1123

**SANDIA REPORT** SAND84—1351 • Unlimited Release • UC—70
Printed December 1984

# Two-Stage Repository Development at Yucca Mountain: An Engineering Feasibility Study

Compiled by Hugh R. MacDougall

**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**

HYDROLOGY DOCUMENT NUMBER 150

SF2900Q(8-81)

SAND84-1351
Unlimited Release
Printed December 1984

Distribution
Category UC-70

# TWO-STAGE REPOSITORY DEVELOPMENT AT YUCCA MOUNTAIN: AN ENGINEERING FEASIBILITY STUDY

Compiled by
H. R. MacDougall
Nuclear Waste Engineering Projects Division
Sandia National Laboratories
Albuquerque, New Mexico 87185

Bechtel National, Inc.
San Francisco, California 94119

Los Alamos Technical Associates, Inc.
Los Alamos, New Mexico 87544

and

Parsons Brinckerhoff Quade & Douglas, Inc.
San Francisco, California 94109

## Abstract

The preliminary concepts for a repository for high-level radioactive waste at Yucca Mountain specify construction of a 70,000-MTU-capacity repository by January 31, 1998, as mandated in the Nuclear Waste Policy Act of 1982. Current schedules for constructing the repository indicate that the 1998 deadline established by the Act cannot be met if the repository is constructed in one stage. Therefore, the Department of Energy has requested the preparation of this engineering study to determine the feasibility of constructing the repository in two stages. The two-stage approach examined in this study involves concurrent construction of two waste-handling buildings. The first would be completed in time to accept the equivalent of 400 MTU/yr of waste by January 31, 1998. It would operate for 5 years, during which time construction of a full-capacity, 3,000-MTU/yr waste-handling building would be completed. The design includes six accesses to the underground facility: four vertical shafts and two ramps. Four alternative concepts have been explored to determine whether savings in costs could be accomplished. All four alternatives appear technically feasible and are potentially more cost effective than the reference approach. The principal conclusion derived from this study is that two-stage repository construction can allow receipt and disposal of the 400 MTU/yr of waste by January 1, 1998.

## FOREWORD

This preliminary engineering feasibility study of two-stage development of a repository in tuff at Yucca Mountain has been prepared at the request of the Department of Energy (DOE). The report has two principal goals: (1) to establish the feasibility of receiving and disposing of radioactive waste on or before January 31, 1998, and (2) to establish an estimate of the life-cycle cost of the repository. The report develops the rationale for these two goals and provides conclusions. These conclusions must be considered preliminary, considering that the repository design is still in the preconceptual phase and the impact of certain regulatory requirements (such as the performance confirmation program) is unknown.

In accordance with the DOE's directives, it is assumed in this study that repository construction schedules can be developed without allowances for institutional and regulatory delays, labor disputes, or other unavoidable delays. In addition, in accordance with the DOE Mission Plan, approximately 6 mo has been scheduled for testing before beginning to operate the waste-handling facilities. Should any delays occur, the 6-mo limitation on the testing period may not be achievable. Consequently, the schedule described in this report should be considered as a feasibility estimate only.

Because site characterization and engineering studies are still under way for the conceptual design, many of the assumptions in this study are based on preliminary data; thus, this engineering feasibility study report does not reflect the engineering detail that will be developed in the conceptual or Title I designs.

## ACKNOWLEDGEMENT

The following individuals contributed to this report:

W. D. Blackwell
R. I. Brasier
R. L. Brunnenmeyer
M. Comar
J. D. Grenia
R. F. Harig
J. L. Jackson
L. J. Jardine
R. B. Jones
T. P. Krivoy
B. W. Lawrence
H. R. MacDougall
G. F. Mahr
J. T. Neal
N. A. Norman
J. M. Redenbo
F. K. Flaherty
R. M. Robb
G. A. Rocha
B. Schmidt
L. W. Scully
L. P. Skousen
V. J. Stephens
R. J. Stinebaugh
K. Wallace
C. Wu

A. W. Dennis and A. Stevens were peer reviewers. E. B. Barnett was the technical editor.

The authors wish to thank the Department of Energy for its assistance in providing cost estimates and Los Alamos National Laboratory for Exploratory Shaft Test Program cost and schedule information.

## SUMMARY

A conceptual design of a radioactive waste repository in tuff is being developed by Sandia National Laboratories (SNL) for the Nevada Nuclear Waste Storage Investigations (NNWSI) Project under the direction of the Department of Energy (DOE) Nevada Operations Office. An area near Yucca Mountain, consisting of the southwest corner of the Nevada Test Site (NTS) and adjacent federal property, is being investigated as a potential site for this repository. SNL is conducting this effort in cooperation with other NNWSI Project participants: Los Alamos National Laboratory (LANL), Lawrence Livermore National Laboratory (LLNL), and the U.S. Geological Survey (USGS).

The Nuclear Waste Policy Act (NWPA) of 1982 states that the first repository shall be ready to receive waste by January 31, 1998. The schedules for constructing the first repository indicate that this deadline cannot be met if the repository is constructed in one stage. Thus, DOE has requested that the three contractors responsible for the repository studies for tuff, salt, and basalt assess the feasibility of two-stage repository construction. The purpose of this engineering study is to examine the feasibility of constructing a repository in tuff in two stages to meet the requirements of the NWPA and the DOE's Mission Plan schedule. The schedules developed for this study do not include time lost as the result of institutional delays, labor disputes, or other unavoidable events.

The underground facilities in the reference repository are located primarily within the central block of Yucca Mountain. Although the central block has been the focus of attention for the underground facilities, it may not be necessary to limit the disposal area to one geologic block. The disposal area finally selected will encompass the central block and any contiguous zones that meet geological, structural, engineering, and performance assessment considerations and constraints.

The boundaries of the central block have been determined based on available overburden (at least 650 ft), available thickness of acceptable rock (approximately 100 ft), and areas of potentially unsuitable rock in the vicinity of faults. At Drillhole USW G-4 adjacent to the proposed exploratory shaft (ES) location, the disposal horizon is 940 ft below the surface. The water table is several hundred feet below the disposal horizon.

The parameters for the design, construction, and waste emplacement operations of the reference repository are based on a [redacted] In this mode, vertical boreholes, each containing a single waste canister, are drilled in the floor of the emplacement drift. This design concept is used as the reference design for the purposes of this study only; other design alternatives currently under consideration may eventually be selected for technical, economic, or schedule reasons.

The assumptions used for cost comparison for the reference repository include (1) emplacement of waste in boreholes drilled vertically in drift floors, (2) construction of one waste-handling building, and (3) construction of the repository in one stage. The assumptions made in the reference case are described by Weston (1984).

The two-stage approach to repository construction examined in this study involves concurrent construction of two waste-handling buildings. The first waste-handling building (WHB-1) would be completed in time to accept spent fuel waste for emplacement in the repository by January 31, 1998, and would handle the equivalent of 400 metric tons of uranium per year (MTU/yr). WHB-1 would operate for 5 yr, during which time construction of a full-capacity, 3,000-MTU/yr waste-handling building (WHB-2) would be completed.

To handle fluctuations in operational requirements, surface storage capacity of 100 MTU is provided for canistered spent fuel in WHB-1. The canisters of spent fuel are stored in a dry, air-cooled vault equipped with supplementary evaporative cooling. Adequate rack storage for bare fuel

assemblies is provided to maintain operational continuity. Outside storage space is provided for 133 MTU of spent fuel in truck or rail shipping casks. Although DOE guidance does not require the use of WHB-1 during Stage 2, capabilities for handling defense high-level waste (DHLW) and West Valley high-level waste (WVHLW), including canister overpacking, can be incorporated in WHB-1 for use during Stage 2 operations.

WHB-2 provides space for the annual receipt and packaging of spent fuel assemblies for full-scale repository operation based on 80% shipment by rail and 20% by truck. Fuel is consolidated in two hot cells, each of which has two parallel processing lines that use a dry consolidation process. Surface storage for more than 390 MTU of canistered spent fuel (13% of the annual receipt) is provided in dry, air-cooled vaults in WHB-2. A small amount of surface storage is also provided inside the hot cells in WHB-2. Outside surface storage space is provided for 360 MTU of high-level waste (HLW) (12% of the annual receipt) in truck and rail shipping casks, for a total of 750 MTU of surface storage (25% of the annual receipt).

Site access, consisting of approximately 98 mi of new railroad, 16 mi of new highway, and a bridge for combined rail and highway use, is provided as part of the initial construction. All offsite utilities, site and yard utility distribution systems, onsite rail systems, administrative, and certain other facilities are designed and constructed during Stage 1 to serve the requirements of the full repository.

The design in this engineering feasibility study of two-stage repository construction includes six openings to the underground facilities that consist of four vertical shafts and two ramps. During the mining and waste emplacement phases, these openings serve the following purposes:

- <u>Waste Emplacement Area Ventilation Intake Shafts (Exploratory Shaft and 6-Ft-Diameter Second Shaft)</u> - Provide access to the exploratory shaft facility (ESF) and intake ventilation air for the waste emplacement area.

- Men-and-Materials Shaft - Provides access to the mining area for men and materials and intake ventilation air for the mining area.
- Waste Emplacement Area Ventilation Exhaust Shaft - Exhausts air from the waste emplacement area.
- Muck-Handling Ramp - Allows the use of a conveyor to remove excavated rock (muck) and exhausts air from the mining area.
- Waste-Handling Ramp - Used to transport waste to the disposal horizon. The waste-handling ramp is ventilated by a downcast air flow.

Four alternative concepts have been explored to determine whether savings in costs could be accomplished.

- Use of a horizontal emplacement mode in which multiple canisters are placed in long, horizontally drilled holes. Preliminary studies indicate that the horizontal emplacement mode would permit the most efficient use of the central block for waste emplacement and would reduce mining requirements and costs.

- Modification of the existing Engine Maintenance, Assembly, and Disassembly (E-MAD) Facility instead of constructing WHB-1. At the request of the DOE, this alternative has been examined to determine whether savings in time and cost can be achieved. It is not clear that using the E-MAD facility would save either time or money. Investigations performed to date indicate that it would be necessary to evaluate the potential of the E-MAD facility to meet Nuclear Regulatory Commission (NRC) licensing requirements. Actual total construction costs might be larger if the E-MAD facility were used instead of WHB-1 because (1) extensive modification of operations at the E-MAD facility would be required and operations would cease after 5 yr, (2) a larger WHB-2 would have to be constructed to include the functions that would otherwise have been performed at WHB-1, and (3) a road dedicated exclusively to the transport of canistered waste from the E-MAD facility to the waste-handling ramp portal might be required.

- Alternative ES concepts that include an additional access (shaft or ramp) to the ESF to increase ventilation capacity and to allow early construction of the muck-handling ramp.

- Use of WHB-1 for receiving and handling WVHLW and DHLW during Stage 2 to relieve operational loads and to provide additional storage during Stage 2.

All four alternatives appear technically feasible and are potentially more cost-effective than the approach selected for evaluation in this study. The issues of demonstrating prototype equipment (in the case of horizontal emplacement) and the licensability of the E-MAD facility remain to be resolved before either or both of these alternatives could be adopted.

The principal conclusion derived from this study is that development of the facilities for a repository in tuff at Yucca Mountain, based on the two-stage approach shown on the schedule in Figure S-1, can allow receipt and disposal of 400 MTU/yr of waste by January 31, 1998, thereby meeting Mission Plan objectives. Under ideal conditions, operations could begin earlier in Stage 1 than is indicated in Figure S-1.

No allowance has been made for institutional or regulatory delays, labor disputes, or other unavoidable delays. Moreover, DOE guidelines and the Mission Plan indicate that operational testing is to be completed in a 6-mo period. Large and complex construction projects require more than 6 mo for preoperational testing leading to production. It may not be possible to complete testing for a first-of-a-kind facility in the 6 mo allowed by the Mission Plan.

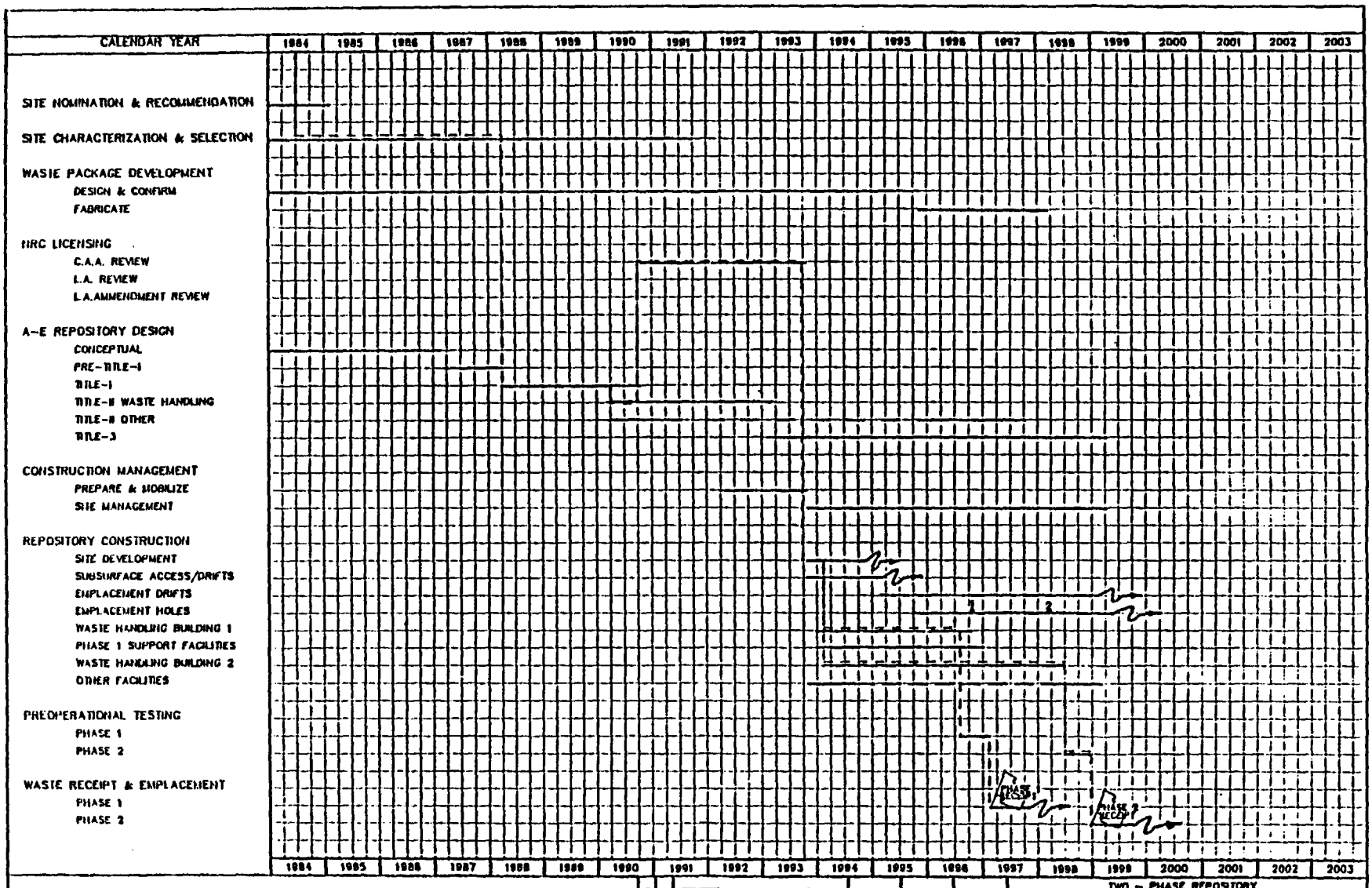

CALENDAR YEAR
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
SITE NOMINATION & RECOMMENDATION
SITE CHARACTERIZATION & SELECTION
WASTE PACKAGE DEVELOPMENT
DESIGN & CONFIRM
FABRICATE
NRC LICENSING
C.A.A. REVIEW
L.A. REVIEW
L.A.AMMENDMENT REVIEW
A-E REPOSITORY DESIGN
CONCEPTUAL
PRE-TITLE-I
TITLE-I
TITLE-II WASTE HANDLING
TITLE-II OTHER
TITLE-3
CONSTRUCTION MANAGEMENT
PREPARE & MOBILIZE
SITE MANAGEMENT
REPOSITORY CONSTRUCTION
SITE DEVELOPMENT
SUBSURFACE ACCESS/DRIFTS
EMPLACEMENT DRIFTS
EMPLACEMENT HOLES
WASTE HANDLING BUILDING 1
PHASE 1 SUPPORT FACILITIES
WASTE HANDLING BUILDING 2
OTHER FACILITIES
PREOPERATIONAL TESTING
PHASE 1
PHASE 2
WASTE RECEIPT & EMPLACEMENT
PHASE 1
PHASE 2
PHASE 1 RECEIPT
PHASE 2 RECEIPT
CRITICAL PATH
CONTINUING CYCLE
1 - PANEL 1 READY
2 - PANEL 2 READY
NO.
DATE
REVISION
PC
PE
PM
TWO - PHASE REPOSITORY
ENGINEERING FEASIBILITY STUDY - TUFF
SUMMARY PROGRAM SCHEDULE
SHEET 1 OF 1
JOB NUMBER 16039
DRAWING NUMBER SK-100-X-001
REVISION

FIGURE 3-1

TABLE OF CONTENTS


| | | Page |
|---|---|---|
| | FOREWORD | ii |
| | ACKNOWLEDGEMENT | iii |
| | SUMMARY | iv |
| 1.0 | INTRODUCTION | 1-1 |
| | 1.1 Mission Plan and Generic Requirements for a Mined Geologic Disposal System | 1-1 |
| | 1.1.1 Exploratory Shaft Facilities | 1-2 |
| | 1.1.2 Rationale for Two-Stage Construction of the Repository | 1-3 |
| | 1.2 Organization of This Report | 1-3 |
| 2.0 | DESIGN BASES AND CRITERIA | 2-1 |
| | 2.1 Radioactive Waste | 2-1 |
| | 2.1.1 Assumed Waste Receipt Rates and Characteristics | 2-2 |
| | 2.1.2 Assumed Waste Transportation Modes and Surface Storage Configuration | 2-3 |
| | 2.1.3 Defense High-Level Waste (DHLW) and West Valley High-Level Waste (WVHLW) | 2-4 |
| | 2.2 Site Selection and Description | 2-4 |
| | 2.3 Design Criteria: Surface Facilities | 2-5 |
| | 2.3.1 Surface Facility Access | 2-5 |
| | 2.3.2 Building Design | 2-5 |
| | 2.3.3 Standby Power | 2-6 |
| | 2.3.4 Waste Receipt and Packaging Rates | 2-6 |
| | 2.3.5 Surface Storage Requirements | 2-6 |
| | 2.4 Design Criteria: Underground Facilities | 2-7 |
| | 2.4.1 Boundaries of the Underground Facilities | 2-7 |
| | 2.4.2 Exploratory Shafts | 2-7 |
| | 2.4.3 Waste Emplacement Modes | 2-7 |
| | 2.4.4 Ventilation | 2-7 |
| | 2.4.5 Thermomechanical Effects | 2-8 |
| | 2.4.6 Retrievability and the Confirmation Program | 2-8 |

TABLE OF CONTENTS
(continued)


| | Page |
|---|---|
| 3.0 DESCRIPTION OF TWO-STAGE REPOSITORY FACILITIES | 3-1 |
| 3.1 Total Concept Overview | 3-1 |
| 3.2 Surface Facilities | 3-5 |
| 3.2.1 Master Plan of Surface Facilities | 3-5 |
| 3.2.2 Waste-Handling Building and Related Facilities in Stage 1 | 3-14 |
| 3.2.3 Waste-Handling Building and Related Facilities in Stage 2 | 3-21 |
| 3.2.4 Performance Confirmation Support Facility | 3-25 |
| 3.2.5 Support, Administration, and Other Facilities | 3-29 |
| 3.2.6 Monitoring and Computer Services | 3-31 |
| 3.2.7 Yard Utilities and Services | 3-32 |
| 3.2.8 Off-Plot Surface Facilities | 3-33 |
| 3.2.9 Utility and Transportation Access | 3-34 |
| 3.3 Underground Facilities | 3-35 |
| 3.3.1 Exploratory Shaft Facility (ESF) | 3-35 |
| 3.3.2 Access Shafts and Ramps | 3-35 |
| 3.3.3 Subsurface Facilities in Stage 1 | 3-40 |
| 3.3.4 Subsurface Facilities in Stage 2 | 3-47 |
| 3.3.5 Design, Operation, and Control of the Ventilation Systems | 3-57 |
| 4.0 OPERATIONS DESCRIPTIONS | 4-1 |
| 4.1 Stage 1 Operations | 4-1 |
| 4.1.1 Surface Facilities | 4-1 |
| 4.1.2 Waste Emplacement | 4-2 |
| 4.1.3 Continuing Underground Development | 4-5 |
| 4.2 Stage 2 Operations | 4-6 |
| 4.2.1 Surface Facilities | 4-6 |
| 4.2.2 Waste Emplacement | 4-6 |
| 4.2.3 Continuing Underground Development | 4-7 |
| 4.3 Performance Confirmation Operations | 4-7 |
| 4.4 Retrievability Period | 4-7 |
| 4.5 Manpower Requirements | 4-8 |

TABLE OF CONTENTS
(continued)


| | | Page |
|---|---|---|
| 5.0 | DESIGN, CONSTRUCTION, AND TESTING SCHEDULES | 5-1 |
| 5.1 | Basis and Method of Scheduling | 5-1 |
| 5.2 | Transition from Construction to Operations | 5-2 |
| 5.2.1 | Transition from Construction to Operations in Stage 1 | 5-2 |
| 5.2.2 | Transition from Construction to Operations in Stage 2 | 5-12 |
| 5.3 | Critical Path Identification | 5-12 |
| 5.3.1 | Surface Facilities | 5-12 |
| 5.3.2 | Underground Facilities | 5-13 |
| 5.4 | Exploratory Shaft Test Plan (ESTP) | 5-14 |
| 6.0 | COST ESTIMATES | 6-1 |
| 6.1 | Cost Estimates for an Exploratory Shaft Test Program | 6-1 |
| 6.2 | Cost Estimates for the Repositories | 6-2 |
| 6.2.1 | Cost of Engineering and Construction | 6-3 |
| 6.2.2 | Cost of Operations | 6-6 |
| 6.2.3 | Cost of Decommissioning | 6-10 |
| 6.3 | Comparison of Costs for Vertical Emplacement | 6-10 |
| 7.0 | ALTERNATE CONCEPTS | 7-1 |
| 7.1 | Horizontal Waste Emplacement | 7-1 |
| 7.1.1 | Description | 7-1 |
| 7.1.2 | Cost Comparison | 7-2 |
| 7.2 | Utilization of the E-MAD Facility | 7-2 |
| 7.3 | Alternative Exploratory Shaft Concepts | 7-11 |
| 7.4 | Use of WHB-1 for Handling WVHLW and DHLW in Stage 2 | 7-12 |
| 8.0 | PROGRAMMATIC IMPACTS AND UNCERTAINTIES | 8-1 |
| 8.1 | Regulatory and Licensing Issues | 8-1 |
| 8.2 | Exploratory Shaft Test Plan (ESTP) | 8-2 |
| 8.3 | Performance Confirmation Program and Retrieval Period | 8-3 |
| 8.4 | Continued Use of Waste-Handling Building 1 (WHB-1) | 8-3 |

TABLE OF CONTENTS
(concluded)


| | Page |
|---|---|
| 8.5 Research, Development, and Impacts of Long-Lead Procurement | 8-4 |
| 8.6 Cost and Schedule Uncertainty | 8-4 |
| 9.0 CONCLUSIONS AND RECOMMENDATIONS | 9-1 |
| 10.0 REFERENCES | 10-1 |
| GLOSSARY AND ACRONYMS | GA-1 |
| APPENDIX | |
| DISTRIBUTION LIST | |

## LIST OF TABLES


| Table No. | Title | Page |
|---|---|---|
| 2-1 | Annual Receipts of Spent Fuel | 2-2 |
| 2-2 | Characteristics of Spent Fuel in Stage 1 | 2-3 |
| 2-3 | Characteristics of Consolidated Spent Fuel in Stage 2 | 2-3 |
| 3-1 | List of Buildings and Personnel Assignments | 3-30 |
| 3-2 | Summary of Mining Parameters for the Horizontal and Vertical Emplacement Modes in Stages 1 and 2 | 3-41 |
| 6-1 | Summary Costs for an Exploratory Shaft Test Program | 6-2 |
| 6-2 | Complexity Values and Contingency | 6-3 |
| 6-3 | Complexity Values and Engineering | 6-4 |
| 6-4 | Summary Costs for a Revised Reference Repository - Vertical Emplacement | 6-12 |
| 6-5 | Summary Costs for a Two-Stage Repository - Vertical Emplacement | 6-13 |
| 6-6 | Comparison of Costs for a Revised Reference Repository and a Two-Stage Repository - Vertical Emplacement | 6-14 |
| 6-7 | Definitions of Cost Breakdown Elements | 6-15 |
| 6-8 | Engineering Costs for a Revised Reference Repository - Vertical Emplacement | 6-16 |
| 6-9 | Engineering Costs for a Two-Stage Repository - Vertical Emplacement | 6-16 |
| 7-1 | Summary Costs for a Revised Reference Repository - Horizontal Emplacement | 7-3 |
| 7-2 | Summary Costs for a Two-Stage Repository - Horizontal Emplacement | 7-4 |
| 7-3 | Comparison of Costs for a Revised Reference Repository and a Two-Stage Repository - Horizontal Emplacement | 7-5 |

## LIST OF TABLES
(concluded)


| Table No. | Title | Page |
|---|---|---|
| 7-4 | Comparison of Costs for a Two-Stage Repository Using Horizontal Emplacement and a Two-Stage Repository Using Vertical Emplacement | 7-6 |
| 7-5 | Engineering Costs for a Revised Reference Repository - Horizontal Emplacement | 7-7 |
| 7-6 | Engineering Costs for a Two-Stage Repository - Horizontal Emplacement | 7-7 |

## LIST OF FIGURES


| Figure No. | Title | Page |
|---|---|---|
| S-1 | Summary Program Schedule | ix |
| 3-1 | Tuff Repository Perspective Sketch | 3-3 |
| 3-2 | Central Facilities Plot Plan | 3-7 |
| 3-3 | Overall Site Plan | 3-9 |
| 3-4 | Location and Access Plan | 3-11 |
| 3-5 | Waste-Handling Building 1, Overall General Arrangement, Plan and Section | 3-15 |
| 3-6 | Waste-Handling Building 1, Stage 1 Operations, Material Flow Diagram | 3-17 |
| 3-7 | Waste-Handling Building 1, Hot Cell General Arrangement, Plan and Section | 3-19 |
| 3-8 | Waste-Handling Building 2, Overall General Arrangement, Plan and Section | 3-23 |
| 3-9 | Waste-Handling Building 2, Stage 2 Operations, Material Flow Diagram | 3-27 |
| 3-10 | General Layout, Underground Facility | 3-37 |
| 3-11 | Underground Facility Layout - Vertical Emplacement, Years 1 to 6 | 3-43 |
| 3-12 | Underground Facility Layout - Horizontal Emplacement, Years 1 to 6 | 3-45 |
| 3-13A | Vertical Emplacement Plan - Stage 1 | 3-48 |
| 3-13B | Vertical Emplacement Plan - Stage 1 | 3-49 |
| 3-14A | Horizontal Emplacement Plan - Stage 1 | 3-50 |
| 3-14B | Horizontal Emplacement Plan - Stage 1 | 3-51 |
| 3-15A | Vertical Emplacement Plan - Stage 2 | 3-52 |
| 3-15B | Vertical Emplacement Plan - Stage 2 | 3-53 |
| 3-16A | Horizontal Emplacement Plan - Stage 2 | 3-54 |
| 3-16B | Horizontal Emplacement Plan - Stage 2 | 3-55 |

## LIST OF FIGURES
(concluded)


| Figure No. | Title | Page |
|---|---|---|
| 5-1 | Repository Construction Schedule | 5-3 |
| 5-2 | Exploratory Shaft Test Program Schedule | 5-15 |
| 7-1 | E-MAD Facility Modification Plan | 7-9 |
| 7-2 | Waste-Handling Building 1, Stage 2 Operations, Material Flow Diagram | 7-13 |

# 1.0 INTRODUCTION

## 1.1 Mission Plan and Generic Requirements for a Mined Geologic Disposal System

The Nuclear Waste Policy Act (NWPA) of 1982 assigns responsibility to the Department of Energy (DOE) for the siting, design, construction, and operation of geologic repositories for disposal of spent nuclear fuel and other high-level waste (HLW). The DOE program to meet the NWPA requirements is described in the Mission Plan for the Civilian Radioactive Waste Management Program (DOE, 1984a). Four different geologic media--tuff, salt, basalt, and crystalline rock--are prime candidates for the disposal of these wastes, and a project has been organized to investigate each medium. The minimum set of requirements a repository must meet are defined in Generic Requirements for a Mined Geologic Disposal System (DOE, in review). That document will ensure that repositories in all four media are developed from a common set of requirements.

In this report, the feasibility is addressed of constructing a repository in tuff in two stages to permit receipt of 400 MTU/yr of radioactive waste by January 31, 1998. The conclusion that two-stage construction is feasible is based on preconceptual designs and assumptions about major project activities. One major assumption is that all policy decisions, guidance, and budget requirements are appropriate to meet the design and construction schedule. Changes in design that result from new requirements, new data, or changes in policy or in the decision schedule could negate the results of this report.

The cost estimates described in later sections of this report include many assumptions. One assumption pertains to the performance confirmation program called for in 10 CFR 60 (NRC, 1983). This program is currently being defined but is not sufficiently developed to permit cost estimates to be made. Therefore, the allowance made for the possible costs of this program is tentative. Mandatory activities associated with the retrieval

period (caretaker period) have not been defined either. It is assumed that an appropriate approach is to perform all confirmation activities during the operating period in the expectation that a license amendment allowing closure will be requested at the end of this period. Therefore, the costs reflect only a skeleton crew during the retrieval period.

The discussions of design criteria are not intended to be all-inclusive but only to provide a broad perspective of the overall design effort. The technical criteria and performance criteria contained in 10 CFR 60, for example, have not been reproduced here but are being used to guide the design effort.

Several DOE directives have been issued pertaining to the construction of a repository in two stages. In its memo of May 10, 1984 (DOE, 1984b), DOE provided basic policy guidance and listed the engineering topics to be addressed in the feasibility study. By its memo of May 29, 1984 (DOE, 1984d), DOE transmitted guidelines to provide the level of schedule and cost detail to be included in studies of two-stage repository construction. Major items of agreement and discussion pertaining to two-stage repository development are contained in a DOE memo dated June 13, 1984 (DOE, 1984e). On June 15, 1984, DOE issued revised cost and schedule guidelines (DOE, 1984f). A status review meeting was held on July 9, 1984, for participants in the tuff, salt, and basalt projects to provide supplementary budget information on the second access to the exploratory shaft (ES) and other aspects of repository development (DOE, 1984g). On June 27, 1984, DOE distributed a revised version of cost guidelines for two-stage repository evaluations (DOE, 1984h). Finally, additional clarification on operating cost breakdown was provided on July 17, 1984 (DOE, 1984i).

### 1.1.1 Exploratory Shaft Facilities

The NWPA requires the DOE to characterize candidate sites before the President recommends a location for the first repository. An important part of the site characterization process is the construction of exploratory shafts, or ramps, or both, to provide access to the geologic medium under

consideration. Data gathered from site characterization will be used by the DOE to obtain a construction authorization from the Nuclear Regulatory Commission (NRC) as required by 10 CFR 60 (NRC, 1983).

A special study has been performed in which eight different configurations for a second access to the ESF were investigated (SNL, 1984a). In accordance with DOE guidance, the reference ES design for this two-stage engineering feasibility study consists of a 12-ft-diameter ES and a 6-ft-diameter second shaft (DOE, 1984e; DOE, 1984g).

### 1.1.2 Rationale for Two-Stage Construction of the Repository

The NWPA requires the DOE to begin accepting waste on January 31, 1998. In order to meet this date, two-stage construction of the repository is deemed necessary. The Mission Plan (DOE, 1984a) indicates that significantly less time is required to reach operability by using a phased approach to construction than would be required by alternatives based on single-stage construction. The reference schedule for the first geologic repository presented in the Mission Plan indicates that the two-stage approach can meet the January 31, 1998, deadline, whereas single-stage construction could not. Therefore, the DOE is exploring the feasibility of constructing the first repository in two stages. Stage 1 would involve the construction of a repository with a capacity of 400 metric tons of uranium per year (MTU/yr) that would be ready for operation by January 31, 1998. The Stage 1 repository would be followed by the completion of the full (Stage 2) repository, with a capacity of 3,000 MTU/yr, which would begin operation in 2003.

## 1.2 Organization of This Report

The first section of this report provides an introduction and background information. The design bases and criteria that form the basis for the study are discussed in Section 2. The facilities in each stage of repository construction are described in Section 3. A description of the operation of these facilities is given in Section 4. Schedules for the design, construction, and testing undertaken during the two stages are

delineated in Section 5. Section 6 contains cost estimates. Alternate design concepts and their possible impact on the design, cost, and schedule of the two-stage effort are presented in Section 7. Programmatic impacts and uncertainties are reviewed in Section 8. Section 9 contains the principal conclusions and recommendations reached during the study. References are given in Section 10. A glossary of special or unfamiliar terms is also provided.

# 2.0 DESIGN BASES AND CRITERIA

This section briefly discusses the design bases and criteria that form the basis for this feasibility study and is not intended as an all-inclusive listing of the design criteria. The design criteria and performance criteria in numerous DOE orders and NRC documents are being incorporated in the design. Specific design criteria are also derived from national codes and standards developed for the design and construction of surface facilities and underground mines and structures. In some cases, specific criteria have not been fully developed, and the full impact of broad requirements (for example, the performance confirmation program) is unknown.

There are two design bases for the repository design: (1) the radioactive waste that is emplaced in a deep geologic repository, and (2) the repository site at which that waste is emplaced.

Although not explicitly mentioned in this report, specific criteria are being used or are being developed to ensure that the repository will comply with NRC preclosure performance criteria for radiation safety and retrievability. In addition, as the performance confirmation program develops, design criteria will be incorporated to ensure that the performance confirmation program is compatible with the repository.

## 2.1 Radioactive Waste

The NWPA specifies that, until a second repository begins to operate, the first repository accommodate commercially generated high-level radioactive waste in the forms of spent fuel or reprocessing wastes in a quantity not to exceed that derived from 70,000 metric tons of heavy metal [referred to as metric tons of uranium (MTU) in this report] initially loaded in commercial power reactors. Spent fuel receipt rates, age, burnup, and quantities contained in shipping casks and canisters are discussed in Subsection 2.1.1. Transportation modes and the amount of waste contained in each type of shipping cask are discussed in Subsection 2.1.2. In Subsection 2.1.3, the disposal of DHLW and WVHLW is discussed.

### 2.1.1 Assumed Waste Receipt Rates and Characteristics

Two-thirds by weight of the spent fuel shipped to the repository comes from pressurized water reactors (PWRs) and one-third from boiling water reactor (BWRs). The average burnups are 33,000 MWd(megawatt-days)/MTU and 27,500 MWd/MTU, respectively. The receipts by year are shown in Table 2-1.

TABLE 2-1

ANNUAL RECEIPTS OF SPENT FUEL
(MTU equivalent)

| | Year | Stage 1 | Stage 2 | Total |
|---|---|---|---|---|
| | 1998 | 400 | - | 400 |
| | 1999 | 400 | - | 400 |
| | 2000 | 400 | - | 400 |
| Transition | 2001 | 400 | 500 | 900 |
| Period | 2002 | 400 | 1,400 | 1,800 |
| | 2003 | - | 3,000 | 3,000 |
| | 2024 | - | 100 | 100 |
| | 2025 | 2,000 | 68,000 | 70,000 |

Table 2-1 also shows that Stage 1 is a 5-yr period lasting from 1998 through the year 2002. In the 2-yr transition from Stage 1 to Stage 2, annual waste emplacement increases from 400 MTU to 900 MTU in 2001 and to 1,800 MTU in 2002. By 2003, the transition is completed as the repository begins to receive its full annual capacity of 3,000 MTU.

In accordance with the DOE directives listed in Section 1, it is assumed that the spent fuel is at least 10 yr out of reactor at the time of emplacement. During Stage 1, spent fuel is not consolidated but is packaged in canisters. Each canister contains either 9 BWR assemblies or 3 PWR assemblies that have a maximum initial heat output of 1.6 kW/canister. The characteristics assumed for spent fuel in Stage 1 are shown in Table 2-2.

TABLE 2-2

CHARACTERISTICS OF SPENT FUEL IN STAGE 1

| Type | Number of Assemblies/ Canister | Equivalent MTU/Assembly | Equivalent MTU/Canister | Initial Heat Output/ Assembly (kW) | Initial Heat Output/ Canister (kW) |
|---|---|---|---|---|---|
| BWR | 9 | 0.19 | 1.71 | 0.170 | 1.53 |
| PWR | 3 | 0.46 | 1.38 | 0.535 | 1.60 |

During Stage 2, spent fuel is consolidated and packaged in canisters. Each canister contains either 18 BWR or 6 PWR assemblies that have a maximum initial heat ouput of 3.2 kW/canister. The characteristics of these canisters are shown in Table 2-3.

TABLE 2-3

CHARACTERISTICS OF CONSOLIDATED SPENT FUEL IN STAGE 2

| Type | Number of Assemblies/ Canister | Equivalent MTU/Assembly | Equivalent MTU/Canister | Initial Heat Output/ Assembly (kW) | Initial Heat Output/ Canister (kW) |
|---|---|---|---|---|---|
| BWR | 18 | 0.19 | 3.42 | 0.170 | 3.1 |
| PWR | 6 | 0.46 | 2.76 | 0.535 | 3.2 |

### 2.1.2 Assumed Waste Transportation Modes and Surface Storage Configuration

For the purposes of this report, it is assumed that waste is delivered by truck or by rail. During Stage 1, either mode can accommodate all waste received at the repository. Each truck carries a cask that contains 2 PWR or 5 BWR assemblies (Wilmot et al., 1983). A parking lot for 82 trucks, which contain about 76 MTU of spent fuel, is provided. Railroad access will be constructed during Stage 1, thus providing contingency storage in the

marshalling yard for 10 rail casks containing a total of approximately 57 MTU. Each rail cask carries 12 PWR or 32 BWR assemblies (Wilmot et al., 1983). An additional 100 MTU of surface storage is provided in WHB-1 to accommodate fluctuations in operations.

During Stage 2, marshalling facilities for 40 railcars will be added to the existing parking lot and marshalling yard. An additional 390 MTU of surface storage will be provided in WHB-2, for a total of 750 MTU surface storage.

### 2.1.3 Defense High-Level Waste (DHLW) and West Valley High-Level Waste (WVHLW)

It is expected that WVHLW will be emplaced at the repository. Solidified DHLW may also be emplaced at the repository. These wastes would supplant, on an MTU basis, the capacity provided for commercial waste. DHLW and WVHLW are lower in thermal output and have lower radiation levels than the reference 10-yr-old spent fuel (SNL, 1984b); therefore, the design criteria used for spent fuel are also applicable to DHLW and WVHLW.

## 2.2 Site Selection and Description

Because the rugged topography immediately above the underground facility at Yucca Mountain is unsuitable as a site for the surface facilities, two general locations for the surface facilities--one immediately to the east and the other to the southwest of the proposed underground facility--have been evaluated. Institutional considerations have precluded further study of the southwestern location. The siting procedure used adheres to the DOE siting guidelines (10 CFR 960; DOE, 1984c).

Six candidate sites for the surface facilities were selected for study in the eastern area. Existing data on meteorology, operating safety, environmental quality, surface characteristics, rock characteristics, tectonics, and operating factors were used in reaching the conclusion that the site east of Exile Hill should be the reference location for this study.

The reference site is situated on gently sloping (3%) alluvial fans that extend eastward from the base of Exile Hill. The top of Exile Hill is approximately 150 ft above the surface facilities site. Surface soils are coarse, sandy gravels interspersed with abundant cobbles and boulders. The alluvium exhibits considerable cementation, thus making excavation more difficult than excavation in uncemented alluvium. The east-dipping tuff of Exile Hill extends beneath the surface facility site and is overlain near the center of the site by about 100 ft of tuffaceous sediments. The tuff outcropping provides a good foundation for construction of the portal to the waste-handling ramp. The tuff on the east, north, and south sides of Exile Hill offers the advantage of founding the waste-handling facilities on bedrock, but siting on alluvium is also practicable.

The underground portion of the repository is located in the Topopah Spring Member of the Paintbrush Tuff. The Topopah Spring Member is a densely welded, devitrified ash-flow tuff varying from 220 to 720 ft in thickness (Lipman et al., 1966). The primary, or central block, is bounded by a series of steeply dipping (60° to 90°) northwest and northeast trending faults (Scott et al., 1983).

## 2.3 Design Criteria: Surface Facilities

### 2.3.1 Surface Facility Access

New rail and road access will be constructed to connect the surface facilities to existing transportation networks. A heliport will be constructed to permit emergency medical evacuations.

### 2.3.2 Building Design

Buildings that contain radioactive materials are designed to withstand a peak horizontal acceleration of 0.4 g resulting from a postulated seismic event. Buildings that contain radioactive materials operate at a slightly negative internal pressure to ensure containment of radionuclides in the event of an accidental release. These buildings are also designed to ensure

that worker exposures are as low as reasonably achievable (ALARA). The design objective is to limit the total annual worker exposure to penetrating radiation to less than 1.0 rem/yr (DOE, 1981). Buildings that do not contain radioactive materials are designed according to applicable national and state building codes.

### 2.3.3 Standby Power

In the event that normal onsite power is lost, standby power will be provided by diesel generators. These generators provide sufficient power to maintain critical systems (e.g., ventilation and hoists) until normal sources of power have been restored.

### 2.3.4 Waste Receipt and Packaging Rates

WHB-1 is designed to receive and package 400 MTU/yr of spent fuel for the first 5 yr of repository operations. It is assumed that 100% of the waste is received by truck, although rail access is also available. Fuel consolidation does not take place in Stage 1, nor is there any operational redundancy in WHB-1.

WHB-2 is designed to receive, consolidate, and package 3,000 MTU/yr of spent fuel for the remainder of the operating lifetime of the repository. WHB-2 is equipped with redundant processing lines in which all spent fuel assemblies are consolidated before emplacement.

Facilities will be provided, either in WHB-2 or in a separate facility, to accommodate the retrievability demonstration and performance confirmation programs.

### 2.3.5 Surface Storage Requirements

In Stage 1, surface storage for 100 MTU is required for spent fuel. In Stage 2, 750 MTU of surface storage is required, for a total of 850 MTU.

## 2.4 Design Criteria: Underground Facilities

### 2.4.1 Boundaries of the Underground Facilities

The subsurface facility is located within the central block of the Yucca Mountain site. Boundaries of suitable rock are determined based on available overburden, thickness of the acceptable tuff, and potentially unsuitable rock in the vicinity of faults. At Drillhole USW G-4, the disposal horizon is approximately 940 ft below the surface.

### 2.4.2 Exploratory Shafts

A 12-ft-diameter ES and a 6-ft-diameter second shaft will be constructed as part of the Exploratory Shaft Facility (ESF) and will be available for use during construction of the subsurface facilities in Stage 1, assuming that a design can be found that does not compromise the tests being conducted at the base of the ESF. They will be incorporated in the repository design in such a way as to permit maximum beneficial use in the full repository. These shaft sizes are used in this feasibility study and are taken from a second access study (SNL, 1984a) in which several options for a second access to the ES were considered.

### 2.4.3 Waste Emplacement Modes

Vertical waste emplacement is the reference emplacement mode, and horizontal waste emplacement is an alternative mode being considered for the repository in tuff (see Subsection 7.1.1).

### 2.4.4 Ventilation

The waste emplacement area and the mining area are served by independent ventilation systems. As each emplacement drift is filled, ventilation to the completed drift will be discontinued. The following basic parameters are assumed:

- The maximum temperature in working areas (wet-bulb temperature index) is 79°F.
- The air quantity needed per brake hp (diesel) is 125 $ft^3$/min.
- The air quantity needed per brake hp (electrical) is 20 $ft^3$/min.
- The air quantity needed per underground worker is 210 $ft^3$/min.
- The minimum air velocity in working areas is 60 ft/min.
- The maximum air velocity for ventilation shafts is 4,000 ft/min.
- The maximum air velocity for the men-and-materials shaft is 2,000 ft/min.

### 2.4.5 Thermomechanical Effects

A design criterion of 57 kW/acre was used for waste heat load in this study (Johnstone et al., 1984).

### 2.4.6 Retrievability and the Confirmation Program

The underground openings will be designed and constructed to ensure that the requirements of retrievability and the performance confirmation program will be met. As a minimum, long-term (approximately 100-yr) stability of the underground openings, adequate ventilation equipment to support the operations, and an instrumentation and control system to monitor performance will be required.

# 3.0 DESCRIPTION OF TWO-STAGE REPOSITORY FACILITIES

## 3.1 Total Concept Overview

The two-stage repository in this report is integrated with the topographic and geologic features of Yucca Mountain as illustrated in Figure 3-1. Current site access consists of U.S. Highway 95 and secondary gravel and lightly surfaced roads. A new 16-mi road from Amargosa Valley will be constructed. In addition, approximately 98 mi of new railroad will be constructed from an existing siding northeast of Las Vegas.

The waste-handling facilities and most of the support facilities are grouped just east of the disposal area at the foot of Exile Hill. The two waste-handling buildings are located so that they can share the portal of the waste-handling ramp and so that they can be protected by a single security and radiation monitoring area. An area adjacent to the two waste-handling buildings has been reserved in case it is needed for the construction of a facility to accommodate retrievability and performance confirmation activities. The need for this facility will be determined as performance confirmation program requirements are developed. The waste disposal area exhaust shaft and filter building are located between the radiation-monitoring area and the boundary of the waste disposal area. The muck-handling ramp, conveyors, and muck pile are located about a mile northwest of the waste-handling buildings. The ESF and men-and-materials shaft and facilities are located just inside the northeast boundary of the disposal area and at the junction of the two access ramps and the main entries.

The main ES is 12 ft in diameter, and the second shaft is 6 ft in diameter. The waste disposal area ventilation shaft is 20 ft in diameter, and the men-and-materials shaft is 25 ft in diameter. All shafts are sunk conventionally, except the 6-ft diameter shaft, which is raise-bored. The muck-handling ramp and the waste-handling ramp are 19 ft and 24 ft in diameter, respectively. The muck-handling ramp will be driven on a 15% grade, and the waste-handling ramp on an 8% grade. The two ramps converge and enter the disposal area on the northeast side of the area.

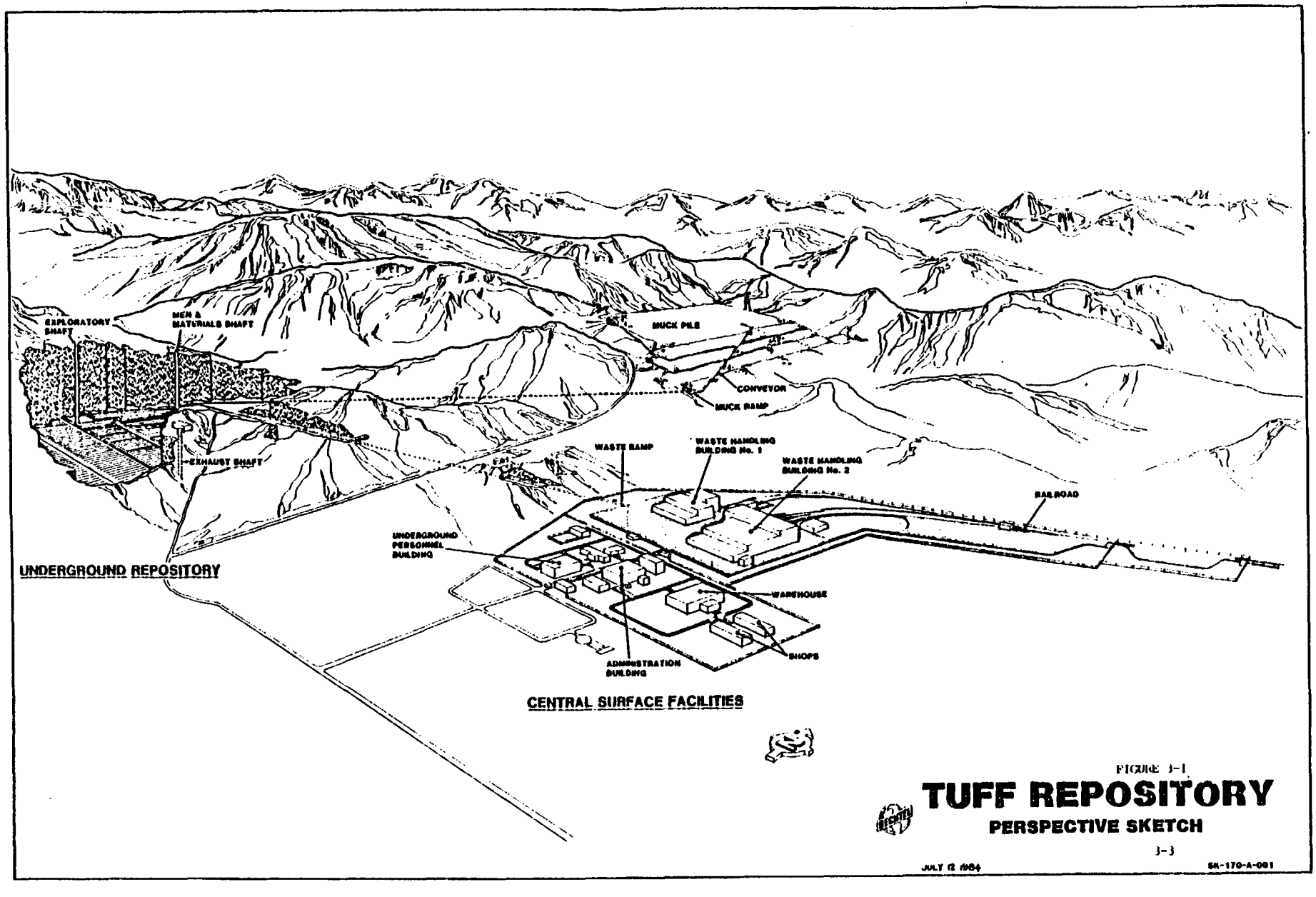



FIGURE 3-1

# TUFF REPOSITORY

## PERSPECTIVE SKETCH



JULY 12 1984

SK-170-A-001

The disposal area lies within the Topopah Spring Member, which dips generally eastward about 5° to 9°. The disposal area and main haulageways are excavated in a generally northeast-to-southwest pattern to minimize the grades and to take best advantage of the expected rock fracture patterns and in situ stress orientation. Mining and emplacement proceed from the northeast corner toward the southwest and then northward in a clockwise direction. Waste emplacement area ventilation air enters through the two ESF shafts, passes through the emplacement drifts, and exits through a ventilation drift on the perimeter of the emplacement area and through the exhaust shaft. Ventilation air for the mining area enters through the men-and-materials shaft, passes through the mining area, and exits through the muck-handling ramp. Air coming down the waste-handling ramp is short-circuited to the waste.emplacement area and exhaust shaft.

## 3.2 Surface Facilities

The surface facilities may be grouped in the following three categories.

- Central facilities, including waste-handling and general support facilities (Figure 3-2).

- Onsite facilities that are not contiguous with the central facilities (Figure 3-3). These facilities are referred to in this report as "off-plot facilities" and are described briefly in Subsection 3.2.7.

- Offsite transportation access (Figure 3-4).

### 3.2.1 Master Plan of Surface Facilities

The reference site east of Exile Hill (Figure 3-3) provides easy access for truck and rail, a broad, flat area for truck and railcar parking, and a solid foundation for construction of the portal of the waste-handling ramp. As more data are obtained, other factors will be considered in the selection of the final locations for the shafts and ramps in the Title I design.

