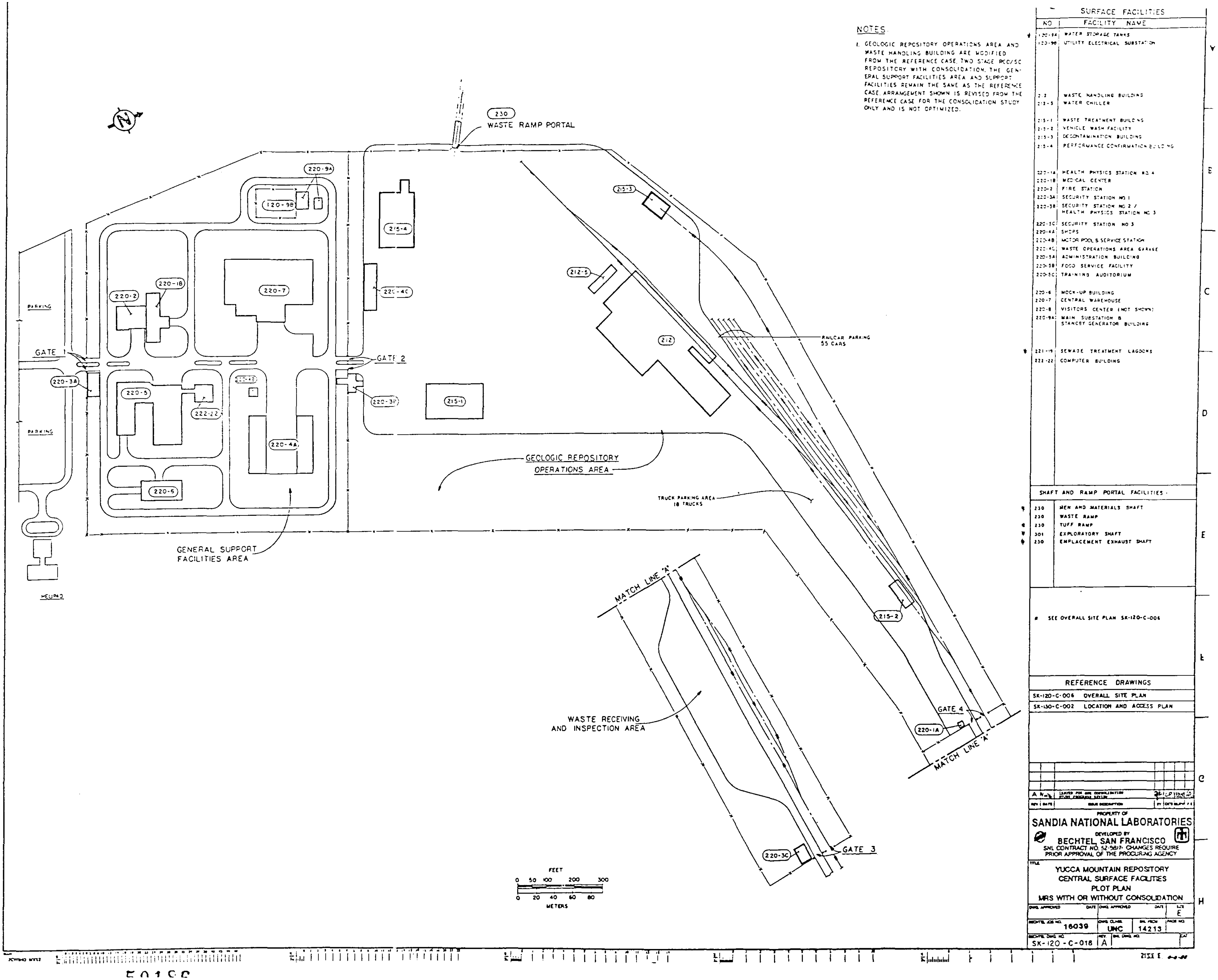


Figure 12-2. Repository Plot Plan (Case 9)