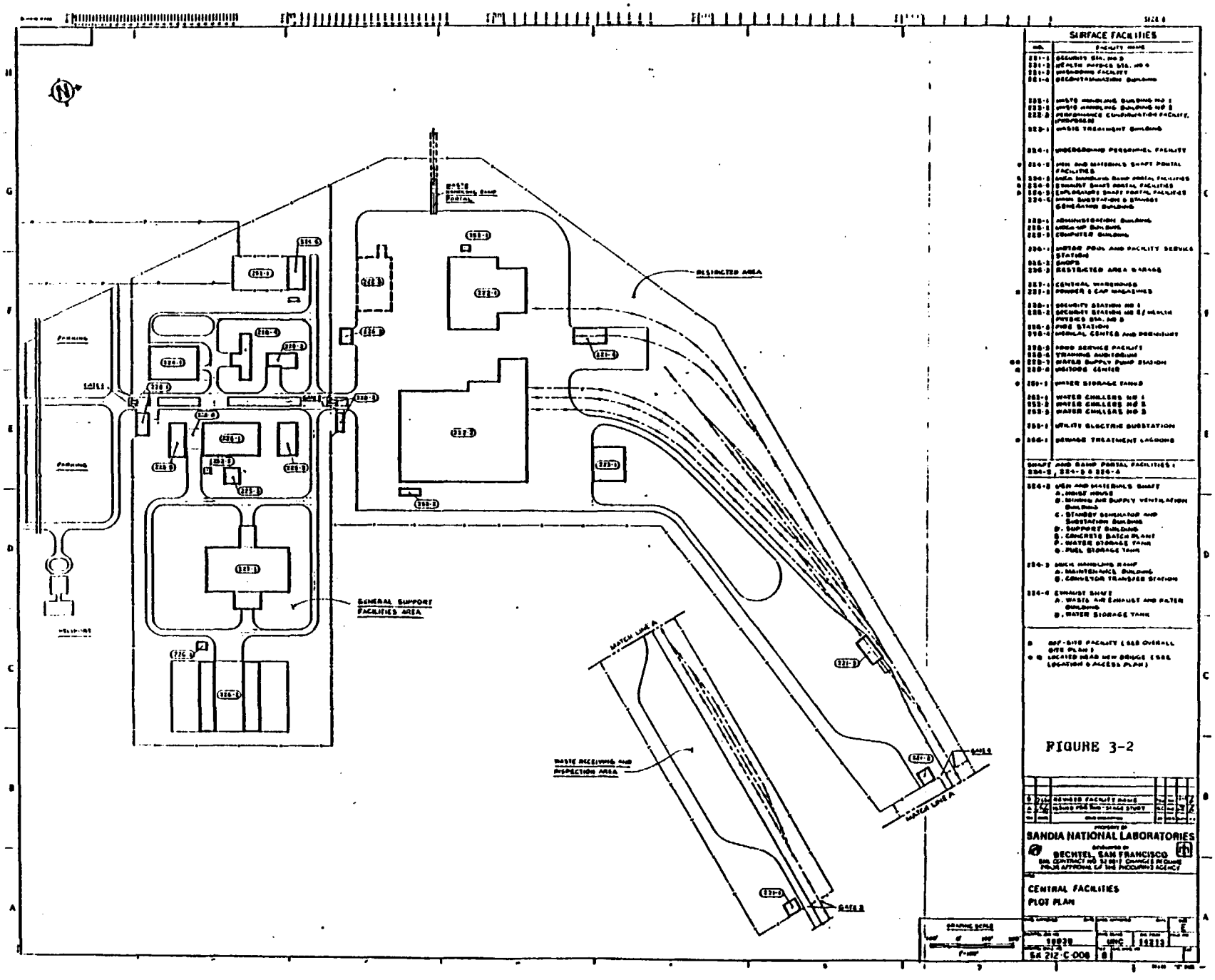

SURFACE FACILITIES
RESTRICTED AREA
GENERAL SUPPORT FACILITIES AREA
WASTE RECEIVING AND INSPECTION AREA
MATCH LINE A
PARKING
SANDIA NATIONAL LABORATORIES
BECHTEL, SAN FRANCISCO
CENTRAL FACILITIES
PLOT PLAN

FIGURE 3-2

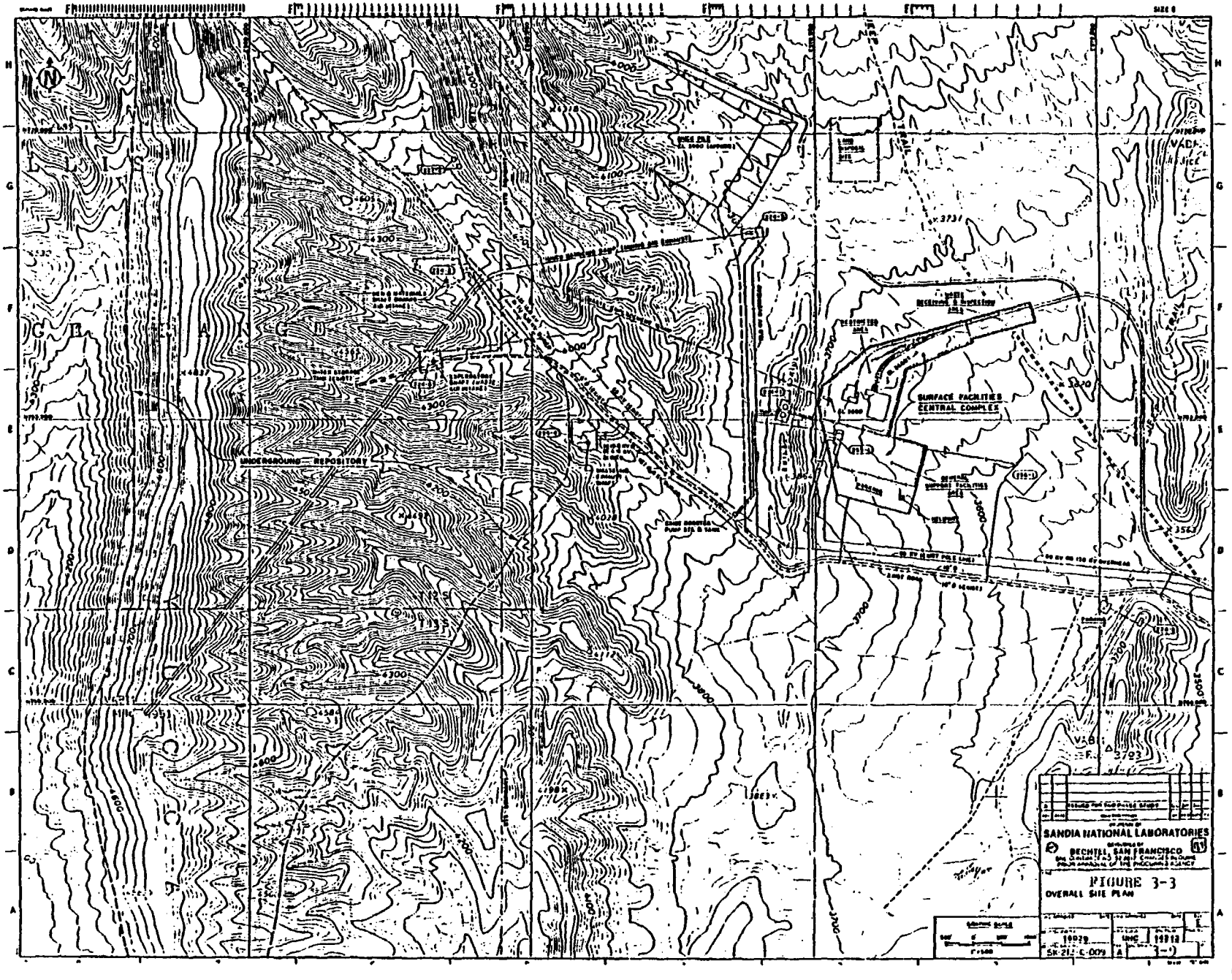
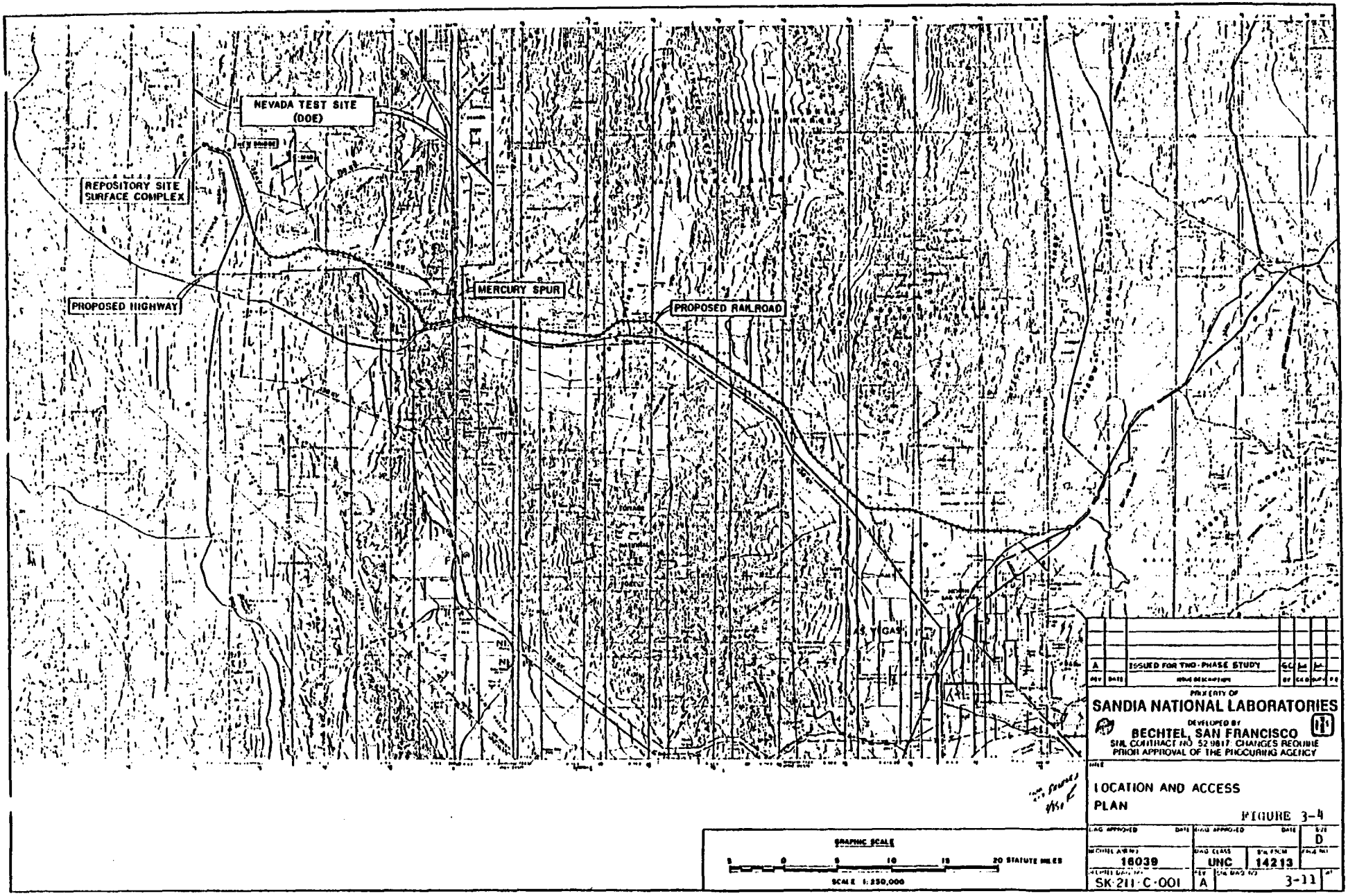



FIGURE 3-3
OVERALL SITE PLAN

SIZE D 22 x 34




| REV | DATE | DESCRIPTION | BY | CKD | APP | PE |
|---|---|---|---|---|---|---|
| A | | ISSUED FOR TWO-PHASE STUDY | GC | | | |

PROPERTY OF
SANDIA NATIONAL LABORATORIES
DEVELOPED BY
BECHTEL, SAN FRANCISCO
SNL CONTRACT NO. 52 9817. CHANGES REQUIRE PRIOR APPROVAL OF THE PROCURING AGENCY

LOCATION AND ACCESS PLAN

FIGURE 3-4

| | | | |
|---|---|---|---|
| DRAWING APPROVED | DATE | DRAWING APPROVED | DATE |
| BECHTEL DRAWING NO. 16039 | | DRAWING CLASS UNC | SNL FSCM 14213 |
| SK-211-C-001 | REV A | SNL DRAWING NO. 3-11 | |

SIZE D

Because the central facilities are not located directly above the disposal area, a ramp is used for transporting waste from the surface to the disposal area. Another ramp is used for the conveyance of muck to the surface. A men-and-materials shaft is provided for the efficient flow of personnel, supplies, and equipment to the underground facilities.

Description of the Central Facilities Area

To control access, the central facilities area is completely surrounded by a chain link fence. As shown in Figures 3-2 and 3-3, access to this area is provided by two principal routes. The first provides access for personnel, visitors, plant vehicles, and delivery of nonradioactive materials via Gate 1 and Security Station No. 1. The second provides access for shipments of radioactive waste (both by rail and by truck) via Gate 3 and Security Station No. 3. The central facilities area is further divided into a restricted area, a waste-receiving and inspection area, and a general support facilities area.

The restricted area includes the waste-handling buildings, the waste-handling ramp portal, and all surface facilities in which radioactive materials are handled or stored. In addition to the two waste-handling facilities, a performance confirmation support facility may be required. The exact functions to be performed in this building will not be known until the performance confirmation program has been defined. It may be possible to incorporate the support facilities in WHB-2 if they are not too extensive and do not significantly disrupt receiving operations. These facilities are separated from the other areas by a chain link fence and guarded access. Health physics stations are situated at each entrance to the restricted area to provide radiological monitoring of personnel and equipment. During Stage 1, the restricted area includes parking space for about 10 railcars and 82 truck trailers.

In the waste-receiving and inspection area, control of incoming waste casks on trucks and railcars is transferred from the shipper to the facility operator, eliminating the need for commercial shippers and their equipment to enter the restricted area. Inspection of waste shipments for sabotage

devices and for contamination levels that exceed regulatory limits also takes place in this area. In the event of excessive surface contamination, the shipping casks are routed to the decontamination building inside the restricted area.

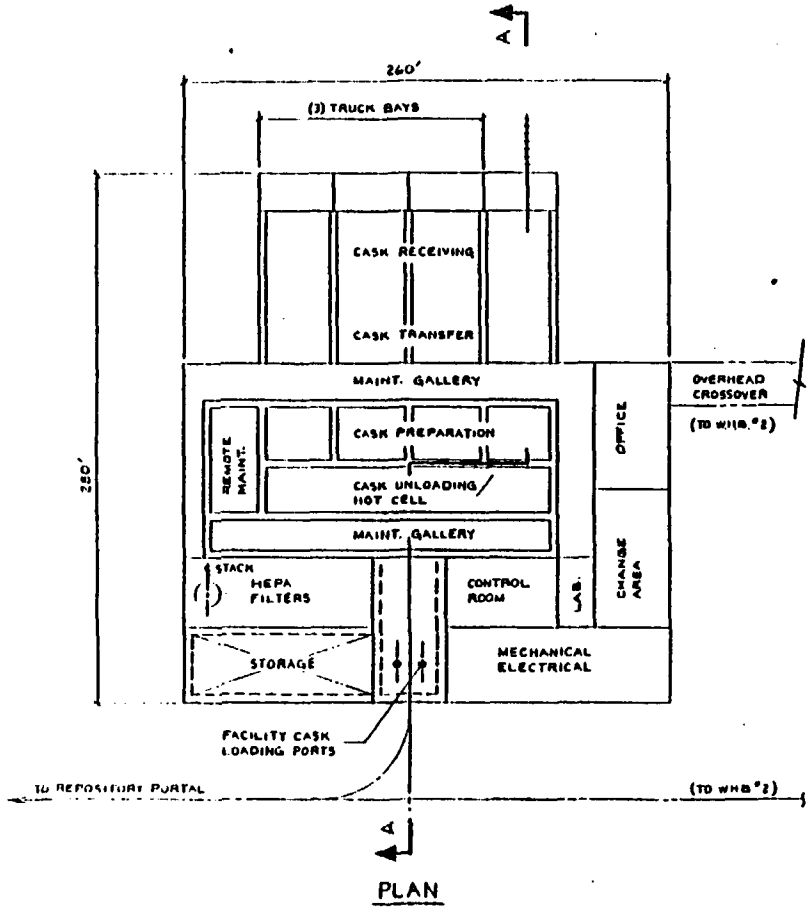
The general support facilities area includes the administration building, central warehouse, shops, and all facilities that do not involve the handling or treatment of radioactive material. To control traffic within the site and to minimize congestion and utility requirements at the men-and-materials shaft, underground workers are transported to the men-and-materials shaft in shuttle buses. The surface facility for underground personnel is located inside the general support facilities area.

### 3.2.2 Waste-Handling Building and Related Facilities in Stage 1

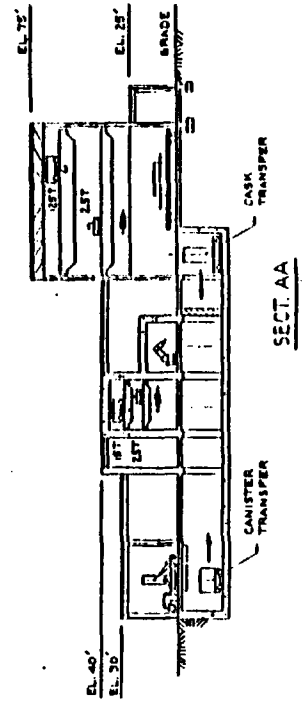
WHB-1 is designed to receive and package 400 MTU/yr equivalent of spent fuel in a single processing line in the ratio of one-third MTU equivalent from BWR assemblies and two-thirds MTU equivalent from PWR assemblies. WHB-1 is designed to process only intact spent fuel assemblies during Stage 1 operations. These assemblies are placed in canisters for storage in temporary surface storage racks or for disposal. Shielding and ventilation are designed for spent fuel 10 yr out of reactor, with average burnups of 33,000 MWd/MTU for PWR and 27,500 MWd/MTU for BWR assemblies. WHB-1 (Figure 3-5) can accommodate 100% shipment by truck, 100% shipment by rail, or any mix of these modes. Figure 3-6 shows the material flow for WHB-1 from receipt of the spent fuel shipment to subsurface disposal, and Figure 3-7 shows the hot cell arrangement in WHB-1 during Stage 1.

To accommodate fluctuations in operating requirements, below-grade vault storage is provided for temporary storage of fuel assemblies that contain 100 MTU equivalent (approximately 70 canisters). The canisters are emplaced or retrieved by a bridge-mounted, shielded machine. The heat generated by the canisters is removed from the storage cell by forced ventilation. Because the fuel assemblies are canistered, the ventilation air is normally free of radioactive material and can be exhausted via the stack without HEPA filtration. However, the air may be directed through

SIZE D 22 x 34




PLAN




SECT. AA

GRAPHIC SCALE:
1/32" = 1'-0"

FIGURE 3-5

| REV | DATE | REVISION DESCRIPTION | BY | CHK'D | APP'D | PE |
|---|---|---|---|---|---|---|
| A | | ISSUED FOR TWO-PHASE STUDY | DJ | | | |

PROPERTY OF
SANDIA NATIONAL LABORATORIES
DEVELOPED BY
BECHTEL, SAN FRANCISCO
BNL CONTRACT NO. 52 9817: CHANGES REQUIRE PRIOR APPROVAL OF THE PROCURING AGENCY

TITLE
WASTE HANDLING BUILDING #1
OVERALL GENERAL ARRANGEMENT
PLAN & SECTION

DWG APPROVED | DATE | DWG APPROVED | DATE | SIZE D

BECHTEL JOB NO 18039 | DWG CLASS UNC | BNL FSCM 14213 | PAGE NO

BECHTEL DWG NO SK-222-P-301 | REV A | BNL DWG NO

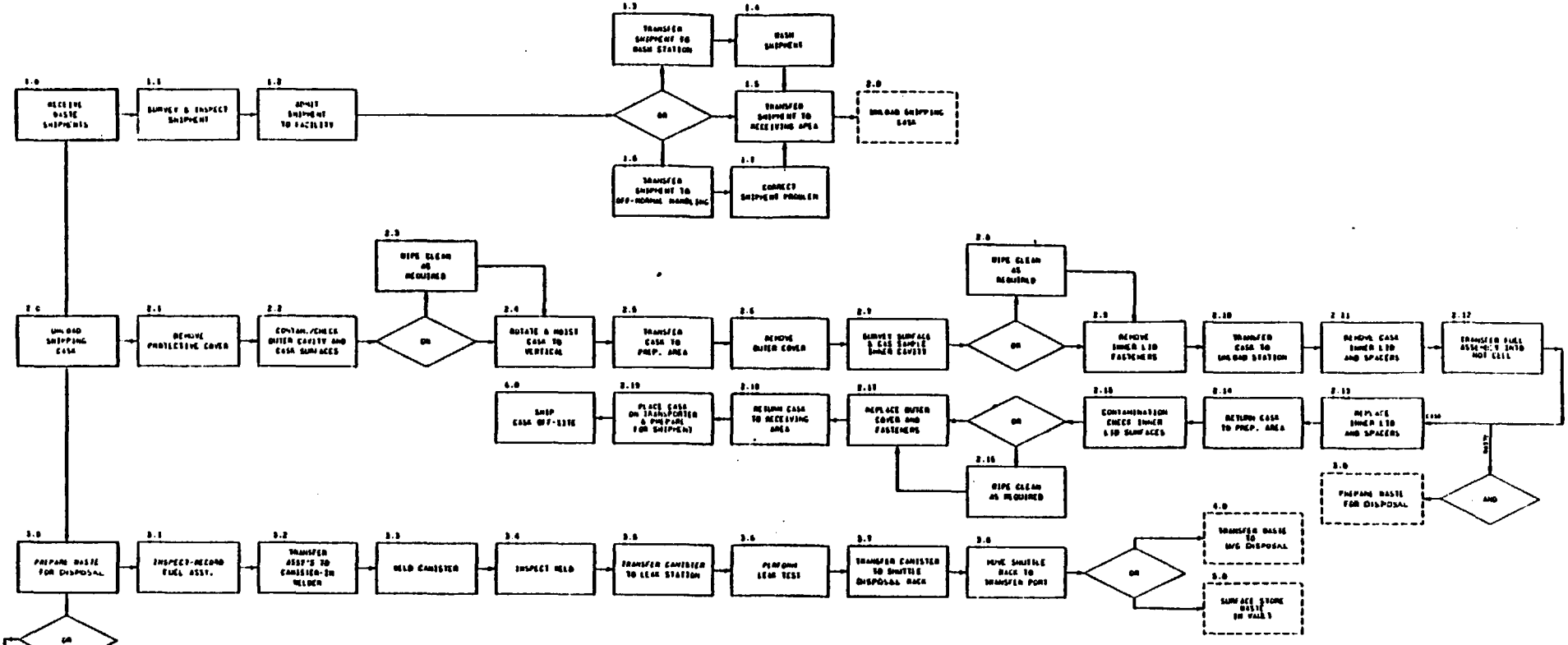



FIGURE 3-6

| REV | DATE | DESCRIPTION | BY | CK'D | APP'D | DR |
|---|---|---|---|---|---|---|
| A | | ISSUED FOR TWO-STAGE STUDY | JF | 25 | | |

PROPERTY OF
**SANDIA NATIONAL LABORATORIES**
DEVELOPED BY
**BECHTEL, SAN FRANCISCO**
SNL CONTRACT NO. 52-9817 CHANGES REQUIRE PRIOR APPROVAL OF THE PROCURING AGENCY

TITLE
WASTE HANDLING BUILDING #1
STAGE I OPERATIONS
MATERIAL FLOW DIAGRAM

| | | | |
|---|---|---|---|
| BECHTEL JOB NO 16039 | SANG CLASS UNC | SNL FACN 14213 | SIZE D |
| BECHTEL DWG NO SK-222-M-101 | REV A | | SHEET 3-17 |

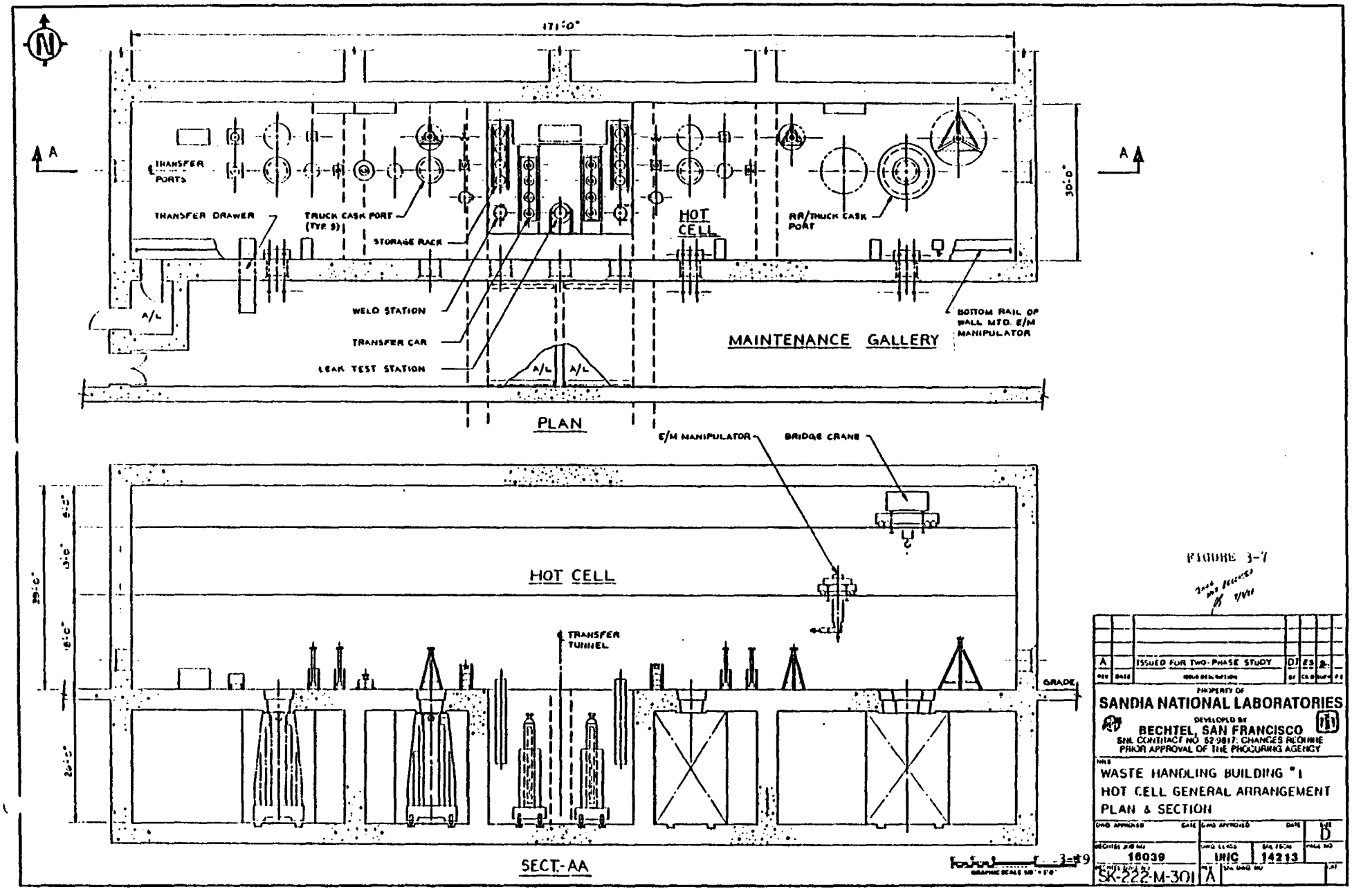

SIZE D 22 x 34
171'-0"
30'-0"
A
TRANSFER PORTS
TRANSFER DRAWER
TRUCK CASK PORT (TYP 9)
STORAGE RACK
WELD STATION
TRANSFER CAR
LEAK TEST STATION
A/L
HOT CELL
RR/TRUCK CASK PORT
BOTTOM RAIL OF WALL MTD. E/M MANIPULATOR
MAINTENANCE GALLERY
PLAN
E/M MANIPULATOR
BRIDGE CRANE
HOT CELL
TRANSFER TUNNEL
GRADE
SECT.-AA
1=#9
A
ISSUED FOR TWO-PHASE STUDY
PROPERTY OF
SANDIA NATIONAL LABORATORIES
DEVELOPED BY
BECHTEL, SAN FRANCISCO
SNL CONTRACT NO. 62-9817; CHANGES REQUIRE PRIOR APPROVAL OF THE PROCURING AGENCY
WASTE HANDLING BUILDING #1
HOT CELL GENERAL ARRANGEMENT
PLAN & SECTION
16039
INIC
14213
SK-222-M-301
A

FIGURE 3-7

filters in case high radiation or contamination is detected. To maintain contamination control, pressure in areas with greater potential for contamination is lower than the pressures in other areas.

### 3.2.3 Waste-Handling Building and Related Facilities in Stage 2

WHB-2 is designed to receive and package 3,000 MTU equivalent annually of spent fuel in the ratio of two-thirds PWR and one-third BWR assemblies. Approximately 420 canisters/yr of fuel assembly hardware will also be packaged in the hot cells. A small quantity (about 900 drums/yr) of contact-handled transuranic (TRU) waste may also be packaged in WHB-2.

Both intact fuel assemblies and fuel rods consolidated and placed in containers at reactor sites can be received. These containers have the same dimensions as an intact fuel assembly. The handling of containers prepared at reactors is the same as that for intact fuel assemblies. Three PWR containers or 9 BWR containers are placed in canisters at the repository.

Shielding and ventilation designs for the waste-handling buildings are based on spent fuel 10 yr out of reactor with average burnup of 33,000 MWd/MTU and 27,500 MWd/MTU for PWR and BWR assemblies, respectively.

Figure 3-8 shows the overall arrangement of WHB-2. The receiving bays are sized to receive 20% truck and 80% rail shipments (Subsection B.2; DOE, in review). To receive 70% of the MTU equivalent by truck and 30% by rail, approximately 10 more receiving bays for trucks would be necessary. Portions of WHB-2, such as the hot cells, cask preparation areas, and the storage vault, are constructed of reinforced concrete, and other portions are constructed of steel frame and metal siding.

The procedures for receiving and handling incoming trucks and railcars and shipping casks, for unloading the fuel assemblies, and for transferring the assemblies to the hot cells are the same as those used at WHB-1 (see Subsection 3.2.2).

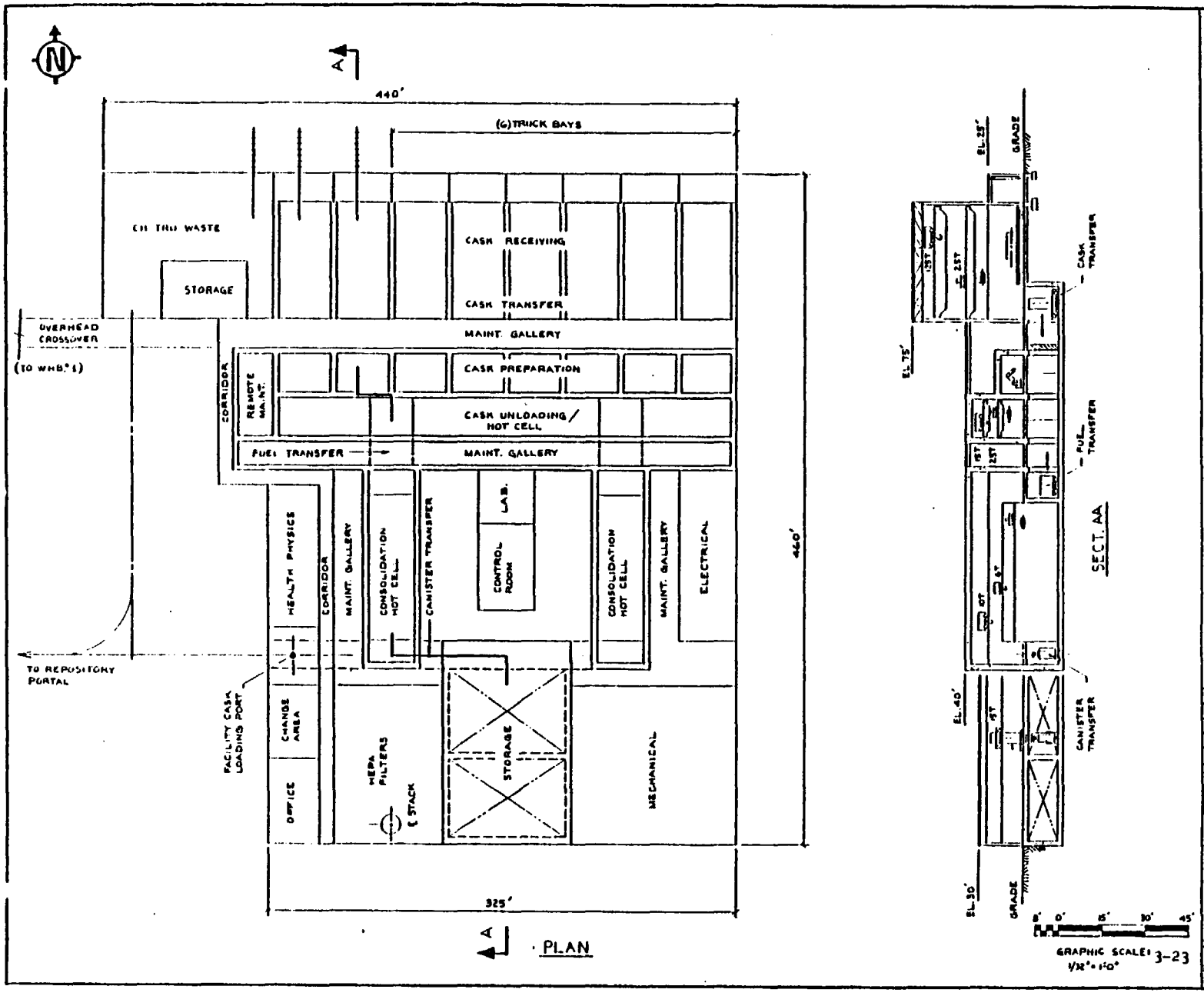

SIZE D 22 x 34
N
A
440'
(6) TRUCK BAYS
CH TRU WASTE
STORAGE
OVERHEAD CROSSOVER
(TO WHB #1)
CASK RECEIVING
CASK TRANSFER
MAINT. GALLERY
CORRIDOR
REMOTE MAINT.
CASK PREPARATION
CASK UNLOADING / HOT CELL
FUEL TRANSFER
MAINT. GALLERY
HEALTH PHYSICS
CORRIDOR
MAINT. GALLERY
CONSOLIDATION HOT CELL
CANISTER TRANSFER
LAB.
CONTROL ROOM
CONSOLIDATION HOT CELL
MAINT. GALLERY
ELECTRICAL
460'
TO REPOSITORY PORTAL
FACILITY CASK LOADING PORT
CHANGE AREA
OFFICE
HEPA FILTERS
℄ STACK
STORAGE
MECHANICAL
325'
A
PLAN
EL. 25'
GRADE
CASK TRANSFER
EL. 15'
FUEL TRANSFER
SECT. AA
EL. 40'
CANISTER TRANSFER
EL. 30'
GRADE
GRAPHIC SCALE: 1/32" = 1'-0"
3-23
A
ISSUED FOR TWO-PHASE STUDY
PROPERTY OF
SANDIA NATIONAL LABORATORIES
DEVELOPED BY
BECHTEL, SAN FRANCISCO
SNL CONTRACT NO. 52 9817: CHANGES REQUIRE PRIOR APPROVAL OF THE PROCURING AGENCY
WASTE HANDLING BUILDING #2
OVERALL GENERAL ARRANGEMENT
PLAN & SECTION
D
18039
UNC
14213
SK-222-P-302
A

FIGURE 3-8

Figure 3-9 shows the material flow in WHB-2 during Stage 2. Two hot cells are provided for dry consolidation of spent fuel assemblies. Each cell has 2 redundant process lines, each of which is capable of processing 1,500 MTU/yr. In the hot cells, the fuel rods are removed from their hardware (assembly frames and end fittings) and the consolidated fuel rods and hardware are placed in canisters. The emplacement rate for canisters containing consolidated spent fuel or fuel hardware is approximately six canisters/day, approximately two of which are used for the fuel hardware. The canisters used for fuel hardware have no thermal output. If fuel is not consolidated at the repository, the hot cells could be modified to package intact fuel assemblies (3 PWR or 9 BWR assemblies/canister). The emplacement rate in this case would be about 8 canisters/day.

Approximately 900 drums/yr of contact-handled TRU waste can also be received and prepared for disposal. Receiving bays for both railcars and trucks are provided to receive this waste form.

The WHB-2 design includes five separate heating, ventilation, and air-conditioning (HVAC) systems. These systems provide radiological and environmental control throughout the building. The ventilation of the vault and handling of stored canisters in WHB-2 are the same as those described for WHB-1.

The waste-treatment building (WTB) is designed to receive, handle, package, and temporarily store all radioactive wastes generated onsite. The WTB contains a truck bay, loading dock, and a process area for treating liquid and solid wastes. This building includes areas for four functions: (1) processing and storing of liquid waste, (2) processing and storing of solid waste, (3) truck bay and loading dock, and (4) office/control room and mechanical equipment. Contamination and ventilation control equipment is designed to ensure safe operations in each area.

### 3.2.4 Performance Confirmation Support Facility

The inclusion of a performance confirmation facility is optional at this time. The program required to support the performance confirmation specified in 10 CFR 60 has not been established. Preliminary estimates and

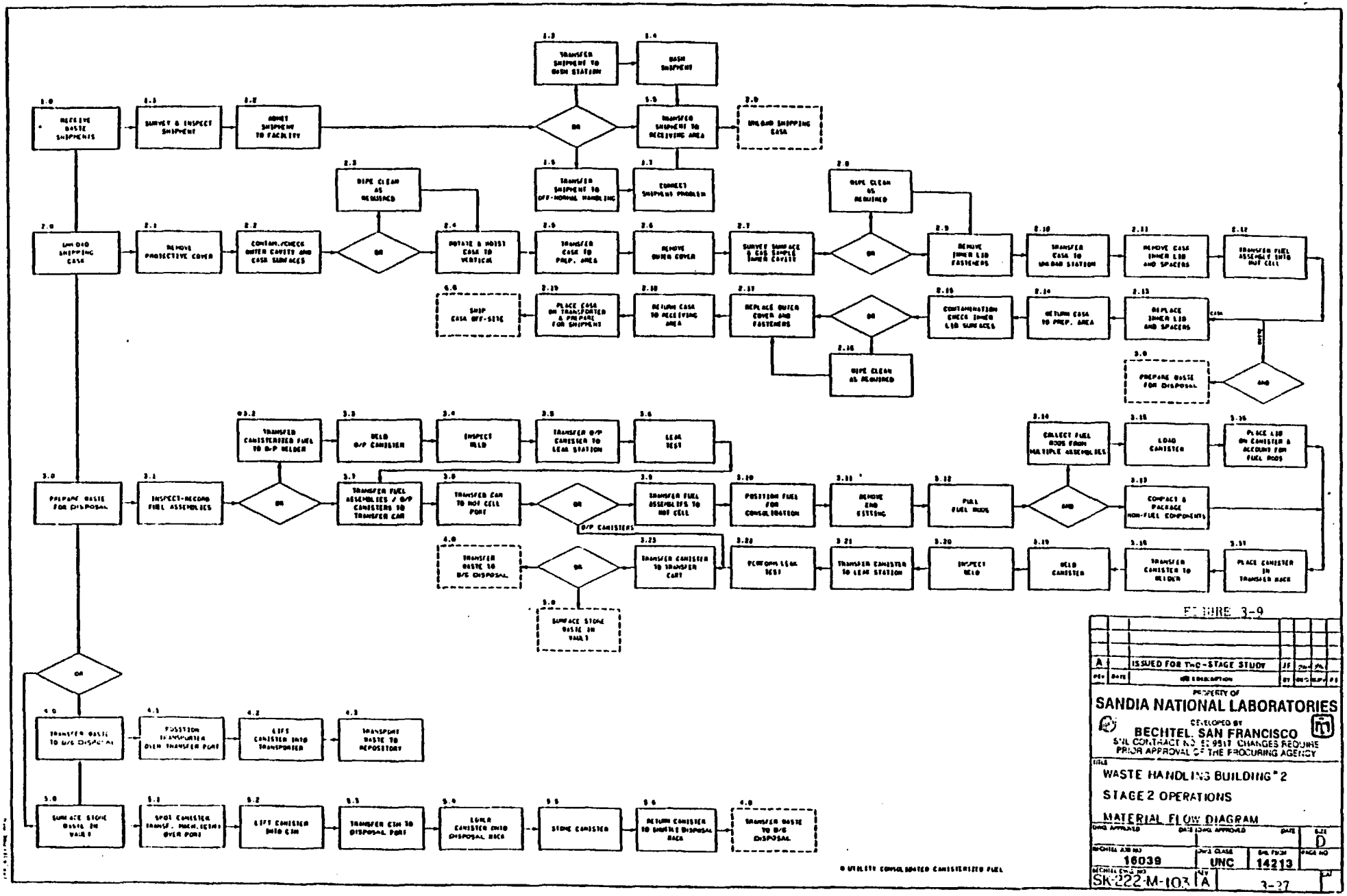



FIGURE 3-9

| REV | DATE | DESCRIPTION | BY | CHK | APP | PE |
|---|---|---|---|---|---|---|
| A | | ISSUED FOR TWO-STAGE STUDY | JF | | | |

PROPERTY OF
SANDIA NATIONAL LABORATORIES
DEVELOPED BY
BECHTEL, SAN FRANCISCO
SNL CONTRACT NO. 19951 CHANGES REQUIRE PRIOR APPROVAL OF THE PROCURING AGENCY

TITLE
WASTE HANDLING BUILDING #2
STAGE 2 OPERATIONS
MATERIAL FLOW DIAGRAM

DWG APPROVED | DATE DWG APPROVED | DATE | SIZE D

BECHTEL JOB NO 16039 | DWG CLASS UNC | SNL FIGURE 14213 | PAGE NO

BECHTEL DWG NO SK-222-M-103 | REV A | 3-27

judgments about the program indicate that extensive monitoring of underground site conditions will be required. This monitoring will be performed using experiments concentrated in small areas and monitoring equipment distributed throughout the developed area. Part of this monitoring could consist of the retrieval and inspection of selected waste packages. The extent of the sampling is unknown, but sampling activities will probably require a separate facility to prevent disruption of the receiving and packaging operations.

Confirmation operations include opening retrieved canisters, extracting samples from canister materials, and repackaging the fuel. The repackaged fuel would either be shipped offsite or emplaced again at the repository. Corrosion and metalographic examination could be conducted in hot cells or glove boxes adjacent to the hot cell in which the confirmation operations are performed, but it is not anticipated that the fuel itself will be examined.

No design of this facility is available for this report.

### 3.2.5 Support, Administration, and Other Facilities

General support facilities for Stages 1 and 2 include facilities necessary for onsite management, operations, storage, and maintenance activities. The descriptions of the support facilities provided below are based on the vertical emplacement mode. Table 3-1 shows the estimated floor area and personnel loads for vertical and horizontal waste emplacement operations.

#### Administration and Computer Buildings

The two-story administration building includes office space for about 200 people involved in administration, waste transportation, waste-handling operations, plant management, safety, and training.

TABLE 3-1

LIST OF BUILDINGS AND PERSONNEL ASSIGNMENTS

| | Buildings | Personnel Vert. | Personnel Horiz. | Gross Building Area ($ft^2$) Vert. | Gross Building Area ($ft^2$) Horiz. |
|---|---|---|---|---|---|
| 221-1 | Security Station No. 3 | 18 | 18 | 2,400 | 2,400 |
| 221-2 | Health Physics Station No. 4 | 6 | 6 | 600 | 600 |
| 221-3 | Washdown Facility | 16 | 17 | 10,800 | 10,800 |
| 221-4 | Decontamination Building | 0 | 0 | 6,000 | 6,000 |
| 222-1 | Waste-Handling Building No. 1 | 31* | 31* | 62,800 | 62,800 |
| 222-2 | Waste-Handling Building No. 2 | 65* | 65* | 165,000 | 165,000 |
| 222-3 | Performance Confirmation Support | 10 | 10 | 24,500 | 24,500 |
| 223-1 | Waste-Treatment Building | 22 | 22 | 20,000 | 20,000 |
| 224-1 | Underground Personnel Facility (Change House) | ** | ** | 20,000 | 20,000 |
| 225-1 | Administration Building | 202 | 120 | 57,600 | 34,200 |
| 225-2 | Mockup Building | 4 | 4 | 8,640 | 8,640 |
| 225-3 | Computer Building | 21 | 20 | 3,600 | 3,600 |
| 226-1 | Motor Pool | 20 | 20 | 1,200 | 1,200 |
| 226-2 | Central Shops | 180 | 152 | 30,000 | 25,000 |
| 226-3 | Restricted Area Garage | 12 | 12 | 2,400 | 2,400 |
| 227-1 | Central Warehouse | 76 | 50 | 60,000 | 42,000 |
| 227-2 | Powder and Cap Magazines | 0 | 0 | 300 | 300 |
| 228-1 | Security Station No. 1 | 25 | 25 | 4,000 | 4,000 |
| 228-2 | Security Station No. 2 | 17 | 17 | 2,400 | 2,400 |
| 228-3 | Fire Station | 48 | 36 | 5,000 | 5,000 |
| 228-4 | Medical Center and Dormitory | 31 | 19 | 13,800 | 8,500 |
| 228-5 | Food Service Facility | 36 | 36 | 9,150 | 6,400 |
| 228-6 | Training Auditorium | 0 | 0 | 1,000 | 1,000 |
| 228-7 | Water Supply Pump Station | 0 | 0 | 800 | 800 |
| 228-8 | Visitors' Center | 6 | 6 | 9,000 | 9,000 |
| | SUBTOTAL | 946 | 686 | - | - |
| | Mining Personnel | 341 | 133 | - | - |
| | TOTAL | 1,196 | 876 | 549,190 | 462,540 |

* Stage 1 and Stage 2 personnel overlap only in 2001 and 2002. After 2002, the 31 personnel in WHB-1 are no longer needed. The total number of staff from 2005 on is 1,165.

** Counted as mining personnel.

Facility for Underground Personnel

This building contains a laundry, lockers, showers, and toilets for 341 men and women regularly employed underground in mining, waste handling, or monitoring activities. Similar but smaller facilities are provided for visitors. It is assumed in this study that shuttle buses provide transportation between this building and the men-and-materials shaft 2.5 mi to the west. Office space is provided for surface personnel who support the mining operations, for underground surveyors, engineers, and geologists, and for radiation technicians involved in disposal operations.

Other Facilities

Other facilities shown on the site plan include warehouse facilities for the inventory, control, and storage of a 3-mo supply of consumables (including spare parts, tires, tools). Shops, motor pool, fire station, limited medical facilities, security station, dormitory, food service facility, and a training building are also included.

### 3.2.6 Monitoring and Computer Services

The Repository Integrated Management and Control System (RIMACS) uses state-of-the-art control and monitoring technology to ensure safe and efficient repository operations. The hierarchical and distributed structure of the system provides high reliability and flexibility. Management information and overall operational functions are performed by a general-purpose computer system located in the computer building. The following monitoring and control functions are performed in individual facilities by stand-alone systems as needed:

- process monitoring and control,
- radiation monitoring,
- environmental monitoring,
- geotechnical monitoring,

- safeguards and security monitoring,
- health physics monitoring, and
- fire alarm monitoring.

Local networks and repository computer systems form the integrated network for the repository.

WHB-1 and WHB-2 include a control room for a system to monitor and control all waste-handling operations in Stages 1 and 2, respectively.

### 3.2.7 Yard Utilities and Services

In addition to the site-wide electrical power distribution systems, yard utilities consist of the water distribution and other systems described below. In general, steam, compressed air, and vacuum services are not centralized but are provided in individual facilities, as required.

#### Water Distribution

Fire and domestic water distribution systems that serve the central waste-handling and support facilities are gravity-fed by two storage tanks located on Exile Hill. The water supply system (see Figure 3-3) provided to distribute water to the men-and-materials shaft, muck-handling ramp, and exhaust shaft in the ESF will be incorporated in the full repository. New lines will be provided from the existing tanks to provide water to the men-and-materials shaft.

#### Electrical Distribution System

The electrical distribution system is designed to provide power for all surface and subsurface facilities. Electrical power for normal operations is provided by two independent offsite public utilities. The total repository load is normally divided between these two feeders; however, either feeder can supply the entire load in the event that one feeder has a temporary outage.

Electrical services for equipment important to safety are redundant to the extent necessary to ensure continuous performance. In the event of loss of all offsite power, standby power is provided by diesel-driven generators located at the men-and-materials shaft and at the main substation of the repository. Uninterruptible power supplies are provided for computers, monitoring systems, alarm systems, and instruments that are important to safety. Emergency power is provided for ventilation and hoisting systems.

Nonradioactive Waste

The sanitary sewage from the central waste-handling and general support facilities areas is collected and discharged to sewage treatment lagoons. The small quantity of sanitary sewage at offsite surface facilities is discharged to local septic tanks and leach fields. Sewage from the underground facilities is collected in tanks and trucked to sewage treatment lagoons. Solid waste is buried. Any hazardous nonradioactive wastes that accumulate could be processed at the WTB or shipped to an offsite commercial facility.

### 3.2.8 Off-Plot Surface Facilities

Off-plot surface facilities include facilities associated with the men-and-materials shaft, the muck-handling ramp portal, the collar of the waste emplacement area ventilation exhaust shaft, and the ES. The off-plot surface facilities at shaft collars and ramp portals are enclosed by fences to prevent unauthorized entry.

Men-and-Materials Shaft Facilities

The major surface facilities at the men-and-materials shaft are the hoist house, headframe, and the ventilation building in which the fans that supply air to the mining area are located.

Waste Emplacement Area Ventilation Exhaust Shaft Facilities

The major structure associated with this exhaust shaft is the high-efficiency particulate air (HEPA) filter building. The exhaust fans located in this building pull air down through the ES. A small amount of air enters the waste-handling ramp, and this air is exhausted through the waste emplacement area exhaust shaft (see Subsection 3.3.2).

### 3.2.9 Utility and Transportation Access

Figure 3-4 shows the site for the prospective repository at the NTS, northwest of Las Vegas, Nevada. The nearest existing facility is the E-MAD facility located approximately 10 mi from the site. The central surface facilities are located on the NTS; however, some of the subsurface facilities are located on the adjoining military reservation.

Existing utility and transportation facilities that serve the repository are

- truck access, provided by U.S. Highway 95 and 34 mi of existing minor paved road;
- water supply, provided by a 6-in. line from Well J-13 to the repository site;
- electric power, supplied by 2 existing 138-kv transmission lines 3 mi and 12 mi from the site; and
- communications, provided by the NTS microwave system and radio and telephone networks.

Utility and transportation facilities that must be constructed include

- an additional 16 mi of highway access from Amargosa Valley;
- rail access, requiring the construction of 98 mi of new track from Dike Siding 10 mi northeast of Las Vegas; and
- helicopter access, provided by a heliport to be constructed at the site.

## 3.3 Underground Facilities

### 3.3.1 Exploratory Shaft Facility (ESF)

Access to the underground portion of the ESF (for exploration and testing) is provided by a 12-ft-diameter ES and a 6-ft-diameter second shaft as described in Option 2 of a second access study (SNL, 1984a). During initial repository development, the ES is used for muck handling; during waste emplacement operations, both the 12-ft-diameter ES and the 6-ft-diameter second shaft serve as air intakes for the waste emplacement area.