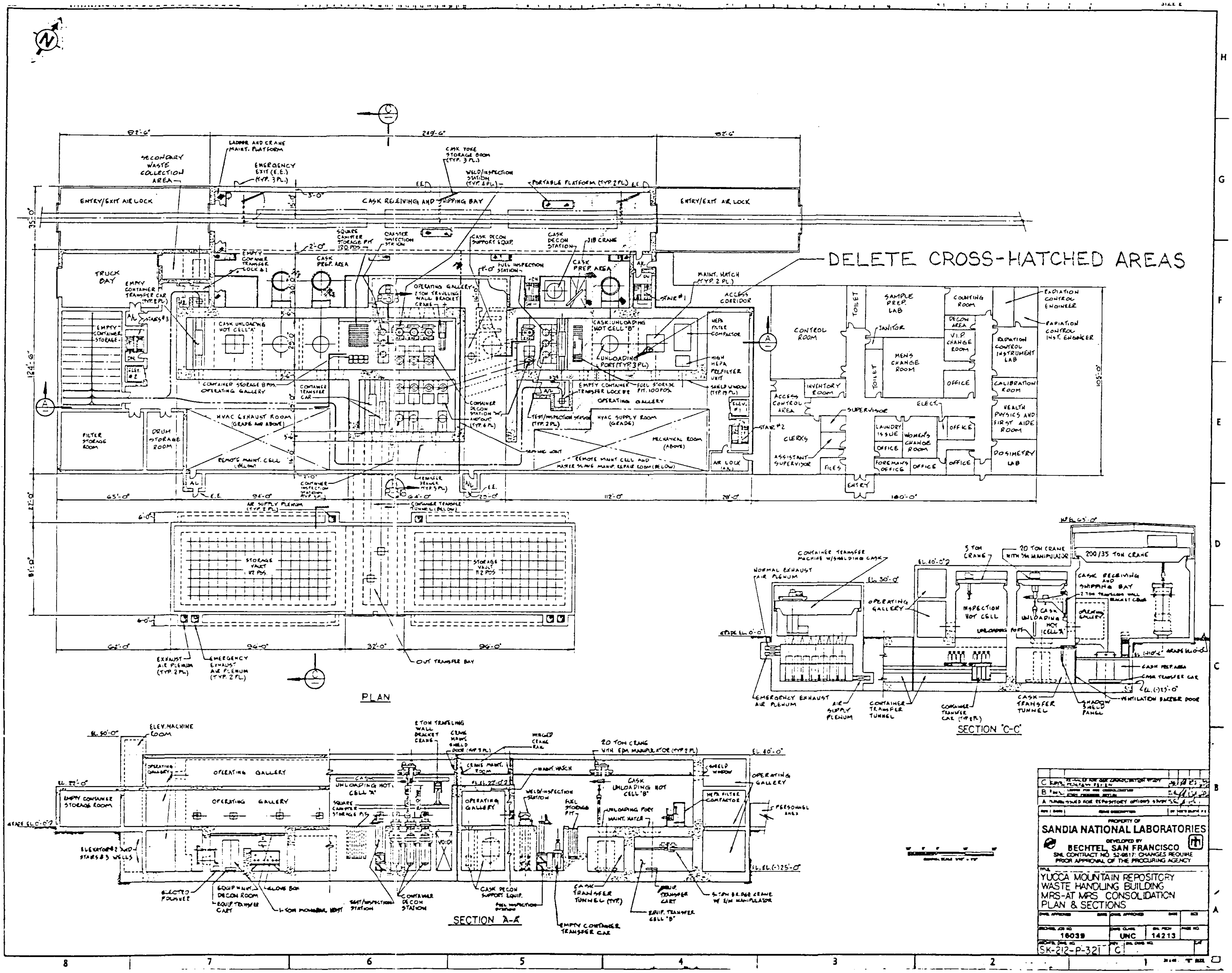


Figure 12-3. Waste Handling Building Layout (Case 9)