### 3.3.2 Access Shafts and Ramps

The additional principal accesses to the subsurface facilities include:

- a shaft for personnel, materials, and utilities required for mining and support activities,
- a waste-handling ramp,
- a muck-handling ramp, and
- a waste emplacement area exhaust shaft.

#### Men-and-Materials Shaft

Access for men and materials is provided by a shaft as indicated on Figure 3-10. This shaft has a 25-ft finished diameter and is 1,110 ft deep. This shaft is also used for utilities and as an air intake for the mining area.

#### Waste-Handling Ramp

The approximately 6,700-ft-long, 24-ft-diameter waste-handling ramp will be excavated by a tunnel-boring machine (TBM) on a planned grade of 8%. The ramp contains a roadway that permits safe operation of a waste transporter.

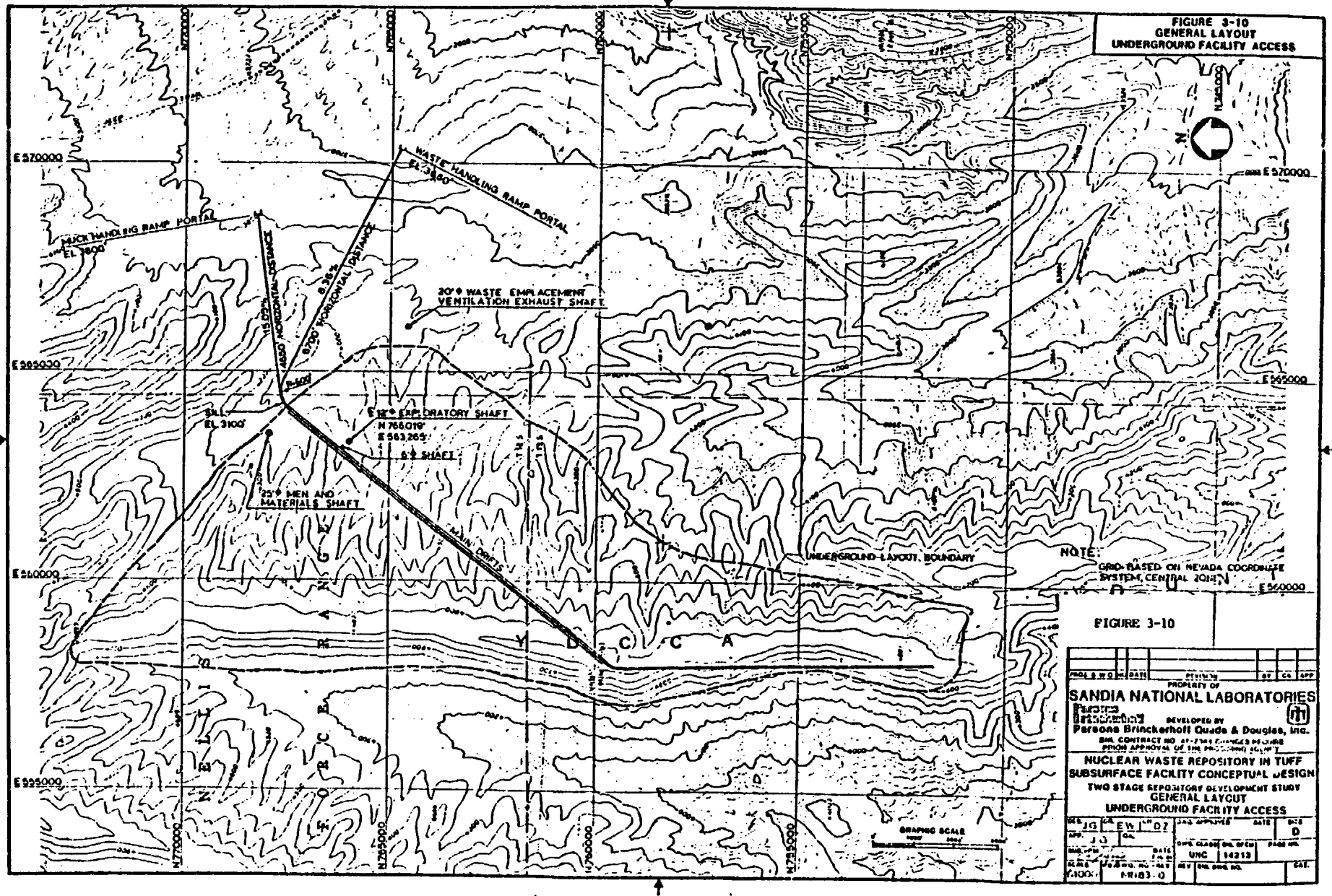


FIGURE 3-10
GENERAL LAYOUT
UNDERGROUND FACILITY ACCESS
WASTE HANDLING RAMP PORTAL
EL. 3800'
MUCK HANDLING RAMP PORTAL
EL. 3800
30'Φ WASTE EMPLACEMENT VENTILATION EXHAUST SHAFT
8'Φ EXPLORATORY SHAFT
N 766019'
E 563265'
8'Φ SHAFT
25'Φ MEN AND MATERIALS SHAFT
EL. 3100'
MAIN DRIFTS
UNDERGROUND LAYOUT BOUNDARY
NOTE:
GRID BASED ON NEVADA COORDINATE SYSTEM, CENTRAL ZONE
GRAPHIC SCALE
E 570000
E 565000
E 560000
E 555000
N 770000
N 765000
N 760000
N 755000
N 750000
FIGURE 3-10
PROPERTY OF
SANDIA NATIONAL LABORATORIES
Parsons Brinckerhoff
DEVELOPED BY
Parsons Brinckerhoff Quade & Douglas, Inc.
NUCLEAR WASTE REPOSITORY IN TUFF
SUBSURFACE FACILITY CONCEPTUAL DESIGN
TWO STAGE REPOSITORY DEVELOPMENT STUDY
GENERAL LAYOUT
UNDERGROUND FACILITY ACCESS
JG
EW
07
D
UNC
14213
M-183-0

Muck-Handling Ramp

The location of the muck-handling ramp is based on current underground layouts. This ramp is used as an access for initial construction of the underground facilities and for removing muck from mining operations. The muck-handling ramp is large enough to permit installation of a conveyor and passage of mining equipment in the full repository.

The approximately 4,650-ft-long, 19-ft-diameter ramp will be excavated by a TBM on a planned grade of 15%. A large radius will be made at the base of the ramp to facilitate entry into the underground facility perpendicular to the boundary of the underground layout.

Waste Emplacement Area Exhaust Shaft

A 20-ft-diameter shaft (finished diameter) will be constructed outside the boundary of the underground layout east of the main entry drifts (Figure 3-10). This shaft will be used for waste emplacement area ventilation exhaust.

Underground Service

An underground service area located at the men-and-materials shaft contains a control room that houses the communications, ventilation, water, electrical, and ground control systems. This control room is the subsurface terminus for repository monitoring and control systems. The main control console for these systems is on the surface. Other facilities in the underground service area (ventilated by the air circuit for the mining area) include maintenance shops; space for equipment parking, bulk materials storage, supplies, service equipment; personnel and underground administrative functions; and maintenance facilities for waste-handling and ground support equipment for the waste emplacement area.

Main Entries

Three main entry drifts will be used for (1) waste transport, (2) muck-handling and bulk materials transport systems, and (3) ventilation. Space is also provided along the three main entries for electrical distribution systems and maintenance facilities. A rock pillar separates the main entries from the waste emplacement panels. The layout and spacing of the main entries allow the ventilation air circuits for the mining area and waste emplacement area to remain entirely separate. The main entries will remain operational throughout the mining, waste emplacement, and retrieval periods.

### 3.3.3 Subsurface Facilities in Stage 1

Subsurface facilities in Stage 1 include areas for emplacement of spent fuel and contact-handled waste. These facilities at the disposal horizon are excavated from the base of the ramps and the ES station. Capacity is provided for the first 5 yr of radioactive waste received at the rate of 400 MTU/yr. The first waste emplacement panel holds waste for the first 3 yr of operation. Space for the next 2 yr of operation is provided in the next panel. Mining parameters are shown in Table 3-2, and the layouts for the vertical and horizontal waste emplacement modes are shown on Figures 3-11 and 3-12.

Both vertical and horizontal emplacement configurations for Stage 1 begin with a triangular panel (Panel 1, Figure 3-11) roughly 2,000 ft long by 700 ft wide. This panel is bounded on the southwest by two conventionally mined access drifts and on the northeast by a peripheral ventilation drift 19 ft in diameter. An area of approximately 8 acres between this panel and the main entries is used for emplacement of contact-handled waste.

If the vertical emplacement mode is used, one emplacement drift can accommodate up to 60 canisters. Emplacement drifts in the vertical mode are 21 ft high by 15 ft wide and are spaced 116 ft apart (Table 3-2). One canister per hole is placed in the floor of the drift. Boreholes are spaced

TABLE 3-2

SUMMARY OF MINING PARAMETERS FOR THE HORIZONTAL AND VERTICAL EMPLACEMENT MODES IN STAGES 1 AND 2

| Parameter | Vertical | | Horizontal | |
|---|---|---|---|---|
| | Stage 1 | Stage 2 | Stage 1 | Stage 2 |
| Spacing of Boreholes | 9 ft | 13 ft | 56 ft | 105 ft |
| Number of Canisters per Borehole | 1 | 1 | Variable | 34 |
| Length and Depth of Borehole | 25 ft | 25 ft | Variable | 656 ft |
| Borehole Diameter | 28 in. | 28 in. | 32 in. | 32 in. |
| Canister Length | 15 ft | 15 ft | 15 ft | 15 ft |
| Standoff from Access Drift | 82 ft | 82 ft | 82 ft | 82 ft |
| Standoff from Emplacement Drift | 10 ft | 10 ft | 82 ft | 82 ft |
| Access Drift Height | 15 ft | 15 ft | 15 ft | 15 ft |
| Access Drift Width | 20 ft | 20 ft | 20 ft | 20 ft |
| Emplacement Drift Height | 21 ft | 21 ft | 15 ft | 15 ft |
| Emplacement Drift Width | 15 ft | 15 ft | 21 ft | 21 ft |
| Spacing of Emplacement Drifts | 116 ft | 150 ft | 1,320 ft | 1,320 ft |
| Spent Fuel Canisters Placed per Year [400 MTU (Stage 1) and 3,000 MTU (Stage 2)] | ~272 | ~1,018 | 272 | 1,018 |
| Kilowatts per Acre | 57 | 57 | 57 | 57 |
| Assembly Hardware Canisters Placed per Year | 0 | 420 | 0 | 420 |
| Typical Panel Size (Stage 2) | 660 ft W x 3,100 ft L | | 1,320 ft W x 3,100 ft L | |
| Number of Emplacement Drifts per Panel | Variable | 20 | 2 | 2 |
| Number of Boreholes per Drift | Variable | 37 | 28 | 28 |
| Tons of Rock Mined per Day (Stage 2) | | 2,750 | | 600 |

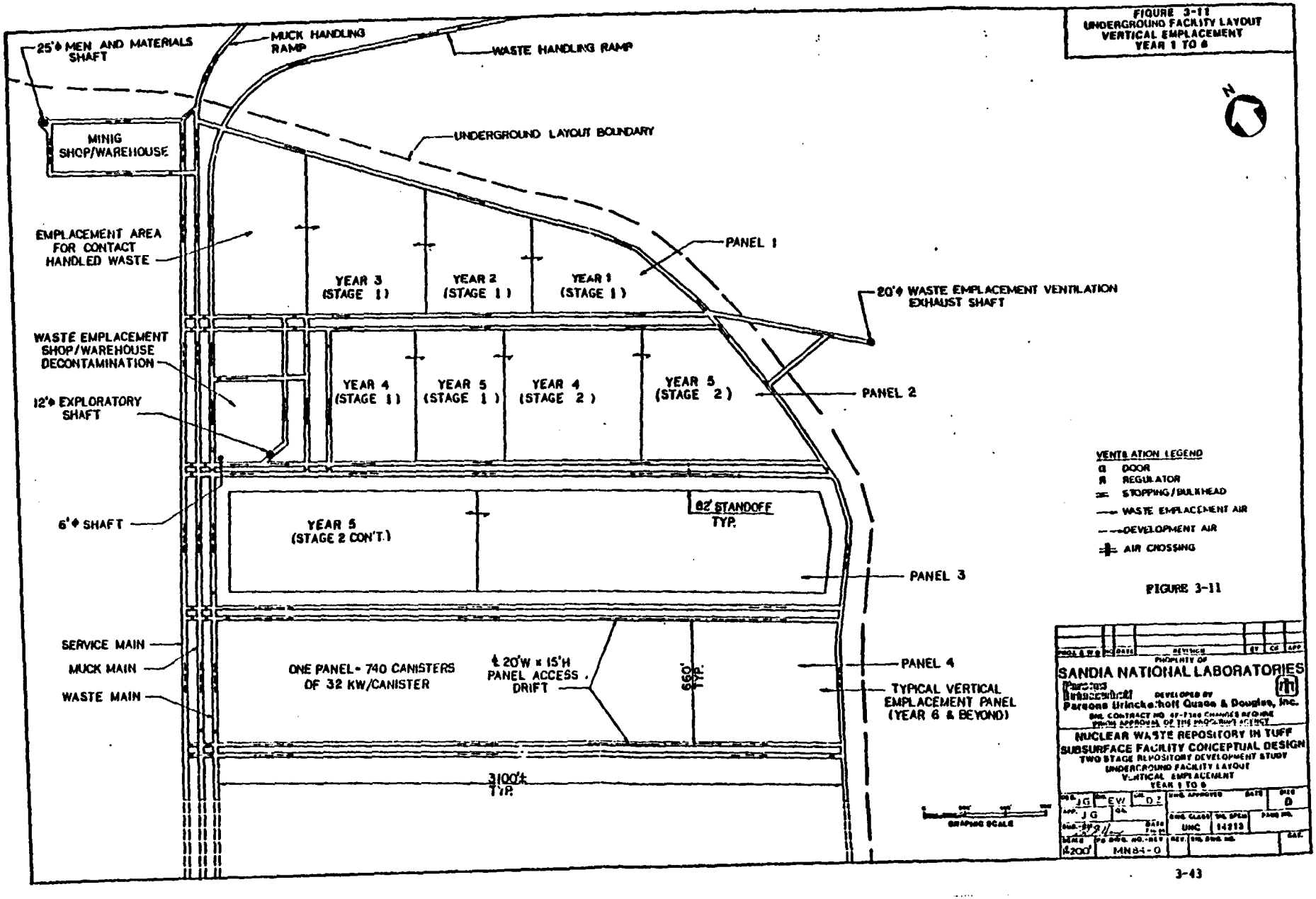


FIGURE 3-11
UNDERGROUND FACILITY LAYOUT
VERTICAL EMPLACEMENT
YEAR 1 TO 6
25'Φ MEN AND MATERIALS SHAFT
MUCK HANDLING RAMP
WASTE HANDLING RAMP
MINIG SHOP/WAREHOUSE
UNDERGROUND LAYOUT BOUNDARY
EMPLACEMENT AREA FOR CONTACT HANDLED WASTE
PANEL 1
YEAR 3 (STAGE 1)
YEAR 2 (STAGE 1)
YEAR 1 (STAGE 1)
20'Φ WASTE EMPLACEMENT VENTILATION EXHAUST SHAFT
WASTE EMPLACEMENT SHOP/WAREHOUSE DECONTAMINATION
YEAR 4 (STAGE 1)
YEAR 5 (STAGE 1)
YEAR 4 (STAGE 2)
YEAR 5 (STAGE 2)
PANEL 2
12'Φ EXPLORATORY SHAFT
6'Φ SHAFT
YEAR 5 (STAGE 2 CON'T.)
82' STANDOFF TYP.
PANEL 3
SERVICE MAIN
MUCK MAIN
WASTE MAIN
ONE PANEL - 740 CANISTERS OF 32 KW/CANISTER
℄ 20'W x 15'H PANEL ACCESS DRIFT
660' TYP.
PANEL 4
TYPICAL VERTICAL EMPLACEMENT PANEL (YEAR 6 & BEYOND)
3100'± TYP.
GRAPHING SCALE
VENTILATION LEGEND
DOOR
REGULATOR
STOPPING/BULKHEAD
WASTE EMPLACEMENT AIR
DEVELOPMENT AIR
AIR CROSSING
FIGURE 3-11
SANDIA NATIONAL LABORATORIES
Parsons Brinckerhoff Quade & Douglas, Inc.
NUCLEAR WASTE REPOSITORY IN TUFF
SUBSURFACE FACILITY CONCEPTUAL DESIGN
TWO STAGE REPOSITORY DEVELOPMENT STUDY
UNDERGROUND FACILITY LAYOUT
VERTICAL EMPLACEMENT
YEAR 1 TO 6
JG
EW
D
UNC
14213
1:200'
MN84-0

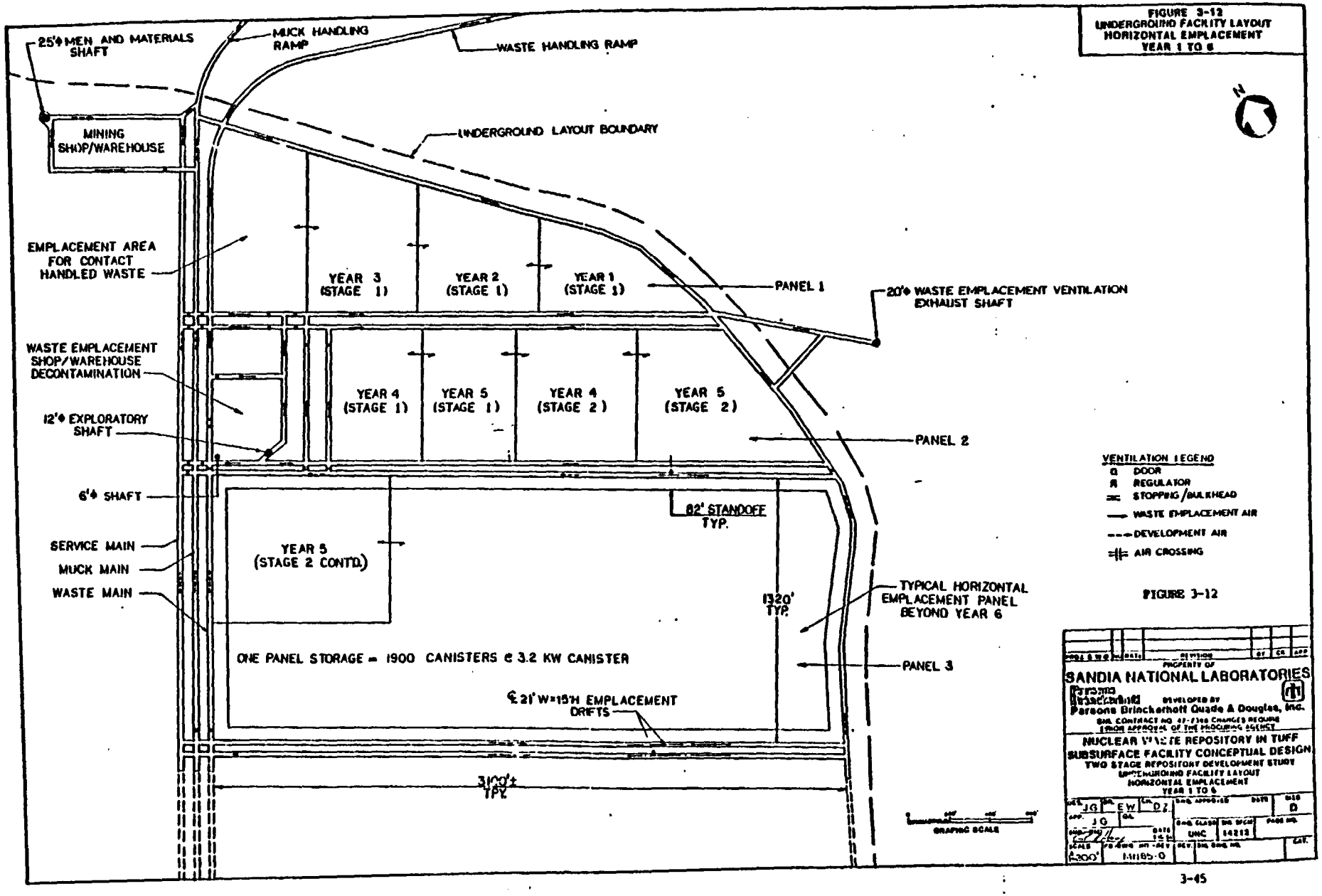


FIGURE 3-12
UNDERGROUND FACILITY LAYOUT
HORIZONTAL EMPLACEMENT
YEAR 1 TO 6
25'Φ MEN AND MATERIALS SHAFT
MUCK HANDLING RAMP
WASTE HANDLING RAMP
MINING SHOP/WAREHOUSE
UNDERGROUND LAYOUT BOUNDARY
EMPLACEMENT AREA FOR CONTACT HANDLED WASTE
YEAR 3 (STAGE 1)
YEAR 2 (STAGE 1)
YEAR 1 (STAGE 1)
PANEL 1
20'Φ WASTE EMPLACEMENT VENTILATION EXHAUST SHAFT
WASTE EMPLACEMENT SHOP/WAREHOUSE DECONTAMINATION
YEAR 4 (STAGE 1)
YEAR 5 (STAGE 1)
YEAR 4 (STAGE 2)
YEAR 5 (STAGE 2)
12'Φ EXPLORATORY SHAFT
PANEL 2
6'Φ SHAFT
82' STANDOFF TYP.
SERVICE MAIN
MUCK MAIN
WASTE MAIN
YEAR 5 (STAGE 2 CONTD.)
1320' TYP.
TYPICAL HORIZONTAL EMPLACEMENT PANEL BEYOND YEAR 6
ONE PANEL STORAGE = 1900 CANISTERS @ 3.2 KW CANISTER
PANEL 3
℄ 21' W×15'H EMPLACEMENT DRIFTS
3100'± TYP.
GRAPHIC SCALE
VENTILATION LEGEND
D DOOR
R REGULATOR
STOPPING/BULKHEAD
WASTE EMPLACEMENT AIR
DEVELOPMENT AIR
AIR CROSSING
FIGURE 3-12
PROPERTY OF
SANDIA NATIONAL LABORATORIES
DEVELOPED BY
Parsons Brinckerhoff Quade & Douglas, Inc.
NUCLEAR WASTE REPOSITORY IN TUFF
SUBSURFACE FACILITY CONCEPTUAL DESIGN
TWO STAGE REPOSITORY DEVELOPMENT STUDY
UNDERGROUND FACILITY LAYOUT
HORIZONTAL EMPLACEMENT
YEAR 1 TO 6
JG
EW
DZ
D
UNC
54213
1:1185-0

on 9-ft centers and are 25 ft deep. Access drifts 15 ft high by 20 ft wide provide access to the emplacement drifts. The access drifts are separated from the main entries by bulkheads with access doors and air locks.

Figures 3-13A and 3-13B and Figures 3-14A and 3-14B illustrate the design of panels for vertical and horizontal emplacement during Stage 1. Emplacement calculations for both vertical and horizontal emplacement assume an areal power density of 57 kW/acre and a canister heat output as shown in Table 2-2.

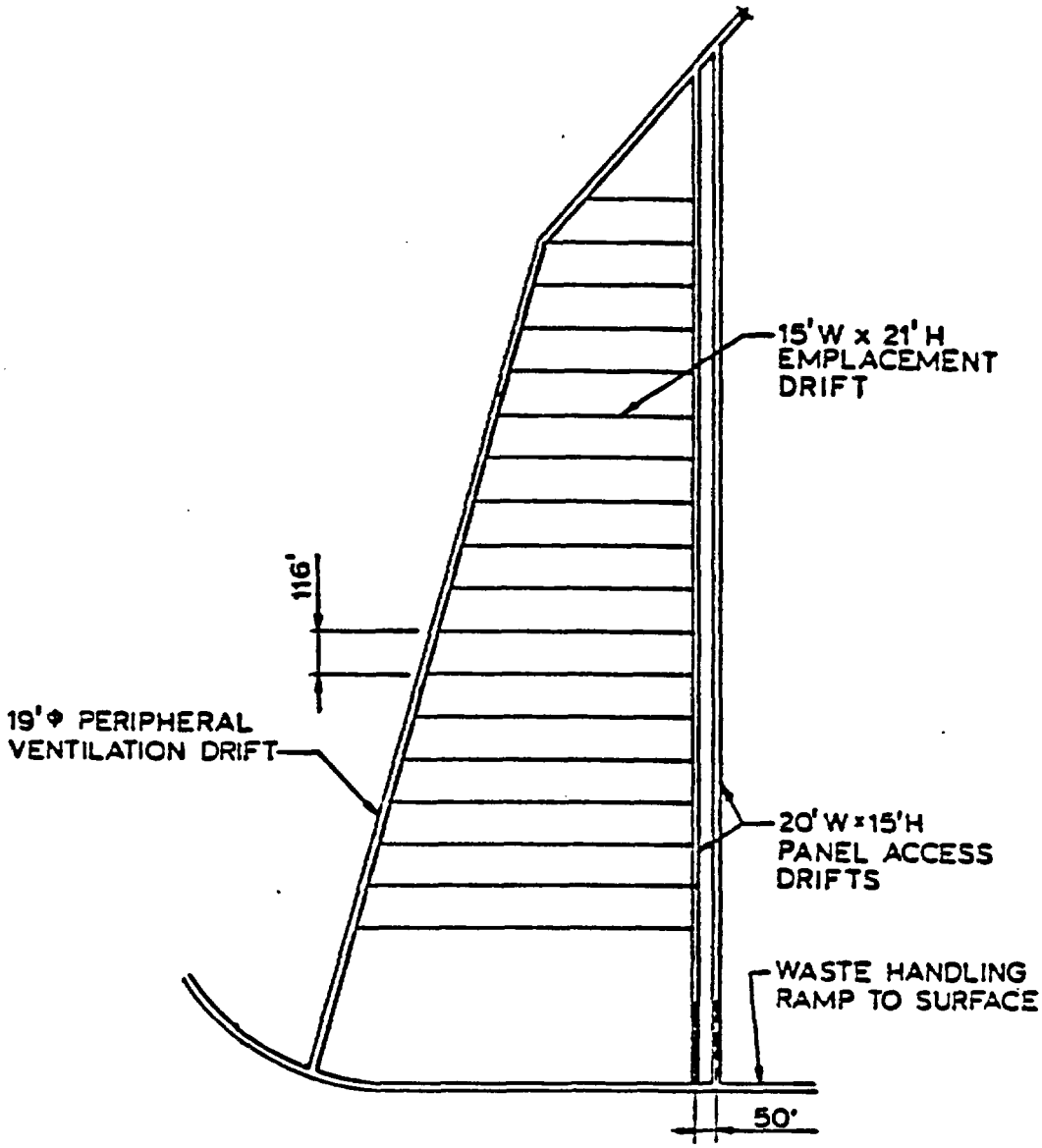
The emplacement areas in both the vertical and horizontal modes will be excavated by drill-and-blast methods. Studies are being conducted by Parsons Brinckerhoff to determine whether mechanical mining machines can be used to excavate the underground facilities.

### 3.3.4 Subsurface Facilities in Stage 2

The subsurface facilities to accommodate 3,000 MTU/yr in Stage 2 are similar to those in Stage 1 and are designed to receive approximately 1,018 canisters/yr containing consolidated BWR and PWR fuel assemblies and approximately 420 canisters/yr of assembly hardware.

A typical emplacement area layout is based on a panel system consisting of panels 660 ft wide by 3,100 ft long for vertical emplacement and 1,320 ft wide by 3,100 ft long for horizontal emplacement. The first panel will be developed in the northeast area of the underground layout, and development will proceed, panel by panel, southwest to the end of the underground layout. When development in this area has been completed, the area on the other side of the main entries will be developed in a northwest direction.

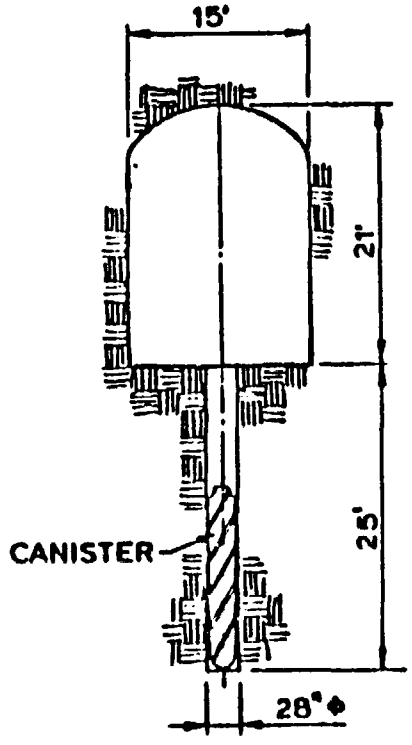
A typical panel in the vertical emplacement mode during Stage 2 is illustrated in Figures 3-15A and 3-15B, and a typical panel for horizontal emplacement is illustrated in Figures 3-16A and 3-16B. To meet the criteria for an areal power density of 57 kW/acre and for the canister heat loads shown in Table 2-3, vertical emplacement drifts are located 150 ft apart and emplacement holes 13 ft apart. In the basic horizontal configuration,




VERTICAL EMPLACEMENT PLAN - STAGE I

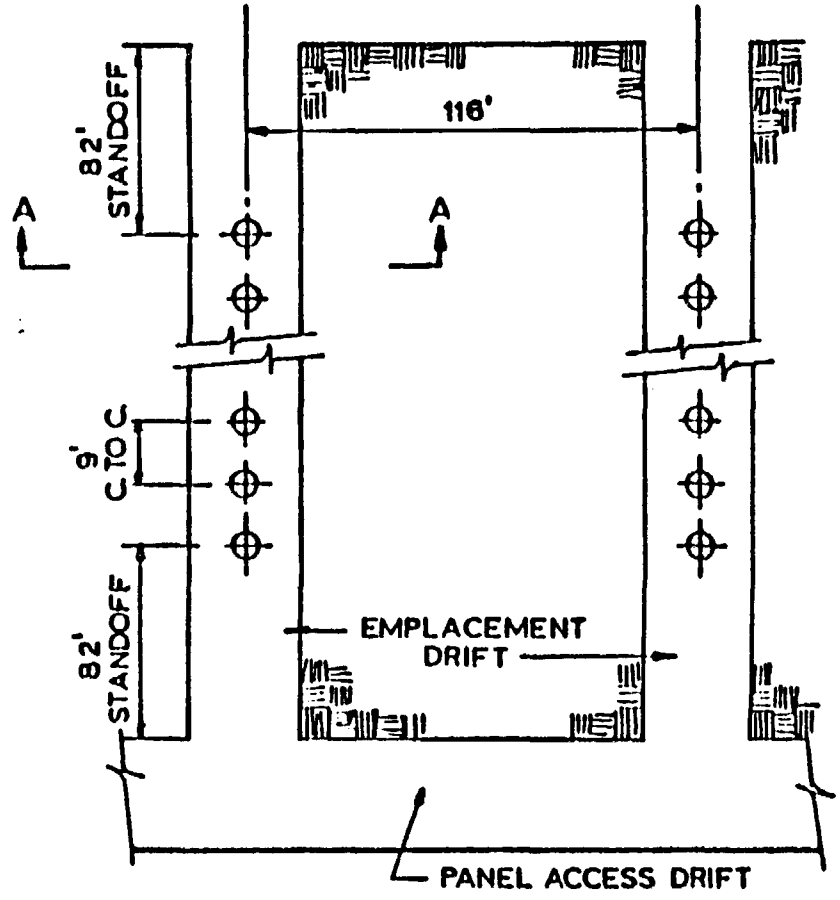
NOT TO SCALE

FIGURE 3-13A




SECTION A-A

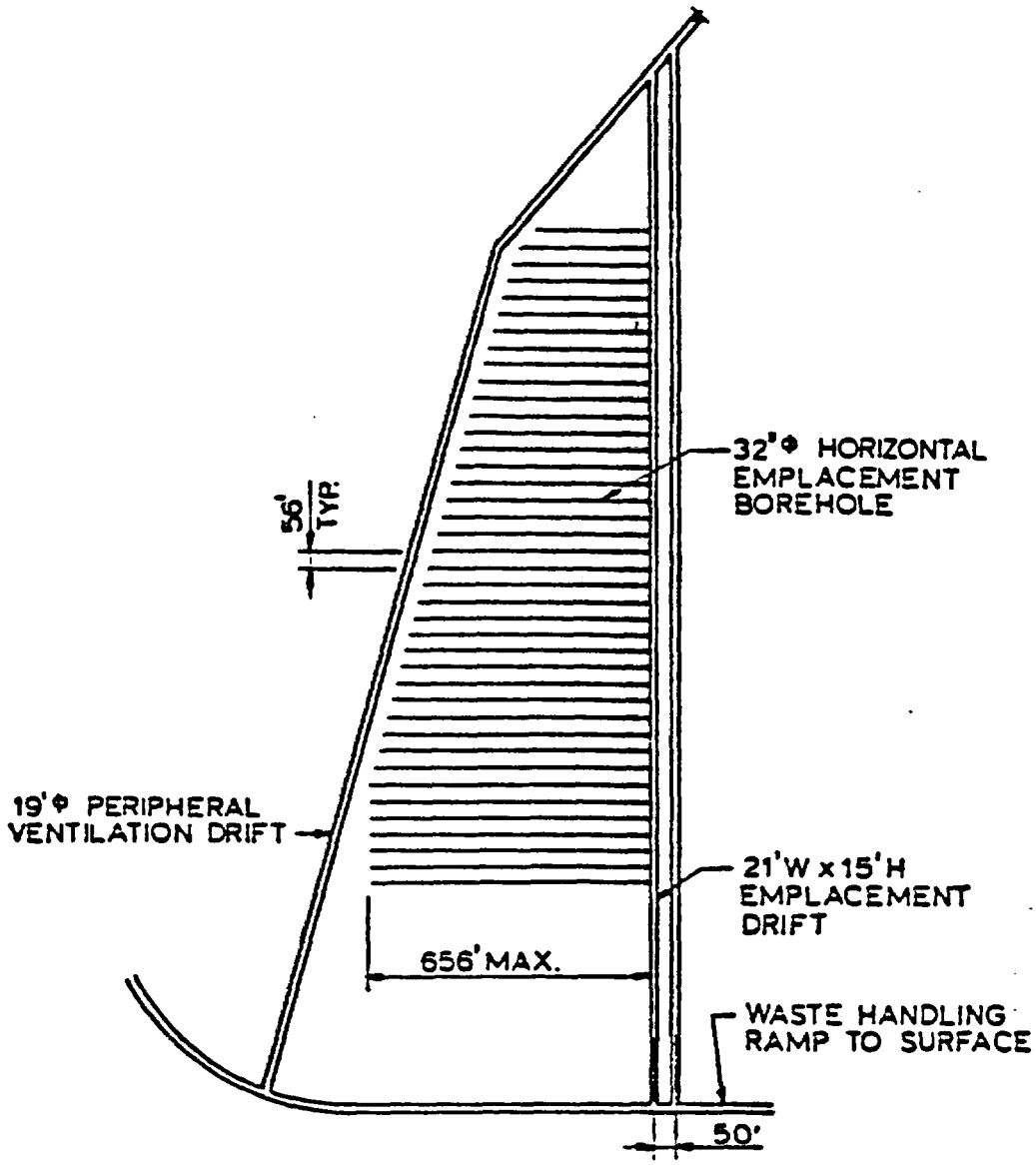
NOT TO SCALE




VERTICAL EMPLACEMENT PLAN - STAGE I

NOT TO SCALE

FIGURE 3-13B




HORIZONTAL EMPLACEMENT PLAN - STAGE I

NOT TO SCALE

FIGURE 3-14A

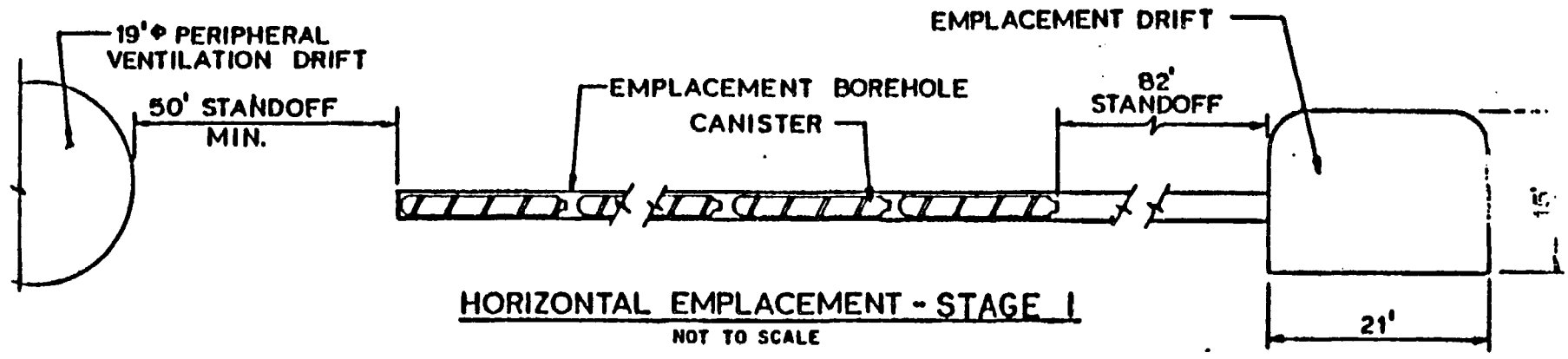
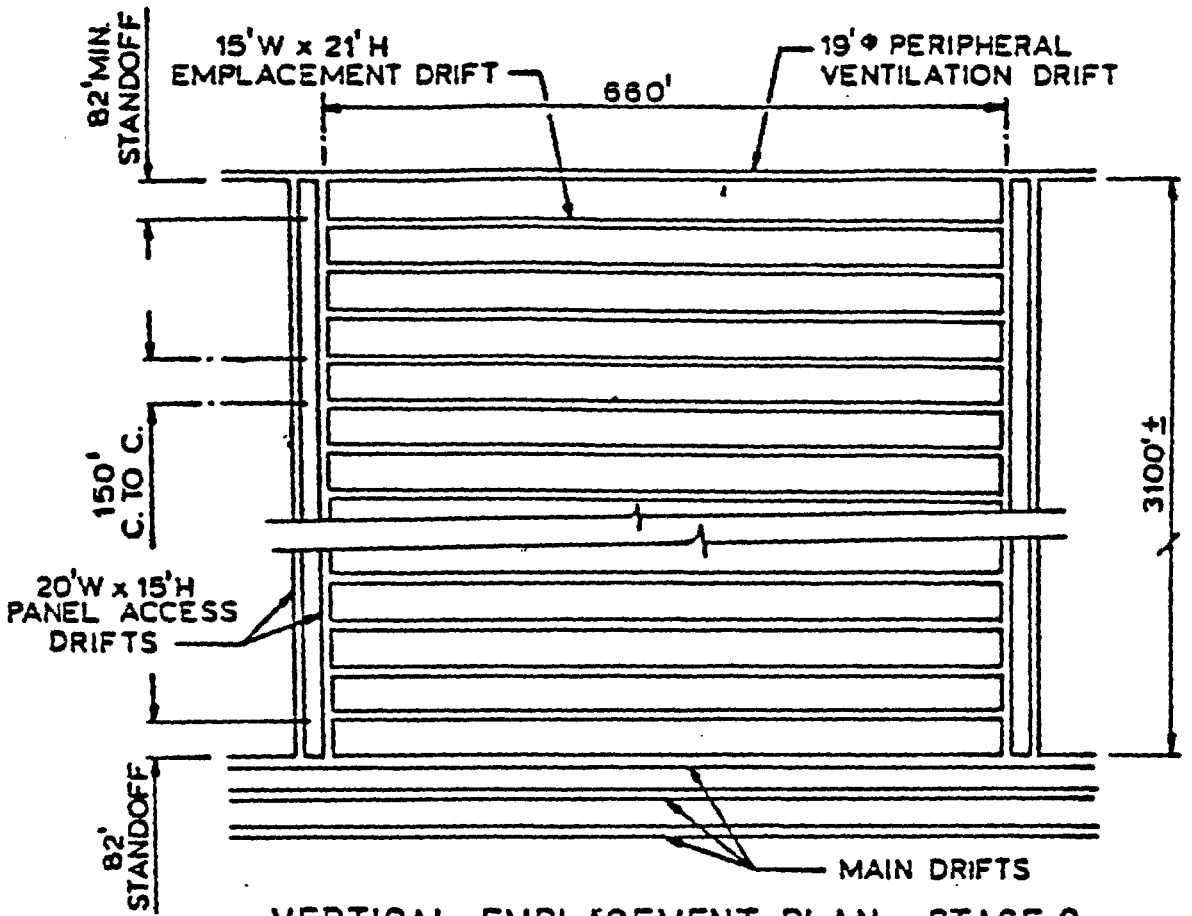

19'Φ PERIPHERAL
VENTILATION DRIFT
50' STANDOFF
MIN.
EMPLACEMENT BOREHOLE
CANISTER
EMPLACEMENT DRIFT
82'
STANDOFF
15'
21'
HORIZONTAL EMPLACEMENT - STAGE I
NOT TO SCALE

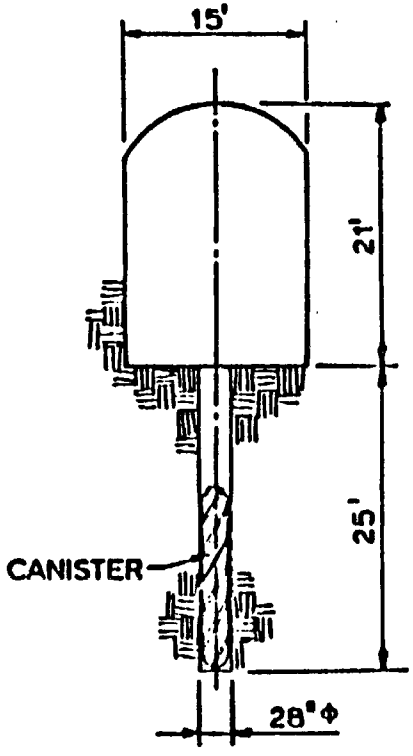
FIGURE 3-14B




VERTICAL EMPLACEMENT PLAN - STAGE 2

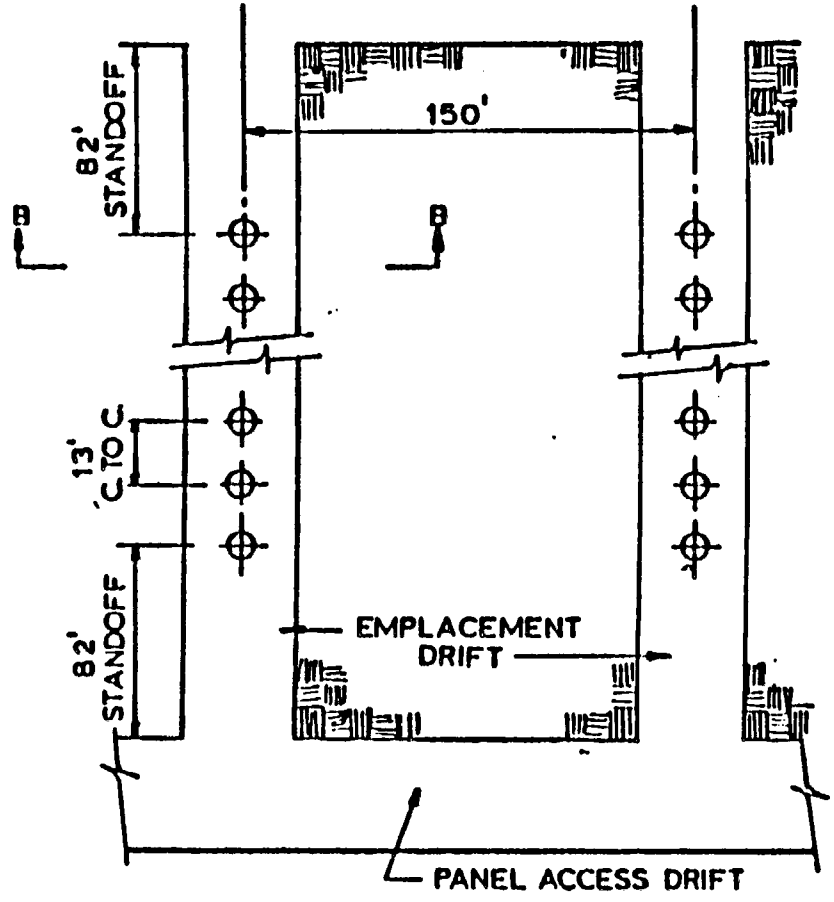
NOT TO SCALE
( 1 CANISTER / HOLE )
( 37 HOLES / DRIFT )
( 20 DRIFTS / PANEL )

FIGURE 3-15A




SECTION B-B

NOT TO SCALE




VERTICAL EMPLACEMENT PLAN - STAGE 2

NOT TO SCALE

FIGURE 3-15B

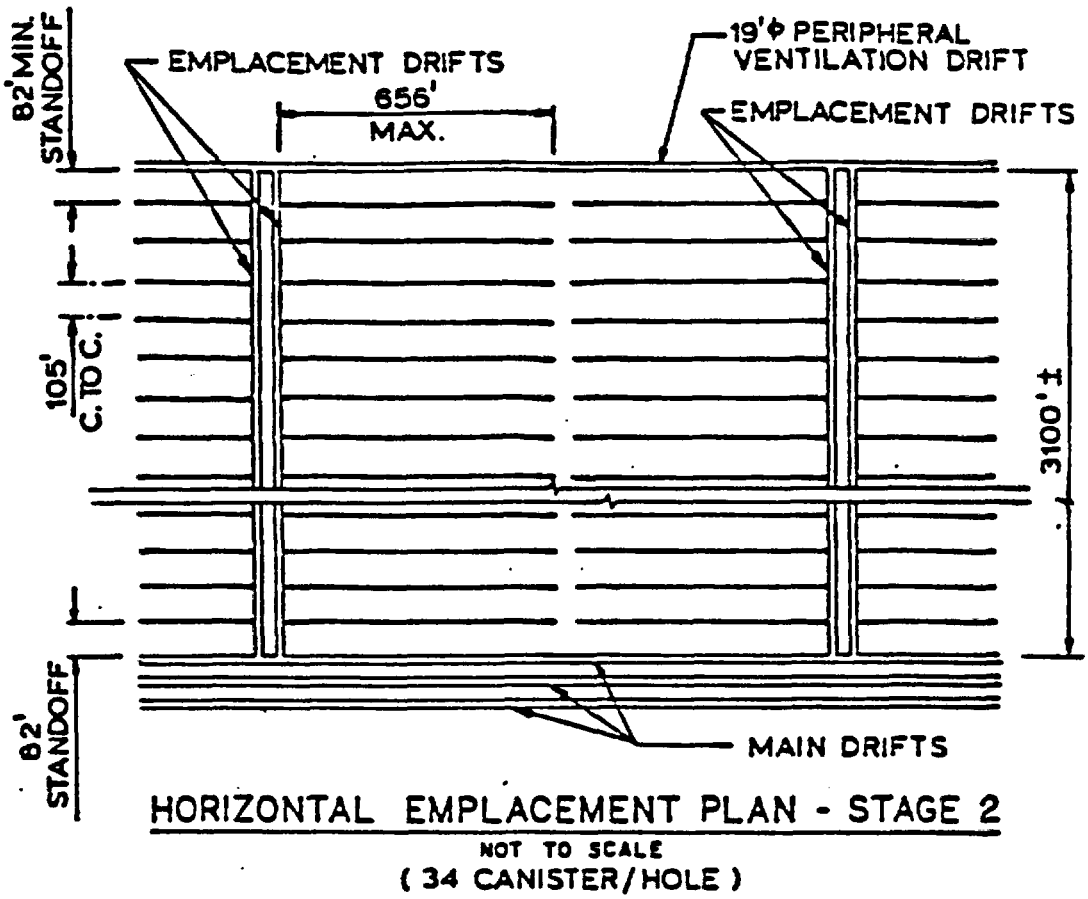
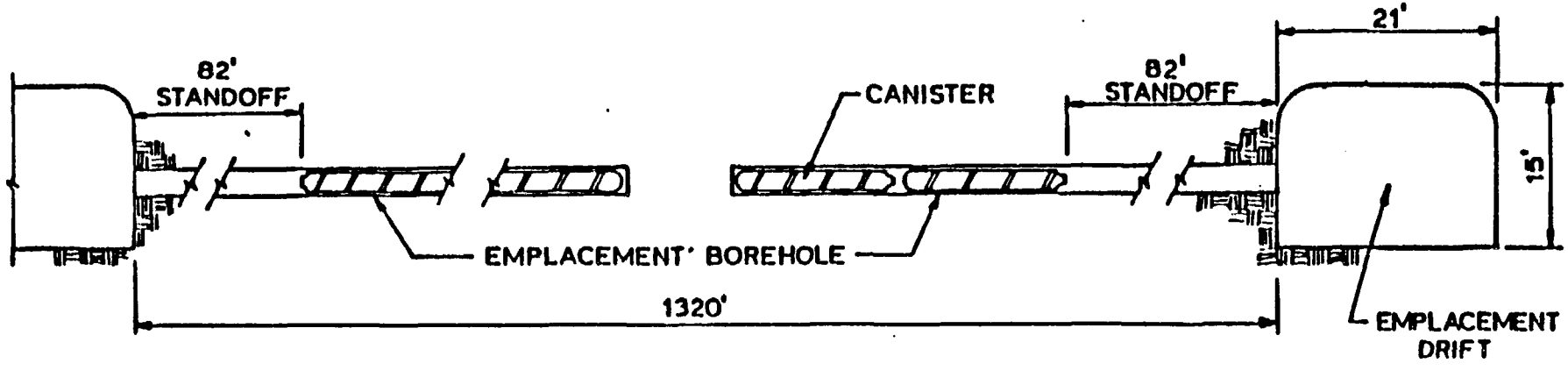

82' MIN. STANDOFF
EMPLACEMENT DRIFTS
656'
MAX.
19'Φ PERIPHERAL VENTILATION DRIFT
EMPLACEMENT DRIFTS
105' C. TO C.
3100' ±
82' STANDOFF
MAIN DRIFTS
HORIZONTAL EMPLACEMENT PLAN - STAGE 2
NOT TO SCALE
( 34 CANISTER/HOLE )

FIGURE 3-16A




HORIZONTAL EMPLACEMENT - STAGE 2

NOT TO SCALE

FIGURE 3-16B

28 boreholes are placed on each side of an emplacement drift 21 ft wide by 15 ft high. Each 32-in.-diameter borehole is designed to hold 34 canisters. A 6.5-ft rock pillar separates the ends of adjacent blind boreholes. The areal power density was averaged over a typical emplacement panel (Figure 3-16A). The emplacement drifts and the appropriate portion of the main entries were included in the areal power density calculations.

### 3.3.5 Design, Operation, and Control of the Ventilation Systems

The design, operation, and control of the subsurface ventilation systems are critical to the construction and operation of the subsurface facilities. To ensure safe operations, separate ventilation systems will be used for the mining area and waste emplacement area, and the connections and air crossings between these two systems will be kept to a minimum. Completion of the first panel before beginning emplacement operations in Stage 1 will eliminate the need for a second peripheral ventilation drift and will minimize the number of connections between the two ventilation systems during Stage 1 operations. After completion of the first panel, the ventilation systems operate as described in Section 4.

Ventilation in the mining area is supplied by an intake fan on the men-and-materials shaft and exhausted through the muck-handling ramp. Ventilation in the waste emplacement area is accomplished by using the ES as an air intake and the waste emplacement area exhaust shaft for ventilation exhaust. A fan house equipped with HEPA filters is located at the surface of the exhaust shaft.

The ventilation system for the waste emplacement area uses the ES for an air intake and a shaft with fans for exhaust. HEPA filters are located at the exhaust fan building for the waste emplacement area. During normal operations, the HEPA filters are bypassed; however, if the radiation monitoring system in the subsurface return airways detects radioactive particulates, the filters are automatically activated.