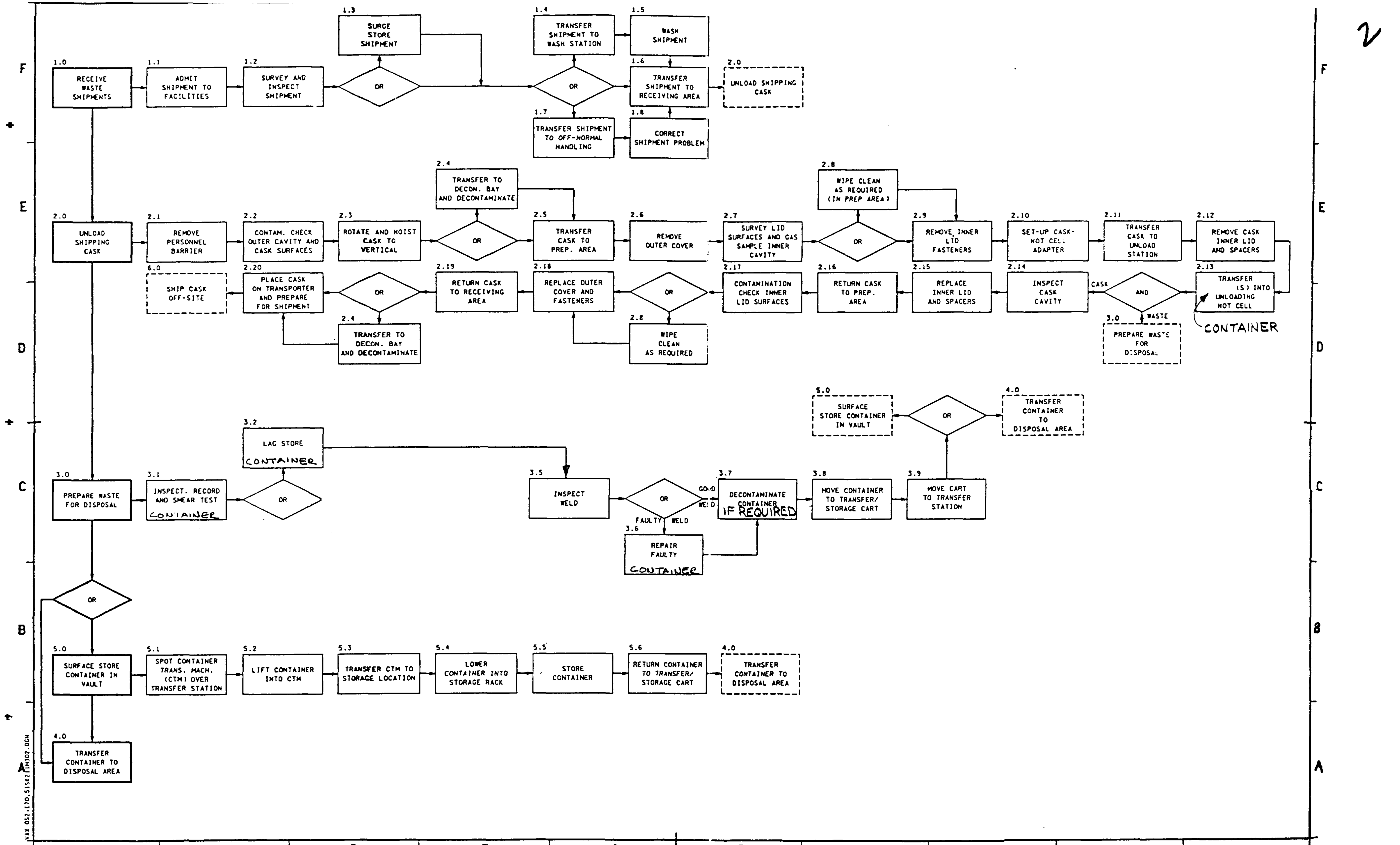


Figure 12.4. Material Flow Diagram for DHLW and WVHLW (Case 9)