Minimum access between the separate ventilation systems is provided by a connecting drift sealed by bulkheads with airtight doors. After the

panels have been excavated, the bulkheads are moved. The air for the mining area is at a higher pressure than that for the waste emplacement area; therefore, the pressure differential across any of the bulkheads forces air leakage into the waste emplacement area.

The waste emplacement area air system serves not only the panels for spent fuel but also provides fresh air to the ESF and to the disposal area for contact-handled wastes. The waste-handling ramp is ventilated by a regulated quantity of fresh intake air that is drawn down the ramp and exhausted directly to the exhaust shaft. The amount of air drawn through the waste-handling ramp is sufficient to dilute the diesel exhaust from the waste transporters to acceptable levels.

In the vertical emplacement mode, air is routed from the base of the ES, down the main entries and access drifts, and through the emplacement area where operations are in progress. The air then passes through the peripheral ventilation drift to the waste emplacement area exhaust shaft. After one emplacement drift has been filled with waste, the drift is closed with bulkheads fitted with pipes to sample air within the emplacement drift. During Stage 1, however, sufficient airflow capacity is available to provide continuous ventilation to control waste heat in the emplacement drifts.

As the emplacement drifts are sealed, the temperature of the drifts gradually rises. Should retrieval be deemed necessary, the temperature in the drifts would eventually become too high to permit entry for canister retrieval, and a period of precooling would be required.

For cost estimating purposes, waste emplacement ventilation system requirements, as determined by engineering calculations performed by the underground architect/engineer, are

- vertical emplacement, Stage 1: 460,000 $ft^3$/min at 2 in. water gauge;
- vertical emplacement, Stage 2: 624,000 $ft^3$/min at 13.6 in. water gauge;

- horizontal emplacement, Stage 1: 200,000 $ft^3$/min at 2 in. water gauge; and
- horizontal emplacement, Stage 2: 200,000 $ft^3$/min at 2 in. water gauge.

These calculations were performed with the aid of a commercially available computer program for ventilation analysis.

# 4.0 OPERATIONS DESCRIPTIONS

The operations described in this section are based on the feasibility study design presented in Section 3 of this report. Retrieval and decommissioning activities are not addressed.

The principal operations at the repository are

- o receiving, handling, storing, and transporting radioactive wastes aboveground,
- o transporting radioactive wastes to the disposal area,
- o mining the emplacement drifts, drilling the boreholes, and placing the canisters in the boreholes, and
- o monitoring the performance of the repository.

Stage 1 and Stage 2 operations are described separately, and surface operations, mining, and waste emplacement are described for each stage.

## 4.1 Stage 1 Operations

### 4.1.1 Surface Facilities

Preliminary operational procedures are described in detail in a Sandia report (Dennis, 1984). It is assumed that all incoming waste is shipped by truck in shipping casks that contain either 2 PWR or 5 BWR spent fuel assemblies. An average of approximately 2 casks/day arrives by truck at the surface facilities, where the contents are removed and packaged. The flow diagram (Figure 3-6) provides an outline of the steps required for normal handling of spent fuel from the time the shipping casks are received through vault storage before transfer to the waste disposal area.

Before entering the waste-handling building, the waste shipment is surveyed for surface contamination and washed down if necessary to remove road dirt from the trailer and from the protective covers on the shipping casks. If contamination is found, the suspect trailer is routed to the

decontamination station. The shipping trailer is taken into the receiving bay. A bridge-mounted robotic arm is provided in the receiving bays to remove the cask tiedowns and protective cover. A 125-ton-capacity bridge crane is used to transfer the cask by remote control to a transfer cart.

The transfer cart moves the cask into the cask preparation cell. This cell is equipped with a floor-mounted manipulator and closed-circuit TV system so that the cask cover can be removed and the cask can be prepared for removal of the fuel assemblies. The transfer cart then moves the prepared cask into position under the unloading hot cell, where the fuel assemblies are removed from the shipping cask.

The intact assemblies are placed in canisters that contain either 3 PWR or 9 BWR assemblies. The canister is welded, tested for leaks, filled with helium, and decontaminated, if necessary. The prepared canister is transferred from the hot cell to either the loading port for transport to the disposal area or to the temporary vault storage cell. The emplacement rate is about 1 canister/day.

### 4.1.2 Waste Emplacement

Activities associated with waste-handling and emplacement operations are described in the following paragraphs.

#### General Description of Waste-Handling Equipment and Emplacement Operations

A waste transporter is used to move waste packages from the waste-handling building to the disposal area. The transporter is rubber-tired and diesel-powered. Although the transporter can be operated by one person, a two-man crew will be used to ensure safety. The transporter can move forward or backward with nearly equal ease. It is equipped with a shielded cask mounted so that the cask can be rotated to a vertical position for lowering a canister into a vertical

emplacement hole. Steering and adjustment devices are provided to allow precise positioning of the cask before emplacement of the waste canister in the borehole. The loaded vehicle can negotiate a grade of 10% and is equipped with redundant braking mechanisms. The transporter is fitted with jacking devices for stabilization and leveling.

The transporter used in the horizontal emplacement mode is similar to the transporter used for vertical emplacement. The cask is oriented along the axis of the vehicle during transport and is rotated 90° in the horizontal plane to connect with the horizontal emplacement hole.

The following principal operations are involved in vertical waste emplacement:

- loading the canister into the cask at the waste-handling building,
- transporting the cask from the waste-handling building to the ramp portal and down the ramp to the disposal area,
- transporting the cask through the main entry and the emplacement drift to the emplacement hole,
- coarse positioning by steering, followed by fine positioning and checking of the position and level,
- lowering the canister into the borehole,
- moving the transporter in the reverse direction, and
- placing the shield plug and cover.

Waste Emplacement During the First 3 Years

Approximately 272 canisters/yr of unconsolidated PWR and BWR spent fuel assemblies are emplaced in the first 5 yr of repository operations. Waste emplacement commences in 1998 after completion and separation of the first waste emplacement panel from the ventilation system for the mining area (see Figure 3-13A). This panel is large enough to contain all of the waste received during the first 3 yr.

Transition Period

The transition from Stage 1 to Stage 2 begins in the year 2001 and ends in 2003, as described in Subsection 2.1.1.

The underground facilities will be ready to receive and dispose of waste received at the beginning of Stage 2 as soon as the second panel has been completed. The second panel can accommodate the remainder of the Stage 1 waste and the first canisters of Stage 2 waste. The remainder of Stage 2 waste will be emplaced in subsequent panels. These panels will be developed and isolated one by one.

Contact-handled waste is emplaced in the area shown in Figures 3-11 and 3-12. The detailed layout of this area has not been completed, but it may be possible to use this area for disposal of DHLW also. Because the heat load from these types of waste is low, the waste can be emplaced in a more compact arrangement than that for spent fuel. Equipment different from that used to transport HLW will be used for contact-handled waste.

Ventilation Operation and Control

After the completion and isolation of the first waste emplacement panel described in Subsection 3.3.5, the ventilation systems operate in the following way.

The ventilation system in the mining area operates under positive pressure and independently from the ventilation system in the waste emplacement area. This system uses the men-and-materials shaft as an air intake and the muck-handling ramp as a conduit for exhaust. Fans are placed at the intake to push the air through the mining area.

The primary air intake for the waste emplacement area is the ES, although a small amount of fresh air enters the underground facilities through the waste-handling ramp. From the intakes, the air is directed

through the access drifts to the drift in which waste is being emplaced. After circulating through the emplacement area, the air passes through a peripheral ventilation drift to the waste emplacement area exhaust shaft. Ventilation fans for the waste emplacement area are located on the surface at the exhaust shaft. These fans pull the ventilation air through the waste emplacement area, creating a negative pressure.

Maintenance and Ancillary Operations

It is assumed that major maintenance of the waste transporters and other vehicles takes place at the surface. Routine and emergency services are provided from a central underground shop area. This service area also accommodates the routine inspection and maintenance of electrical, signal, alarm, monitoring systems and devices, and other systems, as required.

Because construction activities in the waste disposal area are minimal during the waste emplacement phase, the principal maintenance activities include erection of bulkheads and their relocation, if necessary. These activities are also serviced from the central underground shop area.

### 4.1.3 Continuing Underground Development

Construction of the panel that will hold the waste received during the first 3 yr (1998-2000) is complete before waste emplacement commences. The second panel, which contains space for the waste received during the transition period (2001-2002) and for the first shipments received during Stage 2, is under construction while the first panel is being filled with waste. Completion of the second panel occurs during the first year of Stage 2 (2001), and mining of subsequent panels occurs in advance of emplacement operations.

## 4.2 Stage 2 Operations

### 4.2.1 Surface Facilities

It is assumed for the purposes of this report that, in Stage 2, 80% of the waste is shipped by rail (Subsection B.2; DOE, in review), 20% by truck, and that rail casks contain 12 PWR or 32 BWR spent fuel assemblies. To achieve an annual emplacement rate of 3,000 MTU, an average 2.6 truck casks and 1.7 rail casks/day must be processed. Spent fuel is consolidated in canisters that contain 6 PWR or 18 BWR assemblies at the rate of approximately 4 canisters/day. The end pieces and frames from consolidation operations are compacted and placed in separate canisters for disposal at the additional rate of approximately 2 canisters/day. These canisters have no thermal output; thus, the spacing is much closer than the spacing between the heat-producing canisters containing the fuel assemblies.

### 4.2.2 Waste Emplacement

Waste emplacement operations during the transition period (2001-2002) are the same as those described in Subsection 4.1.2. The emplacement of 3,000 MTU/yr in Stage 2 requires that 1,018 canisters/yr of consolidated spent fuel be emplaced through 2024. By that time, a total of 70,000 MTU will have been emplaced.

Waste emplacement operations in Stage 2 are similar to operations in Stage 1 (see Subsection 4.1.2), and the same equipment is used. Approximately six canisters/day will be emplaced, two of which contain fuel assembly hardware. Two sets of waste emplacement equipment are needed, one on a standby basis.

By the time the disposal area has been filled to capacity, all subsurface areas will have been incorporated in the waste emplacement area ventilation system. The operations period changes to a standby period that consists only of monitoring and maintenance until retrieval

is ordered or until the repository is permanently sealed. Cooling or ventilation air is not circulated through waste emplacement panels in the standby period, except as required to allow entry to a panel. Backfilling and decommissioning follow the standby period.

### 4.2.3 Continuing Underground Development

In Stage 2, mining and preparation of new waste emplacement panels occur while previously completed panels are being filled with waste. The mining occurs at a rate that permits separation of the ventilation systems for the mining and waste emplacement areas, which ordinarily requires that mining of at least one panel be completed in advance of waste emplacement. It is expected that mining will be completed one or more years before completion of waste emplacement.

## 4.3 Performance Confirmation Operations

Because the confirmation program has not yet been defined, the following assumptions have been made. The program will consist of instrumentation and monitoring of underground conditions, temperature, strain, displacement, fracturing, water content, etc., and sampling of selected rock specimens and waste canisters. The rock samples will be routinely tested to confirm design values of strength and other properties. The waste packages will be removed to the surface (thus demonstrating retrievability), opened, and the spent fuel will be removed. Samples of the materials used in canister construction (and corrosion, if present) will be prepared and examined. No onsite examination of spent fuel is anticipated. If fuel inspection should be necessary, the spent fuel will be packaged and shipped offsite for examination. It is expected that 1 in every 100 to 1,000 canisters will be removed for sampling.

## 4.4 Retrievability Period

Sufficient data will be obtained during the operating period to permit application for a license amendment to allow decommissioning at

the end of the operating period. Thus, major sampling will be necessary after the operating period. If, for some reason, the repository were not decommissioned immediately, current plans provide only a caretaker crew. The caretaker crew would maintain the site so that retrieval operations could be initiated, if necessary. Most facilities would be "mothballed" (maintained in a condition allowing reactivation), but operational status would not be maintained.

## 4.5 Manpower Requirements

Table 3-1 shows the preliminary estimates of the personnel required to conduct operations. The estimates in Table 3-1 are based on the following assumptions: 250 working days/yr, 3 shifts/day for waste receipt and mining operations, and 2 shifts/day for all other activities.

# 5.0 DESIGN, CONSTRUCTION, AND TESTING SCHEDULES

## 5.1 Basis and Method of Scheduling

Schedules for design, construction, and testing of repository facilities assume that an NRC construction authorization will have been granted by the end of August, 1993, as specified in the reference schedule in the Mission Plan (DOE, 1984a). It is also assumed that all preparatory work necessary to start actual construction will have been completed by that time. These preparations include

- completion of all NWPA requirements, including site nomination, characterization, recommendation, preparation of the environmental impact statement, designation, and construction authorization application;

- completion of Title II architect/engineer design packages for critical path facilities;

- selection of the construction manager and mobilization of key contractors; and

- engineering research, development, and initiation of any long-lead procurement items, if necessary.

The construction schedule is based on the description of the feasibility study provided in Section 3. The architectural/engineering companies have identified specific construction activities and have determined the sequence and duration of these activities based on their experience in scheduling and constructing other surface and subsurface projects.

The construction sequence and methods generally follow an approach similar to the construction of commercial nuclear plants. That approach permits procurement and construction to commence before engineering has

been completed, thus shortening the schedule. The schedule is predicated on the economic use of manpower as indicated in the feasibility study estimate rather than on the earliest possible completion date. No overtime is considered beyond the 5% necessary for casual overtime. As directed by the DOE, no allowances for uncertainties, such as work stoppages, regulatory delays, or funding constraints, have been included.

## 5.2 Transition from Construction to Operations

### 5.2.1 Transition from Construction to Operations in Stage 1

Figure 5-1 shows the detailed construction schedule for the two-stage development of the surface and underground facilities. Stage 1 construction is completed in late 1996, at which time the operating contractor for WHB-1 assumes responsibility for the repository from the building contractor. Mechanical and electrical systems in WHB-1 will have been tested to ascertain that they are functioning properly, and the HVAC systems will have been tested and balanced. At that time, all other facilities required for safe waste emplacement operations will be in place and ready for testing and demonstration. In addition to WHB-1, these facilities include:

- shafts and ramps,
- waste transporters,
- access drifts, emplacement drifts, and boreholes for the first panel,
- waste emplacement area exhaust shaft and filter building,
- underground bulkheads and other ventilation controls for the waste emplacement area exhaust system,
- waste treatment building,
- normal and standby power supplies,
- security facilities for the restricted area,
- vehicle decontamination and inspection facilities,
- health physics facilities, and
- computer and monitoring equipment.

REV.0 DATE 19-Jul-84

TWO-STAGE REPOSITORY DEVELOPMENT FEASIBILITY STUDY
---REPOSITORY CONSTRUCTION---

000000 = CRITICAL PATH

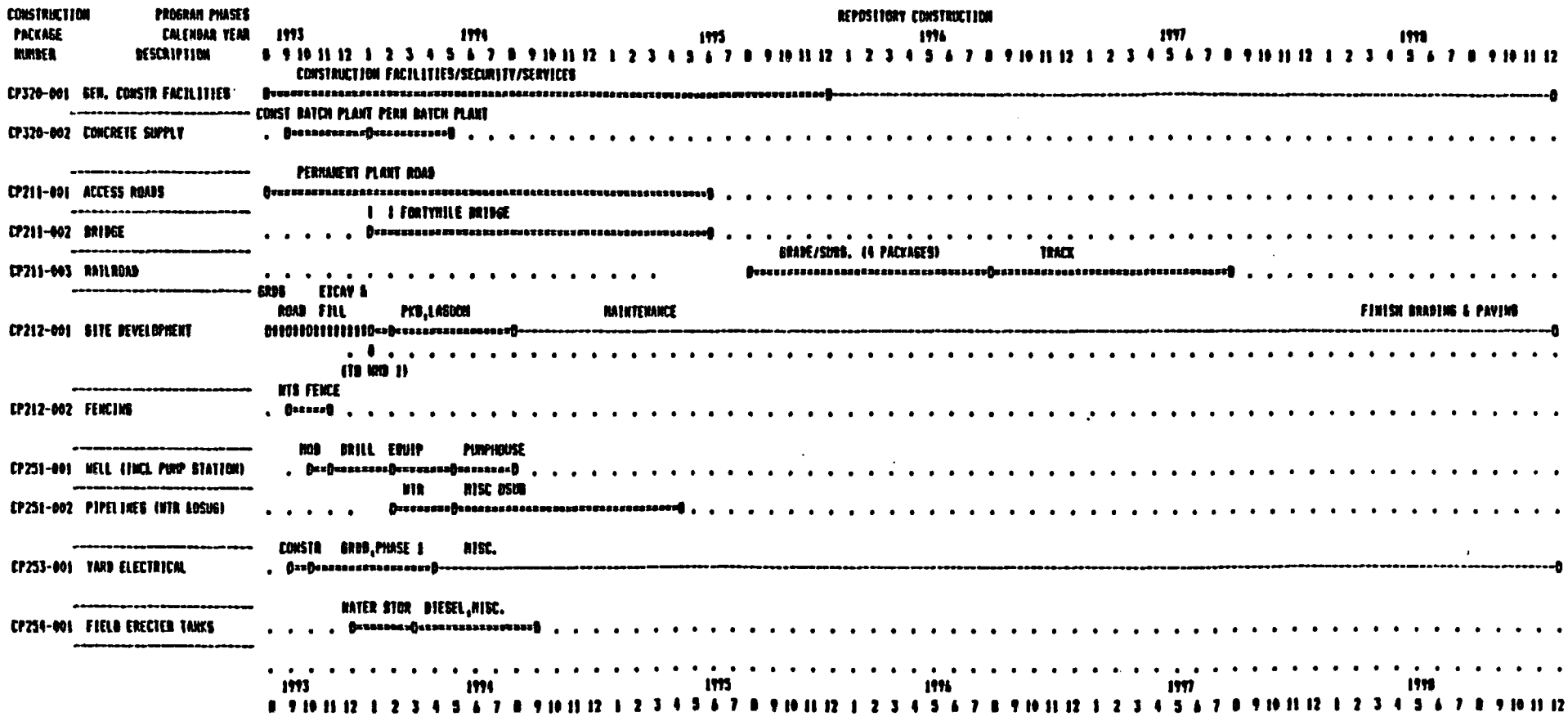



FIGURE 5-1

REV.0 DATE 19-Jul-84

TWO-STAGE REPOSITORY DEVELOPMENT FEASIBILITY STUDY
---REPOSITORY CONSTRUCTION---

000000 = CRITICAL PATH

REPOSITORY CONSTRUCTION

| CONSTRUCTION PACKAGE NUMBER | PROGRAM PHASES DESCRIPTION | CALENDAR YEAR 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|
| CP232-001 | MEN & MATERIALS SHAFT | | | | | | | |
| CP232-002 | WASTE EMPL EXHAUST SHAFT | | | | | | | |
| CP234-001 | WASTE RAMP & MAIN G3 DRIFT | | | | | | | |
| CP234-002 | ROCK RAMP & MAIN G2 DRIFT | | | | | | | |
| CP234-003 | WASTE EMPL AREA DR & SHOPS | | | | | | | |
| CP234-005 | MAIN ACCESS DRIFTS | P1 & P2 | | P3 | P4 | P5 | P6 | P7 |
| CP235-001 | MINE SHOPS | | | | | | | |
| CP234-006 | ACCESS DRIFTS | | | | | | | |
| CP242-001 | EQUIP MAIN & 2 | | | | | | | |
| CP234-007 | PERIPHERAL DRIFT | PANELS 1,2 & 3 | | | | P4 | P5 | P6 P7 |
| CP234-008 | VENT DRIFT | | | | | | | |
| CP234-009 | EMPLACEMENT ROOMS | | | PANEL 1 | PANEL 2 | PANEL 3 | PANEL 4 | |
| | | | | | PANEL 1 READY | PANEL 2 READY | PANEL 3 READY | |
| CP234-010 | DRILL & PREP EMPLACEMENT HOLE | | | | | | | |
| | D/G PREOP TEST | | | | | | | |
| | WASTE HANDLING BLDG #1 | | | 33 MONTHS | | | | |
| CP222-001 | STRUCTURAL/ARCHITECTURAL | SLAB FDN WALLS | | | | | | |
| | | EXDEDS & ELEV SLABS | & STEEL RFB | | | | | |
| CP222-002 | MECHANICAL/PIPING | | MECHANICAL/PIPING | | | | RECEIPT OF STAGE 1 WASTE | |
| CP222-003 | ELECTRICAL/CONTROLS | | ELECTRICAL/CONTROLS | | | | | |
| | PREOP TEST (BY OPERATOR) | | | | TURNOVER & PREOP TESTING | | | |
| | WASTE HANDLING BLDG # 2 | | | | | 33 MONTHS | | |
| CP222-004 | STRUCTURAL/ARCHITECTURAL | SLAB FOUNDATION,EXDEDS WALLS | | | | | | |
| | | ELEV SLABS | | STEEL RFB | | | | |
| CP222-005 | MECHANICAL/PIPING | | | MECHANICAL/PIPING | | | RECEIPT OF STAGE 2 WASTE | |
| CP222-006 | ELECTRICAL/CONTROLS | | | | ELECTRICAL CONTROLS | | | |
| | PREOP TEST (BY OPERATOR) | | | | | TURNOVER & PREOP TESTING | | |

REV.0 DATE 19-Jul-84

TWO-STAGE REPOSITORY DEVELOPMENT FEASIBILITY STUDY
---REPOSITORY CONSTRUCTION---

000000 = CRITICAL PATH

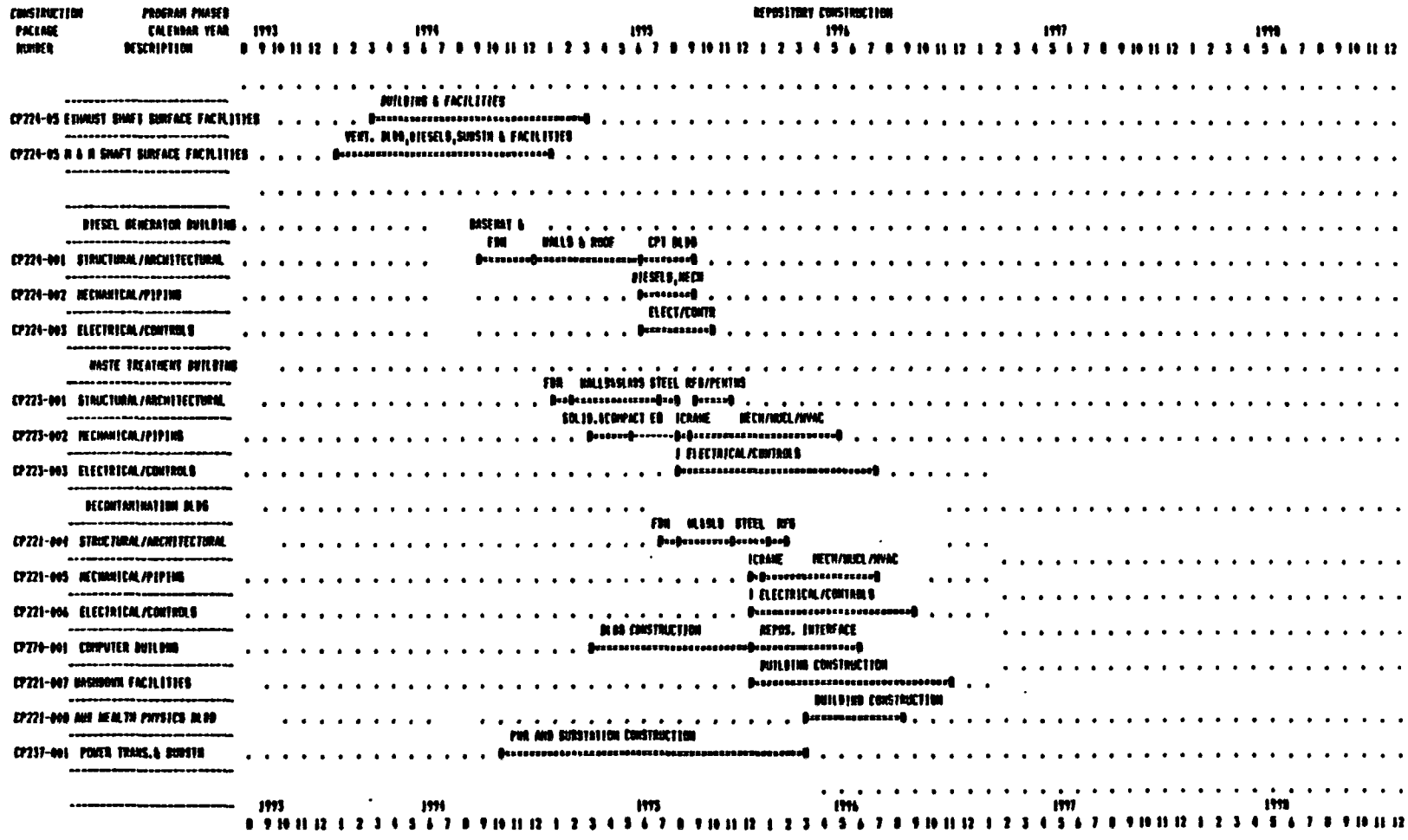



FIGURE 5-1

REV.0 DATE 19-Jul-84

TWO-STAGE REPOSITORY DEVELOPMENT FEASIBILITY STUDY
---REPOSITORY CONSTRUCTION---

000000 = CRITICAL PATH

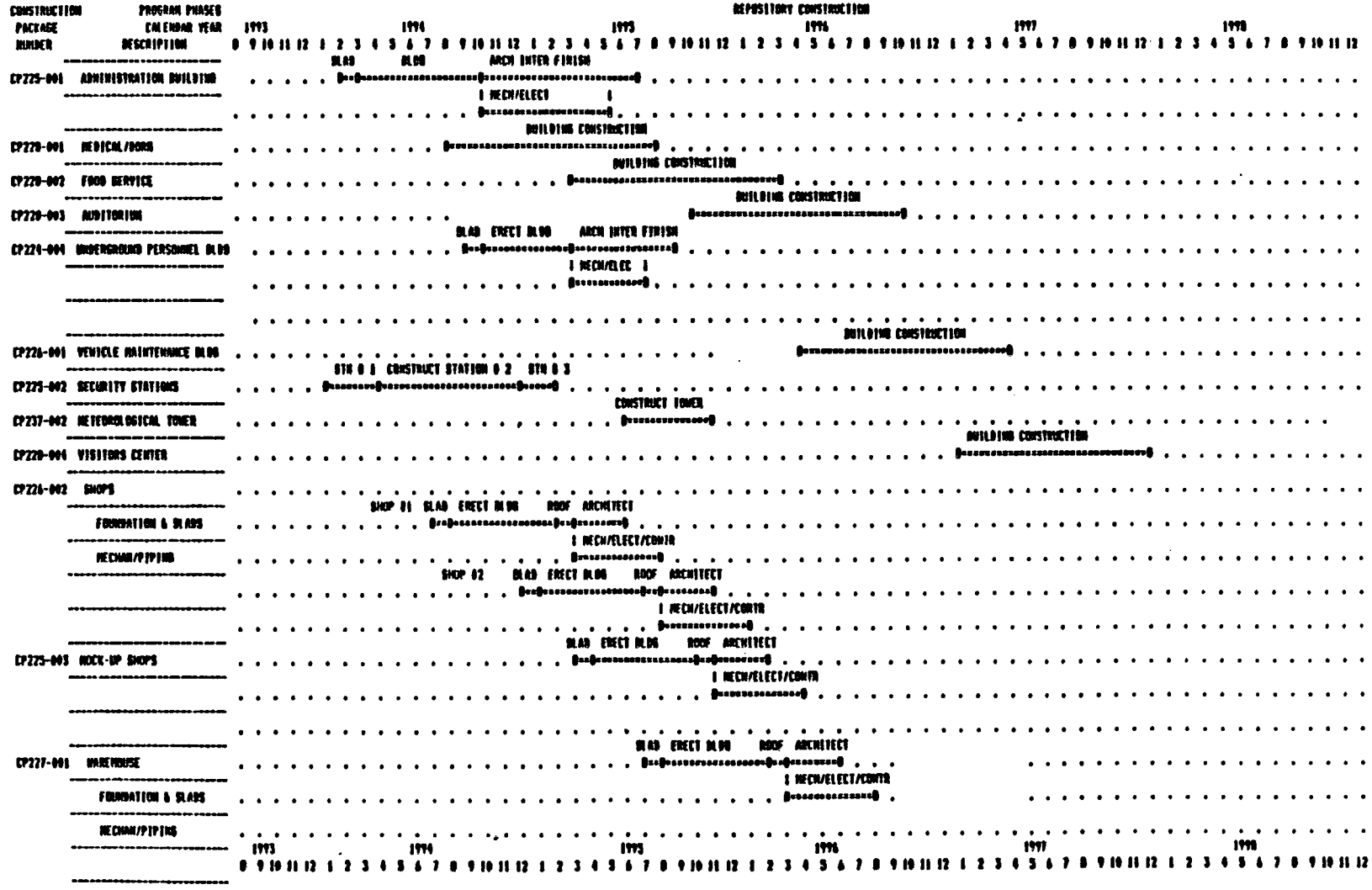



FIGURE 5-1

Other site facilities, such as administration, personnel, and other support buildings, will be complete enough to support Stage 1 operations.

The guidelines set forth in the DOE Mission Plan specify that operational testing be completed in a 6-mo period, as illustrated in Figure 5-1. Large and complex construction projects (such as oil refineries involving new processes) may require as much as 24 mo of preoperational testing leading to production. Engineering judgment suggests that the 6 mo allowed by the Mission Plan may be inadequate.

The equipment demonstrations will be performed using actual equipment, but simulated fuel assemblies will be used. Factors that will help to minimize the time required for preoperational testing and modification are (1) a prototype of unique pieces of equipment essential for Stage 1 operations will have been developed and tested independently on the site or elsewhere, and (2) the waste-handling system is an established mechanical operation that is not significantly influenced by process uncertainties such as high temperature and chemical instabilities.

A period of transition will occur during which construction activities and Stage 1 operations overlap. Some construction activities will not have been completed at the time preoperational tests and actual waste emplacement operations begin in Stage 1. These activities involve certain facilities common to both stages and the waste-handling facilities in Stage 2. Therefore, it will be necessary to provide temporary measures to separate construction and waste emplacement activities and personnel. These measures include installation of temporary fencing to regulate personnel access and modification of the power supply system.

These measures can be readily achieved as a result of the overall arrangement of the surface facilities. At the completion of preoperational testing in Stage 1 and upon receipt of appropriate NRC operating permits, waste receipt and emplacement in Stage 1 can begin without interfering with ongoing construction.

### 5.2.2 Transition from Construction to Operations in Stage 2

The transition from construction to full-scale operations in Stage 2 will be similar to the transition in Stage 1 except that no continuing construction activities will be involved. The waste-handling operations in Stage 2 are somewhat more complex than those in Stage 1, and the quantities of muck and radioactive waste are greater. Experience gained in testing and modification during Stage 1 will be of significant help in reducing the required preoperational testing period during Stage 2. However, as in Stage 1, the 6-mo testing period may be inadequate (see Subsection 5.2.1).

## 5.3 Critical Path Identification

### 5.3.1 Surface Facilities

The critical path for the overall construction program is shown in Figure S-1. The critical path for development of the site and WHB-1 is shown in Figure 5-1. Access roads, utilities, and other facilities that already exist to support the ESF are adequate to serve construction needs until additional temporary facilities can be put in place.

The construction program starts with site preparation activities (clearing, rough grading, etc.) in the area of the portal to the waste-handling ramp and WHB-1 and WHB-2. The primary objective in the early site preparation is to clear and level sufficient space for portal construction so that the boring of the waste-handling ramp can begin as soon as possible. Concurrently, the respective areas for WHB-1, WHB-2, and adjacent support areas for waste-handling operations, will be leveled and prepared for construction. The remaining site preparation work consists of leveling the site of the railcar marshalling yard and preparing areas for construction of conventional support and administration buildings. This preparation immediately follows site preparation for the waste-handling facilities to allow concurrent construction of the balance of the required facilities.

Those activities that comprise the critical path for the construction of WHB-1 include construction of the foundation and walls, mechanical piping, electrical/control testing, and preoperational testing of the facility.

### 5.3.2 Underground Facilities

It is assumed that a 12-ft-diameter ES and a 6-ft-diameter second shaft have been constructed before construction of the subsurface facilities commences in Stage 1. It is also assumed that all in situ testing essential to the Exploratory Shaft Test Program (ESTP) has been completed by the beginning of Stage 1 construction.

Before Stage 1 construction is completed, the ES will be converted to a fresh air intake for the waste emplacement area. A 25-ft-diameter men-and-materials shaft, a 19-ft-diameter muck-handling ramp, a 24-ft-diameter waste-handling ramp, and a 20-ft-diameter exhaust shaft for the waste emplacement area will be constructed. The necessary access drifts, connecting drifts, and emplacement drifts will be developed (see Figures 3-11 and 3-12).

The construction time required before emplacement can begin is 3.5 yr in the vertical emplacement mode and 3.3 yr in the horizontal mode.

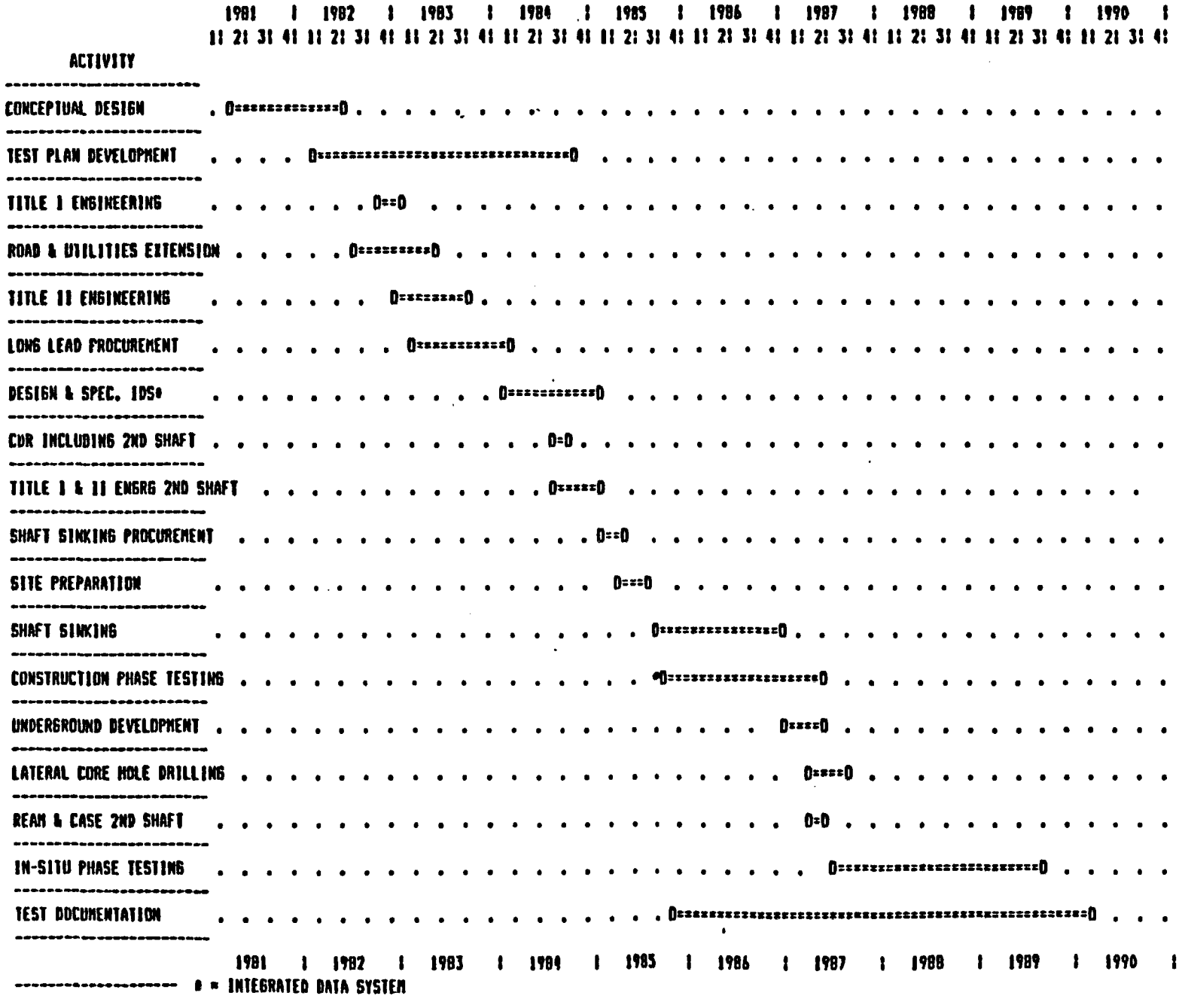
It is possible that the 12-ft-diameter ES may not be able to supply an adequate volume of air to the emplacement area. If so, it would be necessary either to construct an additional ventilation shaft or to enlarge the ES. The construction of an additional ventilation shaft has not been included in the construction schedule. Should enlargement of the ES or construction of an additional shaft be necessary, this construction would be performed concurrently with construction of the men-and-materials shaft and would have no effect on the overall schedule.

The underground facilities are not on the critical path of repository completion.

## 5.4 Exploratory Shaft Test Plan (ESTP)

In accordance with the DOE directive to include schedule information for the ESTP, the schedule shown in Figure 5-2 was developed by Los Alamos National Laboratory (LANL) (Division WX-4) and is included in this report for the purpose of providing schedule information. The ESTP is still evolving. Figure 5-2 shows the schedule for construction of the 12-ft-diameter ES and the 6-ft second shaft in the ESTP.

## EXPLORATORY SHAFT TEST PROGRAM



# 6.0 COST ESTIMATES

Five preconceptual cost estimates have been prepared: (1) for an ESF that includes a 12-ft-diameter shaft and a 6-ft-diameter shaft; (2) for a two-stage repository based on emplacement of canisters in short vertical holes; (3) for a two-stage repository based on emplacement of canisters in long horizontal holes; (4) for a repository based on vertical emplacement using the assumptions in the cost guidelines for a reference repository (Weston, 1984); and (5) for a repository based on horizontal emplacement using the assumptions in the cost guidelines for a reference repository. In order to avoid confusing the reference repository in the guidelines prepared by Weston with either of the reference repositories developed for this report, the reference repository in the cost guidelines will be referred to as the "reference repository" and the others will be referred to as a "revised reference repository," for the vertical or horizontal emplacement concepts, as appropriate.

Supporting cost information for all of the costs developed for this report are contained in the appendix.

## 6.1 Cost Estimates for an Exploratory Shaft Test Program

For purposes of developing the cost of a two-stage repository and a revised reference repository, it is assumed that the ESF includes a 12-ft-diameter shaft and a 6-ft-diameter shaft and that these two shafts are incorporated in the repository design to serve as ventilation supply shafts.

Cost information for the ESTP was furnished by LANL and by DOE's Nevada Operations Office. SNL and Parsons Brinckerhoff have addressed several options for adding a shaft or a ramp to the ESTP to provide a second means of access and egress to the ESF (SNL, 1984a). The SNL study was used as the basis for estimating the cost of the second shaft. The costs for the ESTP are summarized in Table 6-1.

TABLE 6-1

SUMMARY COSTS FOR AN EXPLORATORY SHAFT TEST PROGRAM
(Mid-1984 Dollars in Millions)

| | Prior Years | FY84 | FY85 | FY86 | FY87 | FY88 | FY89 | FY90 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| 12-Ft-Diameter ES and Facilities | 10.4 | 3.0 | 12.4 | 35.3 | 30.3 | 18.2 | 9.5 | 2.4 | 121.5 |
| 6-Ft-Diameter Second Shaft | - | 0.3 | 0.2 | - | 2.4 | - | - | - | 2.9 |
| TOTALS | 10.4 | 3.3 | 12.6 | 35.3 | 32.7 | 18.2 | 9.5 | 2.4 | 124.4 |

Source: DOE Nevada Operations Office.

## 6.2 Cost Estimates for the Repositories

All cost estimates are based on preconceptual engineering information developed by the architect/engineering firms. The development of the costs for the various versions of the repository conforms to the instructions contained in the cost guidelines: costs were developed for engineering and construction, operation, and decommissioning for each work breakdown element of the work breakdown structure provided in the guidelines. For the two-stage estimates, costs were further broken down into costs for Stage 1, costs for Stage 2, and costs common to both stages.

To account for any additional quality assurance that may be required in order to comply with unforeseen licensing requirements, all costs were increased by 5%.

Contingency was added to all costs by evaluating the complexity of each line item in the estimate summary on a scale of 1 to 5 and applying contingency appropriate to the complexity. The contingency percentages used are outlined in Table 6-2. Contingency is provided to cover unforeseen and unpredictable circumstances but does not provide for increasing the scope of the project.

TABLE 6-2

COMPLEXITY VALUES AND CONTINGENCY

| Complexity Number | Contingency % |
|---|---|
| 1 | 20 |
| 2 | 25 |
| 3 | 30 |
| 4 | 35 |
| 5 | 40 |

### 6.2.1 Cost of Engineering and Construction

Estimated capital costs include Titles I, II, and III engineering and other similar architect/engineer services. Engineering costs were estimated as a percentage of total construction costs. The percentage to be used was determined by using the complexity number previously described and by assigning an appropriate engineering percentage to be used with each complexity value. The percentages used are outlined in Table 6-3.

Total construction cost includes the cost for overall construction management, which has been estimated at 10% of total construction cost (direct construction cost plus indirect construction cost). Construction management includes formulation of contract packages for advertisement, bid, and award; monitoring and inspection of construction in progress; at-cost provision of certain common services, such as concrete supply, materials testing, and site security; and other similar activities.

The information used in preparing the construction cost estimate consists of drawings, sketches, flowsheets, equipment lists, and scope narratives. Estimating methods consistent with the preconceptual nature of the design information have been used. Wherever possible, comparisons have been made to ongoing or completed projects. Costs are stated at mid-1984 price and wage levels and have not been escalated.

TABLE 6-3

COMPLEXITY VALUES AND ENGINEERING

| Complexity Number | Engineering % |
|---|---|
| 1 | 5 |
| 2 | 10 |
| 3 | 15 |
| 4 | 20 |
| 5 | 25 |

The estimate is based on the following assumptions.

- Design and QA procedures are similar to those applied to recent commercial nuclear projects.
- Equipment and materials come from U.S. sources.
- Commercially available delivery schedules are acceptable.
- Craft and professional personnel are available in the general project area, including Las Vegas.

Surface Facility Construction Costs

The cost estimate for construction of the surface facilities includes:

- site access,
- site improvements,
- waste-receiving buildings,
- waste-handling buildings,
- waste treatment buildings,
- support buildings,
- service buildings,
- maintenance buildings,
- warehouses,

- miscellaneous buildings, and
- utilities.

Costs of special facilities and standard equipment associated with the above have also been included in the estimate. The greatest building cost is associated with the waste-handling buildings. These buildings contain hot cells in which spent fuel and/or waste are handled and include the performance confirmation facilities and packaging facilities.

The construction cost estimate for the surface facilities includes the direct cost of permanent equipment, materials, and labor and indirect costs.

A parametric estimating approach is routinely used to estimate direct costs where design detail is not available. Materials and equipment quantities have been obtained from preconceptual drawings. The onsite average construction unit labor rate used is based on craft agreements at the NTS and on crew mix distributions developed from current estimating standards. Rates used are in accordance with the Davis-Bacon wage rates for the area and include all applicable additives and allowances, including travel. Indirect costs include temporary construction facilities, miscellaneous construction services, construction equipment, and tools.

Underground Facility Construction Costs

The construction estimate for the underground facilities reflects the cost for all excavation from the start of construction through station development to a phased start of waste emplacement. The tasks that make up these costs are drilling, loading, blasting, mucking, and installing rockbolts, mesh, and shotcrete. The construction estimate also includes the shafts and ramps, and the conveyor, ventilation, electrical distribution, and instrumentation systems. All labor, equipment, material, and utilities required for these tasks and systems are included.

The estimate is based on the following factors:

- Davis-Bacon wage rates,
- 250 operating days/yr,
- 3 shifts/day,
- 6.25 productive hr/8-hr shift,
- 3-mo learning curve for new workers, and
- replacement of mining equipment every 5 yr.

The amounts of underground work to be performed have been calculated from the layouts presented in this report or from the design criteria. The procedure for determining the costs of the work took into account cycle times for drilling and mucking, the drilling pattern, powder factors, and equipment requirements. The number of miners and the equipment necessary to perform the items of work at the selected hourly productions were determined. Material unit prices were applied to the quantities of material required to perform the work.

### 6.2.2 Cost of Operations

In order to estimate the cost of operation of the repository, it was assumed that an operating contractor would be selected by DOE and that the operating contractor would be responsible for all aspects of the operation of the repository. It was also assumed that the operating contractor would subcontract underground mining and maintenance activities but would retain responsibility for underground emplacement and retrieval activities. The only retrieval costs included in the estimates were those associated with the performance confirmation program. All costs reflect mid-1984 prices and wage levels for the appropriate crafts.

Functions associated with repository operation include: waste receiving, i.e., activities associated with spent fuel or other waste while within the original shipping cask or container; waste handling, i.e., activities involving unshielded spent fuel or other waste, such as packaging of incoming material and repackaging of material during

performance confirmation; waste emplacement (retrieval), i.e., loading (unloading) canisters into (from) the transporter; transporting canisters to (from) the emplacement area; emplacement (retrieval) of the canister into (from) the previously prepared emplacement hole and placing (removing) the plug in (from) the emplacement hole; support, i.e., activities directly supporting waste operations, such as treatment and repair; mining, i.e., removal of rock from the working faces (by blasting or by use of a tunnel-boring machine), conveying the muck to the surface; placement of rock support features, drilling of boreholes, and placement of the liner in the borehole; underground maintenance, i.e., maintaining the integrity of the ground support systems and the ventilation flow paths for both the mining area and the emplacement area; and utility operation.

Costs of operation were developed for three periods: (1) emplacement, (2) caretaker (standby), and (3) backfilling. The method of estimating the costs associated with each of these periods is described in the following paragraphs.

Emplacement Period Costs

Based on the emplacement schedule contained in the cost guidelines (Weston, 1984), it is assumed that the emplacement periods are 27 yr for the two-stage repositories and 25 yr for the revised reference repositories.

The operating and maintenance costs for the surface facilities were estimated for a typical year of plant operation, and the annual costs were multiplied by the number of years. Minor adjustments were made to the annual costs for the first several years to account for reduced staffing requirements during startup. Costs include operating labor and supplies, maintenance labor and materials, utilities, and personnel transportation costs. Operating labor costs are based on staffing requirements for two operating shifts and on a third shift for maintenance and surface support of underground operations. Based on studies of similar projects, an average loaded salary of $50,000/yr has

been assumed for all personnel. The annual costs for supplies consumed in the operation of the plant are included. These costs are based on estimated quantities, vendor quotations, catalogs, and current experience. The costs of labor and materials for plant maintenance have been assessed at 3% of plant construction costs. The cost of electric power is the major utility. Power costs are based on estimated load requirements and on an average rate of $0.0467/kWh. Employee transportation costs are based on roundtrip transportation for all personnel via chartered bus from Las Vegas.

Costs for waste emplacement were determined by multiplying the estimated cost for emplacing one canister by the total number of canisters. Retrieval costs for performance confirmation were estimated in a similar manner, assuming that 1 canister/mo would be retrieved during the last 20 yr of the emplacement period.

Underground excavation (mining) was considered to be a continuation of construction activities for costing purposes; therefore, underground operating and maintenance costs have been determined using the same method as that used for estimating engineering and construction costs, except that engineering costs were not included. At the estimated mining rate, excavation of the entire emplacement area will be complete approximately 20 yr after start of emplacement. Therefore, it was assumed that underground maintenance crews will be needed for the balance of the emplacement period, and an annual cost for these crews was developed. The annual cost was then multiplied by the number of years remaining after completion of mining and before completion of emplacement.

Caretaker Period Costs

The maximum time required to preserve the ability to retrieve is 50 yr after start of emplacement [see 10 CFR 60, Sec. 60.111(b)(1) (NRC, 1983)]. The caretaker period is that period of time between the end of emplacement and 50 yr from the start of emplacement; in the case of the two-stage repositories, the caretaker period is 23 yr and, in the case of the revised reference repositories, 25 yr.

It was assumed that only those buildings, or parts of buildings, required to support the maintenance activities and the performance confirmation program will be maintained in a fully operable condition. These buildings include the administration building, the computer building, the fire station, the warehouse, the maintenance shops, security headquarters, the performance confirmation support facility, the men-and-materials shaft portal building, and the underground ventilation building. The remaining surface facilities and buildings, and the unused portions of the buildings listed above, would be mothballed. Highway access would be fully maintained, but only minimal maintenance would be performed on the railroad.

Costs for operation of the surface facilities during the caretaker period were derived using methods similar to those used in deriving the costs for the emplacement period by estimating the staffing requirements for the curtailed activities described above. It was assumed that most of the performance confirmation requirements would be completed during the emplacement period and that the retrieval of only one canister per year would be required during the caretaker period. It was assumed that the annual costs for the maintenance of the subsurface facilities during the final years of the emplacement period, as described above, will continue during the caretaker period.

Backfilling Period Costs

It was assumed that backfilling will not start until the end of the caretaker period. Assuming that screened tuff from the surface muck pile will be returned to the underground by reversing the belt conveyor originally used to carry the muck to the surface, it will require 7 yr to backfill the disposal area.

The operating costs for the surface facilities during the backfilling period were derived using methods similar to those used for the caretaker period except that the size of the surface crews engaged in backfilling operations was derived on a per-ton basis using methods similar to those used in deriving the costs for mining. It was assumed

that the density of the backfill will be 60% of the original density. It was also assumed that the underground maintenance costs used during the final years of emplacement and during the caretaker period will continue during most of the backfilling period.

The requirements for backfilling the tuff repository are still being evaluated as the conceptual design is developed. If it is determined that backfilling is not required, the cost of the repository may be reduced by the cost of backfilling.

### 6.2.3 Cost of Decommissioning

For purposes of estimating the cost of decommissioning, it is assumed that the surface facilities will be put to other uses by the operating contractor at the NTS after decommissioning. Therefore, for the surface facilities, only the costs for decontaminating the waste-handling buildings have been included in the decommissioning costs. The decommissioning costs for the underground facilities include sealing and backfilling the shafts and ramps.

It is assumed that the cost for decontaminating the waste-handling buildings is approximately 10% of the construction costs, plus an allowance for contingency. The costs for sealing and backfilling the ramps and shafts have been developed in a manner similar to that for the costs of construction.

## 6.3 Comparison of Costs for Vertical Emplacement

Using the methods outlined in Subsection 6.2, the costs of the revised reference repositories and the costs of the two-stage repositories have been developed for both vertical and horizontal emplacement. Revised reference repository costs have been developed for use in this study instead of the reference case developed in the original cost guidelines (Weston, 1984) because it was felt that comparison of estimates developed by the same organizations, on the same bases, and using the same methods would be more meaningful.

In the remainder of this section, only the costs for vertical emplacement are discussed because vertical emplacement has been chosen as the base case. Cost comparisons for horizontal emplacement are discussed in Section 7.

Table 6-4 summarizes the cost of a revised reference repository, Table 6-5 summarizes the cost of a two-stage repository, and Table 6-6 compares the cost of these two approaches to repository construction. It is assumed that the ES configuration (one 12-ft-diameter shaft and one 6-ft-diameter shaft) is the same for both Stage 1 and Stage 2. The cost of the ESTP is not included in the cost tables cited above. Table 6-7 contains definitions of the cost breakdown elements used in Tables 6-4, 6-5, and 6-6. The definitions were taken from Weston (1984). Tables 6-8 and 6-9 summarize the engineering costs for the revised reference and two-stage repositories.

TABLE 6-4

SUMMARY COSTS FOR A REVISED REFERENCE REPOSITORY - VERTICAL EMPLACEMENT
(Mid-1984 Dollars in Millions)

| | Engineering and Construction | Operation | Decommissioning | Total |
|---|---|---|---|---|
| WASTE PREPARATION | 310 | 1,508 | 29 | 1,847 |
| Waste Form Subsystem | 87 | 0 | 0 | 87 |
| Waste Package Subsystem | 223 | 1,508 | 29 | 1,760 |
| REPOSITORY SYSTEM | 726 | 4,153 | 6 | 4,885 |
| Site | 182 | 0 | 0 | 182 |
| Waste Handling and Emplacement | 128 | 1,134 | 1 | 1,263 |
| Underground Workings and Muck Handling | 194 | 425 | 2 | 621 |
| Ventilation | 88 | 298 | 3 | 389 |
| Support/Utilities | 134 | 2,296 | 0 | 2,430 |
| TOTALS | 1,036 | 5,661 | 35 | 6,732 |

## TABLE 6-5

### SUMMARY COSTS FOR A TWO-STAGE REPOSITORY - VERTICAL EMPLACEMENT
(Mid-1984 Dollars in Millions)

| | Engineering and Construction | Operation | Decommis-sioning | Total |
|---|---|---|---|---|
| WASTE PREPARATION | 394 | 1,547 | 37 | 1,978 |
| Waste Form Subsystem | 100 | 0 | 0 | 100 |
| Waste Package Subsystem | 294 | 1,547 | 37 | 1,878 |
| REPOSITORY SYSTEM | 736 | 4,294 | 6 | 5,036 |
| Site | 182 | 0 | 0 | 182 |
| Waste Handling and Emplacement | 134 | 1,138 | 1 | 1,273 |
| Underground Workings and Muck Handling | 198 | 425 | 2 | 625 |
| Ventilation | 88 | 298 | 3 | 389 |
| Support/Utilities | 134 | 2,433 | 0 | 2,567 |
| TOTALS | 1,130 | 5,841 | 43 | 7,014 |

TABLE 6-6

COMPARISON OF COSTS FOR A REVISED REFERENCE REPOSITORY AND A TWO-STAGE REPOSITORY
- VERTICAL EMPLACEMENT
(Mid-1984 Dollars in Millions)

| | Reference Repository | | Two-Stage Repository | | Differential | |
|---|---|---|---|---|---|---|
| WASTE PREPARATION | | 1,847 | | 1,978 | | +131 |
| Waste Form Subsystem | 87 | | 100 | | +13 | |
| Waste Package Subsystem | 1,760 | | 1,878 | | +118 | |
| REPOSITORY SYSTEM | | 4,885 | | 5,036 | | +151 |
| Site | 182 | | 182 | | 0 | |
| Waste Handling and Emplacement | 1,263 | | 1,273 | | +10 | |
| Underground Workings and Muck Handling | 621 | | 625 | | +4 | |
| Ventilation | 389 | | 389 | | 0 | |
| Support/Utilities | 2,430 | | 2,567 | | +137 | |
| TOTALS | | 6,732 | | 7,014 | | +282 |

TABLE 6-7

DEFINITIONS OF COST BREAKDOWN ELEMENTS

WASTE PREPARATION

Waste Form Subsystem--Volume reduction equipment, including equipment for consolidation of spent fuel, and performance confirmation hot cell equipment.

Waste-Packaging Subsystem--Canisters for spent fuel and hardware, packages for waste generated onsite, packaging facilities, and facilities for loading, sealing, and testing. Facilities for treatment of waste generated onsite.

REPOSITORY SYSTEM

Site--Land and land rights; onsite and offsite improvements.

Underground Workings/Muck-Handling--Men-and-materials shafts, shaft pillars and facilities, access corridors, muck-handling, and muck pile.

Waste-Handling and Emplacement--Receiving and decontamination facilities, waste-handling ramp, emplacement drifts, emplacement boreholes, and transfer equipment.

Ventilation--Ventilation structures on the surface for the underground facilities, ventilation supply shafts, mining exhaust shafts, ventilation flow paths, and waste emplacement area exhaust shaft.

Support and Utilities--All support facilities and utilities and the operation of these facilities not included in the categories listed above.

Sources: Weston, 1984; DOE, 1984e, 1984g, and 1984h.

TABLE 6-8

ENGINEERING COSTS FOR THE REVISED REFERENCE REPOSITORY
- VERTICAL EMPLACEMENT
(Mid-1984 Dollars in Millions)

| | |
|---|---|
| Title I | 35.1 |
| Title II | 77.2 |
| Title III | 28.1 |
| TOTAL | 140.4 |

TABLE 6-9

ENGINEERING COSTS FOR A TWO-STAGE REPOSITORY
- VERTICAL EMPLACEMENT
(Mid-1984 Dollars in Millions)

| | |
|---|---|
| Title I | 39.6 |
| Title II | 87.0 |
| Title III | 31.7 |
| TOTAL | 158.3 |

# 7.0 ALTERNATE CONCEPTS

## 7.1 Horizontal Waste Emplacement

### 7.1.1 Description

In the horizontal waste emplacement mode, waste canisters are emplaced in long horizontal boreholes drilled in the wall of the emplacement drifts. The current design permits emplacement of 34 canisters in each borehole and offers the following advantages over the vertical emplacement method.

- The emplacement drifts may be designed so that temperatures throughout the 50-yr retrieval period are low; thus, the need to blast-cool the emplacement drifts before re-entry may be reduced or eliminated entirely.

- There is less opportunity for accidents because the reduction in the number of emplacement holes requires fewer operating personnel.

- Safety is improved because fewer personnel are exposed to mining hazards as the result of the reduction in mined material.

- Because fewer emplacement drifts are needed, there is a 78% reduction in mined material, resulting in significantly lower costs.

- Additional cost savings result from a reduction in capital and operating costs for ventilation and other support facilities.

- The lower extraction ratio may increase the structural integrity of underground openings.

- Muck volume is reduced, decreasing the visual and environmental impacts of the muck pile.

The disadvantage of the horizontal emplacement mode is that it has not yet been demonstrated. In order to establish confidence in the advantages listed above, two tasks must be accomplished: (1) machinery for emplacement and retrieval must be designed, built, and tested, and (2) machinery for drilling long horizontal holes must also be designed, built, and tested. It is not expected that any technological obstacles will prevent these tasks from being accomplished.

### 7.1.2 Cost Comparison

Using the methods outlined in Subsection 6.2, the cost of a revised reference repository and the cost of a two-stage repository have been developed for horizontal emplacement. Table 7-1 summarizes the cost of horizontal emplacement in a revised reference repository. Table 7-2 summarizes the cost of horizontal emplacement in a two-stage repository. Table 7-3 compares the cost of horizontal emplacement in a revised reference repository to the cost of horizontal emplacement in a two-stage repository. Table 7-4 compares the cost of horizontal emplacement in a two-stage repository to the cost of vertical emplacement in a two-stage repository (as costed in Section 6).

Tables 7-5 and 7-6 summarize the engineering costs of the revised reference and two-stage repositories. The definitions contained in Table 6-6 also apply to these tables. Supporting detail for the costs contained in this subsection may be found in the appendix.

## 7.2 Utilization of the E-MAD Facility

The E-MAD facility is located on the NTS approximately 10 mi from the central surface facilities site east of Exile Hill. This facility was constructed during the mid-1960s to maintain, assemble, and disassemble nuclear rocket engines being tested nearby as part of the NERVA Program. Since that time, the facility has been used by the Nevada Nuclear Waste Storage Investigations (NNWSI) Project to demonstrate the feasibility of various methods of storing and handling spent fuel. The E-MAD facility is

TABLE 7-1

SUMMARY COSTS FOR A REVISED REFERENCE REPOSITORY - HORIZONTAL EMPLACEMENT
(Mid-1984 Dollars in Millions)

| | Engineering and Construction | | Operation | | Decommis-sioning | | Total | |
|---|---|---|---|---|---|---|---|---|
| WASTE PREPARATION | | 310 | | 1,508 | | 29 | | 1,847 |
| Waste Form Subsystem | 87 | | 0 | | 0 | | 87 | |
| Waste Package Subsystem | 223 | | 1,508 | | 29 | | 1,760 | |
| REPOSITORY SYSTEM | | 658 | | 3,064 | | 6 | | 3,728 |
| Site | 182 | | 0 | | 0 | | 182 | |
| Waste Handling and Emplacement | 108 | | 630 | | 1 | | 739 | |
| Underground Workings and Muck Handling | 158 | | 70 | | 2 | | 230 | |
| Ventilation | 85 | | 243 | | 3 | | 331 | |
| Support/Utilities | 125 | | 2,121 | | 0 | | 2,246 | |
| TOTALS | | 968 | | 4,572 | | 35 | | 5,575 |

TABLE 7-2

SUMMARY COSTS FOR A TWO-STAGE REPOSITORY - HORIZONTAL EMPLACEMENT
(Mid-1984 Dollars in Millions)

| | Engineering and Construction | | Operation | | Decommis-sioning | | Total |
|---|---|---|---|---|---|---|---|
| WASTE PREPARATION | | 394 | | 1,547 | | 37 | 1,978 |
| Waste Form Subsystem | 100 | | 0 | | 0 | 100 | |
| Waste Package Subsystem | 294 | | 1,547 | | 37 | 1,878 | |
| REPOSITORY SYSTEM | | 669 | | 3,271 | | 6 | 3,946 |
| Site | 182 | | 0 | | 0 | 182 | |
| Waste Handling and Emplacement | 116 | | 635 | | 1 | 752 | |
| Underground Workings and Muck Handling | 161 | | 71 | | 2 | 234 | |
| Ventilation | 85 | | 243 | | 3 | 331 | |
| Support/Utilities | 125 | | 2,332 | | 0 | 2,447 | |
| TOTALS | | 1,063 | | 4,818 | | 43 | 5,924 |

## TABLE 7-3

### COMPARISON OF COSTS FOR A REVISED REFERENCE REPOSITORY AND A TWO-STAGE REPOSITORY - HORIZONTAL EMPLACEMENT (Mid-1984 Dollars in Millions)

| | Reference Repository | | Two-Stage Repository | | Differential | |
|---|---|---|---|---|---|---|
| WASTE PREPARATION | | 1,847 | | 1,978 | | +131 |
| Waste Form Subsystem | 87 | | 100 | | +13 | |
| Waste Package Subsystem | 1,760 | | 1,878 | | +118 | |
| REPOSITORY SYSTEM | | 3,728 | | 3,946 | | +218 |
| Site | 182 | | 182 | | 0 | |
| Waste Handling and Emplacement | 739 | | 752 | | +13 | |
| Underground Workings and Muck Handling | 230 | | 234 | | +4 | |
| Ventilation | 331 | | 331 | | 0 | |
| Support/Utilities | 2,246 | | 2,447 | | +201 | |
| TOTALS | | 5,575 | | 5,924 | | +349 |

TABLE 7-4

COMPARISON OF COSTS FOR A TWO-STAGE REPOSITORY USING HORIZONTAL EMPLACEMENT AND A TWO-STAGE REPOSITORY USING VERTICAL EMPLACEMENT
(Mid-1984 Dollars in Millions)

| | Horizontal | | Vertical | | Differential | |
|---|---|---|---|---|---|---|
| WASTE PREPARATION | | 1,978 | | 1,978 | | 0 |
| Waste Form Subsystem | 100 | | 100 | | 0 | |
| Waste Package Subsystem | 1,878 | | 1,878 | | 0 | |
| REPOSITORY SYSTEM | | 3,946 | | 5,036 | | +1,090 |
| Site | 182 | | 182 | | 0 | |
| Waste Handling and Emplacement | 752 | | 1,273 | | +521 | |
| Underground Workings and Muck Handling | 234 | | 625 | | +391 | |
| Ventilation | 331 | | 389 | | +58 | |
| Support/Utilities | 2,447 | | 2,567 | | +120 | |
| TOTALS | | 5,924 | | 7,014 | | +1,090 |

TABLE 7-5

ENGINEERING COSTS FOR A REVISED REFERENCE REPOSITORY
- HORIZONTAL EMPLACEMENT
(Mid-1984 Dollars in Millions)

| | |
|---|---|
| Title I | 33.8 |
| Title II | 74.4 |
| Title III | 27.0 |
| TOTAL | 135.2 |

TABLE 7-6

ENGINEERING COSTS FOR A TWO-STAGE REPOSITORY
- HORIZONTAL EMPLACEMENT
(Mid-1984 Dollars in Millions)

| | |
|---|---|
| Title I | 38.3 |
| Title II | 84.3 |
| Title III | 30.7 |
| TOTAL | 153.3 |

equipped to handle large, radioactive objects and could be modified to serve as WHB-1, provided an interim NRC permit to receive and handle spent fuel can be obtained.

A preliminary study of the feasibility of using the existing E-MAD facility as an alternative to designing and constructing a new waste-handling building for Stage 1 has been completed. Possible advantages to be gained from this alternative are that

- the schedule time is shortened between project authorization and initiation of emplacement of the first waste, and
- overall project costs are reduced through utilization of existing, fully depreciated facilities.

During the study, design aspects of the existing buildings, installed features, and equipment of the E-MAD facility were reviewed and inspected. A process has been developed for receiving, handling, and packaging 400 MTU/yr of spent fuel and for storing 100 MTU of spent fuel within or adjacent to the existing structure. Modifications to the E-MAD facility needed to achieve the process flow requirements have been identified. Figure 7-1 shows a concept that illustrates these modifications. Other concepts, which use outside surface storage in vertical dry wells or in shipping casks, are also considered feasible and may be preferable from an economic or operational standpoint.

A preliminary assessment has also been made to determine what modifications to the E-MAD facility would be necessary to obtain an NRC permit. Features to facilitate licensing have been incorporated in the preconceptual design. Details on possible licensing implications are discussed in Subsection 8.1.

The results of the analysis indicate that the E-MAD facility could serve as a waste-handling building in Stage 1 after some major modifications. The most feasible approach to obtaining an NRC operating permit for the E-MAD facility is to request a permit that limits the operating period at this facility to 3 to 5 yr.

The E-MAD facility also appears to be a feasible alternative in terms of construction status, location, and schedule; however, further evaluation is needed. It is possible that the total construction costs of using the E-MAD facility in Stage 1 would be larger than those for constructing a new WHB-1 as part of the central facilities at Yucca Mountain. The E-MAD facility would operate for a maximum of 5 yr; therefore, a larger WHB-2 would have to be built to accommodate functions that would otherwise have been performed in WHB-1 (see Subsection 7.4). Moreover, it would be necessary to study construction of a heavy-duty road to be used exclusively for transport of canistered waste from the E-MAD building to the portal of the waste-handling ramp. It would also

SIZE D 22 x 34

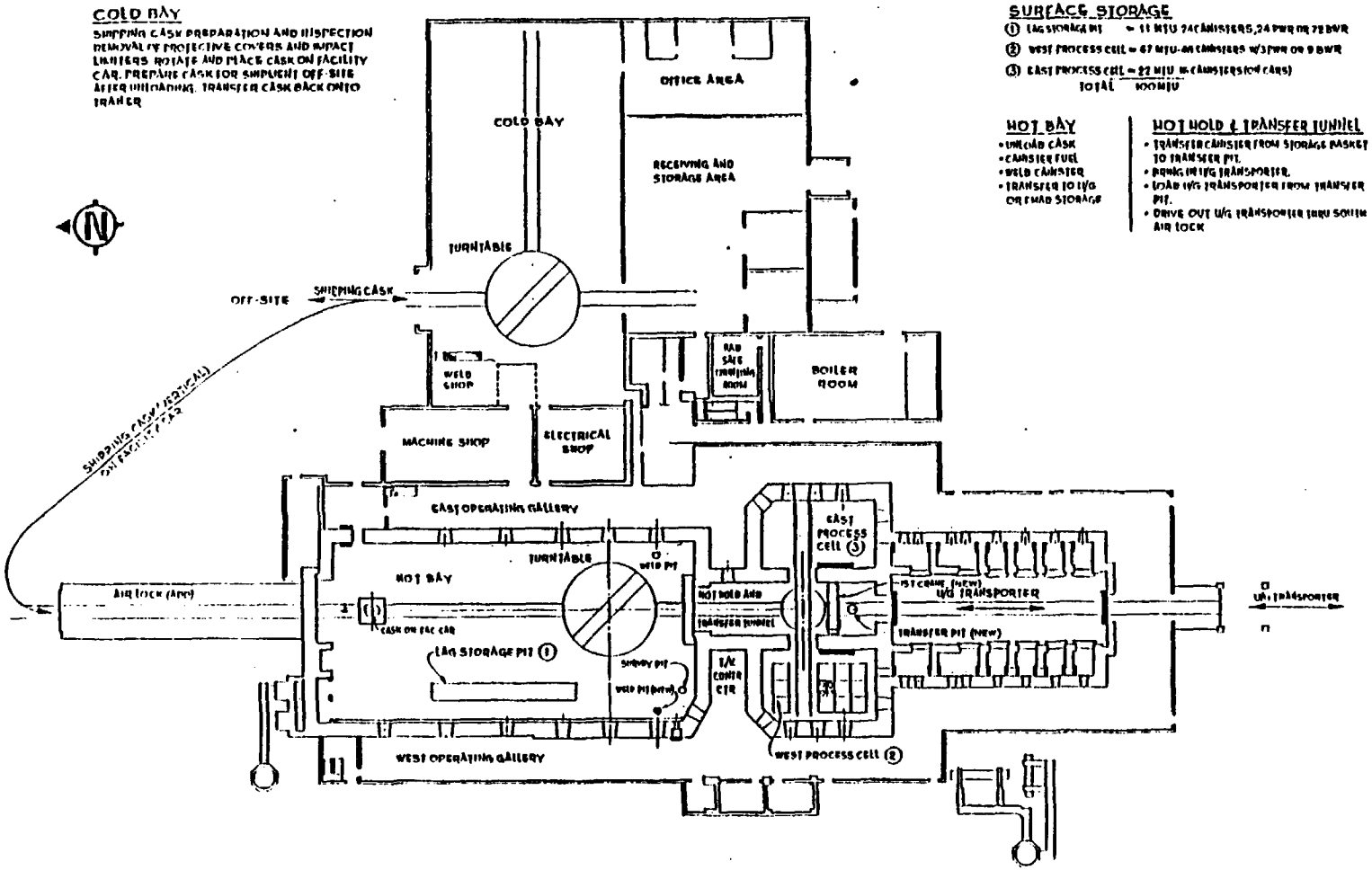



FIGURE 7-1

| REV | DATE | REVISION DESCRIPTION | BY | CHK | APPD | PE |
|---|---|---|---|---|---|---|
| A | | ISSUED FOR TWO-PHASE STUDY | TF | JZ | | |

PROPERTY OF
SANDIA NATIONAL LABORATORIES

DEVELOPED BY
BECHTEL, SAN FRANCISCO
SNL CONTRACT NO. 52 9817: CHANGES REQUIRE PRIOR APPROVAL OF THE PROCURING AGENCY

TITLE
E-MAD FACILITY MODIFICATION PLAN

| | | | |
|---|---|---|---|
| DWG APPROVED | DATE | DWG APPROVED | DATE |
| BECHTEL JOB NO. 18039 | DWG CLASS UNC | DWG SIZE D | REV 0 |
| INTERFACE DWG NO. SK-222-M-100 | REV A | SYS DWG NO. | |

be necessary to perform a safety analysis of a joint-use road and to study the results of the safety analysis as they affect design of the waste transporter.

The unresolved issue of E-MAD licensability, even for a short operating period of 3 to 5 yr, suggests that consideration of the E-MAD facility should be pursued in parallel with the development of a new Stage 1 waste-handling facility at the central facilities.

## 7.3 Alternative Exploratory Shaft Concepts

The underground development described in this report is based on the assumption that the ESF consists of a 12-ft-diameter ES and a 6-ft-diameter second shaft to be used as air intakes for the waste emplacement area; however, it is possible that some other option for a second access to the ES will be selected (SNL, 1984a).

One of the other options for underground development consists of enlarging the current 12-ft-diameter ES to a diameter of 16 ft. In this option, the 16-ft-diameter ES would be connected to a 19-ft-diameter muck-handling ramp by a 2,000-ft drift on the disposal level. This connecting drift would be located along one of the planned main entries. The second means of egress from the test level would be provided by an internal raise connecting the test area to the disposal level. In addition to the three proposed breakouts in the ES, another breakout would be constructed at the disposal level during shaft sinking. This breakout would permit construction of the escape raise between the disposal level and test level and permit the connection to the disposal level without interfering with the test program. The second access will provide an additional means of access and egress to the ESF and thus enhance operational safety.

The location of the 19-ft-diameter muck-handling ramp is based on current underground layouts. This ramp will be used for transporting muck from the mining operations to the surface. The diameter of the

muck-handling ramp was selected as that necessary to permit installation of the largest muck-handling equipment for operation of the full repository. The approximately 4,700-ft-long muck-handling ramp will be constructed by a TBM on a grade of 15%. The base of the ramp will have a large turning radius to facilitate crossing the geologic structure at a right angle. Construction will occur concurrently with the ESF construction. The muck-handling ramp is an important part of the final underground facility. Its early completion would greatly facilitate the construction of the final repository and help ensure that the 1998 startup date is met. In addition, it would provide a unique opportunity for enhancing the site characterization program.

## 7.4 Use of WHB-1 for Handling WVHLW and DHLW in Stage 2

With minor changes to the design of WHB-1, this building could be modified to receive and handle WVHLW and DHLW during Stage 2. These modifications would result in cost reductions in WHB-2 because throughput requirements would be reduced. In addition, the reduction in the types of wastes handled in WHB-2 would improve material flow in that building.

WHB-1 should be used in Stage 2 so that all WVHLW and DHLW can be received and packaged in this building (Figure 7-2). If the E-MAD facility were to be used for waste handling in Stage 1, its use should be terminated at the completion of Stage 1 (see Subsection 7.2).

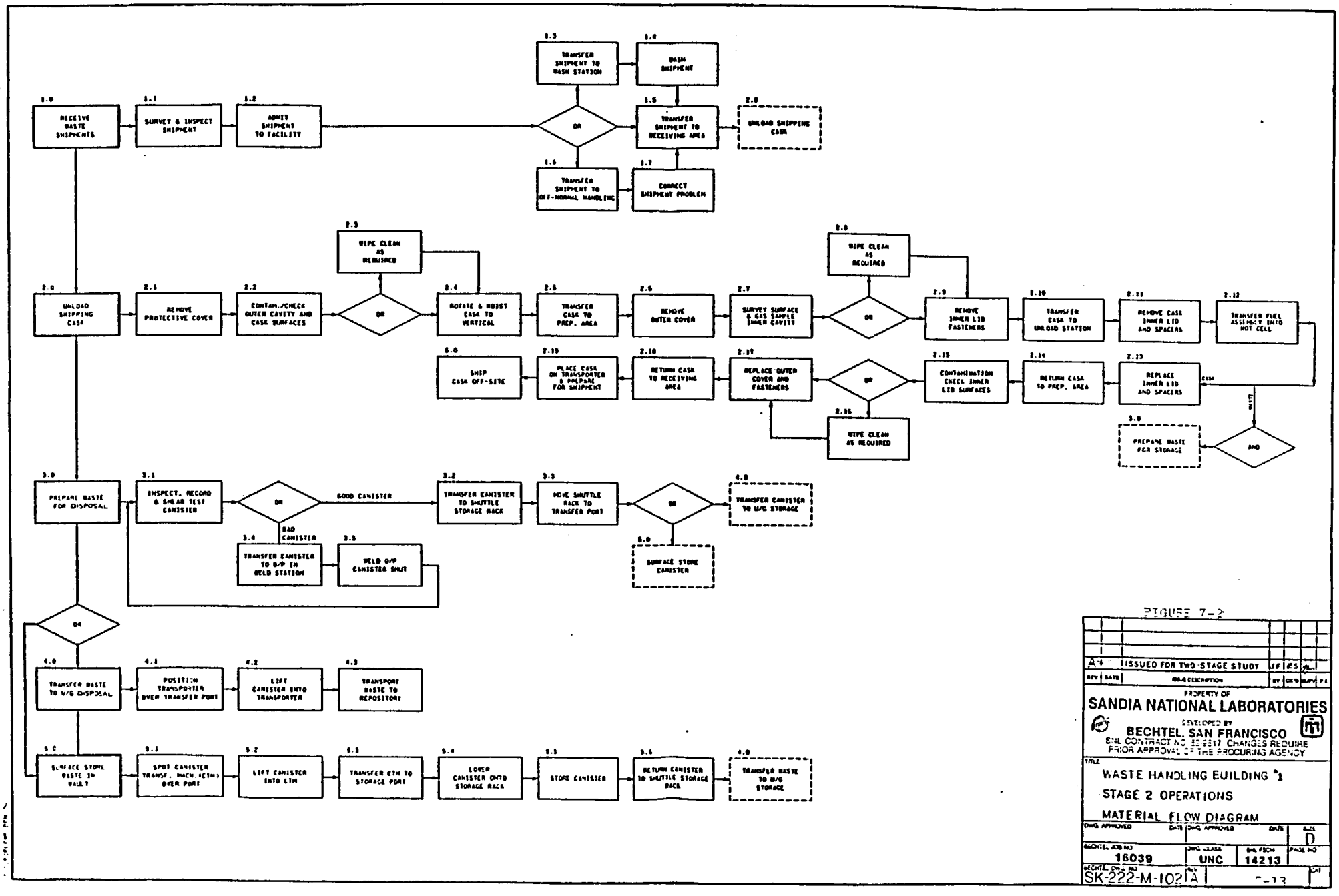



FIGURE 7-2

| REV | DATE | DESCRIPTION | BY | CK'D | SUPV | P.E. |
|---|---|---|---|---|---|---|
| A+ | | ISSUED FOR TWO-STAGE STUDY | JF | RS | | |

PROPERTY OF
SANDIA NATIONAL LABORATORIES
DEVELOPED BY
BECHTEL, SAN FRANCISCO
SNL CONTRACT NO. 30 5817. CHANGES REQUIRE PRIOR APPROVAL OF THE PROCURING AGENCY

TITLE
WASTE HANDLING BUILDING #1
STAGE 2 OPERATIONS
MATERIAL FLOW DIAGRAM

DWG APPROVED | DATE | DWG APPROVED | DATE | SIZE D

BECHTEL JOB NO 16039 | DWG CLASS UNC | SNL FORM 14213 | PAGE NO

BECHTEL DWG NO SK-222-M-102 | REV A | 7-13

# 8.0 PROGRAMMATIC IMPACTS AND UNCERTAINTIES

## 8.1 Regulatory and Licensing Issues

The Environmental Assessment (EA) and Site Characterization Plan (SCP) are major documents being prepared by DOE to satisfy regulations and licensing requirements. A draft of the EA is undergoing review; however, the draft could not fully incorporate the two-stage approach to repository construction. The draft EA is scheduled for release in December 1984. The draft SCP is scheduled for initial submission to the NRC late in 1985. If it is necessary to incorporate the two-stage repository feasibility study in the EA and SCP, a significant amount of effort will be required to meet the current schedule for these documents.

The possible use of the E-MAD facility during Stage 1 of the repository program raises several licensing issues. The original use of this facility was different from that intended in the radioactive waste management program, even though spent fuel from reactors has been handled and stored at the E-MAD facility in recent years. As-built construction drawings exist in the Holmes and Narver, Inc., archive collection at the NTS and can provide details that would be required by NRC during licensing. Records of construction materials, methods, and procedures must be thoroughly investigated to ascertain their adequacy for purposes of quality assurance and nuclear safety, should the E-MAD facility be used as the waste-handling building in Stage 1.

To ensure compatibility with current seismic criteria, further evaluation is needed to determine the level of hardening required before the E-MAD facility could be used as part of the repository. Also, because the waste must be transported an additional 10 mi, there may be increased risk of accident, particularly if the road is not used exclusively for waste transport. Accident scenarios in which the E-MAD facility is used in Stage 1 would have to be analyzed and then described in a safety analysis report.

An additional factor to be considered involves the separate licensing of WHB-1 and WHB-2. License applications for both facilities must be planned so that any interruption in operations is avoided. The licensing procedure is considerably more complex for two buildings than for one. If an existing building (the E-MAD facility) were used as the waste-handling building in Stage 1, obtaining a license might proceed more rapidly because a temporary permit rather than a full-term license would be sought.

## 8.2 Exploratory Shaft Test Plan (ESTP)

The integration of the muck-handling ramp option (see Subsection 7.3) in the ESTP offers several advantages.

- The site characterization program would be improved significantly because a large segment of the geologic structure on the north side of Drillhole Wash would be transected. The information gained in lateral extensions from a ramp could not be gained as readily or as reliably in any other way.

- Drilling and coring operations for obtaining geological information could be extended laterally from a ramp, and adjacent alcoves could be constructed without significantly delaying the extension of the ramp. If a shaft were the second access, lateral drilling and coring operations could not proceed without interrupting shaft excavation.

- The in situ mapping of the geologic structure being considered for the disposal area and the mapping of fractures would add significantly to subsurface information that would be difficult to obtain by any other means.

- Early experience could be obtained in the use of the TBM in tuff. The geologic conditions encountered in the ESF would be similar to conditions in the disposal level.

- Additional positive slack in the construction schedule would occur because additional access to the underground portion of the repository would be provided. The time gained would increase the likelihood of meeting the construction schedule, should institutional delays occur.

## 8.3 Performance Confirmation Program and Retrieval Period

As explained in Sections 1, 2, 3, and 4, concepts for the performance confirmation and retrieval programs are still preliminary, and the specific activities necessary to implement these programs have not yet been identified. Tasks that may be necessary to establish the performance confirmation and retrieval programs include

- formulating design criteria (see Section 2);
- designing an additional building to house a performance confirmation laboratory (see Section 3);
- designing an extensive underground monitoring system (see Section 3);
- determining whether the assumed operations decribed in Subsection 4.3 are appropriate and complete; and
- developing cost estimates.

## 8.4 Continued Use of Waste-Handling Building 1 (WHB-1)

Once WHB-2 has begun to operate, WHB-1 could be used in Stage 2 for

- surface storage of waste awaiting packaging or emplacement;
- handling and processing of canistered DHLW and WVHLW; these functions would be the principal use of WHB-1 and would permit elimination of one hot cell in WHB-2.

- handling and packaging offnormal waste;
- a staging area for retrieval and performance confirmation operations; or
- limited operations in case of a shutdown of WHB-2.

## 8.5 Research, Development, and Impacts of Long-Lead Procurement

The horizontal emplacement concept has been shown to be advantageous in principle, but extended use of equipment for boring horizontal boreholes in hard rock has yet to be demonstrated and requires further research and development. The manufacturers of mining equipment believe it is possible to construct practical prototypes by mid-1985. However, until such equipment is actually procured, uncertainty will remain.

The development and testing of fuel consolidation equipment and the waste transporter must be demonstrated.

## 8.6 Cost and Schedule Uncertainty

Uncertainty arises in most of the areas discussed above and could thus lead directly to protractions in schedules and associated increases in cost. At the direction of the DOE, the likelihood of licensing delays has not been addressed in this report, but these delays may be significant because a licensed repository for HLW is a first-of-a-kind facility.

The estimated costs associated with mining labor are thought to be reliable, as are the costs for civil and structural materials and construction. Uncertainties remain with regard to costs of special equipment and materials for the two waste-handling facilities.

# 9.0 CONCLUSIONS AND RECOMMENDATIONS

The principal conclusion of this study is that development of the repository at Yucca Mountain based on the two-stage approach and on the reference schedule for the first geologic repository presented in the Mission Plan (DOE 1984a) will allow receipt of 400 MTU of waste by January 31, 1998. This conclusion is predicated on NRC construction authorization by August 31, 1993, and on the assumption that no unforeseen delays occur. Ten months of positive schedule slack for the surface facilities and up to 11 mo of positive schedule slack for the subsurface facilities are estimated. The positive slack indicated for the surface facilities may be used for preoperational testing of WHB-1 if more than 6 mo of testing is required. Earlier operational status for both Stages 1 and 2 could be achieved under ideal conditions. The two-stage repository concept and schedule are feasible and will meet the objectives stated in the Mission Plan (DOE, 1984a).

The following are recommendations for future consideration and study.

- Repository development and waste-handling operations based on emplacement of multiple canisters in long, horizontally drilled holes is an attractive option from both the operational and economic viewpoints. Conceptual design of the repository should continue to address the horizontal emplacement option. Research and development activities to demonstrate the feasibility of developing machinery for drilling long, horizontal boreholes and the feasibility of retrieving waste canisters from horizontal boreholes should be vigorously pursued.

- The use of the existing E-MAD facility instead of the proposed WHB-1 should be explored further. The licensing implications of a short-term NRC operating permit and the feasibility of modifying the E-MAD facility to permit such licensing should be explored further. The potential savings in capital cost and construction time could be significant.

- The use of WHB-1 for handling DHLW and WVHLW after the conclusion of Stage 1 operations should be considered. The use of WHB-1 for offnormal operations (such as overpacking of leaking emplacement canisters) or for retrieval operations should also be considered.

- The option of a ramp for a second access during ES operations should be considered as a cost-effective alternative to a raised-bored 6-ft shaft.

## 10.0 REFERENCES


Dennis, A. W., et al., "NNWSI Repository Operational Procedures for Receiving, Packaging, Emplacing, and Retrieving High-Level and Transuranic Waste," SAND83-1166, Sandia National Laboratories, Albuquerque, NM, May 1984.

DOE (Department of Energy), "Environmental Protection, Safety and Health Protection Programs for DOE Operations," DOE Order 5480.1A, August 1981.

DOE (Department of Energy), "Mission Plan for the Civilian Radioactive Waste Management Program, Volume 1, Overview and Current Program Plans," DOE/RW-0005, (draft), April 1984a.

DOE (Department of Energy), "Two-Phase Repository Development," memo to Lee Olson (RL), Donald Vieth (NV), Jeff Neff (SRPO), May 10, 1984b.

DOE (Department of Energy), "Revised Proposed Siting Guidelines," Code of Federal Regulations, Energy, Title 10, Part 960, Subpart D, submitted to the Nuclear Regulatory Commission on May 14, 1984c.

DOE (Department of Energy), "Two-Phase Repository Engineering Feasibility Study Status Review Meeting," memo to Lee Olson (RL), Donald Vieth (NV), Jeff Neff (SRPO), May 29, 1984d.

DOE (Department of Energy), "Record of Meeting, Engineering Feasibility Study for Two-Stage Repository Concept," memo to distribution, June 13, 1984e.

DOE (Department of Energy), "Engineering Feasibility Study for Two-Stage Repository; Revised Cost and Schedule Guidelines," memo to Donald Vieth (NV), Lee Olson (BWIP), Jeff Neff (SRPO), June 15, 1984f.

DOE (Department of Energy), "July 12 Budget Review Meeting Supplementary Information," telecommunication to E. Mann, J. Neff, L. Olson, D. Vieth, June 19, 1984g.

DOE (Department of Energy), "Revised Version of Cost Guidelines for Two-Stage Repository Technical Evaluation Study," memo to distribution, June 27, 1984h.

DOE (Department of Energy), "Additional Clarification in Operating Cost Breakdown for the Two-Stage Repository Study," memo to distribution, July 17, 1984i.

DOE (Department of Energy), "Generic Requirements for a Mined Geologic Disposal System," (in review).

Johnstone, J. K., et al., "Unit Evaluation at Yucca Mountain, Nevada Test Site: Summary Report and Recommendation," SAND83-0372, Sandia National Laboratories, June 1984.

Lipman, P. W., et al., "A Compositionally Zoned Ash-Flow Sheet in Southern Nevada," U.S. Geological Survey Professional Paper 524-F, 1966.

NRC (Nuclear Regulatory Commission), "Disposal of High-Level Radioactive Waste in Geologic Repositories," Code of Federal Regulations, Energy, Title 10, Part 60, July 1983.

NWPA (Nuclear Waste Policy Act of 1982), PL 97-425.

Scott, R. B., et al., "Geologic Character of Tuffs in the Unsaturated Zone at Yucca Mountain, Southern Nevada," in Role of the Unsaturated Zone in Radioactive and Hazardous Waste Disposal, J. Mercer, ed., Ann Arbor, MI, 1983.

SNL (Sandia National Laboratories), "Recommendation for a Second Access for the Yucca Mountain Exploratory Shaft Facility," SAND84-1261, (draft) prepared by Sandia National Laboratories and Parsons Brinckerhoff Quade & Douglas, Inc., June 1984a.

SNL (Sandia National Laboratories), "Preliminary Repository Concepts Report," SAND83-1877, compiled by J. L. Jackson, August 1984b.

Weston, Roy F., Inc., "Cost Guidelines for Two-Stage Repository Technical Evaluation Study," (draft), prepared under Contract No. DE-AC01-83-NE-44301 for the Department of Energy Office of Civilian Radioactive Waste Management, June 1984.

Wilmot, E. L., et al., "A Preliminary Analysis of the Cost and Risk of Transporting Nuclear Waste to a Potential Candidate Commercial Repository," SAND83-0867, TTC-0434, June 1983.

## GLOSSARY AND ACRONYMS

Access drift - A drift in the repository that connects the parallel emplacement drifts. Access drifts serve as passageways for waste transporters and are used as haulageways for muck, materials, and equipment.

ALARA - As low as reasonably achievable.

Areal power density - The total amount of thermal power produced by emplaced waste, averaged over the area of an emplacement panel, expressed in watts per square meter or in kilowatts per acre. The initial value at the time the waste is emplaced is a design input parameter used in far-field and thermomechanical response calculations.

Burnup - A measure of nuclear fuel consumption in a reactor, expressed as the total amount of heat released per unit weight of fuel (megawatt-days per metric ton of initial heavy metal).

BWR - Boiling water reactor.

Canister - As used in this document, a metal container for solid radioactive waste. A canister provides physical containment but little shielding against penetrating gamma radiation. During transfer from work station to work station, shielding is provided by a cask.

Cask - A container that holds one or more canisters and provides shielding for highly radioactive materials during transportation. (See "facility cask" and "shipping cask.")

Central block - The primary area for development of the underground facilities at Yucca Mountain.

Collar - The junction of a mine shaft and the surface.

Commercial high-level waste - Products from solidification of high-level liquid wastes generated from the reprocessing of spent nuclear reactor fuel from commercial electric power plants.

Conceptual design - Defined as that design which thoroughly establishes the scope of a project and provides a basis for a reliable budget estimate. The types of construction, utilities, power, services, equipment, shielding, processes, instrument requirements, and space allocations are all established.

Confinement - The confinement of radioactive materials within an enclosure, (hot cell, glovebox, or building) from which the release of material is controlled.

Consolidation - As used in this document, consolidation refers to the process whereby fuel rods removed from either BWR or PWR assemblies are repackaged in a more compact package for waste disposal.

Construction authorization - Permit issued by the NRC to construct a nuclear facility.

Contact-handled waste - Low-level radioactive waste that can be handled manually.

Containment - The containment of radioactive materials within an airtight enclosure; e.g., a waste package.

Contamination - Any unwanted material in the air, in process fluids, or on surfaces. For the purposes of this report, it is assumed that contamination is radioactive.

Conventional mining methods - The drill-and-blast method is the standard method of mining; it involves drilling holes in the rock, filling the holes with explosives, detonating the explosive, and removing the broken rock.

Decommissioning - Preparations taken for retiring nuclear facilities from active service, accompanied by the execution of a program to reduce or stabilize radioactive contamination. The objective of decommissioning is to place the facility in a condition that ensures that future risk to the public safety is within acceptable bounds.

Defense high-level waste (DHLW) - Products from the solidification of high-level liquid wastes that have been generated by the reprocessing of spent fuel produced by nuclear reactors used in federal defense programs.

Design basis - A principal component of the repository that determines facility design. There are two bases for the repository design: (1) the waste to be disposed and (2) the geologic characteristics of the site.

Design criteria - Rules, regulations, codes, standards, and design-dependent constraints that govern the design of the repository. These criteria have been developed to ensure that facility design, construction, and performance objectives will be met.

Disposal - The permanent emplacement of high-level radioactive waste, spent nuclear fuel, or other highly radioactive material in a repository to isolate these wastes from the accessible environment. The repository will be designed to allow the retrieval of the waste, if necessary.

Disposal level (horizon) - The level of the specific subsurface geologic unit in which radioactive waste is emplaced.

DOE - Department of Energy.

Drift - Horizontal, or nearly horizontal, mined passageway. In this document, the term "access drift" is used to describe the passageways that provide access to the emplacement drifts.

EA - Environmental Assessment.

E-MAD - Engine Maintenance, Assembly, and Disassembly facility. An existing facility on the NTS that has large hot cell facilities.

Emplacement drift - Drift in which radioactive waste packages are disposed in either horizontal or vertical boreholes.

ESTP - Exploratory Shaft Test Plan.

Exploratory Shaft Facility (ESF) - The area located at the 2,960-elevation in the ES where scientific experiments are conducted.

Exploratory Shaft (ES) - A vertical shaft sunk through the candidate emplacement horizon to allow in situ characterization of the underground environment.

Facility cask - A specially designed container that provides shielding and containment for waste disposal packages during transfer from the surface facility to the disposal locations underground.

Fault - A fracture or fracture zone within a rock formation along which vertical, horizontal, or transverse slippage has occurred.

GRMGDS - Generic requirements for a mined geologic disposal system. A licensed system for disposing of commercial spent fuel and high-level and transuranic waste in mined excavations in a geologic formation. The system is composed of three major subsystems: the geologic setting, the repository, and the waste disposal package.

Ground support (or control) - Methods by which underground openings are artifically supported to provide long-term stability; e.g., rockbolts, steel sets, shotcrete.

High-efficiency particulate air (HEPA) filter - An air filter capable of removing from an air stream at least 99.97% of particulate material as small as 0.3 micron in diameter.

High-level waste (HLW) - (a) The highly radioactive material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly from reprocessing and any solid material derived from this liquid waste that contains concentrated fission products; (b) other highly radioactive material that the NRC, in compliance with existing law, determines by rule requires permanent isolation.

Horizontal emplacement mode - A waste emplacement configuration in which multiple waste packages are inserted in long, horizontal boreholes drilled in the sides of emplacement drift walls.

Hot cell - A heavily shielded containment structure, usually constructed of concrete and equipped to permit remote viewing and handling of highly radioactive material. It is used during the removal of waste from the shipping cask, repackaging, and transferring the waste to the waste transporter.

HVAC - Heating, ventilating and air conditioning.

In situ - In the natural or original position or condition.

LANL - Los Alamos National Laboratory.

LLNL - Lawrence Livermore National Laboratory.

Licensing - The process of obtaining the authorizations from the NRC to site, construct, operate, and decommission a repository for radioactive waste before commencing these activities. Licensing is conducted in accordance with 10 CFR 60.

Main entries - Three adjacent drifts leading from the muck-handling and waste-handling ramps to the access drifts. One of the main entries is used for waste transport, the second for muck handling and materials transport, and the third for ventilation.

Medium - A surrounding or enveloping substance; the geologic medium for radioactive waste disposal is the formation (host rock) in which the waste is emplaced. Several media are being considered: salt, basalt, crystalline rock, and tuff.

Mission Plan - The Department of Energy document describing the mission of the Office of Civilian Radioactive Waste Management.

MTU - Metric tons of uranium.

MWd - Megawatt-day.

NERVA - A series of tests conducted at the NTS to evaluate nuclear propulsion systems.

Nevada Test Site (NTS) - An area of 1,300 square miles in Clark and Nye counties in southern Nevada dedicated to U.S. Department of Energy programs.

NNWSI - Nevada Nuclear Waste Storage Investigations.

NRC - Nuclear Regulatory Commission.

NWPA - Nuclear Waste Policy Act of 1982.

Panel - A usually rectangular section of the underground layout sized to accommodate a certain amount of waste and used in planning, scheduling, and design analyses.

Portal - The surface entrance to a ramp.

Pressurized water reactor (PWR) - A reactor system that uses pressurized water in its primary cooling system. Steam produced in a secondary cooling system is used to turn turbines to generate electricity.

Ramp - An inclined opening that leads from the surface to the underground facility. Separate ramp access is planned for waste emplacement activities and for muck handling.

Repository - Any system licensed by the NRC that is intended to be used for the permanent deep geologic disposal of high-level radioactive waste and spent nuclear fuel. This term includes both surface and subsurface areas in which waste-handling activities are conducted.

Reprocessing - Chemical processing of spent nuclear reactor fuel to recover fissionable materials.

Retrievability - Capability of removing waste from its place of isolation using planned engineering procedures.

Retrieval - The act of intentionally removing radioactive waste from the underground location at which the waste had been previously emplaced for disposal.

Retrieval period - The period after the waste has been emplaced in the repository during which retrievability is maintained.

RIMACS - Repository Integrated Management and Control System.

SCP - Site Characterization Plan.

Sealing - Those activities associated with the permanent closure of the underground facility, shafts, ramps, and boreholes. Materials used in sealing may include crushed tuff, grout, and concrete.

Shaft - A vertical excavation, commonly made from the surface. Compared to its depth, it has a small cross-section area. A shaft may be used for lowering and hoisting men and materials, for collecting water, or for ventilation.

Shielding - A material interposed between a source of radiation and personnel for protection against radiation. Commonly used shielding materials are concrete, water, lead, and steel.

Shipping cask - A specially designed and certified massive metal container that provides shielding and containment in accordance with federal and/or international radiological safety rules and regulations for safe transportation of radioactive materials through the public domain.

Site - The controlled area required by 10 CFR 60 that surrounds the repository.

Spent fuel (nuclear) - Fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing.

Spent fuel assemblies - Fuel assemblies that have been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated or reprocessed.

Storage - Retention of high-level radioactive waste, spent nuclear fuel, or transuranic waste with the intent of recovering this waste or fuel for subsequent use, processing, or disposal.

Standoff - The distance between the emplacement drift and the last canister emplaced in a horizontal borehole.

Subsurface facility - See "underground facility."

Title I Design - A more detailed design than the conceptual design that uses the conceptual design and the project design criteria as a basis for project development. Title 1 design develops topographical and subsurface data and determines the requirements and criteria that will govern the definitive design. Tasks include preparation of preliminary planning and engineering studies, preliminary drawings and outline specifications, life-cycle cost analysis, preliminary cost estimates, and scheduling for project completion. Preliminary design provides identification of long-lead procurement items and analysis of risks associated with continued project development.

Title II Design - The definitive design that continues the development of the project based on approved preliminary design. Title II design includes any revisions required of the Title I effort; preparation of final working drawings, specifications, bidding documents, cost estimates, and coordination with all involved parties; development of firm construction and procurement schedules; and assistance in analyzing proposals or bids.

Title III Services - Those activities required to ensure that the project is constructed in accordance with the plans and specifications and that the quality of materials and workmanship is consistent with the requirements of the project.

Transfer cart - A cart used in hot cell facilities to move spent fuel assemblies from one station to another within the hot cell.

Transition period - Years 2001 and 2002 during which both WHB-1 and WHB-2 operate simultaneously.

Transporter - The machine used to move radioactive waste from place to place outside the hot cell. The transporter includes a prime mover and a shielded cask for the waste material.

TRU - Transuranic waste.

Tunnel-boring machine (TBM) - A machine that excavates a circular ramp or drift by rotary cutting of the face.

Underground facility - The underground structure, including openings and backfill materials, but excluding shafts, boreholes and their seals, as required in 10 CFR 60.

USGS - U.S. Geological Survey.

Vertical emplacement mode - A waste emplacement configuration in which a single waste package is inserted in boreholes drilled vertically in emplacement drift floors.

Waste (radioactive) - Radioactive material emplaced in the repository.

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

Waste-Handling Building 1 (WHB-1) - The facility at which waste is received, prepared, and packaged for emplacement in Stage 1. It would handle 400 MTU/yr from 1998 through 2002.

Waste-Handling Building 2 (WHB-2) - The facility at which waste is received, prepared, consolidated, and packaged for emplacement in Stage 2. It would handle 3,000 MTU/yr and would operate between 2001 and the close of the repository.

WTB - Waste treatment building. The building in which radioactive waste generated onsite is processed and placed in containers for disposal underground.

West Valley high-level waste (WVHLW) - Products from solidification of high-level liquid waste currently stored at the West Valley Nuclear Fuel Services facility in West Valley, New York. The high-level liquid wastes were generated from reprocessing spent nuclear reactor fuel.

# APPENDIX

TABLE OF CONTENTS

1 INTRODUCTION.....A1-1

2 COST DOCUMENTATION.....A2-1

3 HORIZONTAL EMPLACEMENT.....A3-1

## 1 INTRODUCTION

The tables in this Appendix were prepared in accordance with the "Cost Guidelines for Two-Stage Repository Technical Evaluation Study," dated June 27, 1984, and prepared by Roy F. Weston, Inc. The one exception taken to those guidelines concerned the cost data for the reference repository to be used as the basis for comparison to the two-stage repository. It was felt that the cost data presented in Table 2.14C of the Weston guidelines were not representative of the costs for a repository in tuff as currently conceived. Therefore, cost estimates were developed for a "revised reference repository" based on preliminary concepts for a two-stage repository for vertical emplacement, using the assumptions contained in Appendix C of the Weston guidelines and the methods described in Subsection 6.2 of this report.

Estimates of costs for the reference repository and a revised reference repository for vertical emplacement are compared in the following tables: Table 1.0 duplicates Table 2.14C from the guidelines; Table 1.1 is a cost matrix for the revised reference repository; and Table 1.2 is a comparison of the two repositories.

An element of the work breakdown structure contained in the guidelines for which no cost estimates were developed is "Test Facilities." After the requirements for a test facility have been defined, cost estimates will be developed.