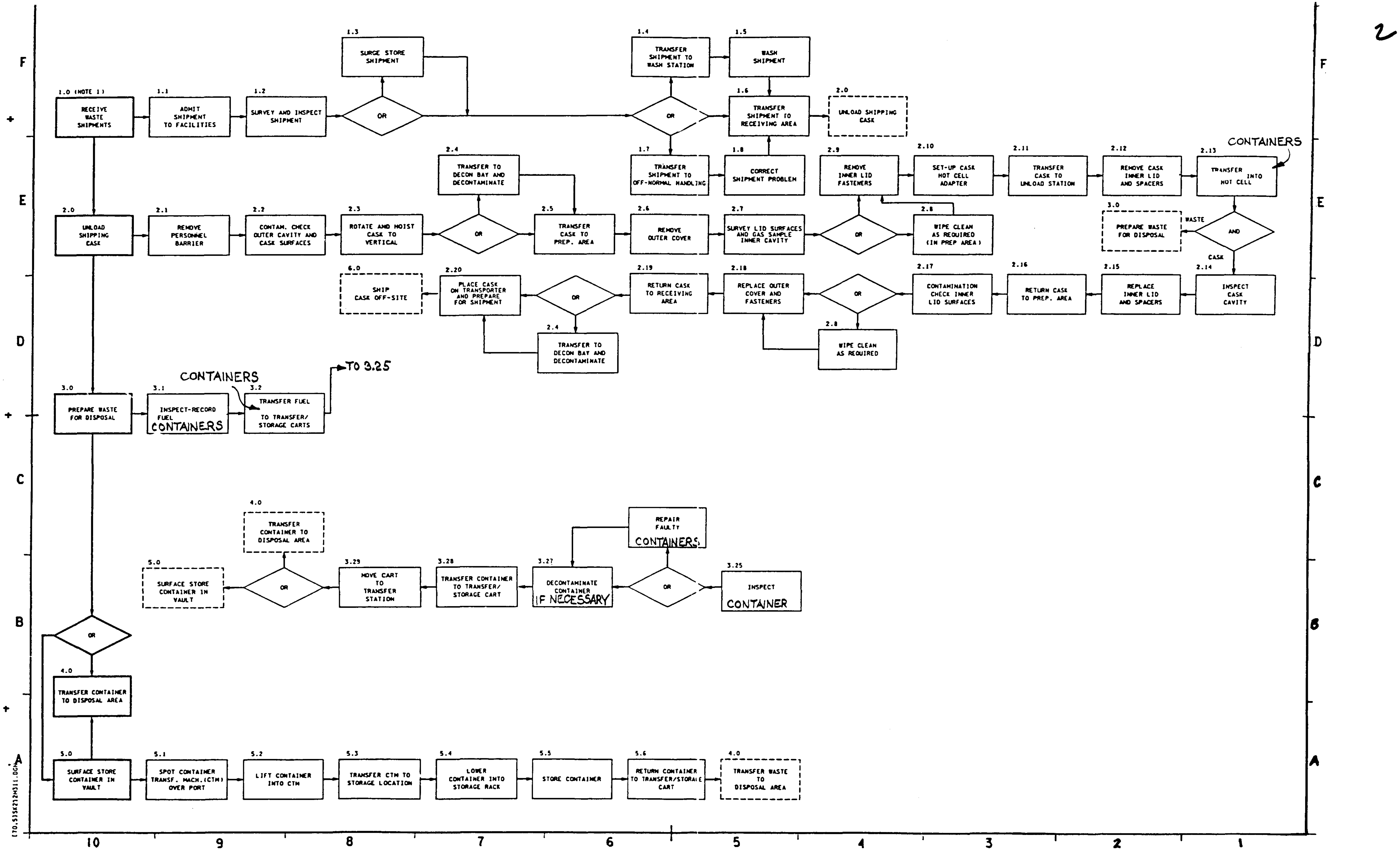


Figure 12-5. Material Flow Diagram for SNF (Case 9)