Table 1.0 Project: NNWSI

Reference Repository Cost Matrix

(Millions of Mid-1984 Dollars)

| SYSTEM | Engineering & Construction | Operation | Decommis-sioning | Total |
|---|---|---|---|---|
| WASTE PREPARATION | 310.000 | 1,022.000 | 45.000 | 1,377.000 |
| Waste Form Subsys | 160.000 | 306.000 | 24.000 | 490.000 |
| --Spent Fuel | 121.000 | 295.000 | 15.000 | 431.000 |
| --On-Site Generated | 39.000 | 11.000 | 9.000 | 59.000 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Waste Pkg Subsys | 150.000 | 716.000 | 21.000 | 887.000 |
| --Spent Fuel | 132.000 | 586.000 | 18.000 | 736.000 |
| Pkg Components | 0.000 | 320.000 | 0.000 | 320.000 |
| Ass'bly Fac | 132.000 | 266.000 | 18.000 | 416.000 |
| --On-Site Generated | 18.000 | 130.000 | 3.000 | 151.000 |
| Pkg Components | 0.000 | 96.000 | 0.000 | 96.000 |
| Ass'bly Fac | 18.000 | 34.000 | 3.000 | 55.000 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Pkg Components | 0.000 | 0.000 | 0.000 | 0.000 |
| Ass'bly Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| REPOSITORY SYSTEM | 1,518.000 | 2,130.000 | 183.000 | 3,831.000 |
| Site | 380.000 | 87.000 | 50.000 | 517.000 |
| --Land & Land Rts | 0.000 | 0.000 | 0.000 | 0.000 |
| --On-Site Impr'mt | 98.000 | 87.000 | 13.000 | 198.000 |
| --Off-Site Impr'mt | 282.000 | 0.000 | 37.000 | 319.000 |
| Waste Hdlg & Empl | 228.000 | 660.000 | 15.000 | 903.000 |
| --Receiving | 39.000 | 62.000 | 6.000 | 107.000 |
| --Other Surf Fac | 64.000 | 102.000 | 6.000 | 172.000 |
| --Waste Shafts | 61.000 | 56.000 | 1.000 | 118.000 |
| --Transfer & Empl | 64.000 | 440.000 | 2.000 | 506.000 |
| Rooms | 35.000 | 335.000 | 0.000 | 370.000 |
| Boreholes | 5.000 | 25.000 | 0.000 | 30.000 |
| Transfer Equip | 24.000 | 80.000 | 2.000 | 106.000 |
| U/G Wkgs/Rock Hdlg | 382.000 | 250.000 | 53.000 | 685.000 |
| --Men/Mat'ls Shaft | 88.000 | 90.000 | 3.000 | 181.000 |
| --Shaft Pillar | 61.000 | 3.000 | 11.000 | 75.000 |
| --Corridors | 139.000 | 121.000 | 33.000 | 293.000 |
| --Rock Hdlg/Disp'l | 94.000 | 36.000 | 6.000 | 136.000 |
| --Test Facilities | 0.000 | 0.000 | 0.000 | 0.000 |
| Ventilation | 329.000 | 540.000 | 44.000 | 913.000 |
| --Vent Structures | 228.000 | 532.000 | 31.000 | 791.000 |
| --Vent Supply Shft | 68.000 | 8.000 | 5.000 | 81.000 |
| --Dev Exhaust Shft | 10.000 | 0.000 | 6.000 | 16.000 |
| --Vent Flow Paths | 18.000 | 0.000 | 0.000 | 18.000 |
| --Repos Exh Shaft | 5.000 | 0.000 | 2.000 | 7.000 |
| Support/Utilities | 199.000 | 593.000 | 21.000 | 813.000 |
| TOTALS | 1,828.000 | 3,152.000 | 228.000 | 5,208.000 |

Table 1.1 Project: NNWSI

Revised Reference Repository Cost Matrix

(Millions of Mid-1984 Dollars)

| SYSTEM | Engineering & Construction | Operation | Decommis-sioning | Total |
|---|---|---|---|---|
| WASTE PREPARATION | 309.886 | 1,508.582 | 28.988 | 1,847.456 |
| Waste Form Subsys | 86.959 | 0.000 | 0.000 | 86.959 |
| --Spent Fuel | 86.959 | 0.000 | 0.000 | 86.959 |
| --On-Site Generated | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Waste Pkg Subsys | 222.927 | 1,508.582 | 28.988 | 1,760.497 |
| --Spent Fuel | 202.942 | 1,497.490 | 28.988 | 1,729.420 |
| Pkg Components | 0.000 | 1,103.471 | 0.000 | 1,103.471 |
| Ass'bly Fac | 202.942 | 394.019 | 28.988 | 625.949 |
| --On-Site Generated | 19.985 | 11.092 | 0.000 | 31.077 |
| Pkg Components | 0.000 | 11.092 | 0.000 | 11.092 |
| Ass'bly Fac | 19.985 | 0.000 | 0.000 | 19.985 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Pkg Components | 0.000 | 0.000 | 0.000 | 0.000 |
| Ass'bly Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| REPOSITORY SYSTEM | 726.564 | 4,152.456 | 5.877 | 4,884.897 |
| Site | 181.630 | 0.000 | 0.000 | 181.630 |
| --Land & Land Rts | 1.300 | 0.000 | 0.000 | 1.300 |
| --On-Site Impr'mt | 17.499 | 0.000 | 0.000 | 17.499 |
| --Off-Site Impr'mt | 162.831 | 0.000 | 0.000 | 162.831 |
| Waste Hdlg & Empl | 128.285 | 1,133.545 | 0.840 | 1,262.670 |
| --Receiving | 5.648 | 0.000 | 0.000 | 5.648 |
| --Other Surf Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| --Waste Shafts | 28.924 | 0.000 | 0.840 | 29.764 |
| --Transfer & Empl | 93.713 | 1,133.545 | 0.000 | 1,227.258 |
| Rooms | 59.043 | 682.801 | 0.000 | 741.844 |
| Boreholes | 23.832 | 279.267 | 0.000 | 303.099 |
| Transfer Equip | 10.838 | 171.477 | 0.000 | 182.315 |
| U/G Wkgs/Rock Hdlg | 194.136 | 424.874 | 2.251 | 621.261 |
| --Men/Mat'ls Shaft | 29.952 | 0.000 | 1.393 | 31.345 |
| --Shaft Pillar | 14.693 | 2.534 | 0.000 | 17.227 |
| --Corridors | 112.942 | 382.995 | 0.000 | 495.937 |
| --Rock Hdlg/Disp'l | 36.549 | 39.345 | 0.858 | 76.752 |
| --Test Facilities | 0.000 | 0.000 | 0.000 | 0.000 |
| Ventilation | 88.133 | 297.933 | 2.786 | 388.852 |
| --Vent Structures | 11.605 | 0.000 | 0.000 | 11.605 |
| --Vent Supply Shft | 1.912 | 0.000 | 1.393 | 3.305 |
| --Dev Exhaust Shft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Vent Flow Paths | 64.975 | 297.933 | 0.000 | 362.908 |
| --Repos Exh Shaft | 9.641 | 0.000 | 1.393 | 11.034 |
| Support/Utilities | 134.380 | 2,296.104 | 0.000 | 2,430.484 |
| TOTALS | 1,036.450 | 5,661.038 | 34.865 | 6,732.353 |

Table 1.2 Project: NNWSI

Repository Cost Matrix Comparison
Reference Repository vs Revised Reference Repository
(Millions of Mid-1984 Dollars)

| SYSTEM | Reference Repository | Revised Ref. Repository | | Difference |
|---|---|---|---|---|
| WASTE PREPARATION | 1,377.000 | 1,847.456 | + | 470.456 |
| Waste Form Subsys | 490.000 | 86.959 | - | 403.041 |
| --Spent Fuel | 431.000 | 86.959 | - | 344.041 |
| --On-Site Generated | 59.000 | 0.000 | - | 59.000 |
| --Other | 0.000 | 0.000 | + | 0.000 |
| Waste Pkg Subsys | 887.000 | 1,760.497 | + | 873.497 |
| --Spent Fuel | 736.000 | 1,729.420 | + | 993.420 |
| Pkg Components | 320.000 | 1,103.471 | + | 783.471 |
| Ass'bly Fac | 416.000 | 625.949 | + | 209.949 |
| --On-Site Generated | 151.000 | 31.077 | - | 119.923 |
| Pkg Components | 96.000 | 11.092 | - | 84.908 |
| Ass'bly Fac | 55.000 | 19.985 | - | 35.015 |
| --Other | 0.000 | 0.000 | + | 0.000 |
| Pkg Components | 0.000 | 0.000 | + | 0.000 |
| Ass'bly Fac | 0.000 | 0.000 | + | 0.000 |
| REPOSITORY SYSTEM | 3,831.000 | 4,884.897 | + | 1,053.897 |
| Site | 517.000 | 181.630 | - | 335.370 |
| --Land & Land Rts | 0.000 | 1.300 | + | 1.300 |
| --On-Site Impr'mt | 198.000 | 17.499 | - | 180.501 |
| --Off-Site Impr'mt | 319.000 | 162.831 | - | 156.169 |
| Waste Hdlg & Empl | 903.000 | 1,262.670 | + | 359.670 |
| --Receiving | 107.000 | 5.648 | - | 101.352 |
| --Other Surf Fac | 172.000 | 0.000 | - | 172.000 |
| --Waste Shafts | 118.000 | 29.764 | - | 88.236 |
| --Transfer & Empl | 506.000 | 1,227.258 | + | 721.258 |
| Rooms | 370.000 | 741.844 | + | 371.844 |
| Boreholes | 30.000 | 303.099 | + | 273.099 |
| Transfer Equip | 106.000 | 182.315 | + | 76.315 |
| U/G Wkgs/Rock Hdlg | 685.000 | 621.261 | - | 63.739 |
| --Men/Mat'ls Shaft | 181.000 | 31.345 | - | 149.655 |
| --Shaft Pillar | 75.000 | 17.227 | - | 57.773 |
| --Corridors | 293.000 | 495.937 | + | 202.937 |
| --Rock Hdlg/Disp'l | 136.000 | 76.752 | - | 59.248 |
| --Test Facilities | 0.000 | 0.000 | + | 0.000 |
| Ventilation | 913.000 | 388.852 | - | 524.148 |
| --Vent Structures | 791.000 | 11.605 | - | 779.395 |
| --Vent Supply Shft | 81.000 | 3.305 | - | 77.695 |
| --Dev Exhaust Shft | 16.000 | 0.000 | - | 16.000 |
| --Vent Flow Paths | 18.000 | 362.908 | + | 344.908 |
| --Repos Exh Shaft | 7.000 | 11.034 | + | 4.034 |
| Support/Utilities | 813.000 | 2,430.484 | + | 1,617.484 |
| TOTALS | 5,208.000 | 6,732.353 | + | 1,524.353 |

## 2 COST DOCUMENTATION

In this section, cost estimates are presented for: (1) the exploratory shaft program; (2) a revised reference repository for vertical emplacement; and (3) a two-stage repository for vertical emplacement. Cost estimates for the two repositories are compared, and estimates of the costs of engineering for the two repository cases are also presented.

The cost estimates for the exploratory shaft program were taken from the Schedule 47 for an Exploratory Shaft at Yucca Mountain dated July 6, 1984, prepared by the Waste Management Project Office, US Department of Energy, Nevada Operations Office. Subsequent adjustments to expenditures for FY 1985 and FY 1986 were also included. Costs from the Schedule 47 were adjusted to mid-1984 dollars. Cost details for the exploratory shaft program were prepared by the Los Alamos National Laboratory

Cost estimates for the surface facilities and operations and for the off-site improvements were prepared by Bechtel National, Inc. Cost estimates for the underground development and operations and for the underground decomissioning were prepared by Parsons Brinckerhoff Quade & Douglas, Inc. Estimates of costs for emplacement equipment and for emplacement operations were prepared by Sandia National Laboratories. Cost estimates for emplacement canisters and hardware were prepared by Lawrence Livermore National Laboratory. Los Alamos Technical Associates, Inc., prepared cost estimates for activities not otherwise covered and compiled all the cost data in an integrated, composite estimate.

The tables are numbered in the same manner and in the same order as the tables in Section 2 of the Weston guidelines. Because of lack of detail regarding the cost estimates associated with the exploratory shaft program, some of the table numbers relative to the costs of the exploratory shaft program were not used.

Tables 2.0 and 2.1 are the summary costs and the detail costs, respectively, for the total exploratory shaft program, including a 12-ft-diameter shaft or ES (referred to as the "first shaft") and a 6-ft-diameter shaft (referred to as the "second shaft"). Tables 2.2 and 2.3 are the summary and detail costs for the first shaft, and Tables 2.4 and 2.5 are the summary and detail costs for the second shaft. Table numbers 2.6 through 2.13 were not used.

Table 2.14 is the revised reference repository cost matrix (identical to Table 1.1), and Table 2.15 outlines the Title I, II, and III engineering costs, by fiscal year, associated with that repository. Tables 2.16A through 2.16E are the two-stage repository cost matrixes, and Tables 2.17A through 2.17D are the related engineering costs. Table 2.18 compares the costs between the revised reference repository and the two-stage repository.

Table 2.19 defines the cost accounts used in the cost matrixes, and Table 2.20 is a copy of the same table number from the guidelines. Table 2.21 and Tables 2.22A and 2.22B contain details of the operating costs for the revised reference repository and the two-stage repository, respectively.

The worksheets in Appendix A and Appendix B of the guidelines were not filled out.

Table 2.0
Exploratory Shaft Summary Costs
(Thousands of Mid-1984 Dollars)

Project: NNWSI

| | Cum Year | FY 1984 | FY 1985 | FY 1986 | FY 1987 | FY 1988 | FY 1989 | FY 1990 | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1 OPERATING EXPENSES | | | | | | | | | |
| Design & Construction | 4,124 | 593 | 4,504 | 14,325 | 12,626 | 3,531 | 221 | 59 | 39,983 |
| Evaluation & Testing | 0 | 0 | 2,684 | 10,559 | 10,802 | 6,236 | 3,285 | 875 | 34,441 |
| Operations & Maintenance | 212 | 250 | 859 | 3,047 | 4,616 | 5,243 | 3,444 | 916 | 18,587 |
| Planning & Direction | 2,294 | 1,620 | 2,605 | 2,243 | 2,235 | 1,948 | 1,535 | 330 | 14,810 |
| Integrated Data System | 210 | 360 | 734 | 2,650 | 1,471 | 997 | 947 | 220 | 7,589 |
| R&D Related to Const. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL OPERATING EXPENSES | 6,840 | 2,823 | 11,386 | 32,824 | 31,750 | 17,955 | 9,432 | 2,400 | 115,410 |
| 2 CAPITAL EQUIPMENT | 3,515 | 520 | 1,200 | 2,440 | 960 | 220 | 110 | 0 | 8,965 |
| 3 TOTAL DOE FUNDING | 10,355 | 3,343 | 12,586 | 35,264 | 32,710 | 18,175 | 9,542 | 2,400 | 124,375 |
| 4 NON-DOE FUNDING | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 TOTAL PROJECT | 10,355 | 3,343 | 12,586 | 35,264 | 32,710 | 18,175 | 9,542 | 2,400 | 124,375 |

Table 2.1
Exploratory Shaft Detail Costs
(Thousands of Mid-1984 Dollars)

Project: NNWSI

| | Cum Year | FY 1984 | FY 1985 | FY 1986 | FY 1987 | FY 1988 | FY 1989 | FY 1990 | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1 OPERATING EXPENSES | | | | | | | | | |
| Design & Construction | | | | | | | | | |
| Surface Facilities | | | | | | | | | |
| Site & Roads | 2,194 | 50 | 700 | 0 | 0 | 0 | 0 | 0 | 2,944 |
| Utilities & Comm Sys | 1,475 | 20 | 1,075 | 0 | 0 | 0 | 0 | 0 | 2,570 |
| Buildings | 184 | 0 | 450 | 0 | 0 | 0 | 0 | 0 | 634 |
| Mine Plant | 0 | 0 | 359 | 12 | 0 | 0 | 0 | 0 | 371 |
| Contingency | 0 | 0 | 260 | 1 | 0 | 0 | 0 | 0 | 261 |
| Subsurface Facilities | | | | | | | | | |
| Shafts | 167 | 350 | 301 | 7,703 | 2,000 | 0 | 0 | 0 | 10,521 |
| Shaft Internals | 32 | 10 | 31 | 870 | 12 | 0 | 0 | 0 | 955 |
| Underground Openings | 30 | 20 | 22 | 871 | 5,928 | 2,278 | 0 | 0 | 9,149 |
| Utilities & Comm Sys | 0 | 90 | 425 | 1,215 | 0 | 0 | 0 | 0 | 1,730 |
| Lateral Core Holes | 0 | 10 | 0 | 0 | 1,325 | 0 | 0 | 0 | 1,335 |
| Contingency | 0 | 0 | 109 | 1,599 | 1,390 | 342 | 0 | 0 | 3,440 |
| NTS Allocation | | | | | | | | | |
| F&S Alloc | 0 | 8 | 18 | 57 | 65 | 17 | 0 | 0 | 165 |
| H&N Alloc | 0 | 10 | 61 | 121 | 33 | 13 | 3 | 0 | 241 |
| REECo Alloc | 0 | 15 | 201 | 169 | 686 | 424 | 189 | 51 | 1,735 |
| Subcontractor Alloc | 0 | 0 | 8 | 559 | 120 | 0 | 0 | 0 | 687 |
| Contingency | 0 | 0 | 43 | 136 | 136 | 68 | 29 | 8 | 420 |
| Other | | | | | | | | | |
| Engineering Data | 42 | 10 | 441 | 1,012 | 931 | 389 | 0 | 0 | 2,825 |
| Subtotal | 4,124 | 593 | 4,504 | 14,325 | 12,626 | 3,531 | 221 | 59 | 39,983 |
| Evaluation & Testing | | | | | | | | | |
| Geotechnical Data | 0 | 0 | 1,934 | 8,145 | 8,355 | 4,761 | 2,628 | 700 | 26,523 |
| Management Reports | 0 | 0 | 125 | 100 | 100 | 150 | 0 | 0 | 475 |
| Contingency | 0 | 0 | 625 | 2,314 | 2,347 | 1,325 | 657 | 175 | 7,443 |
| Subtotal | 0 | 0 | 2,684 | 10,559 | 10,802 | 6,236 | 3,285 | 875 | 34,441 |

Table 2.1 (Concluded)

Project: NNWSI

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Operations & Maintenance | | | | | | | | | |
| Site & Equipment | 212 | 150 | 46 | 495 | 475 | 475 | 330 | 0 | 2,183 |
| Project Operations | 0 | 100 | 724 | 2,246 | 3,659 | 4,232 | 2,789 | 833 | 14,583 |
| Training | 0 | 0 | 11 | 29 | 62 | 59 | 12 | 0 | 173 |
| Contingency | 0 | 0 | 78 | 277 | 420 | 477 | 313 | 83 | 1,648 |
| Subtotal | 212 | 250 | 859 | 3,047 | 4,616 | 5,243 | 3,444 | 916 | 18,587 |
| Planning & Technical Direction | | | | | | | | | |
| Tecnical Direction | 2,294 | 775 | 639 | 600 | 500 | 400 | 400 | 100 | 5,708 |
| Test Plan | 0 | 800 | 1,305 | 900 | 900 | 900 | 600 | 100 | 5,505 |
| Safety & QA | 0 | 45 | 424 | 539 | 632 | 471 | 395 | 100 | 2,606 |
| Contingency | 0 | 0 | 237 | 204 | 203 | 177 | 140 | 30 | 991 |
| Subtotal | 2,294 | 1,620 | 2,605 | 2,243 | 2,235 | 1,948 | 1,535 | 330 | 14,810 |
| Integrated Data System | | | | | | | | | |
| IDS Development & Oper. | 210 | 360 | 506 | 2,268 | 1,291 | 860 | 815 | 200 | 6,510 |
| IDS Support | 0 | 0 | 170 | 132 | 46 | 46 | 46 | 0 | 440 |
| Contingency | 0 | 0 | 58 | 250 | 134 | 91 | 86 | 20 | 639 |
| Subtotal | 210 | 360 | 734 | 2,650 | 1,471 | 997 | 947 | 220 | 7,589 |
| R&D Related to Const. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL OPERATING EXPENSES | 6,840 | 2,823 | 11,386 | 32,824 | 31,750 | 17,955 | 9,432 | 2,400 | 115,410 |
| 2 CAPITAL EQUIPMENT | 3,515 | 520 | 1,200 | 2,440 | 960 | 220 | 110 | 0 | 8,965 |
| 3 TOTAL DOE FUNDING | 10,355 | 3,343 | 12,586 | 35,264 | 32,710 | 18,175 | 9,542 | 2,400 | 124,375 |
| 4 NON-DOE FUNDING | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 TOTAL PROJECT | 10,355 | 3,343 | 12,586 | 35,264 | 32,710 | 18,175 | 9,542 | 2,400 | 124,375 |

Table 2.2
First Shaft Summary Costs
(Thousands of Mid-1984 Dollars)

Project: NNWSI

| | Cum Year | FY 1984 | FY 1985 | FY 1986 | FY 1987 | FY 1988 | FY 1989 | FY 1990 | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1 OPERATING EXPENSES | | | | | | | | | |
| Design & Construction | 4,124 | 293 | 4,342 | 14,325 | 10,188 | 3,531 | 221 | 59 | 37,083 |
| Evaluation & Testing | 0 | 0 | 2,684 | 10,559 | 10,802 | 6,236 | 3,285 | 875 | 34,441 |
| Operations & Maintenance | 212 | 250 | 859 | 3,047 | 4,616 | 5,243 | 3,444 | 916 | 18,587 |
| Planning & Direction | 2,294 | 1,620 | 2,605 | 2,243 | 2,235 | 1,948 | 1,535 | 330 | 14,810 |
| Integrated Data System | 210 | 360 | 734 | 2,650 | 1,471 | 997 | 947 | 220 | 7,589 |
| R&D Related to Const. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL OPERATING EXPENSES | 6,840 | 2,523 | 11,224 | 32,824 | 29,312 | 17,955 | 9,432 | 2,400 | 112,510 |
| 2 CAPITAL EQUIPMENT | 3,515 | 520 | 1,200 | 2,440 | 960 | 220 | 110 | 0 | 8,965 |
| 3 TOTAL DOE FUNDING | 10,355 | 3,043 | 12,424 | 35,264 | 30,272 | 18,175 | 9,542 | 2,400 | 121,475 |
| 4 NON-DOE FUNDING | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 TOTAL PROJECT | 10,355 | 3,043 | 12,424 | 35,264 | 30,272 | 18,175 | 9,542 | 2,400 | 121,475 |

Table 2.3
First Shaft Detail Costs
(Thousands of Mid-1984 Dollars)

Project: NNWSI

| | Cum Year | FY 1984 | FY 1985 | FY 1986 | FY 1987 | FY 1988 | FY 1989 | FY 1990 | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1 OPERATING EXPENSES | | | | | | | | | |
| Design & Construction | | | | | | | | | |
| Surface Facilities | | | | | | | | | |
| Site & Roads | 2,194 | 0 | 600 | 0 | 0 | 0 | 0 | 0 | 2,794 |
| Utilities & Comm Sys | 1,475 | 20 | 1,075 | 0 | 0 | 0 | 0 | 0 | 2,570 |
| Buildings | 184 | 0 | 450 | 0 | 0 | 0 | 0 | 0 | 634 |
| Mine Plant | 0 | 0 | 359 | 12 | 0 | 0 | 0 | 0 | 371 |
| Contingency | 0 | 0 | 248 | 1 | 0 | 0 | 0 | 0 | 249 |
| Subsurface Facilities | | | | | | | | | |
| Shafts | 167 | 100 | 251 | 7,703 | 0 | 0 | 0 | 0 | 8,221 |
| Shaft Internals | 32 | 10 | 31 | 870 | 12 | 0 | 0 | 0 | 955 |
| Underground Openings | 30 | 20 | 22 | 871 | 5,928 | 2,278 | 0 | 0 | 9,149 |
| Utilities & Comm Sys | 0 | 90 | 425 | 1,215 | 0 | 0 | 0 | 0 | 1,730 |
| Lateral Core Holes | 0 | 10 | 0 | 0 | 1,325 | 0 | 0 | 0 | 1,335 |
| Contingency | 0 | 0 | 109 | 1,599 | 1,090 | 342 | 0 | 0 | 3,140 |
| NTS Allocation | | | | | | | | | |
| F&S Alloc | 0 | 8 | 18 | 57 | 65 | 17 | 0 | 0 | 165 |
| H&N Alloc | 0 | 10 | 61 | 121 | 33 | 13 | 3 | 0 | 241 |
| REECo Alloc | 0 | 15 | 201 | 169 | 686 | 424 | 189 | 51 | 1,735 |
| Subcontractor Alloc | 0 | 0 | 8 | 559 | 0 | 0 | 0 | 0 | 567 |
| Contingency | 0 | 0 | 43 | 136 | 118 | 68 | 29 | 8 | 402 |
| Other | | | | | | | | | |
| Engineering Data | 42 | 10 | 441 | 1,012 | 931 | 389 | 0 | 0 | 2,825 |
| Subtotal | 4,124 | 293 | 4,342 | 14,325 | 10,188 | 3,531 | 221 | 59 | 37,083 |
| Evaluation & Testing | | | | | | | | | |
| Geotechnical Data | 0 | 0 | 1,934 | 8,145 | 8,355 | 4,761 | 2,628 | 700 | 26,523 |
| Management Reports | 0 | 0 | 125 | 100 | 100 | 150 | 0 | 0 | 475 |
| Contingency | 0 | 0 | 625 | 2,314 | 2,347 | 1,325 | 657 | 175 | 7,443 |
| Subtotal | 0 | 0 | 2,684 | 10,559 | 10,802 | 6,236 | 3,285 | 875 | 34,441 |

Table 2.3 (Concluded) Project: NNWSI

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Operations & Maintenance | | | | | | | | | |
| Site & Equipment | 212 | 150 | 46 | 495 | 475 | 475 | 330 | 0 | 2,183 |
| Project Operations | 0 | 100 | 724 | 2,246 | 3,659 | 4,232 | 2,789 | 833 | 14,583 |
| Training | 0 | 0 | 11 | 29 | 62 | 59 | 12 | 0 | 173 |
| Contingency | 0 | 0 | 78 | 277 | 420 | 477 | 313 | 83 | 1,648 |
| Subtotal | 212 | 250 | 859 | 3,047 | 4,616 | 5,243 | 3,444 | 916 | 18,587 |
| Planning & Technical Direction | | | | | | | | | |
| Tecnical Direction | 2,294 | 775 | 639 | 600 | 500 | 400 | 400 | 100 | 5,708 |
| Test Plan | 0 | 800 | 1,305 | 900 | 900 | 900 | 600 | 100 | 5,505 |
| Safety & QA | 0 | 45 | 424 | 539 | 632 | 471 | 395 | 100 | 2,606 |
| Contingency | 0 | 0 | 237 | 204 | 203 | 177 | 140 | 30 | 991 |
| Subtotal | 2,294 | 1,620 | 2,605 | 2,243 | 2,235 | 1,948 | 1,535 | 330 | 14,810 |
| Integrated Data System | | | | | | | | | |
| IDS Development & Oper. | 210 | 360 | 506 | 2,268 | 1,291 | 860 | 815 | 200 | 6,510 |
| IDS Support | 0 | 0 | 170 | 132 | 46 | 46 | 46 | 0 | 440 |
| Contingency | 0 | 0 | 58 | 250 | 134 | 91 | 86 | 20 | 639 |
| Subtotal | 210 | 360 | 734 | 2,650 | 1,471 | 997 | 947 | 220 | 7,589 |
| R&D Related to Const. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL OPERATING EXPENSES | 6,840 | 2,523 | 11,224 | 32,824 | 29,312 | 17,955 | 9,432 | 2,400 | 112,510 |
| 2 CAPITAL EQUIPMENT | 3,515 | 520 | 1,200 | 2,440 | 960 | 220 | 110 | 0 | 8,965 |
| 3 TOTAL DOE FUNDING | 10,355 | 3,043 | 12,424 | 35,264 | 30,272 | 18,175 | 9,542 | 2,400 | 121,475 |
| 4 NON-DOE FUNDING | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 TOTAL PROJECT | 10,355 | 3,043 | 12,424 | 35,264 | 30,272 | 18,175 | 9,542 | 2,400 | 121,475 |

Table 2.4
Second Shaft Summary Costs
(Thousands of Mid-1984 Dollars)

Project: NNWSI

| | Cum Year | FY 1984 | FY 1985 | FY 1986 | FY 1987 | FY 1988 | FY 1989 | FY 1990 | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1 OPERATING EXPENSES | | | | | | | | | |
| Design & Construction | 0 | 300 | 162 | 0 | 2,438 | 0 | 0 | 0 | 2,900 |
| Evaluation & Testing | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Operations & Maintenance | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Planning & Direction | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Integrated Data System | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| R&D Related to Const. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL OPERATING EXPENSES | 0 | 300 | 162 | 0 | 2,438 | 0 | 0 | 0 | 2,900 |
| 2 CAPITAL EQUIPMENT | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 TOTAL DOE FUNDING | 0 | 300 | 162 | 0 | 2,438 | 0 | 0 | 0 | 2,900 |
| 4 NON-DOE FUNDING | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 TOTAL PROJECT | 0 | 300 | 162 | 0 | 2,438 | 0 | 0 | 0 | 2,900 |

Table 2.5
Second Shaft Detail Costs
(Thousands of Mid-1984 Dollars)

Project: NNWSI

| | Cum Year | FY 1984 | FY 1985 | FY 1986 | FY 1987 | FY 1988 | FY 1989 | FY 1990 | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1 OPERATING EXPENSES | | | | | | | | | |
| Design & Construction | | | | | | | | | |
| Surface Facilities | | | | | | | | | |
| Site & Roads | 0 | 50 | 100 | 0 | 0 | 0 | 0 | 0 | 150 |
| Utilities & Comm Sys | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Buildings | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mine Plant | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Contingency | 0 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 12 |
| Subsurface Facilities | | | | | | | | | |
| Shafts | 0 | 250 | 50 | 0 | 2,000 | 0 | 0 | 0 | 2,300 |
| Shaft Internals | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Underground Openings | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Utilities & Comm Sys | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lateral Core Holes | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Contingency | 0 | 0 | 0 | 0 | 300 | 0 | 0 | 0 | 300 |
| NTS Allocation | | | | | | | | | |
| F&S Alloc | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| H&N Alloc | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| REECo Alloc | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Subcontractor Alloc | 0 | 0 | 0 | 0 | 120 | 0 | 0 | 0 | 120 |
| Contingency | 0 | 0 | 0 | 0 | 18 | 0 | 0 | 0 | 18 |
| Other | | | | | | | | | |
| Engineering Data | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Subtotal | 0 | 300 | 162 | 0 | 2,438 | 0 | 0 | 0 | 2,900 |
| Evaluation & Testing | | | | | | | | | |
| Geotechnical Data | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Management Reports | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Contingency | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Subtotal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 2.5 (Concluded)

Project: NNWSI

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Operations & Maintenance | | | | | | | | | |
| Site & Equipment | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Project Operations | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Training | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Contingency | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Subtotal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Planning & Technical Direction | | | | | | | | | |
| Tecnical Direction | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Test Plan | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Safety & QA | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Contingency | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Subtotal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Integrated Data System | | | | | | | | | |
| IDS Development & Oper. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| IDS Support | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Contingency | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Subtotal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| R&D Related to Const. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL OPERATING EXPENSES | 0 | 300 | 162 | 0 | 2,438 | 0 | 0 | 0 | 2,900 |
| 2 CAPITAL EQUIPMENT | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 TOTAL DOE FUNDING | 0 | 300 | 162 | 0 | 2,438 | 0 | 0 | 0 | 2,900 |
| 4 NON-DOE FUNDING | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 TOTAL PROJECT | 0 | 300 | 162 | 0 | 2,438 | 0 | 0 | 0 | 2,900 |

Table numbers 2.6 through 2.13 not used.

Table 2.14 Project: NNWSI

Revised Reference Repository Cost Matrix
Vertical Emplacement
(Millions of Mid-1984 Dollars)

| SYSTEM | Engineering & Construction | Operation | Decommis-sioning | Total |
|---|---|---|---|---|
| WASTE PREPARATION | 309.886 | 1,508.582 | 28.988 | 1,847.456 |
| Waste Form Subsys | 86.959 | 0.000 | 0.000 | 86.959 |
| --Spent Fuel | 86.959 | 0.000 | 0.000 | 86.959 |
| --On-Site Generated | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Waste Pkg Subsys | 222.927 | 1,508.582 | 28.988 | 1,760.497 |
| --Spent Fuel | 202.942 | 1,497.490 | 28.988 | 1,729.420 |
| Pkg Components | 0.000 | 1,103.471 | 0.000 | 1,103.471 |
| Ass'bly Fac | 202.942 | 394.019 | 28.988 | 625.949 |
| --On-Site Generated | 19.985 | 11.092 | 0.000 | 31.077 |
| Pkg Components | 0.000 | 11.092 | 0.000 | 11.092 |
| Ass'bly Fac | 19.985 | 0.000 | 0.000 | 19.985 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Pkg Components | 0.000 | 0.000 | 0.000 | 0.000 |
| Ass'bly Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| REPOSITORY SYSTEM | 726.564 | 4,152.456 | 5.877 | 4,884.897 |
| Site | 181.630 | 0.000 | 0.000 | 181.630 |
| --Land & Land Rts | 1.300 | 0.000 | 0.000 | 1.300 |
| --On-Site Impr'mt | 17.499 | 0.000 | 0.000 | 17.499 |
| --Off-Site Impr'mt | 162.831 | 0.000 | 0.000 | 162.831 |
| Waste Hdlg & Empl | 128.285 | 1,133.545 | 0.840 | 1,262.670 |
| --Receiving | 5.648 | 0.000 | 0.000 | 5.648 |
| --Other Surf Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| --Waste Shafts | 28.924 | 0.000 | 0.840 | 29.764 |
| --Transfer & Empl | 93.713 | 1,133.545 | 0.000 | 1,227.258 |
| Rooms | 59.043 | 682.801 | 0.000 | 741.844 |
| Boreholes | 23.832 | 279.267 | 0.000 | 303.099 |
| Transfer Equip | 10.838 | 171.477 | 0.000 | 182.315 |
| U/G Wkgs/Rock Hdlg | 194.136 | 424.874 | 2.251 | 621.261 |
| --Men/Mat'ls Shaft | 29.952 | 0.000 | 1.393 | 31.345 |
| --Shaft Pillar | 14.693 | 2.534 | 0.000 | 17.227 |
| --Corridors | 112.942 | 382.995 | 0.000 | 495.937 |
| --Rock Hdlg/Disp'l | 36.549 | 39.345 | 0.858 | 76.752 |
| --Test Facilities | 0.000 | 0.000 | 0.000 | 0.000 |
| Ventilation | 88.133 | 297.933 | 2.786 | 388.852 |
| --Vent Structures | 11.605 | 0.000 | 0.000 | 11.605 |
| --Vent Supply Shft | 1.912 | 0.000 | 1.393 | 3.305 |
| --Dev Exhaust Shft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Vent Flow Paths | 64.975 | 297.933 | 0.000 | 362.908 |
| --Repos Exh Shaft | 9.641 | 0.000 | 1.393 | 11.034 |
| Support/Utilities | 134.380 | 2,296.104 | 0.000 | 2,430.484 |
| TOTALS | 1,036.450 | 5,661.038 | 34.865 | 6,732.353 |

Table 2.15 Project: NNWSI
Revised Reference Repository Engineering Cost
Vertical Emplacement
(Millions of Mid-1984 Dollars)

| | Title I | Title II | Title III | Total |
|---|---|---|---|---|
| Prior to FY 1984 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1984 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1985 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1986 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1987 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1988 | 4.953 | 0.000 | 0.000 | 4.953 |
| FY 1989 | 17.709 | 0.000 | 0.000 | 17.709 |
| FY 1990 | 12.427 | 18.208 | 0.000 | 30.635 |
| FY 1991 | 0.000 | 31.957 | 0.000 | 31.957 |
| FY 1992 | 0.000 | 20.096 | 0.000 | 20.096 |
| FY 1993 | 0.000 | 6.936 | 0.236 | 7.172 |
| FY 1994 | 0.000 | 0.000 | 3.295 | 3.295 |
| FY 1995 | 0.000 | 0.000 | 7.199 | 7.199 |
| FY 1996 | 0.000 | 0.000 | 7.736 | 7.736 |
| FY 1997 | 0.000 | 0.000 | 5.058 | 5.058 |
| FY 1998 | 0.000 | 0.000 | 2.324 | 2.324 |
| FY 1999 | 0.000 | 0.000 | 1.388 | 1.388 |
| FY 2000 | 0.000 | 0.000 | 0.709 | 0.709 |
| FY 2001 | 0.000 | 0.000 | 0.126 | 0.126 |
| TOTALS | 35.089 | 77.197 | 28.071 | 140.357 |

Table 2.16A

Project: NNWSI

Two-Stage Repository Cost Matrix
Vertical Emplacement
(Millions of Mid-1984 Dollars)

| SYSTEM | Engineering & Construction Costs Stage 1 | Stage 2 | Common | Total |
|---|---|---|---|---|
| WASTE PREPARATION | 84.714 | 262.318 | 47.568 | 394.600 |
| Waste Form Subsys | 13.442 | 80.562 | 6.397 | 100.401 |
| --Spent Fuel | 13.442 | 80.562 | 6.397 | 100.401 |
| --On-Site Generated | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Waste Pkg Subsys | 71.272 | 181.756 | 41.171 | 294.199 |
| --Spent Fuel | 71.272 | 181.756 | 21.186 | 274.214 |
| Pkg Components | 0.000 | 0.000 | 0.000 | 0.000 |
| Ass'bly Fac | 71.272 | 181.756 | 21.186 | 274.214 |
| --On-Site Generated | 0.000 | 0.000 | 19.985 | 19.985 |
| Pkg Components | 0.000 | 0.000 | 0.000 | 0.000 |
| Ass'bly Fac | 0.000 | 0.000 | 19.985 | 19.985 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Pkg Components | 0.000 | 0.000 | 0.000 | 0.000 |
| Ass'bly Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| REPOSITORY SYSTEM | 45.042 | 54.554 | 636.324 | 735.920 |
| Site | 0.000 | 0.000 | 181.630 | 181.630 |
| --Land & Land Rts | 0.000 | 0.000 | 1.300 | 1.300 |
| --On-Site Impr'mt | 0.000 | 0.000 | 17.499 | 17.499 |
| --Off-Site Impr'mt | 0.000 | 0.000 | 162.831 | 162.831 |
| Waste Hdlg & Empl | 45.042 | 54.554 | 34.572 | 134.168 |
| --Receiving | 0.000 | 0.000 | 5.648 | 5.648 |
| --Other Surf Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| --Waste Shafts | 0.000 | 0.000 | 28.924 | 28.924 |
| --Transfer & Empl | 45.042 | 54.554 | 0.000 | 99.596 |
| Rooms | 25.644 | 39.283 | 0.000 | 64.927 |
| Boreholes | 15.784 | 8.052 | 0.000 | 23.836 |
| Transfer Equip | 3.614 | 7.219 | 0.000 | 10.833 |
| U/G Wkgs/Rock Hdlg | 0.000 | 0.000 | 197.609 | 197.609 |
| --Men/Mat'ls Shaft | 0.000 | 0.000 | 33.425 | 33.425 |
| --Shaft Pillar | 0.000 | 0.000 | 14.693 | 14.693 |
| --Corridors | 0.000 | 0.000 | 112.942 | 112.942 |
| --Rock Hdlg/Disp'l | 0.000 | 0.000 | 36.549 | 36.549 |
| --Test Facilities | 0.000 | 0.000 | 0.000 | 0.000 |
| Ventilation | 0.000 | 0.000 | 88.133 | 88.133 |
| --Vent Structures | 0.000 | 0.000 | 11.605 | 11.605 |
| --Vent Supply Shft | 0.000 | 0.000 | 1.912 | 1.912 |
| --Dev Exhaust Shft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Vent Flow Paths | 0.000 | 0.000 | 64.975 | 64.975 |
| --Repos Exh Shaft | 0.000 | 0.000 | 9.641 | 9.641 |
| Support/Utilities | 0.000 | 0.000 | 134.380 | 134.380 |
| TOTALS | 129.756 | 316.872 | 683.892 | 1,130.520 |

Table 2.16B

Project: NNWSI

Two-Stage Repository Cost Matrix
Vertical Emplacement
(Millions of Mid-1984 Dollars)

| SYSTEM | Operation Costs Stage 1 | Stage 2 | Common | Total |
|---|---|---|---|---|
| WASTE PREPARATION | 84.616 | 1,456.118 | 4.881 | 1,545.615 |
| Waste Form Subsys | 0.000 | 0.000 | 0.000 | 0.000 |
| --Spent Fuel | 0.000 | 0.000 | 0.000 | 0.000 |
| --On-Site Generated | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Waste Pkg Subsys | 84.616 | 1,456.118 | 4.881 | 1,545.615 |
| --Spent Fuel | 84.288 | 1,445.352 | 4.881 | 1,534.521 |
| Pkg Components | 54.601 | 1,067.197 | 4.881 | 1,126.679 |
| Ass'bly Fac | 29.687 | 378.155 | 0.000 | 407.842 |
| --On-Site Generated | 0.328 | 10.766 | 0.000 | 11.094 |
| Pkg Components | 0.328 | 10.766 | 0.000 | 11.094 |
| Ass'bly Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Pkg Components | 0.000 | 0.000 | 0.000 | 0.000 |
| Ass'bly Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| REPOSITORY SYSTEM | 12.245 | 1,085.618 | 3,196.276 | 4,294.139 |
| Site | 0.000 | 0.000 | 0.000 | 0.000 |
| --Land & Land Rts | 0.000 | 0.000 | 0.000 | 0.000 |
| --On-Site Impr'mt | 0.000 | 0.000 | 0.000 | 0.000 |
| --Off-Site Impr'mt | 0.000 | 0.000 | 0.000 | 0.000 |
| Waste Hdlg & Empl | 12.245 | 1,085.618 | 40.310 | 1,138.173 |
| --Receiving | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other Surf Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| --Waste Shafts | 0.000 | 0.000 | 0.000 | 0.000 |
| --Transfer & Empl | 12.245 | 1,085.618 | 40.310 | 1,138.173 |
| Rooms | 4.811 | 679.091 | 0.000 | 683.902 |
| Boreholes | 0.000 | 282.795 | 0.000 | 282.795 |
| Transfer Equip | 7.434 | 123.732 | 40.310 | 171.476 |
| U/G Wkgs/Rock Hdlg | 0.000 | 0.000 | 424.874 | 424.874 |
| --Men/Mat'ls Shaft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Shaft Pillar | 0.000 | 0.000 | 2.534 | 2.534 |
| --Corridors | 0.000 | 0.000 | 382.995 | 382.995 |
| --Rock Hdlg/Disp'l | 0.000 | 0.000 | 39.345 | 39.345 |
| --Test Facilities | 0.000 | 0.000 | 0.000 | 0.000 |
| Ventilation | 0.000 | 0.000 | 297.932 | 297.932 |
| --Vent Structures | 0.000 | 0.000 | 0.000 | 0.000 |
| --Vent Supply Shft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Dev Exhaust Shft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Vent Flow Paths | 0.000 | 0.000 | 297.932 | 297.932 |
| --Repos Exh Shaft | 0.000 | 0.000 | 0.000 | 0.000 |
| Support/Utilities | 0.000 | 0.000 | 2,433.160 | 2,433.160 |
| TOTALS | 96.861 | 2,541.736 | 3,201.157 | 5,839.754 |

Table 2.16C

Project: NNWSI

Two-Stage Repository Cost Matrix
Vertical Emplacement
(Millions of Mid-1984 Dollars)

| SYSTEM | Decommissioning Costs Stage 1 | Stage 2 | Common | Total |
|---|---|---|---|---|
| WASTE PREPARATION | 8.465 | 26.228 | 2.760 | 37.453 |
| Waste Form Subsys | 0.000 | 0.000 | 0.000 | 0.000 |
| --Spent Fuel | 0.000 | 0.000 | 0.000 | 0.000 |
| --On-Site Generated | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Waste Pkg Subsys | 8.465 | 26.228 | 2.760 | 37.453 |
| --Spent Fuel | 8.465 | 26.228 | 2.760 | 37.453 |
| Pkg Components | 0.000 | 0.000 | 0.000 | 0.000 |
| Ass'bly Fac | 8.465 | 26.228 | 2.760 | 37.453 |
| --On-Site Generated | 0.000 | 0.000 | 0.000 | 0.000 |
| Pkg Components | 0.000 | 0.000 | 0.000 | 0.000 |
| Ass'bly Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Pkg Components | 0.000 | 0.000 | 0.000 | 0.000 |
| Ass'bly Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| REPOSITORY SYSTEM | 0.000 | 0.000 | 5.877 | 5.877 |
| Site | 0.000 | 0.000 | 0.000 | 0.000 |
| --Land & Land Rts | 0.000 | 0.000 | 0.000 | 0.000 |
| --On-Site Impr'mt | 0.000 | 0.000 | 0.000 | 0.000 |
| --Off-Site Impr'mt | 0.000 | 0.000 | 0.000 | 0.000 |
| Waste Hdlg & Empl | 0.000 | 0.000 | 0.840 | 0.840 |
| --Receiving | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other Surf Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| --Waste Shafts | 0.000 | 0.000 | 0.840 | 0.840 |
| --Transfer & Empl | 0.000 | 0.000 | 0.000 | 0.000 |
| Rooms | 0.000 | 0.000 | 0.000 | 0.000 |
| Boreholes | 0.000 | 0.000 | 0.000 | 0.000 |
| Transfer Equip | 0.000 | 0.000 | 0.000 | 0.000 |
| U/G Wkgs/Rock Hdlg | 0.000 | 0.000 | 2.251 | 2.251 |
| --Men/Mat'ls Shaft | 0.000 | 0.000 | 1.393 | 1.393 |
| --Shaft Pillar | 0.000 | 0.000 | 0.000 | 0.000 |
| --Corridors | 0.000 | 0.000 | 0.000 | 0.000 |
| --Rock Hdlg/Disp'l | 0.000 | 0.000 | 0.858 | 0.858 |
| --Test Facilities | 0.000 | 0.000 | 0.000 | 0.000 |
| Ventilation | 0.000 | 0.000 | 2.786 | 2.786 |
| --Vent Structures | 0.000 | 0.000 | 0.000 | 0.000 |
| --Vent Supply Shft | 0.000 | 0.000 | 1.393 | 1.393 |
| --Dev Exhaust Shft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Vent Flow Paths | 0.000 | 0.000 | 0.000 | 0.000 |
| --Repos Exh Shaft | 0.000 | 0.000 | 1.393 | 1.393 |
| Support/Utilities | 0.000 | 0.000 | 0.000 | 0.000 |
| TOTALS | 8.465 | 26.228 | 8.637 | 43.330 |

Table 2.16D

Project: NNWSI

Two-Stage Repository Cost Matrix
Vertical Emplacement
(Millions of Mid-1984 Dollars)

| SYSTEM | Total Costs Stage 1 | Stage 2 | Common | Total |
|---|---|---|---|---|
| WASTE PREPARATION | 177.795 | 1,744.664 | 55.209 | 1,977.668 |
| Waste Form Subsys | 13.442 | 80.562 | 6.397 | 100.401 |
| --Spent Fuel | 13.442 | 80.562 | 6.397 | 100.401 |
| --On-Site Generated | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Waste Pkg Subsys | 164.353 | 1,664.102 | 48.812 | 1,877.267 |
| --Spent Fuel | 164.025 | 1,653.336 | 28.827 | 1,846.188 |
| Pkg Components | 54.601 | 1,067.197 | 4.881 | 1,126.679 |
| Ass'bly Fac | 109.424 | 586.139 | 23.946 | 719.509 |
| --On-Site Generated | 0.328 | 10.766 | 19.985 | 31.079 |
| Pkg Components | 0.328 | 10.766 | 0.000 | 11.094 |
| Ass'bly Fac | 0.000 | 0.000 | 19.985 | 19.985 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Pkg Components | 0.000 | 0.000 | 0.000 | 0.000 |
| Ass'bly Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| REPOSITORY SYSTEM | 57.287 | 1,140.172 | 3,838.477 | 5,035.936 |
| Site | 0.000 | 0.000 | 181.630 | 181.630 |
| --Land & Land Rts | 0.000 | 0.000 | 1.300 | 1.300 |
| --On-Site Impr'mt | 0.000 | 0.000 | 17.499 | 17.499 |
| --Off-Site Impr'mt | 0.000 | 0.000 | 162.831 | 162.831 |
| Waste Hdlg & Empl | 57.287 | 1,140.172 | 75.722 | 1,273.181 |
| --Receiving | 0.000 | 0.000 | 5.648 | 5.648 |
| --Other Surf Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| --Waste Shafts | 0.000 | 0.000 | 29.764 | 29.764 |
| --Transfer & Empl | 57.287 | 1,140.172 | 40.310 | 1,237.769 |
| Rooms | 30.455 | 718.374 | 0.000 | 748.829 |
| Boreholes | 15.784 | 290.847 | 0.000 | 306.631 |
| Transfer Equip | 11.048 | 130.951 | 40.310 | 182.309 |
| U/G Wkgs/Rock Hdlg | 0.000 | 0.000 | 624.734 | 624.734 |
| --Men/Mat'ls Shaft | 0.000 | 0.000 | 34.818 | 34.818 |
| --Shaft Pillar | 0.000 | 0.000 | 17.227 | 17.227 |
| --Corridors | 0.000 | 0.000 | 495.937 | 495.937 |
| --Rock Hdlg/Disp'l | 0.000 | 0.000 | 76.752 | 76.752 |
| --Test Facilities | 0.000 | 0.000 | 0.000 | 0.000 |
| Ventilation | 0.000 | 0.000 | 388.851 | 388.851 |
| --Vent Structures | 0.000 | 0.000 | 11.605 | 11.605 |
| --Vent Supply Shft | 0.000 | 0.000 | 3.305 | 3.305 |
| --Dev Exhaust Shft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Vent Flow Paths | 0.000 | 0.000 | 362.907 | 362.907 |
| --Repos Exh Shaft | 0.000 | 0.000 | 11.034 | 11.034 |
| Support/Utilities | 0.000 | 0.000 | 2,567.540 | 2,567.540 |
| TOTALS | 235.082 | 2,884.836 | 3,893.686 | 7,013.604 |

Table 2.16E

Project: NNWSI

Two-Stage Repository Cost Matrix
Vertical Emplacement
(Millions of Mid-1984 Dollars)

| SYSTEM | Engineering & Construction | Operation | Decommis-sioning | Total |
|---|---|---|---|---|
| WASTE PREPARATION | 394.600 | 1,545.615 | 37.453 | 1,977.668 |
| Waste Form Subsys | 100.401 | 0.000 | 0.000 | 100.401 |
| --Spent Fuel | 100.401 | 0.000 | 0.000 | 100.401 |
| --On-Site Generated | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Waste Pkg Subsys | 294.199 | 1,545.615 | 37.453 | 1,877.267 |
| --Spent Fuel | 274.214 | 1,534.521 | 37.453 | 1,846.188 |
| Pkg Components | 0.000 | 1,126.679 | 0.000 | 1,126.679 |
| Ass'bly Fac | 274.214 | 407.842 | 37.453 | 719.509 |
| --On-Site Generated | 19.985 | 11.094 | 0.000 | 31.079 |
| Pkg Components | 0.000 | 11.094 | 0.000 | 11.094 |
| Ass'bly Fac | 19.985 | 0.000 | 0.000 | 19.985 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Pkg Components | 0.000 | 0.000 | 0.000 | 0.000 |
| Ass'bly Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| REPOSITORY SYSTEM | 735.920 | 4,294.139 | 5.877 | 5,035.936 |
| Site | 181.630 | 0.000 | 0.000 | 181.630 |
| --Land & Land Rts | 1.300 | 0.000 | 0.000 | 1.300 |
| --On-Site Impr'mt | 17.499 | 0.000 | 0.000 | 17.499 |
| --Off-Site Impr'mt | 162.831 | 0.000 | 0.000 | 162.831 |
| Waste Hdlg & Empl | 134.168 | 1,138.173 | 0.840 | 1,273.181 |
| --Receiving | 5.648 | 0.000 | 0.000 | 5.648 |
| --Other Surf Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| --Waste Shafts | 28.924 | 0.000 | 0.840 | 29.764 |
| --Transfer & Empl | 99.596 | 1,138.173 | 0.000 | 1,237.769 |
| Rooms | 64.927 | 683.902 | 0.000 | 748.829 |
| Boreholes | 23.836 | 282.795 | 0.000 | 306.631 |
| Transfer Equip | 10.833 | 171.476 | 0.000 | 182.309 |
| U/G Wkgs/Rock Hdlg | 197.609 | 424.874 | 2.251 | 624.734 |
| --Men/Mat'ls Shaft | 33.425 | 0.000 | 1.393 | 34.818 |
| --Shaft Pillar | 14.693 | 2.534 | 0.000 | 17.227 |
| --Corridors | 112.942 | 382.995 | 0.000 | 495.937 |
| --Rock Hdlg/Disp'l | 36.549 | 39.345 | 0.858 | 76.752 |
| --Test Facilities | 0.000 | 0.000 | 0.000 | 0.000 |
| Ventilation | 88.133 | 297.932 | 2.786 | 388.851 |
| --Vent Structures | 11.605 | 0.000 | 0.000 | 11.605 |
| --Vent Supply Shft | 1.912 | 0.000 | 1.393 | 3.305 |
| --Dev Exhaust Shft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Vent Flow Paths | 64.975 | 297.932 | 0.000 | 362.907 |
| --Repos Exh Shaft | 9.641 | 0.000 | 1.393 | 11.034 |
| Support/Utilities | 134.380 | 2,433.160 | 0.000 | 2,567.540 |
| TOTALS | 1,130.520 | 5,839.754 | 43.330 | 7,013.604 |

Table 2.17A Project: NNWSI

Two-Stage Repository Engineering Cost
Vertical Emplacement
(Millions of Mid-1984 Dollars)

| | Stage 1 Costs | | | |
|---|---|---|---|---|
| | Title I | Title II | Title III | Total |
| Prior to FY 1984 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1984 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1985 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1986 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1987 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1988 | 0.799 | 0.000 | 0.000 | 0.799 |
| FY 1989 | 2.854 | 0.000 | 0.000 | 2.854 |
| FY 1990 | 2.005 | 2.935 | 0.000 | 4.940 |
| FY 1991 | 0.000 | 5.151 | 0.000 | 5.151 |
| FY 1992 | 0.000 | 3.241 | 0.000 | 3.241 |
| FY 1993 | 0.000 | 1.121 | 0.043 | 1.164 |
| FY 1994 | 0.000 | 0.000 | 0.691 | 0.691 |
| FY 1995 | 0.000 | 0.000 | 1.528 | 1.528 |
| FY 1996 | 0.000 | 0.000 | 1.485 | 1.485 |
| FY 1997 | 0.000 | 0.000 | 0.708 | 0.708 |
| FY 1998 | 0.000 | 0.000 | 0.072 | 0.072 |
| FY 1999 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 2000 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 2001 | 0.000 | 0.000 | 0.000 | 0.000 |
| TOTALS | 5.658 | 12.448 | 4.527 | 22.633 |

Table 2.17B Project: NNWSI

Two-Stage Repository Engineering Cost
Vertical Emplacement
(Millions of Mid-1984 Dollars)

| | Stage 2 Costs | | | |
|---|---|---|---|---|
| | Title I | Title II | Title III | Total |
| Prior to FY 1984 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1984 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1985 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1986 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1987 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1988 | 2.075 | 0.000 | 0.000 | 2.075 |
| FY 1989 | 7.420 | 0.000 | 0.000 | 7.420 |
| FY 1990 | 5.209 | 7.631 | 0.000 | 12.840 |
| FY 1991 | 0.000 | 13.394 | 0.000 | 13.394 |
| FY 1992 | 0.000 | 8.422 | 0.000 | 8.422 |
| FY 1993 | 0.000 | 2.901 | 0.074 | 2.975 |
| FY 1994 | 0.000 | 0.000 | 0.808 | 0.808 |
| FY 1995 | 0.000 | 0.000 | 1.694 | 1.694 |
| FY 1996 | 0.000 | 0.000 | 2.381 | 2.381 |
| FY 1997 | 0.000 | 0.000 | 2.508 | 2.508 |
| FY 1998 | 0.000 | 0.000 | 2.075 | 2.075 |
| FY 1999 | 0.000 | 0.000 | 1.388 | 1.388 |
| FY 2000 | 0.000 | 0.000 | 0.709 | 0.709 |
| FY 2001 | 0.000 | 0.000 | 0.126 | 0.126 |
| TOTALS | 14.704 | 32.348 | 11.763 | 58.815 |

Table 2.17C Project: NNWSI

Two-Stage Repository Engineering Cost
Vertical Emplacement
(Millions of Mid-1984 Dollars)

| | Common Costs | | | |
|---|---|---|---|---|
| | Title I | Title II | Title III | Total |
| Prior to FY 1984 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1984 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1985 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1986 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1987 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1988 | 2.710 | 0.000 | 0.000 | 2.710 |
| FY 1989 | 9.696 | 0.000 | 0.000 | 9.696 |
| FY 1990 | 6.804 | 9.967 | 0.000 | 16.771 |
| FY 1991 | 0.000 | 17.495 | 0.000 | 17.495 |
| FY 1992 | 0.000 | 10.999 | 0.000 | 10.999 |
| FY 1993 | 0.000 | 3.799 | 0.156 | 3.955 |
| FY 1994 | 0.000 | 0.000 | 2.342 | 2.342 |
| FY 1995 | 0.000 | 0.000 | 5.187 | 5.187 |
| FY 1996 | 0.000 | 0.000 | 5.044 | 5.044 |
| FY 1997 | 0.000 | 0.000 | 2.404 | 2.404 |
| FY 1998 | 0.000 | 0.000 | 0.235 | 0.235 |
| FY 1999 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 2000 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 2001 | 0.000 | 0.000 | 0.000 | 0.000 |
| TOTALS | 19.210 | 42.260 | 15.368 | 76.838 |

Table 2.17D Project: NNWSI

Two-Stage Repository Engineering Cost
Vertical Emplacement
(Millions of Mid-1984 Dollars)

| | Total Costs | | | |
|---|---|---|---|---|
| | Title I | Title II | Title III | Total |
| Prior to FY 1984 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1984 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1985 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1986 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1987 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1988 | 5.584 | 0.000 | 0.000 | 5.584 |
| FY 1989 | 19.970 | 0.000 | 0.000 | 19.970 |
| FY 1990 | 14.018 | 20.533 | 0.000 | 34.551 |
| FY 1991 | 0.000 | 36.040 | 0.000 | 36.040 |
| FY 1992 | 0.000 | 22.662 | 0.000 | 22.662 |
| FY 1993 | 0.000 | 7.822 | 0.272 | 8.094 |
| FY 1994 | 0.000 | 0.000 | 3.841 | 3.841 |
| FY 1995 | 0.000 | 0.000 | 8.409 | 8.409 |
| FY 1996 | 0.000 | 0.000 | 8.910 | 8.910 |
| FY 1997 | 0.000 | 0.000 | 5.620 | 5.620 |
| FY 1998 | 0.000 | 0.000 | 2.382 | 2.382 |
| FY 1999 | 0.000 | 0.000 | 1.388 | 1.388 |
| FY 2000 | 0.000 | 0.000 | 0.709 | 0.709 |
| FY 2001 | 0.000 | 0.000 | 0.126 | 0.126 |
| TOTALS | 39.572 | 87.057 | 31.657 | 158.286 |

Table 2.18 Project: NNWSI

Repository Cost Matrix Comparison
Revised Reference Repository vs Two-Stage Repository - Vertical Emplacement
(Millions of Mid-1984 Dollars)

| SYSTEM | Revised Ref. Repository | Two-Stage Repository | | Difference |
|---|---|---|---|---|
| WASTE PREPARATION | 1,847.456 | 1,977.668 | + | 130.212 |
| Waste Form Subsys | 86.959 | 100.401 | + | 13.442 |
| --Spent Fuel | 86.959 | 100.401 | + | 13.442 |
| --On-Site Generated | 0.000 | 0.000 | + | 0.000 |
| --Other | 0.000 | 0.000 | + | 0.000 |
| Waste Pkg Subsys | 1,760.497 | 1,877.267 | + | 116.770 |
| --Spent Fuel | 1,729.420 | 1,846.188 | + | 116.768 |
| Pkg Components | 1,103.471 | 1,126.679 | + | 23.208 |
| Ass'bly Fac | 625.949 | 719.509 | + | 93.560 |
| --On-Site Generated | 31.077 | 31.079 | + | 0.002 |
| Pkg Components | 11.092 | 11.094 | + | 0.002 |
| Ass'bly Fac | 19.985 | 19.985 | + | 0.000 |
| --Other | 0.000 | 0.000 | + | 0.000 |
| Pkg Components | 0.000 | 0.000 | + | 0.000 |
| Ass'bly Fac | 0.000 | 0.000 | + | 0.000 |
| REPOSITORY SYSTEM | 4,884.897 | 5,035.936 | + | 151.039 |
| Site | 181.630 | 181.630 | + | 0.000 |
| --Land & Land Rts | 1.300 | 1.300 | + | 0.000 |
| --On-Site Impr'mt | 17.499 | 17.499 | + | 0.000 |
| --Off-Site Impr'mt | 162.831 | 162.831 | + | 0.000 |
| Waste Hdlg & Empl | 1,262.670 | 1,273.181 | + | 10.511 |
| --Receiving | 5.648 | 5.648 | + | 0.000 |
| --Other Surf Fac | 0.000 | 0.000 | + | 0.000 |
| --Waste Shafts | 29.764 | 29.764 | + | 0.000 |
| --Transfer & Empl | 1,227.258 | 1,237.769 | + | 10.511 |
| Rooms | 741.844 | 748.829 | + | 6.985 |
| Boreholes | 303.099 | 306.631 | + | 3.532 |
| Transfer Equip | 182.315 | 182.309 | - | 0.006 |
| U/G Wkgs/Rock Hdlg | 621.261 | 624.734 | + | 3.473 |
| --Men/Mat'ls Shaft | 31.345 | 34.818 | + | 3.473 |
| --Shaft Pillar | 17.227 | 17.227 | + | 0.000 |
| --Corridors | 495.937 | 495.937 | + | 0.000 |
| --Rock Hdlg/Disp'l | 76.752 | 76.752 | + | 0.000 |
| --Test Facilities | 0.000 | 0.000 | + | 0.000 |
| Ventilation | 388.852 | 388.851 | - | 0.001 |
| --Vent Structures | 11.605 | 11.605 | + | 0.000 |
| --Vent Supply Shft | 3.305 | 3.305 | + | 0.000 |
| --Dev Exhaust Shft | 0.000 | 0.000 | + | 0.000 |
| --Vent Flow Paths | 362.908 | 362.907 | - | 0.001 |
| --Repos Exh Shaft | 11.034 | 11.034 | + | 0.000 |
| Support/Utilities | 2,430.484 | 2,567.540 | + | 137.056 |
| TOTALS | 6,732.353 | 7,013.604 | + | 281.251 |

Table 2.19 Project: NNWSI

Definition of Accounts

WASTE PREPARATION
- Waste Form Subsystem
  - --Spent Fuel - Spent fuel consolidation facilities and operations.
  - --On-Site Generated Waste - On-site generated contact-handled waste collection and volume reduction facilities operation.
  - --Other - (Not used).
- Waste Package Subsystem
  - --Spent Fuel
    - Package Components - Spent fuel package costs including fabrication, transportation, and QA.
    - Assembly Facility - Facilities and operation to load spent fuel assemblies and/or pins into waste packages with subsequent sealing and testing.
  - --On-Site Generated Waste
    - Package Components - Overpack and drum costs for on-site generated waste. (if applicable).
    - Assembly Facility - Facilities capable of overpacking, sealing, and testing on-site generated waste packages.
  - --Other (not used).

REPOSITORY SYSTEM
- Site
  - --Land and Land Rights - Costs for land leases, purchases, mineral rights, permitting, etc.
  - --On-site Improvements - Costs for land grading, earthwork, drainage, roads, walkways, railroads, fencing, and landscaping.
  - --Off-Site Improvements - Costs for roads, railroads, pipelines, electrical transmission lines, and monitoring stations.
- Waste Handling and Emplacement
  - --Receiving - Costs for receiving and decontamination facilities and operations.
  - --Other Surface Facilities - Costs for surface storage facilities and operations.
  - --Waste Shafts (Ramps) - Costs for waste ramp (excavation, lining, water control).
  - --Transfer and Emplacement
    - Rooms - Costs for excavation of emplacement drifts for spent fuel. Rock support costs are included.
    - Boreholes - Costs of borehole drilling in emplacement drifts.
    - Transfer Equipment - Costs for surface and underground transportation of spent fuel, including cost of transporters. Emplacement of spent fuel in boreholes is also included.
- Underground Workings/Rock Handling
  - --Men and Material Shaft - Costs of shaft (excavation, lining, water control), hoists, headframe, skips, shaft stations and hoisting of men and materials.
  - --Shaft Pillar - Costs of excavation and backfill within the shaft pillar zone (including rock support and re-excavation).

--Corridors - Costs of excavation of main corridors, access drifts, and perimeter corridors used for ventilation including rock support and re-excavation or workings.
--Rock Handling/Disposal - Costs of rock transfer, storage, and disposal.
--Test Facilities - (not applicable).

Ventilation
--Ventilation Structures - Includes cost of facilities and operations for intake, confinement exhaust, and development exhaust. Costs include main fans, filters, stacks, etc.
--Ventilation Supply Shaft - Cost of modifications to the 12-ft-diameter shaft and the 6-ft-diameter shaft used in the exploratory shaft program.
--Development Exhaust Shaft - The waste ramp is used for development exhaust.
--Ventilation Flow Paths - Costs of doors, distribution fans, dampers, and flow piping for ventilation flow control.
--Repository Exhaust Shaft - Cost of shaft (excavation, water control, and lining).

Support and Utilities - Support facilities and utilities including:
Administration Building
Cafeteria
Training Center
Men and Materials Building
Maintenance Buildings
Fire Station
Health/Emergency Center
Industrial Safety Center
Visitors' Center
Security Center
Gatehouses
Laboratories
Storage
Material Handling and Storage Buildings
Warehouses and Receiving Buildings
Suspect Rail/Truck Storage
Inspection Facilities
Standby Generator Building (Emergency)
Water Supply, Storage, and Distribution System
Explosive Storage
Water Retention and Evaporation Ponds
Instrumentation
Cooling Towers
Sewage Treatment System
Electrical Substations and Distribution System
Chilled Water and Refrigeration Systems
Radiation Monitoring
Mine Monitoring
Communications
Railroad Equipment

TABLE 2.20 - ASSUMED SCHEDULE OF WASTE RECEIVED OR GENERATED ON-SITE

| CALENDAR YEAR | STAGE I SPENT FUEL[a] PWR (MTU) | STAGE I SPENT FUEL[a] BWR (MTU) | STAGE I ON-SITE CH[b] (12-DRUM PALLET) | STAGE II SPENT FUEL[a] PWR (MTU) | STAGE II SPENT FUEL[a] BWR (MTU) | STAGE II ON-SITE RH[c] (CANISTERS) | STAGE II ON-SITE CH[b] (12-DRUM PALLET) |
|---|---|---|---|---|---|---|---|
| 1998-2000 | 267 | 133 | 16 | 0 | 0 | 0 | 0 |
| 2001 | 267 | 133 | 16 | 333 | 167 | 56 | 19 |
| 2002 | 267 | 133 | 16 | 933 | 467 | 157 | 54 |
| 2003-2006 | 0 | 0 | 0 | 2,000 | 1,000 | 336 | 116 |
| 2007-2024 | 0 | 0 | 0 | 2,000 | 1,000 | 336 | 116 |
| 2025 | 0 | 0 | 0 | 67 | 33 | 11 | 4 |
| | 1,335 | 665 | 80 | 45,333 | 22,667 | 7,616 | 2,629 |

[a] Spent Fuel is assumed to be 2/3 PWR, 1/3 BWR by weight.

[b] CH waste generated at a rate of 0.464 drums/MTU.

[c] RH waste generated at a rate of 0.112 canisters/MTU consolidated.

Table 2.21 Project: NNWSI

Revised Reference Repository Operating Cost Summary
Vertical Emplacement
(Millions of Mid-1984 Dollars)

| SYSTEM | Emplacement Phase | Caretaker Phase | Backfilling Phase | Total |
|---|---|---|---|---|
| WASTE PREPARATION | 1,508.123 | 0.459 | 0.000 | 1,508.582 |
| Waste Form Subsys | 0.000 | 0.000 | 0.000 | 0.000 |
| --Spent Fuel | 0.000 | 0.000 | 0.000 | 0.000 |
| --On-Site Generated | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Waste Pkg Subsys | 1,508.123 | 0.459 | 0.000 | 1,508.582 |
| --Spent Fuel | 1,497.031 | 0.459 | 0.000 | 1,497.490 |
| Pkg Components | 1,103.012 | 0.459 | 0.000 | 1,103.471 |
| Ass'bly Fac | 394.019 | 0.000 | 0.000 | 394.019 |
| --On-Site Generated | 11.092 | 0.000 | 0.000 | 11.092 |
| Pkg Components | 11.092 | 0.000 | 0.000 | 11.092 |
| Ass'bly Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Pkg Components | 0.000 | 0.000 | 0.000 | 0.000 |
| Ass'bly Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| REPOSITORY SYSTEM | 3,322.298 | 378.076 | 452.082 | 4,152.456 |
| Site | 0.000 | 0.000 | 0.000 | 0.000 |
| --Land & Land Rts | 0.000 | 0.000 | 0.000 | 0.000 |
| --On-Site Impr'mt | 0.000 | 0.000 | 0.000 | 0.000 |
| --Off-Site Impr'mt | 0.000 | 0.000 | 0.000 | 0.000 |
| Waste Hdlg & Empl | 998.745 | 0.000 | 134.800 | 1,133.545 |
| --Receiving | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other Surf Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| --Waste Shafts | 0.000 | 0.000 | 0.000 | 0.000 |
| --Transfer & Empl | 998.745 | 0.000 | 134.800 | 1,133.545 |
| Rooms | 548.001 | 0.000 | 134.800 | 682.801 |
| Boreholes | 279.267 | 0.000 | 0.000 | 279.267 |
| Transfer Equip | 171.477 | 0.000 | 0.000 | 171.477 |
| U/G Wkgs/Rock Hdlg | 327.094 | 0.000 | 97.780 | 424.874 |
| --Men/Mat'ls Shaft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Shaft Pillar | 0.000 | 0.000 | 2.534 | 2.534 |
| --Corridors | 296.266 | 0.000 | 86.729 | 382.995 |
| --Rock Hdlg/Disp'l | 30.828 | 0.000 | 8.517 | 39.345 |
| --Test Facilities | 0.000 | 0.000 | 0.000 | 0.000 |
| Ventilation | 82.916 | 155.318 | 59.699 | 297.933 |
| --Vent Structures | 0.000 | 0.000 | 0.000 | 0.000 |
| --Vent Supply Shft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Dev Exhaust Shft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Vent Flow Paths | 82.916 | 155.318 | 59.699 | 297.933 |
| --Repos Exh Shaft | 0.000 | 0.000 | 0.000 | 0.000 |
| Support/Utilities | 1,913.543 | 222.758 | 159.803 | 2,296.104 |
| TOTALS | 4,830.421 | 378.535 | 452.082 | 5,661.038 |

Table 2.22A

Project: NNWSI

Two-Stage Repository Emplacement Cost Summary
Vertical Emplacement
(Millions of Mid-1984 Dollars)

| SYSTEM | Emplacement Phase: Stage 1 | Stage 2 | Common | Total |
|---|---|---|---|---|
| WASTE PREPARATION | 84.616 | 1,456.118 | 4.422 | 1,545.156 |
| Waste Form Subsys | 0.000 | 0.000 | 0.000 | 0.000 |
| --Spent Fuel | 0.000 | 0.000 | 0.000 | 0.000 |
| --On-Site Generated | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Waste Pkg Subsys | 84.616 | 1,456.118 | 4.422 | 1,545.156 |
| --Spent Fuel | 84.288 | 1,445.352 | 4.422 | 1,534.062 |
| Pkg Components | 54.601 | 1,067.197 | 4.422 | 1,126.220 |
| Ass'bly Fac | 29.687 | 378.155 | 0.000 | 407.842 |
| --On-Site Generated | 0.328 | 10.766 | 0.000 | 11.094 |
| Pkg Components | 0.328 | 10.766 | 0.000 | 11.094 |
| Ass'bly Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Pkg Components | 0.000 | 0.000 | 0.000 | 0.000 |
| Ass'bly Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| REPOSITORY SYSTEM | 7.434 | 954.528 | 2,527.613 | 3,489.575 |
| Site | 0.000 | 0.000 | 0.000 | 0.000 |
| --Land & Land Rts | 0.000 | 0.000 | 0.000 | 0.000 |
| --On-Site Impr'mt | 0.000 | 0.000 | 0.000 | 0.000 |
| --Off-Site Impr'mt | 0.000 | 0.000 | 0.000 | 0.000 |
| Waste Hdlg & Empl | 7.434 | 954.528 | 40.310 | 1,002.272 |
| --Receiving | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other Surf Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| --Waste Shafts | 0.000 | 0.000 | 0.000 | 0.000 |
| --Transfer & Empl | 7.434 | 954.528 | 40.310 | 1,002.272 |
| Rooms | 0.000 | 548.001 | 0.000 | 548.001 |
| Boreholes | 0.000 | 282.795 | 0.000 | 282.795 |
| Transfer Equip | 7.434 | 123.732 | 40.310 | 171.476 |
| U/G Wkgs/Rock Hdlg | 0.000 | 0.000 | 327.094 | 327.094 |
| --Men/Mat'ls Shaft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Shaft Pillar | 0.000 | 0.000 | 0.000 | 0.000 |
| --Corridors | 0.000 | 0.000 | 296.266 | 296.266 |
| --Rock Hdlg/Disp'l | 0.000 | 0.000 | 30.828 | 30.828 |
| --Test Facilities | 0.000 | 0.000 | 0.000 | 0.000 |
| Ventilation | 0.000 | 0.000 | 95.341 | 95.341 |
| --Vent Structures | 0.000 | 0.000 | 0.000 | 0.000 |
| --Vent Supply Shft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Dev Exhaust Shft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Vent Flow Paths | 0.000 | 0.000 | 95.341 | 95.341 |
| --Repos Exh Shaft | 0.000 | 0.000 | 0.000 | 0.000 |
| Support/Utilities | 0.000 | 0.000 | 2,064.868 | 2,064.868 |
| TOTALS | 92.050 | 2,410.646 | 2,532.035 | 5,034.731 |

Table 2.22B

Project: NNWSI

Two-Stage Repository Operating Cost Summary
Vertical Emplacement
(Millions of Mid-1984 Dollars)

| SYSTEM | Emplacement Phase | Caretaker Phase | Backfilling Phase | Total |
|---|---|---|---|---|
| WASTE PREPARATION | 1,545.156 | 0.459 | 0.000 | 1,545.615 |
| Waste Form Subsys | 0.000 | 0.000 | 0.000 | 0.000 |
| --Spent Fuel | 0.000 | 0.000 | 0.000 | 0.000 |
| --On-Site Generated | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Waste Pkg Subsys | 1,545.156 | 0.459 | 0.000 | 1,545.615 |
| --Spent Fuel | 1,534.062 | 0.459 | 0.000 | 1,534.521 |
| Pkg Components | 1,126.220 | 0.459 | 0.000 | 1,126.679 |
| Ass'bly Fac | 407.842 | 0.000 | 0.000 | 407.842 |
| --On-Site Generated | 11.094 | 0.000 | 0.000 | 11.094 |
| Pkg Components | 11.094 | 0.000 | 0.000 | 11.094 |
| Ass'bly Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Pkg Components | 0.000 | 0.000 | 0.000 | 0.000 |
| Ass'bly Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| REPOSITORY SYSTEM | 3,489.575 | 351.046 | 453.518 | 4,294.139 |
| Site | 0.000 | 0.000 | 0.000 | 0.000 |
| --Land & Land Rts | 0.000 | 0.000 | 0.000 | 0.000 |
| --On-Site Impr'mt | 0.000 | 0.000 | 0.000 | 0.000 |
| --Off-Site Impr'mt | 0.000 | 0.000 | 0.000 | 0.000 |
| Waste Hdlg & Empl | 1,002.272 | 0.000 | 135.901 | 1,138.173 |
| --Receiving | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other Surf Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| --Waste Shafts | 0.000 | 0.000 | 0.000 | 0.000 |
| --Transfer & Empl | 1,002.272 | 0.000 | 135.901 | 1,138.173 |
| Rooms | 548.001 | 0.000 | 135.901 | 683.902 |
| Boreholes | 282.795 | 0.000 | 0.000 | 282.795 |
| Transfer Equip | 171.476 | 0.000 | 0.000 | 171.476 |
| U/G Wkgs/Rock Hdlg | 327.094 | 0.000 | 97.780 | 424.874 |
| --Men/Mat'ls Shaft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Shaft Pillar | 0.000 | 0.000 | 2.534 | 2.534 |
| --Corridors | 296.266 | 0.000 | 86.729 | 382.995 |
| --Rock Hdlg/Disp'l | 30.828 | 0.000 | 8.517 | 39.345 |
| --Test Facilities | 0.000 | 0.000 | 0.000 | 0.000 |
| Ventilation | 95.341 | 142.892 | 59.699 | 297.932 |
| --Vent Structures | 0.000 | 0.000 | 0.000 | 0.000 |
| --Vent Supply Shft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Dev Exhaust Shft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Vent Flow Paths | 95.341 | 142.892 | 59.699 | 297.932 |
| --Repos Exh Shaft | 0.000 | 0.000 | 0.000 | 0.000 |
| Support/Utilities | 2,064.868 | 208.154 | 160.138 | 2,433.160 |
| TOTALS | 5,034.731 | 351.505 | 453.518 | 5,839.754 |

## 3 HORIZONTAL EMPLACEMENT

The cost estimates for the revised reference repository and the two-stage repository in Section 2 were based on the assumption that the spent fuel canisters would be emplaced in shallow vertical boreholes in the floor of the emplacement drifts, one canister to a borehole. As discussed in the body of the report, there would be economic advantages if multiple canisters of spent fuel were emplaced in long horizontal boreholes in the walls of the emplacement drifts.

This section addresses these economic advantages. The table numbering scheme is the same as that used in Section 2, with the exception that Tables 3.24A and 3.18A are comparable to Tables 2.14 and 3.18, and Tables 3.14B, 3.14C, and 3.18B have been added. Table 3.14B is a comparison of the reference repository to the revised reference repository using the horizontal emplacement configuration (similar to Table 1.2). Table 3.14C compares a revised reference repository using vertical emplacement to a revised reference repository using horizontal emplacement. Table 3.18B compares a two-stage repository using horizontal emplacement to a two-stage repository using vertical emplacement.

Where tables are identical to tables in Section 2, they have been renumbered and reproduced here for convenience. These renumbered tables include Tables 3.0 through 3.5 and Tables 3.19 and 3.20.

Table 3.0
Exploratory Shaft Summary Costs
(Thousands of Mid-1984 Dollars)

Project: NNWSI

| | Cum Year | FY 1984 | FY 1985 | FY 1986 | FY 1987 | FY 1988 | FY 1989 | FY 1990 | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1 OPERATING EXPENSES | | | | | | | | | |
| Design & Construction | 4,124 | 593 | 4,504 | 14,325 | 12,626 | 3,531 | 221 | 59 | 39,983 |
| Evaluation & Testing | 0 | 0 | 2,684 | 10,559 | 10,802 | 6,236 | 3,285 | 875 | 34,441 |
| Operations & Maintenance | 212 | 250 | 859 | 3,047 | 4,616 | 5,243 | 3,444 | 916 | 18,587 |
| Planning & Direction | 2,294 | 1,620 | 2,605 | 2,243 | 2,235 | 1,948 | 1,535 | 330 | 14,810 |
| Integrated Data System | 210 | 360 | 734 | 2,650 | 1,471 | 997 | 947 | 220 | 7,589 |
| R&D Related to Const. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL OPERATING EXPENSES | 6,840 | 2,823 | 11,386 | 32,824 | 31,750 | 17,955 | 9,432 | 2,400 | 115,410 |
| 2 CAPITAL EQUIPMENT | 3,515 | 520 | 1,200 | 2,440 | 960 | 220 | 110 | 0 | 8,965 |
| 3 TOTAL DOE FUNDING | 10,355 | 3,343 | 12,586 | 35,264 | 32,710 | 18,175 | 9,542 | 2,400 | 124,375 |
| 4 NON-DOE FUNDING | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 TOTAL PROJECT | 10,355 | 3,343 | 12,586 | 35,264 | 32,710 | 18,175 | 9,542 | 2,400 | 124,375 |

Table 3.1
Exploratory Shaft Detail Costs
(Thousands of Mid-1984 Dollars)

Project: NNWSI

| | Cum Year | FY 1984 | FY 1985 | FY 1986 | FY 1987 | FY 1988 | FY 1989 | FY 1990 | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1 OPERATING EXPENSES | | | | | | | | | |
| Design & Construction | | | | | | | | | |
| Surface Facilities | | | | | | | | | |
| Site & Roads | 2,194 | 50 | 700 | 0 | 0 | 0 | 0 | 0 | 2,944 |
| Utilities & Comm Sys | 1,475 | 20 | 1,075 | 0 | 0 | 0 | 0 | 0 | 2,570 |
| Buildings | 184 | 0 | 450 | 0 | 0 | 0 | 0 | 0 | 634 |
| Mine Plant | 0 | 0 | 359 | 12 | 0 | 0 | 0 | 0 | 371 |
| Contingency | 0 | 0 | 260 | 1 | 0 | 0 | 0 | 0 | 261 |
| Subsurface Facilities | | | | | | | | | |
| Shafts | 167 | 350 | 301 | 7,703 | 2,000 | 0 | 0 | 0 | 10,521 |
| Shaft Internals | 32 | 10 | 31 | 870 | 12 | 0 | 0 | 0 | 955 |
| Underground Openings | 30 | 20 | 22 | 871 | 5,928 | 2,278 | 0 | 0 | 9,149 |
| Utilities & Comm Sys | 0 | 90 | 425 | 1,215 | 0 | 0 | 0 | 0 | 1,730 |
| Lateral Core Holes | 0 | 10 | 0 | 0 | 1,325 | 0 | 0 | 0 | 1,335 |
| Contingency | 0 | 0 | 109 | 1,599 | 1,390 | 342 | 0 | 0 | 3,440 |
| NTS Allocation | | | | | | | | | |
| F&S Alloc | 0 | 8 | 18 | 57 | 65 | 17 | 0 | 0 | 165 |
| H&N Alloc | 0 | 10 | 61 | 121 | 33 | 13 | 3 | 0 | 241 |
| REECo Alloc | 0 | 15 | 201 | 169 | 686 | 424 | 189 | 51 | 1,735 |
| Subcontractor Alloc | 0 | 0 | 8 | 559 | 120 | 0 | 0 | 0 | 687 |
| Contingency | 0 | 0 | 43 | 136 | 136 | 68 | 29 | 8 | 420 |
| Other | | | | | | | | | |
| Engineering Data | 42 | 10 | 441 | 1,012 | 931 | 389 | 0 | 0 | 2,825 |
| Subtotal | 4,124 | 593 | 4,504 | 14,325 | 12,626 | 3,531 | 221 | 59 | 39,983 |
| Evaluation & Testing | | | | | | | | | |
| Geotechnical Data | 0 | 0 | 1,934 | 8,145 | 8,355 | 4,761 | 2,628 | 700 | 26,523 |
| Management Reports | 0 | 0 | 125 | 100 | 100 | 150 | 0 | 0 | 475 |
| Contingency | 0 | 0 | 625 | 2,314 | 2,347 | 1,325 | 657 | 175 | 7,443 |
| Subtotal | 0 | 0 | 2,684 | 10,559 | 10,802 | 6,236 | 3,285 | 875 | 34,441 |

Table 3.1 (Concluded)

Project: NNWSI

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Operations & Maintenance | | | | | | | | | |
| Site & Equipment | 212 | 150 | 46 | 495 | 475 | 475 | 330 | 0 | 2,183 |
| Project Operations | 0 | 100 | 724 | 2,246 | 3,659 | 4,232 | 2,789 | 833 | 14,583 |
| Training | 0 | 0 | 11 | 29 | 62 | 59 | 12 | 0 | 173 |
| Contingency | 0 | 0 | 78 | 277 | 420 | 477 | 313 | 83 | 1,648 |
| Subtotal | 212 | 250 | 859 | 3,047 | 4,616 | 5,243 | 3,444 | 916 | 18,587 |
| Planning & Technical Direction | | | | | | | | | |
| Tecnical Direction | 2,294 | 775 | 639 | 600 | 500 | 400 | 400 | 100 | 5,708 |
| Test Plan | 0 | 800 | 1,305 | 900 | 900 | 900 | 600 | 100 | 5,505 |
| Safety & QA | 0 | 45 | 424 | 539 | 632 | 471 | 395 | 100 | 2,606 |
| Contingency | 0 | 0 | 237 | 204 | 203 | 177 | 140 | 30 | 991 |
| Subtotal | 2,294 | 1,620 | 2,605 | 2,243 | 2,235 | 1,948 | 1,535 | 330 | 14,810 |
| Integrated Data System | | | | | | | | | |
| IDS Development & Oper. | 210 | 360 | 506 | 2,268 | 1,291 | 860 | 815 | 200 | 6,510 |
| IDS Support | 0 | 0 | 170 | 132 | 46 | 46 | 46 | 0 | 440 |
| Contingency | 0 | 0 | 58 | 250 | 134 | 91 | 86 | 20 | 639 |
| Subtotal | 210 | 360 | 734 | 2,650 | 1,471 | 997 | 947 | 220 | 7,589 |
| R&D Related to Const. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL OPERATING EXPENSES | 6,840 | 2,823 | 11,386 | 32,824 | 31,750 | 17,955 | 9,432 | 2,400 | 115,410 |
| 2 CAPITAL EQUIPMENT | 3,515 | 520 | 1,200 | 2,440 | 960 | 220 | 110 | 0 | 8,965 |
| 3 TOTAL DOE FUNDING | 10,355 | 3,343 | 12,586 | 35,264 | 32,710 | 18,175 | 9,542 | 2,400 | 124,375 |
| 4 NON-DOE FUNDING | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 TOTAL PROJECT | 10,355 | 3,343 | 12,586 | 35,264 | 32,710 | 18,175 | 9,542 | 2,400 | 124,375 |

Project: NNWSI

Table 3.2
First Shaft Summary Costs
(Thousands of Mid-1984 Dollars)

| | Cum Year | FY 1984 | FY 1985 | FY 1986 | FY 1987 | FY 1988 | FY 1989 | FY 1990 | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1 OPERATING EXPENSES | | | | | | | | | |
| Design & Construction | 4,124 | 293 | 4,342 | 14,325 | 10,188 | 3,531 | 221 | 59 | 37,083 |
| Evaluation & Testing | 0 | 0 | 2,684 | 10,559 | 10,802 | 6,236 | 3,285 | 875 | 34,441 |
| Operations & Maintenance | 212 | 250 | 859 | 3,047 | 4,616 | 5,243 | 3,444 | 916 | 18,587 |
| Planning & Direction | 2,294 | 1,620 | 2,605 | 2,243 | 2,235 | 1,948 | 1,535 | 330 | 14,810 |
| Integrated Data System | 210 | 360 | 734 | 2,650 | 1,471 | 997 | 947 | 220 | 7,589 |
| R&D Related to Const. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL OPERATING EXPENSES | 6,840 | 2,523 | 11,224 | 32,824 | 29,312 | 17,955 | 9,432 | 2,400 | 112,510 |
| 2 CAPITAL EQUIPMENT | 3,515 | 520 | 1,200 | 2,440 | 960 | 220 | 110 | 0 | 8,965 |
| 3 TOTAL DOE FUNDING | 10,355 | 3,043 | 12,424 | 35,264 | 30,272 | 18,175 | 9,542 | 2,400 | 121,475 |
| 4 NON-DOE FUNDING | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 TOTAL PROJECT | 10,355 | 3,043 | 12,424 | 35,264 | 30,272 | 18,175 | 9,542 | 2,400 | 121,475 |

Table 3.3
First Shaft Detail Costs
(Thousands of Mid-1984 Dollars)

Project: NNWSI

| | Cum Year | FY 1984 | FY 1985 | FY 1986 | FY 1987 | FY 1988 | FY 1989 | FY 1990 | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1 OPERATING EXPENSES | | | | | | | | | |
| Design & Construction | | | | | | | | | |
| Surface Facilities | | | | | | | | | |
| Site & Roads | 2,194 | 0 | 600 | 0 | 0 | 0 | 0 | 0 | 2,794 |
| Utilities & Comm Sys | 1,475 | 20 | 1,075 | 0 | 0 | 0 | 0 | 0 | 2,570 |
| Buildings | 184 | 0 | 450 | 0 | 0 | 0 | 0 | 0 | 634 |
| Mine Plant | 0 | 0 | 359 | 12 | 0 | 0 | 0 | 0 | 371 |
| Contingency | 0 | 0 | 248 | 1 | 0 | 0 | 0 | 0 | 249 |
| Subsurface Facilities | | | | | | | | | |
| Shafts | 167 | 100 | 251 | 7,703 | 0 | 0 | 0 | 0 | 8,221 |
| Shaft Internals | 32 | 10 | 31 | 870 | 12 | 0 | 0 | 0 | 955 |
| Underground Openings | 30 | 20 | 22 | 871 | 5,928 | 2,278 | 0 | 0 | 9,149 |
| Utilities & Comm Sys | 0 | 90 | 425 | 1,215 | 0 | 0 | 0 | 0 | 1,730 |
| Lateral Core Holes | 0 | 10 | 0 | 0 | 1,325 | 0 | 0 | 0 | 1,335 |
| Contingency | 0 | 0 | 109 | 1,599 | 1,090 | 342 | 0 | 0 | 3,140 |
| NTS Allocation | | | | | | | | | |
| F&S Alloc | 0 | 8 | 18 | 57 | 65 | 17 | 0 | 0 | 165 |
| H&N Alloc | 0 | 10 | 61 | 121 | 33 | 13 | 3 | 0 | 241 |
| REECo Alloc | 0 | 15 | 201 | 169 | 686 | 424 | 189 | 51 | 1,735 |
| Subcontractor Alloc | 0 | 0 | 8 | 559 | 0 | 0 | 0 | 0 | 567 |
| Contingency | 0 | 0 | 43 | 136 | 118 | 68 | 29 | 8 | 402 |
| Other | | | | | | | | | |
| Engineering Data | 42 | 10 | 441 | 1,012 | 931 | 389 | 0 | 0 | 2,825 |
| Subtotal | 4,124 | 293 | 4,342 | 14,325 | 10,188 | 3,531 | 221 | 59 | 37,083 |
| Evaluation & Testing | | | | | | | | | |
| Geotechnical Data | 0 | 0 | 1,934 | 8,145 | 8,355 | 4,761 | 2,628 | 700 | 26,523 |
| Management Reports | 0 | 0 | 125 | 100 | 100 | 150 | 0 | 0 | 475 |
| Contingency | 0 | 0 | 625 | 2,314 | 2,347 | 1,325 | 657 | 175 | 7,443 |
| Subtotal | 0 | 0 | 2,684 | 10,559 | 10,802 | 6,236 | 3,285 | 875 | 34,441 |

Table 3.3 (Concluded) Project: NNWSI

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Operations & Maintenance | | | | | | | | | |
| Site & Equipment | 212 | 150 | 46 | 495 | 475 | 475 | 330 | 0 | 2,183 |
| Project Operations | 0 | 100 | 724 | 2,246 | 3,659 | 4,232 | 2,789 | 833 | 14,583 |
| Training | 0 | 0 | 11 | 29 | 62 | 59 | 12 | 0 | 173 |
| Contingency | 0 | 0 | 78 | 277 | 420 | 477 | 313 | 83 | 1,648 |
| Subtotal | 212 | 250 | 859 | 3,047 | 4,616 | 5,243 | 3,444 | 916 | 18,587 |
| Planning & Technical Direction | | | | | | | | | |
| Tecnical Direction | 2,294 | 775 | 639 | 600 | 500 | 400 | 400 | 100 | 5,708 |
| Test Plan | 0 | 800 | 1,305 | 900 | 900 | 900 | 600 | 100 | 5,505 |
| Safety & QA | 0 | 45 | 424 | 539 | 632 | 471 | 395 | 100 | 2,606 |
| Contingency | 0 | 0 | 237 | 204 | 203 | 177 | 140 | 30 | 991 |
| Subtotal | 2,294 | 1,620 | 2,605 | 2,243 | 2,235 | 1,948 | 1,535 | 330 | 14,810 |
| Integrated Data System | | | | | | | | | |
| IDS Development & Oper. | 210 | 360 | 506 | 2,268 | 1,291 | 860 | 815 | 200 | 6,510 |
| IDS Support | 0 | 0 | 170 | 132 | 46 | 46 | 46 | 0 | 440 |
| Contingency | 0 | 0 | 58 | 250 | 134 | 91 | 86 | 20 | 639 |
| Subtotal | 210 | 360 | 734 | 2,650 | 1,471 | 997 | 947 | 220 | 7,589 |
| R&D Related to Const. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL OPERATING EXPENSES | 6,840 | 2,523 | 11,224 | 32,824 | 29,312 | 17,955 | 9,432 | 2,400 | 112,510 |
| 2 CAPITAL EQUIPMENT | 3,515 | 520 | 1,200 | 2,440 | 960 | 220 | 110 | 0 | 8,965 |
| 3 TOTAL DOE FUNDING | 10,355 | 3,043 | 12,424 | 35,264 | 30,272 | 18,175 | 9,542 | 2,400 | 121,475 |
| 4 NON-DOE FUNDING | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 TOTAL PROJECT | 10,355 | 3,043 | 12,424 | 35,264 | 30,272 | 18,175 | 9,542 | 2,400 | 121,475 |

Table 3.4
Second Shaft Summary Costs
(Thousands of Mid-1984 Dollars)

Project: NNWSI

| | Cum Year | FY 1984 | FY 1985 | FY 1986 | FY 1987 | FY 1988 | FY 1989 | FY 1990 | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1 OPERATING EXPENSES | | | | | | | | | |
| Design & Construction | 0 | 300 | 162 | 0 | 2,438 | 0 | 0 | 0 | 2,900 |
| Evaluation & Testing | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Operations & Maintenance | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Planning & Direction | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Integrated Data System | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| R&D Related to Const. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL OPERATING EXPENSES | 0 | 300 | 162 | 0 | 2,438 | 0 | 0 | 0 | 2,900 |
| 2 CAPITAL EQUIPMENT | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 TOTAL DOE FUNDING | 0 | 300 | 162 | 0 | 2,438 | 0 | 0 | 0 | 2,900 |
| 4 NON-DOE FUNDING | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 TOTAL PROJECT | 0 | 300 | 162 | 0 | 2,438 | 0 | 0 | 0 | 2,900 |

Table 3.5
Second Shaft Detail Costs
(Thousands of Mid-1984 Dollars)

Project: NNWSI

| | Cum Year | FY 1984 | FY 1985 | FY 1986 | FY 1987 | FY 1988 | FY 1989 | FY 1990 | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1 OPERATING EXPENSES | | | | | | | | | |
| Design & Construction | | | | | | | | | |
| Surface Facilities | | | | | | | | | |
| Site & Roads | 0 | 50 | 100 | 0 | 0 | 0 | 0 | 0 | 150 |
| Utilities & Comm Sys | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Buildings | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mine Plant | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Contingency | 0 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 12 |
| Subsurface Facilities | | | | | | | | | |
| Shafts | 0 | 250 | 50 | 0 | 2,000 | 0 | 0 | 0 | 2,300 |
| Shaft Internals | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Underground Openings | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Utilities & Comm Sys | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lateral Core Holes | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Contingency | 0 | 0 | 0 | 0 | 300 | 0 | 0 | 0 | 300 |
| NTS Allocation | | | | | | | | | |
| F&S Alloc | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| H&N Alloc | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| REECo Alloc | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Subcontractor Alloc | 0 | 0 | 0 | 0 | 120 | 0 | 0 | 0 | 120 |
| Contingency | 0 | 0 | 0 | 0 | 18 | 0 | 0 | 0 | 18 |
| Other | | | | | | | | | |
| Engineering Data | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Subtotal | 0 | 300 | 162 | 0 | 2,438 | 0 | 0 | 0 | 2,900 |
| Evaluation & Testing | | | | | | | | | |
| Geotechnical Data | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Management Reports | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Contingency | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Subtotal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 3.5 (Concluded) Project: NNWSI

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Operations & Maintenance | | | | | | | | | |
| Site & Equipment | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Project Operations | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Training | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Contingency | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Subtotal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Planning & Technical Direction | | | | | | | | | |
| Tecnical Direction | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Test Plan | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Safety & QA | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Contingency | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Subtotal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Integrated Data System | | | | | | | | | |
| IDS Development & Oper. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| IDS Support | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Contingency | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Subtotal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| R&D Related to Const. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL OPERATING EXPENSES | 0 | 300 | 162 | 0 | 2,438 | 0 | 0 | 0 | 2,900 |
| 2 CAPITAL EQUIPMENT | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 TOTAL DOE FUNDING | 0 | 300 | 162 | 0 | 2,438 | 0 | 0 | 0 | 2,900 |
| 4 NON-DOE FUNDING | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 TOTAL PROJECT | 0 | 300 | 162 | 0 | 2,438 | 0 | 0 | 0 | 2,900 |

Table numbers 3.6 through 3.13 not used.

Table 3.14A

Project: NNWSI

Revised Reference Repository Cost Matrix
Horizontal Emplacement
(Millions of Mid-1984 Dollars)

| SYSTEM | Engineering & Construction | Operation | Decommis-sioning | Total |
|---|---|---|---|---|
| WASTE PREPARATION | 309.886 | 1,508.582 | 28.988 | 1,847.456 |
| Waste Form Subsys | 86.959 | 0.000 | 0.000 | 86.959 |
| --Spent Fuel | 86.959 | 0.000 | 0.000 | 86.959 |
| --On-Site Generated | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Waste Pkg Subsys | 222.927 | 1,508.582 | 28.988 | 1,760.497 |
| --Spent Fuel | 202.942 | 1,497.490 | 28.988 | 1,729.420 |
| Pkg Components | 0.000 | 1,103.471 | 0.000 | 1,103.471 |
| Ass'bly Fac | 202.942 | 394.019 | 28.988 | 625.949 |
| --On-Site Generated | 19.985 | 11.092 | 0.000 | 31.077 |
| Pkg Components | 0.000 | 11.092 | 0.000 | 11.092 |
| Ass'bly Fac | 19.985 | 0.000 | 0.000 | 19.985 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Pkg Components | 0.000 | 0.000 | 0.000 | 0.000 |
| Ass'bly Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| REPOSITORY SYSTEM | 657.728 | 3,063.629 | 5.877 | 3,727.234 |
| Site | 181.630 | 0.000 | 0.000 | 181.630 |
| --Land & Land Rts | 1.300 | 0.000 | 0.000 | 1.300 |
| --On-Site Impr'mt | 17.499 | 0.000 | 0.000 | 17.499 |
| --Off-Site Impr'mt | 162.831 | 0.000 | 0.000 | 162.831 |
| Waste Hdlg & Empl | 108.115 | 630.501 | 0.840 | 739.456 |
| --Receiving | 5.648 | 0.000 | 0.000 | 5.648 |
| --Other Surf Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| --Waste Shafts | 28.924 | 0.000 | 0.840 | 29.764 |
| --Transfer & Empl | 73.543 | 630.501 | 0.000 | 704.044 |
| Rooms | 32.125 | 122.036 | 0.000 | 154.161 |
| Boreholes | 27.875 | 313.528 | 0.000 | 341.403 |
| Transfer Equip | 13.543 | 194.937 | 0.000 | 208.480 |
| U/G Wkgs/Rock Hdlg | 157.913 | 70.248 | 2.251 | 230.412 |
| --Men/Mat'ls Shaft | 29.952 | 0.000 | 1.393 | 31.345 |
| --Shaft Pillar | 14.693 | 2.534 | 0.000 | 17.227 |
| --Corridors | 76.904 | 39.637 | 0.000 | 116.541 |
| --Rock Hdlg/Disp'l | 36.364 | 28.077 | 0.858 | 65.299 |
| --Test Facilities | 0.000 | 0.000 | 0.000 | 0.000 |
| Ventilation | 85.519 | 242.709 | 2.786 | 331.014 |
| --Vent Structures | 8.991 | 0.000 | 0.000 | 8.991 |
| --Vent Supply Shft | 1.912 | 0.000 | 1.393 | 3.305 |
| --Dev Exhaust Shft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Vent Flow Paths | 64.975 | 242.709 | 0.000 | 307.684 |
| --Repos Exh Shaft | 9.641 | 0.000 | 1.393 | 11.034 |
| Support/Utilities | 124.551 | 2,120.171 | 0.000 | 2,244.722 |
| TOTALS | 967.614 | 4,572.211 | 34.865 | 5,574.690 |

Table 3.14B Project: NNWSI

Repository Cost Matrix Comparison
Reference Repository vs Revised Reference Repository, Horizontal Emplacement
(Millions of Mid-1984 Dollars)

| SYSTEM | Reference Repository | Revised Ref. Repository | | Difference |
|---|---|---|---|---|
| WASTE PREPARATION | 1,377.000 | 1,847.456 | + | 470.456 |
| Waste Form Subsys | 490.000 | 86.959 | - | 403.041 |
| --Spent Fuel | 431.000 | 86.959 | - | 344.041 |
| --On-Site Generated | 59.000 | 0.000 | - | 59.000 |
| --Other | 0.000 | 0.000 | + | 0.000 |
| Waste Pkg Subsys | 887.000 | 1,760.497 | + | 873.497 |
| --Spent Fuel | 736.000 | 1,729.420 | + | 993.420 |
| Pkg Components | 320.000 | 1,103.471 | + | 783.471 |
| Ass'bly Fac | 416.000 | 625.949 | + | 209.949 |
| --On-Site Generated | 151.000 | 31.077 | - | 119.923 |
| Pkg Components | 96.000 | 11.092 | - | 84.908 |
| Ass'bly Fac | 55.000 | 19.985 | - | 35.015 |
| --Other | 0.000 | 0.000 | + | 0.000 |
| Pkg Components | 0.000 | 0.000 | + | 0.000 |
| Ass'bly Fac | 0.000 | 0.000 | + | 0.000 |
| REPOSITORY SYSTEM | 3,831.000 | 3,727.234 | - | 103.766 |
| Site | 517.000 | 181.630 | - | 335.370 |
| --Land & Land Rts | 0.000 | 1.300 | + | 1.300 |
| --On-Site Impr'mt | 198.000 | 17.499 | - | 180.501 |
| --Off-Site Impr'mt | 319.000 | 162.831 | - | 156.169 |
| Waste Hdlg & Empl | 903.000 | 739.456 | - | 163.544 |
| --Receiving | 107.000 | 5.648 | - | 101.352 |
| --Other Surf Fac | 172.000 | 0.000 | - | 172.000 |
| --Waste Shafts | 118.000 | 29.764 | - | 88.236 |
| --Transfer & Empl | 506.000 | 704.044 | + | 198.044 |
| Rooms | 370.000 | 154.161 | - | 215.839 |
| Boreholes | 30.000 | 341.403 | + | 311.403 |
| Transfer Equip | 106.000 | 208.480 | + | 102.480 |
| U/G Wkgs/Rock Hdlg | 685.000 | 230.412 | - | 454.588 |
| --Men/Mat'ls Shaft | 181.000 | 31.345 | - | 149.655 |
| --Shaft Pillar | 75.000 | 17.227 | - | 57.773 |
| --Corridors | 293.000 | 116.541 | - | 176.459 |
| --Rock Hdlg/Disp'l | 136.000 | 65.299 | - | 70.701 |
| --Test Facilities | 0.000 | 0.000 | + | 0.000 |
| Ventilation | 913.000 | 331.014 | - | 581.986 |
| --Vent Structures | 791.000 | 8.991 | - | 782.009 |
| --Vent Supply Shft | 81.000 | 3.305 | - | 77.695 |
| --Dev Exhaust Shft | 16.000 | 0.000 | - | 16.000 |
| --Vent Flow Paths | 18.000 | 307.684 | + | 289.684 |
| --Repos Exh Shaft | 7.000 | 11.034 | + | 4.034 |
| Support/Utilities | 813.000 | 2,244.722 | + | 1,431.722 |
| TOTALS | 5,208.000 | 5,574.690 | + | 366.690 |