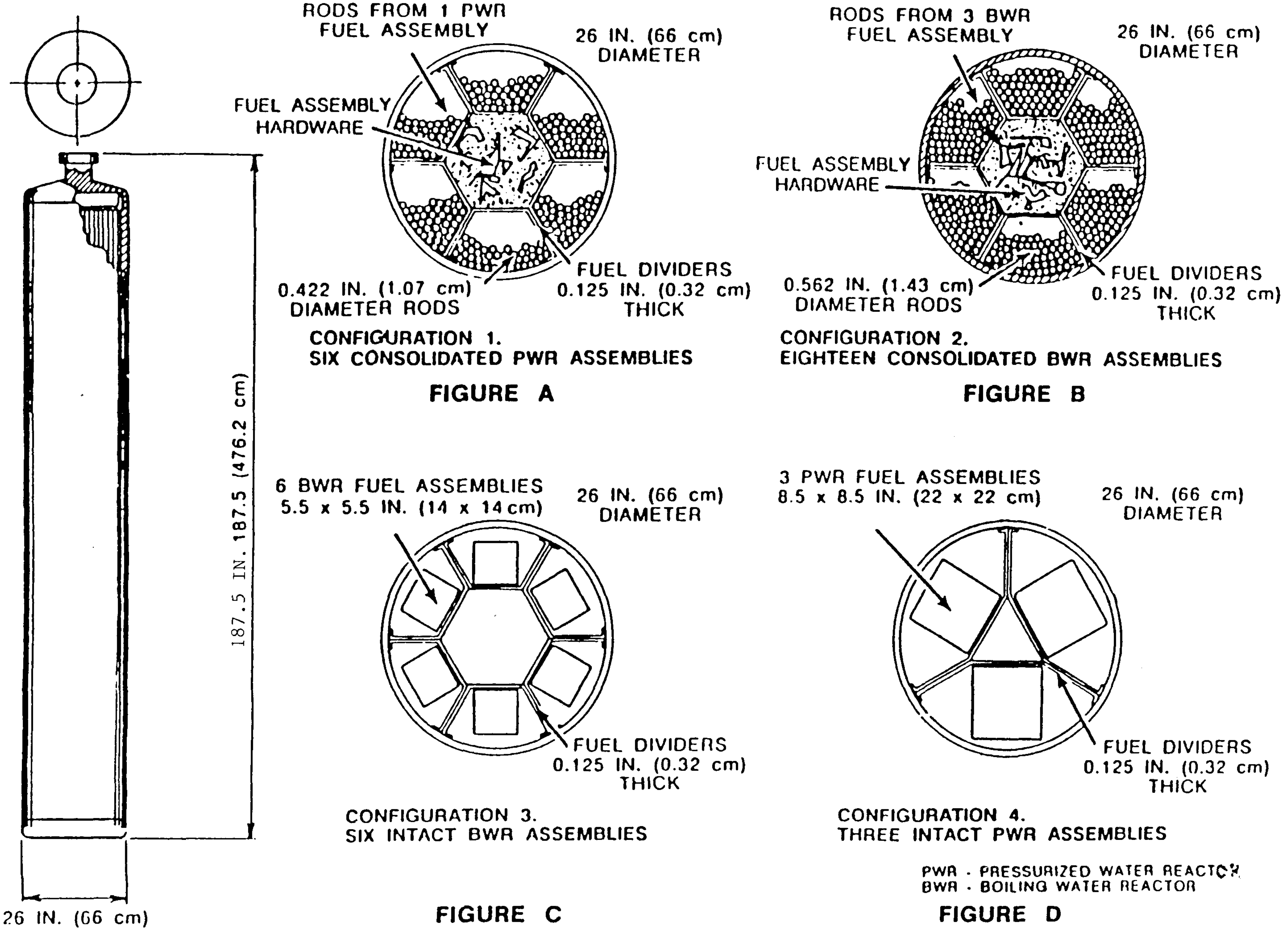


Figure 12-6. Intact Fuel Containers (Case 9)

TABLE 12-1

REPOSITORY THROUGHPUTS (CASE 9)

Year	MTU - First Repository			HLW Containers		Spent Fuel Containers												
							BWR						PWR					
								Assemblies		Disposal Containers				Assemblies		Disposal Containers		
	Spent Fuel	HLW	Cum.	DHLW	WVHLW	MTU	MTU	Intact	Consol.	Intact	Consol.	Hdw.	MTU	Intact	Consol.	Intact	Consol.	Hdw.
2003	400	0	400	0	0	400	133	37	704	6	39	7	267	31	589	10	98	0
2004	400	0	800	0	0	400	133	37	704	6	39	7	267	31	589	10	98	0
2005	400	0	1200	0	0	400	133	37	704	6	39	7	267	31	589	10	98	0
2006	900	0	2100	0	0	900	300	83	1583	14	88	15	600	70	1326	23	221	0
2007	1800	0	3900	0	0	1800	600	167	3167	28	176	29	1200	140	2651	47	442	0
2008	3000	400	7300	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2009	3000	400	10700	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2010	3000	400	14100	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2011	3000	400	17500	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2012	3000	400	20900	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2013	3000	400	24300	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2014	3000	400	27700	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2015	3000	400	31100	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2016	3000	400	34500	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2017	3000	400	37900	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2018	3000	400	41300	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2019	3000	400	44700	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2020	3000	400	48100	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2021	3000	400	51500	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2022	3000	400	54900	800	0	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2023	3000	400	58300	680	28	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2024	3000	400	61700	0	188	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2025	3000	180	64880	0	84	3000	1000	278	5278	46	293	49	2000	233	4419	78	736	0
2026	2700	0	67580	0	0	2700	900	250	4750	42	264	44	1800	209	3977	70	663	0
2027	2420	0	70000	0	0	2420	807	224	4257	37	237	39	1613	188	3564	63	594	0
TOTALS	63020	6980	70000	12680	300	63020	21007	5835	110868	973	6159	1027	42013	4885	92820	1628	15470	0

Notes:

BWRs: 6 intact = 1 container
18 consolidated = 1 container

PWRs: 3 intact = 1 container
6 consolidated = 1 container

Hardware: 0 containers for each consolidated PWR fuel assembly
1 container for each 108 consolidated BWR fuel assembly

DHLW: 0.5 MTU = 1 container

WVHLW: 2.13 MTU = 1 container

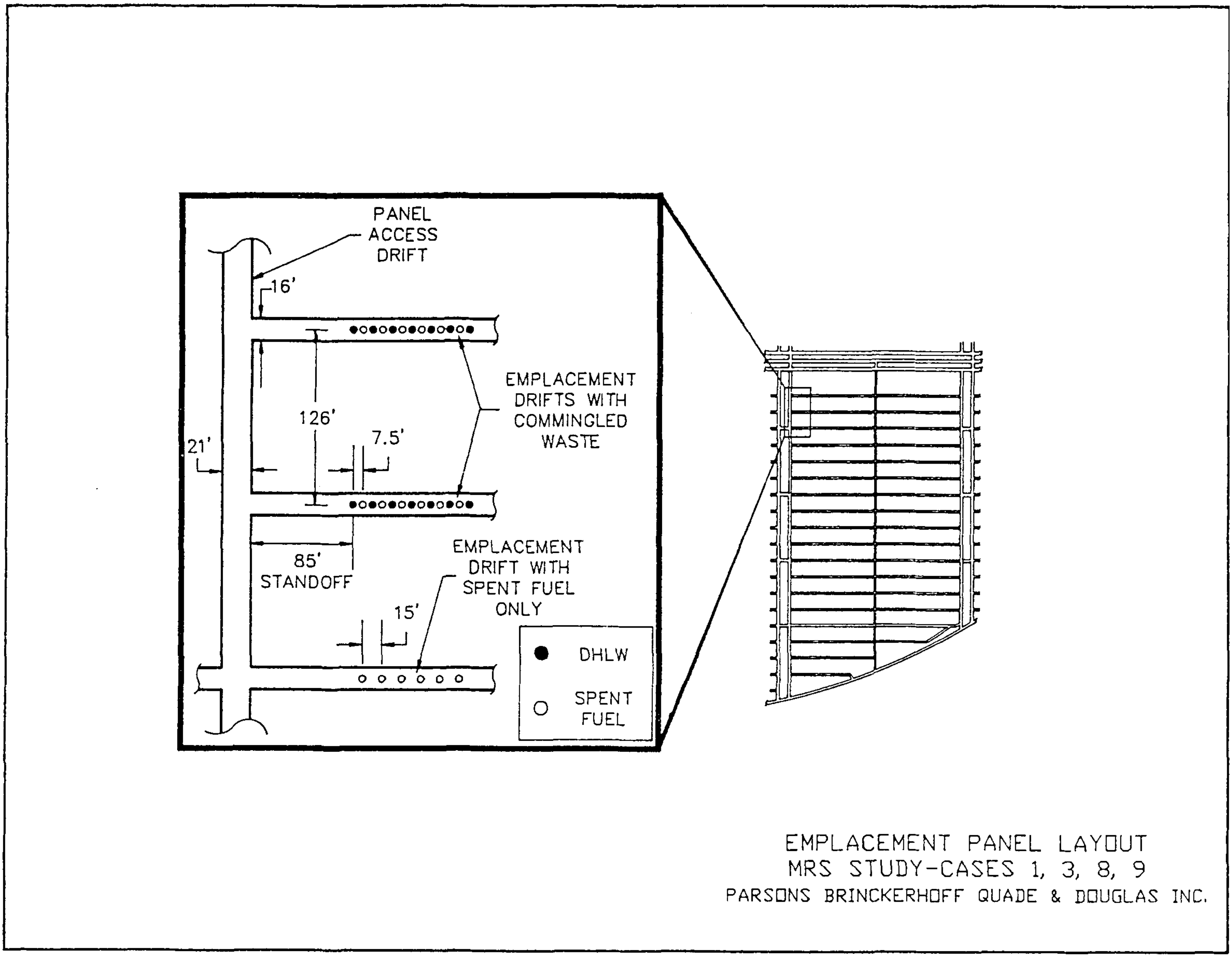


Figure 12-7. Emplacement Panel Layout (Case 9)

12.6 Cost and Schedule

12.6.1 Capital and Operating Costs

A summary of capital, operating, and decommissioning costs is given in Table 12-2.

Staffing requirements for the surface facilities for Case 9 are summarized in Table 12-3.

Staffing requirements for the underground facility for Case 9 are summarized in Table 12-4.

Further detail of these estimates is included in Appendix B.

12.6.2 Construction Schedule

The construction schedules for the underground and surface facilities (including the waste-handling building) for Case 9 are the same as those for Cases 5, 6, 7, and 8. For details, see Subsection 8.6.2.

TABLE 12-2

SUMMARY OF LIFE-CYCLE COSTS (CASE 9)
(in Millions of 1988 Constant Dollars[a])

Cost Category Description	Construction	Operations	Decommissioning	Total
Management and Integration				
Architect/Engineer	148	0	15	
Construction Management	57	0	2	
Other	38	54	4	
Subtotal	243	54	21	318
Surface Facilities				
Site	178	101	41	
High-Level Waste-Handling Facilities	153	566[b]	9	
Other Waste-Handling Facilities	45		4	
Balance of Plant	136	1,177	50	
Subtotal	512	1,844	104	2,460
Subsurface Facilities				
Shafts and Ramps	66	31	3	
Excavation and Emplacement	143	868	108	
Service Systems	100	865	146	
Subtotal	309	1,764	257	2,330
Total w/o Disposal Containers	1,064	3,662	382	5,108
Disposal Containers				
Spent Fuel	0	0	0	
DHLW	0	0	0	
Other	0	31	0	
Subtotal	0	31	0	31
Total	1,064	3,693	382	5,139

a. Unescalated for the life of the repository.
b. Includes cost of operations for all waste-handling facilities.

TABLE 12-3

STAFFING REQUIREMENTS: SURFACE FACILITIES (CASE 9)

Facility	Staff
Waste-Handling Building 1	0
Waste-Handling Building 2	92
Waste Treatment Building	8
Vehicle Wash Facility	0*
Decontamination Building	0*
Performance Confirmation Building	17
Health Physics Station 4	0*
Medical Center	10
Fire Station/Emergency Center	15
Security Station 1	35
Security Station 2/Health Physics Station 3	18
Security Station 3	22
Men-and-Material Shaft Security Station	4
Shops	68
Motor Pool/Facilities Sewage Station	15
Transporter Garage	28
Administration Building	142
Food Services Facility	20
Mockup Building	5
Central Warehouse	17
Visitors Center	3
Change House	0*
Computer Building	44
Concrete Batch Plant and Aggregate Storage	4
Tuff Pile	4
Total Full Time Personnel	569

* Assigned only as required.

TABLE 12-4

STAFFING REQUIREMENTS:
UNDERGROUND FACILITY (CASE 9)

Category	Staff
Shafts and Ramps	12
Drift Excavation	110
Emplacement Borehole Drilling and Lining	67
Emplacement/Retrieval Operations	15
Support Services	240
Total, Subsurface	444

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