Table 3.14C

Project: NNWSI

Repository Cost Matrix Comparison
Rev. Ref. Repository, Horizontal vs Rev. Ref. Repository, Vertical
(Millions of Mid-1984 Dollars)

| SYSTEM | Horizontal Repository | Vertical Repository | | Difference |
|---|---|---|---|---|
| WASTE PREPARATION | 1,847.456 | 1,847.456 | + | 0.000 |
| Waste Form Subsys | 86.959 | 86.959 | + | 0.000 |
| --Spent Fuel | 86.959 | 86.959 | + | 0.000 |
| --On-Site Generated | 0.000 | 0.000 | + | 0.000 |
| --Other | 0.000 | 0.000 | + | 0.000 |
| Waste Pkg Subsys | 1,760.497 | 1,760.497 | + | 0.000 |
| --Spent Fuel | 1,729.420 | 1,729.420 | + | 0.000 |
| Pkg Components | 1,103.471 | 1,103.471 | + | 0.000 |
| Ass'bly Fac | 625.949 | 625.949 | + | 0.000 |
| --On-Site Generated | 31.077 | 31.077 | + | 0.000 |
| Pkg Components | 11.092 | 11.092 | + | 0.000 |
| Ass'bly Fac | 19.985 | 19.985 | + | 0.000 |
| --Other | 0.000 | 0.000 | + | 0.000 |
| Pkg Components | 0.000 | 0.000 | + | 0.000 |
| Ass'bly Fac | 0.000 | 0.000 | + | 0.000 |
| REPOSITORY SYSTEM | 4,884.897 | 3,727.234 | - | 1,157.663 |
| Site | 181.630 | 181.630 | + | 0.000 |
| --Land & Land Rts | 1.300 | 1.300 | + | 0.000 |
| --On-Site Impr'mt | 17.499 | 17.499 | + | 0.000 |
| --Off-Site Impr'mt | 162.831 | 162.831 | + | 0.000 |
| Waste Hdlg & Empl | 1,262.670 | 739.456 | - | 523.214 |
| --Receiving | 5.648 | 5.648 | + | 0.000 |
| --Other Surf Fac | 0.000 | 0.000 | + | 0.000 |
| --Waste Shafts | 29.764 | 29.764 | + | 0.000 |
| --Transfer & Empl | 1,227.258 | 704.044 | - | 523.214 |
| Rooms | 741.844 | 154.161 | - | 587.683 |
| Boreholes | 303.099 | 341.403 | + | 38.304 |
| Transfer Equip | 182.315 | 208.480 | + | 26.165 |
| U/G Wkgs/Rock Hdlg | 621.261 | 230.412 | - | 390.849 |
| --Men/Mat'ls Shaft | 31.345 | 31.345 | + | 0.000 |
| --Shaft Pillar | 17.227 | 17.227 | + | 0.000 |
| --Corridors | 495.937 | 116.541 | - | 379.396 |
| --Rock Hdlg/Disp'l | 76.752 | 65.299 | - | 11.453 |
| --Test Facilities | 0.000 | 0.000 | + | 0.000 |
| Ventilation | 388.852 | 331.014 | - | 57.838 |
| --Vent Structures | 11.605 | 8.991 | - | 2.614 |
| --Vent Supply Shft | 3.305 | 3.305 | + | 0.000 |
| --Dev Exhaust Shft | 0.000 | 0.000 | + | 0.000 |
| --Vent Flow Paths | 362.908 | 307.684 | - | 55.224 |
| --Repos Exh Shaft | 11.034 | 11.034 | + | 0.000 |
| Support/Utilities | 2,430.484 | 2,244.722 | - | 185.762 |
| TOTALS | 6,732.353 | 5,574.690 | - | 1,157.663 |

Table 3.15 Project: NNWSI

Revised Reference Repository Engineering Cost
Horizontal Emplacement
(Millions of Mid-1984 Dollars)

| | Title I | Title II | Title III | Total |
|---|---|---|---|---|
| Prior to FY 1984 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1984 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1985 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1986 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1987 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1988 | 4.775 | 0.000 | 0.000 | 4.775 |
| FY 1989 | 17.059 | 0.000 | 0.000 | 17.059 |
| FY 1990 | 11.971 | 17.543 | 0.000 | 29.514 |
| FY 1991 | 0.000 | 30.788 | 0.000 | 30.788 |
| FY 1992 | 0.000 | 19.360 | 0.000 | 19.360 |
| FY 1993 | 0.000 | 6.681 | 0.229 | 6.910 |
| FY 1994 | 0.000 | 0.000 | 3.137 | 3.137 |
| FY 1995 | 0.000 | 0.000 | 6.853 | 6.853 |
| FY 1996 | 0.000 | 0.000 | 7.397 | 7.397 |
| FY 1997 | 0.000 | 0.000 | 4.896 | 4.896 |
| FY 1998 | 0.000 | 0.000 | 2.309 | 2.309 |
| FY 1999 | 0.000 | 0.000 | 1.388 | 1.388 |
| FY 2000 | 0.000 | 0.000 | 0.709 | 0.709 |
| FY 2001 | 0.000 | 0.000 | 0.126 | 0.126 |
| TOTALS | 33.805 | 74.372 | 27.044 | 135.221 |

Table 3.16A

Project: NNWSI

Two-Stage Repository Cost Matrix
Horizontal Emplacement
(Millions of Mid-1984 Dollars)

| SYSTEM | Engineering & Construction Costs Stage 1 | Stage 2 | Common | Total |
|---|---|---|---|---|
| WASTE PREPARATION | 84.714 | 262.318 | 47.568 | 394.600 |
| Waste Form Subsys | 13.442 | 80.562 | 6.397 | 100.401 |
| --Spent Fuel | 13.442 | 80.562 | 6.397 | 100.401 |
| --On-Site Generated | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Waste Pkg Subsys | 71.272 | 181.756 | 41.171 | 294.199 |
| --Spent Fuel | 71.272 | 181.756 | 21.186 | 274.214 |
| Pkg Components | 0.000 | 0.000 | 0.000 | 0.000 |
| Ass'bly Fac | 71.272 | 181.756 | 21.186 | 274.214 |
| --On-Site Generated | 0.000 | 0.000 | 19.985 | 19.985 |
| Pkg Components | 0.000 | 0.000 | 0.000 | 0.000 |
| Ass'bly Fac | 0.000 | 0.000 | 19.985 | 19.985 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Pkg Components | 0.000 | 0.000 | 0.000 | 0.000 |
| Ass'bly Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| REPOSITORY SYSTEM | 37.903 | 43.106 | 587.658 | 668.667 |
| Site | 0.000 | 0.000 | 181.630 | 181.630 |
| --Land & Land Rts | 0.000 | 0.000 | 1.300 | 1.300 |
| --On-Site Impr'mt | 0.000 | 0.000 | 17.499 | 17.499 |
| --Off-Site Impr'mt | 0.000 | 0.000 | 162.831 | 162.831 |
| Waste Hdlg & Empl | 37.903 | 43.106 | 34.572 | 115.581 |
| --Receiving | 0.000 | 0.000 | 5.648 | 5.648 |
| --Other Surf Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| --Waste Shafts | 0.000 | 0.000 | 28.924 | 28.924 |
| --Transfer & Empl | 37.903 | 43.106 | 0.000 | 81.009 |
| Rooms | 14.931 | 24.659 | 0.000 | 39.590 |
| Boreholes | 18.458 | 9.415 | 0.000 | 27.873 |
| Transfer Equip | 4.514 | 9.032 | 0.000 | 13.546 |
| U/G Wkgs/Rock Hdlg | 0.000 | 0.000 | 161.386 | 161.386 |
| --Men/Mat'ls Shaft | 0.000 | 0.000 | 33.425 | 33.425 |
| --Shaft Pillar | 0.000 | 0.000 | 14.693 | 14.693 |
| --Corridors | 0.000 | 0.000 | 76.904 | 76.904 |
| --Rock Hdlg/Disp'l | 0.000 | 0.000 | 36.364 | 36.364 |
| --Test Facilities | 0.000 | 0.000 | 0.000 | 0.000 |
| Ventilation | 0.000 | 0.000 | 85.519 | 85.519 |
| --Vent Structures | 0.000 | 0.000 | 8.991 | 8.991 |
| --Vent Supply Shft | 0.000 | 0.000 | 1.912 | 1.912 |
| --Dev Exhaust Shft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Vent Flow Paths | 0.000 | 0.000 | 64.975 | 64.975 |
| --Repos Exh Shaft | 0.000 | 0.000 | 9.641 | 9.641 |
| Support/Utilities | 0.000 | 0.000 | 124.551 | 124.551 |
| TOTALS | 122.617 | 305.424 | 635.226 | 1,063.267 |

Table 3.16B

Project: NNWSI

Two-Stage Repository Cost Matrix
Horizontal Emplacement
(Millions of Mid-1984 Dollars)

| SYSTEM | Operation Costs Stage 1 | Stage 2 | Common | Total |
|---|---|---|---|---|
| WASTE PREPARATION | 84.616 | 1,456.118 | 4.881 | 1,545.615 |
| Waste Form Subsys | 0.000 | 0.000 | 0.000 | 0.000 |
| --Spent Fuel | 0.000 | 0.000 | 0.000 | 0.000 |
| --On-Site Generated | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Waste Pkg Subsys | 84.616 | 1,456.118 | 4.881 | 1,545.615 |
| --Spent Fuel | 84.288 | 1,445.352 | 4.881 | 1,534.521 |
| Pkg Components | 54.601 | 1,067.197 | 4.881 | 1,126.679 |
| Ass'bly Fac | 29.687 | 378.155 | 0.000 | 407.842 |
| --On-Site Generated | 0.328 | 10.766 | 0.000 | 11.094 |
| Pkg Components | 0.328 | 10.766 | 0.000 | 11.094 |
| Ass'bly Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Pkg Components | 0.000 | 0.000 | 0.000 | 0.000 |
| Ass'bly Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| REPOSITORY SYSTEM | 11.060 | 578.548 | 2,682.569 | 3,272.177 |
| Site | 0.000 | 0.000 | 0.000 | 0.000 |
| --Land & Land Rts | 0.000 | 0.000 | 0.000 | 0.000 |
| --On-Site Impr'mt | 0.000 | 0.000 | 0.000 | 0.000 |
| --Off-Site Impr'mt | 0.000 | 0.000 | 0.000 | 0.000 |
| Waste Hdlg & Empl | 11.060 | 578.548 | 46.257 | 635.865 |
| --Receiving | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other Surf Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| --Waste Shafts | 0.000 | 0.000 | 0.000 | 0.000 |
| --Transfer & Empl | 11.060 | 578.548 | 46.257 | 635.865 |
| Rooms | 2.800 | 120.636 | 0.000 | 123.436 |
| Boreholes | 0.000 | 317.492 | 0.000 | 317.492 |
| Transfer Equip | 8.260 | 140.420 | 46.257 | 194.937 |
| U/G Wkgs/Rock Hdlg | 0.000 | 0.000 | 70.248 | 70.248 |
| --Men/Mat'ls Shaft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Shaft Pillar | 0.000 | 0.000 | 2.534 | 2.534 |
| --Corridors | 0.000 | 0.000 | 39.637 | 39.637 |
| --Rock Hdlg/Disp'l | 0.000 | 0.000 | 28.077 | 28.077 |
| --Test Facilities | 0.000 | 0.000 | 0.000 | 0.000 |
| Ventilation | 0.000 | 0.000 | 242.708 | 242.708 |
| --Vent Structures | 0.000 | 0.000 | 0.000 | 0.000 |
| --Vent Supply Shft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Dev Exhaust Shft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Vent Flow Paths | 0.000 | 0.000 | 242.708 | 242.708 |
| --Repos Exh Shaft | 0.000 | 0.000 | 0.000 | 0.000 |
| Support/Utilities | 0.000 | 0.000 | 2,323.356 | 2,323.356 |
| TOTALS | 95.676 | 2,034.666 | 2,687.450 | 4,817.792 |

Table 3.16C

Project: NNWSI

Two-Stage Repository Cost Matrix
Horizontal Emplacement
(Millions of Mid-1984 Dollars)

| SYSTEM | Decommissioning Costs Stage 1 | Stage 2 | Common | Total |
|---|---|---|---|---|
| WASTE PREPARATION | 8.465 | 26.228 | 2.760 | 37.453 |
| Waste Form Subsys | 0.000 | 0.000 | 0.000 | 0.000 |
| --Spent Fuel | 0.000 | 0.000 | 0.000 | 0.000 |
| --On-Site Generated | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Waste Pkg Subsys | 8.465 | 26.228 | 2.760 | 37.453 |
| --Spent Fuel | 8.465 | 26.228 | 2.760 | 37.453 |
| Pkg Components | 0.000 | 0.000 | 0.000 | 0.000 |
| Ass'bly Fac | 8.465 | 26.228 | 2.760 | 37.453 |
| --On-Site Generated | 0.000 | 0.000 | 0.000 | 0.000 |
| Pkg Components | 0.000 | 0.000 | 0.000 | 0.000 |
| Ass'bly Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Pkg Components | 0.000 | 0.000 | 0.000 | 0.000 |
| Ass'bly Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| REPOSITORY SYSTEM | 0.000 | 0.000 | 5.877 | 5.877 |
| Site | 0.000 | 0.000 | 0.000 | 0.000 |
| --Land & Land Rts | 0.000 | 0.000 | 0.000 | 0.000 |
| --On-Site Impr'mt | 0.000 | 0.000 | 0.000 | 0.000 |
| --Off-Site Impr'mt | 0.000 | 0.000 | 0.000 | 0.000 |
| Waste Hdlg & Empl | 0.000 | 0.000 | 0.840 | 0.840 |
| --Receiving | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other Surf Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| --Waste Shafts | 0.000 | 0.000 | 0.840 | 0.840 |
| --Transfer & Empl | 0.000 | 0.000 | 0.000 | 0.000 |
| Rooms | 0.000 | 0.000 | 0.000 | 0.000 |
| Boreholes | 0.000 | 0.000 | 0.000 | 0.000 |
| Transfer Equip | 0.000 | 0.000 | 0.000 | 0.000 |
| U/G Wkgs/Rock Hdlg | 0.000 | 0.000 | 2.251 | 2.251 |
| --Men/Mat'ls Shaft | 0.000 | 0.000 | 1.393 | 1.393 |
| --Shaft Pillar | 0.000 | 0.000 | 0.000 | 0.000 |
| --Corridors | 0.000 | 0.000 | 0.000 | 0.000 |
| --Rock Hdlg/Disp'l | 0.000 | 0.000 | 0.858 | 0.858 |
| --Test Facilities | 0.000 | 0.000 | 0.000 | 0.000 |
| Ventilation | 0.000 | 0.000 | 2.786 | 2.786 |
| --Vent Structures | 0.000 | 0.000 | 0.000 | 0.000 |
| --Vent Supply Shft | 0.000 | 0.000 | 1.393 | 1.393 |
| --Dev Exhaust Shft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Vent Flow Paths | 0.000 | 0.000 | 0.000 | 0.000 |
| --Repos Exh Shaft | 0.000 | 0.000 | 1.393 | 1.393 |
| Support/Utilities | 0.000 | 0.000 | 0.000 | 0.000 |
| TOTALS | 8.465 | 26.228 | 8.637 | 43.330 |

Table 3.16D

Project: NNWSI

Two-Stage Repository Cost Matrix
Horizontal Emplacement
(Millions of Mid-1984 Dollars)

| SYSTEM | Total Costs Stage 1 | Stage 2 | Common | Total |
|---|---|---|---|---|
| WASTE PREPARATION | 177.795 | 1,744.664 | 55.209 | 1,977.668 |
| Waste Form Subsys | 13.442 | 80.562 | 6.397 | 100.401 |
| --Spent Fuel | 13.442 | 80.562 | 6.397 | 100.401 |
| --On-Site Generated | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Waste Pkg Subsys | 164.353 | 1,664.102 | 48.812 | 1,877.267 |
| --Spent Fuel | 164.025 | 1,653.336 | 28.827 | 1,846.188 |
| Pkg Components | 54.601 | 1,067.197 | 4.881 | 1,126.679 |
| Ass'bly Fac | 109.424 | 586.139 | 23.946 | 719.509 |
| --On-Site Generated | 0.328 | 10.766 | 19.985 | 31.079 |
| Pkg Components | 0.328 | 10.766 | 0.000 | 11.094 |
| Ass'bly Fac | 0.000 | 0.000 | 19.985 | 19.985 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Pkg Components | 0.000 | 0.000 | 0.000 | 0.000 |
| Ass'bly Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| REPOSITORY SYSTEM | 48.963 | 621.654 | 3,276.104 | 3,946.721 |
| Site | 0.000 | 0.000 | 181.630 | 181.630 |
| --Land & Land Rts | 0.000 | 0.000 | 1.300 | 1.300 |
| --On-Site Impr'mt | 0.000 | 0.000 | 17.499 | 17.499 |
| --Off-Site Impr'mt | 0.000 | 0.000 | 162.831 | 162.831 |
| Waste Hdlg & Empl | 48.963 | 621.654 | 81.669 | 752.286 |
| --Receiving | 0.000 | 0.000 | 5.648 | 5.648 |
| --Other Surf Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| --Waste Shafts | 0.000 | 0.000 | 29.764 | 29.764 |
| --Transfer & Empl | 48.963 | 621.654 | 46.257 | 716.874 |
| Rooms | 17.731 | 145.295 | 0.000 | 163.026 |
| Boreholes | 18.458 | 326.907 | 0.000 | 345.365 |
| Transfer Equip | 12.774 | 149.452 | 46.257 | 208.483 |
| U/G Wkgs/Rock Hdlg | 0.000 | 0.000 | 233.885 | 233.885 |
| --Men/Mat'ls Shaft | 0.000 | 0.000 | 34.818 | 34.818 |
| --Shaft Pillar | 0.000 | 0.000 | 17.227 | 17.227 |
| --Corridors | 0.000 | 0.000 | 116.541 | 116.541 |
| --Rock Hdlg/Disp'l | 0.000 | 0.000 | 65.299 | 65.299 |
| --Test Facilities | 0.000 | 0.000 | 0.000 | 0.000 |
| Ventilation | 0.000 | 0.000 | 331.013 | 331.013 |
| --Vent Structures | 0.000 | 0.000 | 8.991 | 8.991 |
| --Vent Supply Shft | 0.000 | 0.000 | 3.305 | 3.305 |
| --Dev Exhaust Shft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Vent Flow Paths | 0.000 | 0.000 | 307.683 | 307.683 |
| --Repos Exh Shaft | 0.000 | 0.000 | 11.034 | 11.034 |
| Support/Utilities | 0.000 | 0.000 | 2,447.907 | 2,447.907 |
| TOTALS | 226.758 | 2,366.318 | 3,331.313 | 5,924.389 |

Table 3.16E

Project: NNWSI

Two-Stage Repository Cost Matrix
Horizontal Emplacement
(Millions of Mid-1984 Dollars)

| SYSTEM | Engineering & Construction | Operation | Decommis-sioning | Total |
|---|---|---|---|---|
| WASTE PREPARATION | 394.600 | 1,545.615 | 37.453 | 1,977.668 |
| Waste Form Subsys | 100.401 | 0.000 | 0.000 | 100.401 |
| --Spent Fuel | 100.401 | 0.000 | 0.000 | 100.401 |
| --On-Site Generated | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Waste Pkg Subsys | 294.199 | 1,545.615 | 37.453 | 1,877.267 |
| --Spent Fuel | 274.214 | 1,534.521 | 37.453 | 1,846.188 |
| Pkg Components | 0.000 | 1,126.679 | 0.000 | 1,126.679 |
| Ass'bly Fac | 274.214 | 407.842 | 37.453 | 719.509 |
| --On-Site Generated | 19.985 | 11.094 | 0.000 | 31.079 |
| Pkg Components | 0.000 | 11.094 | 0.000 | 11.094 |
| Ass'bly Fac | 19.985 | 0.000 | 0.000 | 19.985 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Pkg Components | 0.000 | 0.000 | 0.000 | 0.000 |
| Ass'bly Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| REPOSITORY SYSTEM | 668.667 | 3,272.177 | 5.877 | 3,946.721 |
| Site | 181.630 | 0.000 | 0.000 | 181.630 |
| --Land & Land Rts | 1.300 | 0.000 | 0.000 | 1.300 |
| --On-Site Impr'mt | 17.499 | 0.000 | 0.000 | 17.499 |
| --Off-Site Impr'mt | 162.831 | 0.000 | 0.000 | 162.831 |
| Waste Hdlg & Empl | 115.581 | 635.865 | 0.840 | 752.286 |
| --Receiving | 5.648 | 0.000 | 0.000 | 5.648 |
| --Other Surf Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| --Waste Shafts | 28.924 | 0.000 | 0.840 | 29.764 |
| --Transfer & Empl | 81.009 | 635.865 | 0.000 | 716.874 |
| Rooms | 39.590 | 123.436 | 0.000 | 163.026 |
| Boreholes | 27.873 | 317.492 | 0.000 | 345.365 |
| Transfer Equip | 13.546 | 194.937 | 0.000 | 208.483 |
| U/G Wkgs/Rock Hdlg | 161.386 | 70.248 | 2.251 | 233.885 |
| --Men/Mat'ls Shaft | 33.425 | 0.000 | 1.393 | 34.818 |
| --Shaft Pillar | 14.693 | 2.534 | 0.000 | 17.227 |
| --Corridors | 76.904 | 39.637 | 0.000 | 116.541 |
| --Rock Hdlg/Disp'l | 36.364 | 28.077 | 0.858 | 65.299 |
| --Test Facilities | 0.000 | 0.000 | 0.000 | 0.000 |
| Ventilation | 85.519 | 242.708 | 2.786 | 331.013 |
| --Vent Structures | 8.991 | 0.000 | 0.000 | 8.991 |
| --Vent Supply Shft | 1.912 | 0.000 | 1.393 | 3.305 |
| --Dev Exhaust Shft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Vent Flow Paths | 64.975 | 242.708 | 0.000 | 307.683 |
| --Repos Exh Shaft | 9.641 | 0.000 | 1.393 | 11.034 |
| Support/Utilities | 124.551 | 2,323.356 | 0.000 | 2,447.907 |
| TOTALS | 1,063.267 | 4,817.792 | 43.330 | 5,924.389 |

Table 3.17A Project: NNWSI

Two-Stage Repository Engineering Cost
Horizontal Emplacement
(Millions of Mid-1984 Dollars)

| | Stage 1 Costs | | | |
|---|---|---|---|---|
| | Title I | Title II | Title III | Total |
| Prior to FY 1984 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1984 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1985 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1986 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1987 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1988 | 0.808 | 0.000 | 0.000 | 0.808 |
| FY 1989 | 2.887 | 0.000 | 0.000 | 2.887 |
| FY 1990 | 2.029 | 2.969 | 0.000 | 4.998 |
| FY 1991 | 0.000 | 5.212 | 0.000 | 5.212 |
| FY 1992 | 0.000 | 3.279 | 0.000 | 3.279 |
| FY 1993 | 0.000 | 1.132 | 0.045 | 1.177 |
| FY 1994 | 0.000 | 0.000 | 0.699 | 0.699 |
| FY 1995 | 0.000 | 0.000 | 1.546 | 1.546 |
| FY 1996 | 0.000 | 0.000 | 1.501 | 1.501 |
| FY 1997 | 0.000 | 0.000 | 0.717 | 0.717 |
| FY 1998 | 0.000 | 0.000 | 0.071 | 0.071 |
| FY 1999 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 2000 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 2001 | 0.000 | 0.000 | 0.000 | 0.000 |
| TOTALS | 5.724 | 12.592 | 4.579 | 22.895 |

Table 3.17B Project: NNWSI

Two-Stage Repository Engineering Cost
Horizontal Emplacement
(Millions of Mid-1984 Dollars)

| | Stage 2 Costs | | | |
|---|---|---|---|---|
| | Title I | Title II | Title III | Total |
| Prior to FY 1984 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1984 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1985 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1986 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1987 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1988 | 2.062 | 0.000 | 0.000 | 2.062 |
| FY 1989 | 7.368 | 0.000 | 0.000 | 7.368 |
| FY 1990 | 5.170 | 7.578 | 0.000 | 12.748 |
| FY 1991 | 0.000 | 13.296 | 0.000 | 13.296 |
| FY 1992 | 0.000 | 8.362 | 0.000 | 8.362 |
| FY 1993 | 0.000 | 2.882 | 0.070 | 2.952 |
| FY 1994 | 0.000 | 0.000 | 0.797 | 0.797 |
| FY 1995 | 0.000 | 0.000 | 1.665 | 1.665 |
| FY 1996 | 0.000 | 0.000 | 2.354 | 2.354 |
| FY 1997 | 0.000 | 0.000 | 2.495 | 2.495 |
| FY 1998 | 0.000 | 0.000 | 2.076 | 2.076 |
| FY 1999 | 0.000 | 0.000 | 1.388 | 1.388 |
| FY 2000 | 0.000 | 0.000 | 0.709 | 0.709 |
| FY 2001 | 0.000 | 0.000 | 0.126 | 0.126 |
| TOTALS | 14.600 | 32.118 | 11.680 | 58.398 |

Table 3.17C Project: NNWSI

Two-Stage Repository Engineering Cost
Horizontal Emplacement
(Millions of Mid-1984 Dollars)

| | Common Costs | | | |
|---|---|---|---|---|
| | Title I | Title II | Title III | Total |
| Prior to FY 1984 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1984 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1985 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1986 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1987 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1988 | 2.544 | 0.000 | 0.000 | 2.544 |
| FY 1989 | 9.084 | 0.000 | 0.000 | 9.084 |
| FY 1990 | 6.374 | 9.341 | 0.000 | 15.715 |
| FY 1991 | 0.000 | 16.394 | 0.000 | 16.394 |
| FY 1992 | 0.000 | 10.306 | 0.000 | 10.306 |
| FY 1993 | 0.000 | 3.562 | 0.147 | 3.709 |
| FY 1994 | 0.000 | 0.000 | 2.194 | 2.194 |
| FY 1995 | 0.000 | 0.000 | 4.861 | 4.861 |
| FY 1996 | 0.000 | 0.000 | 4.728 | 4.728 |
| FY 1997 | 0.000 | 0.000 | 2.250 | 2.250 |
| FY 1998 | 0.000 | 0.000 | 0.221 | 0.221 |
| FY 1999 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 2000 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 2001 | 0.000 | 0.000 | 0.000 | 0.000 |
| TOTALS | 18.002 | 39.603 | 14.401 | 72.006 |

Table 3.17D Project: NNWSI

Two-Stage Repository Engineering Cost
Horizontal Emplacement
(Millions of Mid-1984 Dollars)

| | Total Costs | | | |
|---|---|---|---|---|
| | Title I | Title II | Title III | Total |
| Prior to FY 1984 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1984 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1985 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1986 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1987 | 0.000 | 0.000 | 0.000 | 0.000 |
| FY 1988 | 5.414 | 0.000 | 0.000 | 5.414 |
| FY 1989 | 19.339 | 0.000 | 0.000 | 19.339 |
| FY 1990 | 13.572 | 19.889 | 0.000 | 33.461 |
| FY 1991 | 0.000 | 34.902 | 0.000 | 34.902 |
| FY 1992 | 0.000 | 21.947 | 0.000 | 21.947 |
| FY 1993 | 0.000 | 7.576 | 0.262 | 7.838 |
| FY 1994 | 0.000 | 0.000 | 3.690 | 3.690 |
| FY 1995 | 0.000 | 0.000 | 8.072 | 8.072 |
| FY 1996 | 0.000 | 0.000 | 8.583 | 8.583 |
| FY 1997 | 0.000 | 0.000 | 5.462 | 5.462 |
| FY 1998 | 0.000 | 0.000 | 2.368 | 2.368 |
| FY 1999 | 0.000 | 0.000 | 1.388 | 1.388 |
| FY 2000 | 0.000 | 0.000 | 0.709 | 0.709 |
| FY 2001 | 0.000 | 0.000 | 0.126 | 0.126 |
| TOTALS | 38.325 | 84.314 | 30.660 | 153.299 |

Table 3.18A Project: NNWSI

Repository Cost Matrix Comparison

Revised Reference Repository vs Two-Stage Repository - Horizontal Emplacement

(Millions of Mid-1984 Dollars)

| SYSTEM | Revised Ref. Repository | Reference Repository | | Difference |
|---|---|---|---|---|
| WASTE PREPARATION | 1,847.456 | 1,977.668 | + | 130.212 |
| Waste Form Subsys | 86.959 | 100.401 | + | 13.442 |
| --Spent Fuel | 86.959 | 100.401 | + | 13.442 |
| --On-Site Generated | 0.000 | 0.000 | + | 0.000 |
| --Other | 0.000 | 0.000 | + | 0.000 |
| Waste Pkg Subsys | 1,760.497 | 1,877.267 | + | 116.770 |
| --Spent Fuel | 1,729.420 | 1,846.188 | + | 116.768 |
| Pkg Components | 1,103.471 | 1,126.679 | + | 23.208 |
| Ass'bly Fac | 625.949 | 719.509 | + | 93.560 |
| --On-Site Generated | 31.077 | 31.079 | + | 0.002 |
| Pkg Components | 11.092 | 11.094 | + | 0.002 |
| Ass'bly Fac | 19.985 | 19.985 | + | 0.000 |
| --Other | 0.000 | 0.000 | + | 0.000 |
| Pkg Components | 0.000 | 0.000 | + | 0.000 |
| Ass'bly Fac | 0.000 | 0.000 | + | 0.000 |
| REPOSITORY SYSTEM | 3,727.234 | 3,946.721 | + | 219.487 |
| Site | 181.630 | 181.630 | + | 0.000 |
| --Land & Land Rts | 1.300 | 1.300 | + | 0.000 |
| --On-Site Impr'mt | 17.499 | 17.499 | + | 0.000 |
| --Off-Site Impr'mt | 162.831 | 162.831 | + | 0.000 |
| Waste Hdlg & Empl | 739.456 | 752.286 | + | 12.830 |
| --Receiving | 5.648 | 5.648 | + | 0.000 |
| --Other Surf Fac | 0.000 | 0.000 | + | 0.000 |
| --Waste Shafts | 29.764 | 29.764 | + | 0.000 |
| --Transfer & Empl | 704.044 | 716.874 | + | 12.830 |
| Rooms | 154.161 | 163.026 | + | 8.865 |
| Boreholes | 341.403 | 345.365 | + | 3.962 |
| Transfer Equip | 208.480 | 208.483 | + | 0.003 |
| U/G Wkgs/Rock Hdlg | 230.412 | 233.885 | + | 3.473 |
| --Men/Mat'ls Shaft | 31.345 | 34.818 | + | 3.473 |
| --Shaft Pillar | 17.227 | 17.227 | + | 0.000 |
| --Corridors | 116.541 | 116.541 | + | 0.000 |
| --Rock Hdlg/Disp'l | 65.299 | 65.299 | + | 0.000 |
| --Test Facilities | 0.000 | 0.000 | + | 0.000 |
| Ventilation | 331.014 | 331.013 | - | 0.001 |
| --Vent Structures | 8.991 | 8.991 | + | 0.000 |
| --Vent Supply Shft | 3.305 | 3.305 | + | 0.000 |
| --Dev Exhaust Shft | 0.000 | 0.000 | + | 0.000 |
| --Vent Flow Paths | 307.684 | 307.683 | - | 0.001 |
| --Repos Exh Shaft | 11.034 | 11.034 | + | 0.000 |
| Support/Utilities | 2,244.722 | 2,447.907 | + | 203.185 |
| TOTALS | 5,574.690 | 5,924.389 | + | 349.699 |

Table 3.18B

Project: NNWSI

Repository Cost Matrix Comparison
Two-Stage Repository, Horizontal vs Two-Stage Repository, Vertical
(Millions of Mid-1984 Dollars)

| SYSTEM | Horizontal Repository | Vertical Repository | | Difference |
|---|---|---|---|---|
| WASTE PREPARATION | 1,977.668 | 1,977.668 | + | 0.000 |
| Waste Form Subsys | 100.401 | 100.401 | + | 0.000 |
| --Spent Fuel | 100.401 | 100.401 | + | 0.000 |
| --On-Site Generated | 0.000 | 0.000 | + | 0.000 |
| --Other | 0.000 | 0.000 | + | 0.000 |
| Waste Pkg Subsys | 1,877.267 | 1,877.267 | + | 0.000 |
| --Spent Fuel | 1,846.188 | 1,846.188 | + | 0.000 |
| Pkg Components | 1,126.679 | 1,126.679 | + | 0.000 |
| Ass'bly Fac | 719.509 | 719.509 | + | 0.000 |
| --On-Site Generated | 31.079 | 31.079 | + | 0.000 |
| Pkg Components | 11.094 | 11.094 | + | 0.000 |
| Ass'bly Fac | 19.985 | 19.985 | + | 0.000 |
| --Other | 0.000 | 0.000 | + | 0.000 |
| Pkg Components | 0.000 | 0.000 | + | 0.000 |
| Ass'bly Fac | 0.000 | 0.000 | + | 0.000 |
| REPOSITORY SYSTEM | 3,946.721 | 5,035.936 | + | 1,089.215 |
| Site | 181.630 | 181.630 | + | 0.000 |
| --Land & Land Rts | 1.300 | 1.300 | + | 0.000 |
| --On-Site Impr'mt | 17.499 | 17.499 | + | 0.000 |
| --Off-Site Impr'mt | 162.831 | 162.831 | + | 0.000 |
| Waste Hdlg & Empl | 752.286 | 1,273.181 | + | 520.895 |
| --Receiving | 5.648 | 5.648 | + | 0.000 |
| --Other Surf Fac | 0.000 | 0.000 | + | 0.000 |
| --Waste Shafts | 29.764 | 29.764 | + | 0.000 |
| --Transfer & Empl | 716.874 | 1,237.769 | + | 520.895 |
| Rooms | 163.026 | 748.829 | + | 585.803 |
| Boreholes | 345.365 | 306.631 | - | 38.734 |
| Transfer Equip | 208.483 | 182.309 | - | 26.174 |
| U/G Wkgs/Rock Hdlg | 233.885 | 624.734 | + | 390.849 |
| --Men/Mat'ls Shaft | 34.818 | 34.818 | + | 0.000 |
| --Shaft Pillar | 17.227 | 17.227 | + | 0.000 |
| --Corridors | 116.541 | 495.937 | + | 379.396 |
| --Rock Hdlg/Disp'l | 65.299 | 76.752 | + | 11.453 |
| --Test Facilities | 0.000 | 0.000 | + | 0.000 |
| Ventilation | 331.013 | 388.851 | + | 57.838 |
| --Vent Structures | 8.991 | 11.605 | + | 2.614 |
| --Vent Supply Shft | 3.305 | 3.305 | + | 0.000 |
| --Dev Exhaust Shft | 0.000 | 0.000 | + | 0.000 |
| --Vent Flow Paths | 307.683 | 362.907 | + | 55.224 |
| --Repos Exh Shaft | 11.034 | 11.034 | + | 0.000 |
| Support/Utilities | 2,447.907 | 2,567.540 | + | 119.633 |
| TOTALS | 5,924.389 | 7,013.604 | + | 1,089.215 |

Table 3.19 Project: NNWSI

Definition of Accounts

WASTE PREPARATION
- Waste Form Subsystem
  - --Spent Fuel - Spent fuel consolidation facilities and operations.
  - --On-Site Generated Waste - On-site generated contact-handled waste collection and volume reduction facilities operation.
  - --Other - (Not used).
- Waste Package Subsystem
  - --Spent Fuel
    - Package Components - Spent fuel package costs including fabrication, transportation, and QA.
    - Assembly Facility - Facilities and operation to load spent fuel assemblies and/or pins into waste packages with subsequent sealing and testing.
  - --On-Site Generated Waste
    - Package Components - Overpack and drum costs for on-site generated waste. (if applicable).
    - Assembly Facility - Facilities capable of overpacking, sealing, and testing on-site generated waste packages.
  - --Other (not used).

REPOSITORY SYSTEM
- Site
  - --Land and Land Rights - Costs for land leases, purchases, mineral rights, permitting, etc.
  - --On-site Improvements - Costs for land grading, earthwork, drainage, roads, walkways, railroads, fencing, and landscaping.
  - --Off-Site Improvements - Costs for roads, railroads, pipelines, electrical transmission lines, and monitoring stations.
- Waste Handling and Emplacement
  - --Receiving - Costs for receiving and decontamination facilities and operations.
  - --Other Surface Facilities - Costs for surface storage facilities and operations.
  - --Waste Shafts (Ramps) - Costs for waste ramp (excavation, lining, water control).
  - --Transfer and Emplacement
    - Rooms - Costs for excavation of emplacement drifts for spent fuel. Rock support costs are included.
    - Boreholes - Costs of borehole drilling in emplacement drifts.
    - Transfer Equipment - Costs for surface and underground transportation of spent fuel, including cost of transporters. Emplacement of spent fuel in boreholes is also included.
- Underground Workings/Rock Handling
  - --Men and Material Shaft - Costs of shaft (excavation, lining, water control), hoists, headframe, skips, shaft stations and hoisting of men and materials.
  - --Shaft Pillar - Costs of excavation and backfill within the shaft pillar zone (including rock support and re-excavation).

--Corridors - Costs of excavation of main corridors, access drifts, and perimeter corridors used for ventilation including rock support and re-excavation or workings.
--Rock Handling/Disposal - Costs of rock transfer, storage, and disposal.
--Test Facilities - (not applicable).

Ventilation
--Ventilation Structures - Includes cost of facilities and operations for intake, confinement exhaust, and development exhaust. Costs include main fans, filters, stacks, etc.
--Ventilation Supply Shaft - Cost of modifications to the 12-ft-diameter shaft and the 6-ft-diameter shaft used in the exploratory shaft program.
--Development Exhaust Shaft - The waste ramp is used for development exhaust.
--Ventilation Flow Paths - Costs of doors, distribution fans, dampers, and flow piping for ventilation flow control.
--Repository Exhaust Shaft - Cost of shaft (excavation, water control, and lining).

Support and Utilities - Support facilities and utilities including:
Administration Building
Cafeteria
Training Center
Men and Materials Building
Maintenance Buildings
Fire Station
Health/Emergency Center
Industrial Safety Center
Visitors' Center
Security Center
Gatehouses
Laboratories
Storage
Material Handling and Storage Buildings
Warehouses and Receiving Buildings
Suspect Rail/Truck Storage
Inspection Facilities
Standby Generator Building (Emergency)
Water Supply, Storage, and Distribution System
Explosive Storage
Water Retention and Evaporation Ponds
Instrumentation
Cooling Towers
Sewage Treatment System
Electrical Substations and Distribution System
Chilled Water and Refrigeration Systems
Radiation Monitoring
Mine Monitoring
Communications
Railroad Equipment

TABLE 3-20 - ASSUMED SCHEDULE OF WASTE RECEIVED OR GENERATED ON-SITE

| CALENDAR YEAR | STAGE I | | | STAGE II | | | |
|---|---|---|---|---|---|---|---|
| | SPENT FUEL[a] | | ON-SITE | SPENT FUEL[a] | | ON-SITE | |
| | PWR (MTU) | BWR (MTU) | CH[b] (12-DRUM PALLET) | PWR (MTU) | BWR (MTU) | RH[c] (CANISTERS) | CH[b] (12-DRUM PALLET) |
| 1998-2000 | 267 | 133 | 16 | 0 | 0 | 0 | 0 |
| 2001 | 267 | 133 | 16 | 333 | 167 | 56 | 19 |
| 2002 | 267 | 133 | 16 | 933 | 467 | 157 | 54 |
| 2003-2006 | 0 | 0 | 0 | 2,000 | 1,000 | 336 | 116 |
| 2007-2024 | 0 | 0 | 0 | 2,000 | 1,000 | 336 | 116 |
| 2025 | 0 | 0 | 0 | 67 | 33 | 11 | 4 |
| | 1,335 | 665 | 80 | 45,333 | 22,667 | 7,616 | 2,629 |

[a] Spent Fuel is assumed to be 2/3 PWR, 1/3 BWR by weight.

[b] CH waste generated at a rate of 0.464 drums/MTU.

[c] RH waste generated at a rate of 0.112 canisters/MTU consolidated.

Table 3.21 Project: NNWSI

Revised Reference Repository Operating Cost Summary
Horizontal Emplacement
(Millions of Mid-1984 Dollars)

| SYSTEM | Emplacement Phase | Caretaker Phase | Backfilling Phase | Total |
|---|---|---|---|---|
| WASTE PREPARATION | 1,508.123 | 0.459 | 0.000 | 1,508.582 |
| Waste Form Subsys | 0.000 | 0.000 | 0.000 | 0.000 |
| --Spent Fuel | 0.000 | 0.000 | 0.000 | 0.000 |
| --On-Site Generated | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Waste Pkg Subsys | 1,508.123 | 0.459 | 0.000 | 1,508.582 |
| --Spent Fuel | 1,497.031 | 0.459 | 0.000 | 1,497.490 |
| Pkg Components | 1,103.012 | 0.459 | 0.000 | 1,103.471 |
| Ass'bly Fac | 394.019 | 0.000 | 0.000 | 394.019 |
| --On-Site Generated | 11.092 | 0.000 | 0.000 | 11.092 |
| Pkg Components | 11.092 | 0.000 | 0.000 | 11.092 |
| Ass'bly Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Pkg Components | 0.000 | 0.000 | 0.000 | 0.000 |
| Ass'bly Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| REPOSITORY SYSTEM | 2,607.504 | 331.288 | 124.837 | 3,063.629 |
| Site | 0.000 | 0.000 | 0.000 | 0.000 |
| --Land & Land Rts | 0.000 | 0.000 | 0.000 | 0.000 |
| --On-Site Impr'mt | 0.000 | 0.000 | 0.000 | 0.000 |
| --Off-Site Impr'mt | 0.000 | 0.000 | 0.000 | 0.000 |
| Waste Hdlg & Empl | 603.106 | 0.000 | 27.395 | 630.501 |
| --Receiving | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other Surf Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| --Waste Shafts | 0.000 | 0.000 | 0.000 | 0.000 |
| --Transfer & Empl | 603.106 | 0.000 | 27.395 | 630.501 |
| Rooms | 94.641 | 0.000 | 27.395 | 122.036 |
| Boreholes | 313.528 | 0.000 | 0.000 | 313.528 |
| Transfer Equip | 194.937 | 0.000 | 0.000 | 194.937 |
| U/G Wkgs/Rock Hdlg | 43.332 | 0.000 | 26.916 | 70.248 |
| --Men/Mat'ls Shaft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Shaft Pillar | 0.000 | 0.000 | 2.534 | 2.534 |
| --Corridors | 21.666 | 0.000 | 17.971 | 39.637 |
| --Rock Hdlg/Disp'l | 21.666 | 0.000 | 6.411 | 28.077 |
| --Test Facilities | 0.000 | 0.000 | 0.000 | 0.000 |
| Ventilation | 109.288 | 108.530 | 24.891 | 242.709 |
| --Vent Structures | 0.000 | 0.000 | 0.000 | 0.000 |
| --Vent Supply Shft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Dev Exhaust Shft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Vent Flow Paths | 109.288 | 108.530 | 24.891 | 242.709 |
| --Repos Exh Shaft | 0.000 | 0.000 | 0.000 | 0.000 |
| Support/Utilities | 1,851.778 | 222.758 | 45.635 | 2,120.171 |
| TOTALS | 4,115.627 | 331.747 | 124.837 | 4,572.211 |

Table 3.22A

Project: NNWSI

Two-Stage Repository Emplacement Cost Summary
Horizontal Emplacement
(Millions of Mid-1984 Dollars)

| SYSTEM | Emplacement Phase Stage 1 | Stage 2 | Common | Total |
|---|---|---|---|---|
| WASTE PREPARATION | 84.616 | 1,456.118 | 4.422 | 1,545.156 |
| Waste Form Subsys | 0.000 | 0.000 | 0.000 | 0.000 |
| --Spent Fuel | 0.000 | 0.000 | 0.000 | 0.000 |
| --On-Site Generated | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Waste Pkg Subsys | 84.616 | 1,456.118 | 4.422 | 1,545.156 |
| --Spent Fuel | 84.288 | 1,445.352 | 4.422 | 1,534.062 |
| Pkg Components | 54.601 | 1,067.197 | 4.422 | 1,126.220 |
| Ass'bly Fac | 29.687 | 378.155 | 0.000 | 407.842 |
| --On-Site Generated | 0.328 | 10.766 | 0.000 | 11.094 |
| Pkg Components | 0.328 | 10.766 | 0.000 | 11.094 |
| Ass'bly Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Pkg Components | 0.000 | 0.000 | 0.000 | 0.000 |
| Ass'bly Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| REPOSITORY SYSTEM | 8.260 | 552.553 | 2,276.695 | 2,837.508 |
| Site | 0.000 | 0.000 | 0.000 | 0.000 |
| --Land & Land Rts | 0.000 | 0.000 | 0.000 | 0.000 |
| --On-Site Impr'mt | 0.000 | 0.000 | 0.000 | 0.000 |
| --Off-Site Impr'mt | 0.000 | 0.000 | 0.000 | 0.000 |
| Waste Hdlg & Empl | 8.260 | 552.553 | 46.257 | 607.070 |
| --Receiving | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other Surf Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| --Waste Shafts | 0.000 | 0.000 | 0.000 | 0.000 |
| --Transfer & Empl | 8.260 | 552.553 | 46.257 | 607.070 |
| Rooms | 0.000 | 94.641 | 0.000 | 94.641 |
| Boreholes | 0.000 | 317.492 | 0.000 | 317.492 |
| Transfer Equip | 8.260 | 140.420 | 46.257 | 194.937 |
| U/G Wkgs/Rock Hdlg | 0.000 | 0.000 | 43.332 | 43.332 |
| --Men/Mat'ls Shaft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Shaft Pillar | 0.000 | 0.000 | 0.000 | 0.000 |
| --Corridors | 0.000 | 0.000 | 21.666 | 21.666 |
| --Rock Hdlg/Disp'l | 0.000 | 0.000 | 21.666 | 21.666 |
| --Test Facilities | 0.000 | 0.000 | 0.000 | 0.000 |
| Ventilation | 0.000 | 0.000 | 117.969 | 117.969 |
| --Vent Structures | 0.000 | 0.000 | 0.000 | 0.000 |
| --Vent Supply Shft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Dev Exhaust Shft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Vent Flow Paths | 0.000 | 0.000 | 117.969 | 117.969 |
| --Repos Exh Shaft | 0.000 | 0.000 | 0.000 | 0.000 |
| Support/Utilities | 0.000 | 0.000 | 2,069.137 | 2,069.137 |
| TOTALS | 92.876 | 2,008.671 | 2,281.117 | 4,382.664 |

Table 3.22B

Project: NNWSI

Two-Stage Repository Operating Cost Summary
Horizontal Emplacement
(Millions of Mid-1984 Dollars)

| SYSTEM | Emplacement Phase | Caretaker Phase | Backfilling Phase | Total |
|---|---|---|---|---|
| WASTE PREPARATION | 1,545.156 | 0.459 | 0.000 | 1,545.615 |
| Waste Form Subsys | 0.000 | 0.000 | 0.000 | 0.000 |
| --Spent Fuel | 0.000 | 0.000 | 0.000 | 0.000 |
| --On-Site Generated | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Waste Pkg Subsys | 1,545.156 | 0.459 | 0.000 | 1,545.615 |
| --Spent Fuel | 1,534.062 | 0.459 | 0.000 | 1,534.521 |
| Pkg Components | 1,126.220 | 0.459 | 0.000 | 1,126.679 |
| Ass'bly Fac | 407.842 | 0.000 | 0.000 | 407.842 |
| --On-Site Generated | 11.094 | 0.000 | 0.000 | 11.094 |
| Pkg Components | 11.094 | 0.000 | 0.000 | 11.094 |
| Ass'bly Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other | 0.000 | 0.000 | 0.000 | 0.000 |
| Pkg Components | 0.000 | 0.000 | 0.000 | 0.000 |
| Ass'bly Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| REPOSITORY SYSTEM | 2,837.508 | 308.002 | 126.667 | 3,272.177 |
| Site | 0.000 | 0.000 | 0.000 | 0.000 |
| --Land & Land Rts | 0.000 | 0.000 | 0.000 | 0.000 |
| --On-Site Impr'mt | 0.000 | 0.000 | 0.000 | 0.000 |
| --Off-Site Impr'mt | 0.000 | 0.000 | 0.000 | 0.000 |
| Waste Hdlg & Empl | 607.070 | 0.000 | 28.795 | 635.865 |
| --Receiving | 0.000 | 0.000 | 0.000 | 0.000 |
| --Other Surf Fac | 0.000 | 0.000 | 0.000 | 0.000 |
| --Waste Shafts | 0.000 | 0.000 | 0.000 | 0.000 |
| --Transfer & Empl | 607.070 | 0.000 | 28.795 | 635.865 |
| Rooms | 94.641 | 0.000 | 28.795 | 123.436 |
| Boreholes | 317.492 | 0.000 | 0.000 | 317.492 |
| Transfer Equip | 194.937 | 0.000 | 0.000 | 194.937 |
| U/G Wkgs/Rock Hdlg | 43.332 | 0.000 | 26.916 | 70.248 |
| --Men/Mat'ls Shaft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Shaft Pillar | 0.000 | 0.000 | 2.534 | 2.534 |
| --Corridors | 21.666 | 0.000 | 17.971 | 39.637 |
| --Rock Hdlg/Disp'l | 21.666 | 0.000 | 6.411 | 28.077 |
| --Test Facilities | 0.000 | 0.000 | 0.000 | 0.000 |
| Ventilation | 117.969 | 99.848 | 24.891 | 242.708 |
| --Vent Structures | 0.000 | 0.000 | 0.000 | 0.000 |
| --Vent Supply Shft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Dev Exhaust Shft | 0.000 | 0.000 | 0.000 | 0.000 |
| --Vent Flow Paths | 117.969 | 99.848 | 24.891 | 242.708 |
| --Repos Exh Shaft | 0.000 | 0.000 | 0.000 | 0.000 |
| Support/Utilities | 2,069.137 | 208.154 | 46.065 | 2,323.356 |
| TOTALS | 4,382.664 | 308.461 | 126.667 | 4,817.792 |

DISTRIBUTION LIST

B. C. Rusche (RW-1)
Director
Office of Civilian Radioactive
Waste Management
U.S. Department of Energy
Forrestal Building
Washington, DC 20585

J. W. Bennett (RW-20)
Office of Geologic Repositories
U.S. Department of Energy
Forrestal Building
Washington, DC 20585

Ralph Stein (RW-23)
Office of Geologic Repositories
U.S. Department of Energy
Forrestal Building
Washington, DC 20585

J. J. Fiore, (RW-22)
Program Management Division
Office of Geologic Repositories
U.S. Department of Energy
Forrestal Building
Washington, DC 20585

M. W. Frei (RW-23)
Engineering & Licensing Division
Office of Geologic Repositories
U.S. Department of Energy
Forrestal Building
Washington, DC 20585

E. S. Burton (RW-25)
Siting Division
Office of Geologic Repositories
U.S. Department of Energy
Forrestal Building
Washington, D.C. 20585

C. R. Cooley (RW-24)
Geosciences & Technology Division
Office of Geologic Repositories
U.S. Department of Energy
Forrestal Building
Washington, DC 20585

T. P. Longo (RW-25)
Program Management Division
Office of Geologic Repositories
U.S. Department of Energy
Forrestal Building
Washington, DC 20585

Cy Klingsberg (RW-24)
Geosciences and Technology Division
Office of Geologic Repositories
U. S. Department of Energy
Forrestal Building
Washington, DC 20585

B. G. Gale (RW-25)
Siting Division
Office of Geologic Repositories
U.S. Department of Energy
Forrestal Building
Washington, D.C. 20585

R. J. Blaney (RW-22)
Program Management Division
Office of Geologic Repositories
U.S. Department of Energy
Forrestal Building
Washington, DC 20585

R. W. Gale (RW-44)
Office of Policy, Integration, and
Outreach
U.S. Department of Energy
Forrestal Building
Washington, D.C. 20585

J. E. Shaheen (RW-44)
Outreach Programs
Office of Policy, Integration and
Outreach
U.S. Department of Energy
Forrestal Building
Washington, DC 20585

J. O. Neff
Salt Repository Project Office
U.S. Department of Energy
505 King Avenue
Columbus, OH 43201

D. C. Newton (RW-23)
Engineering & Licensing Division
Office of Geologic Repositories
U.S. Department of Energy
Forrestal Building
Washington, DC 20585

O. L. Olson, Manager
Basalt Waste Isolation Project Office
U.S. Department of Energy
Richland Operations Office
Post Office Box 550
Richland, WA 99352

D. L. Vieth, Director (4)
Waste Management Project Office
U.S. Department of Energy
Post Office Box 14100
Las Vegas, NV 89114

D. F. Miller, Director
Office of Public Affairs
U.S. Department of Energy
Post Office Box 14100
Las Vegas, NV 89114

D. A. Nowack (14)
Office of Public Affairs
U.S. Department of Energy
Post Office Box 14100
Las Vegas, NV 89114

B. W. Church, Director
Health Physics Division
U.S. Department of Energy
Post Office Box 14100
Las Vegas, NV 89114

Chief, Repository Projects Branch
Division of Waste Management
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

S. A. Mann, Manager
Crystalline Rock Project Office
U.S. Department of Energy
9800 South Cass Avenue
Argonne, IL 60439

K. Street, Jr.
Lawrence Livermore National
Laboratory
Post Office Box 808
Mail Stop L-209
Livermore, CA 94550

L. D. Ramspott (3)
Technical Project Officer for NNWSI
Lawrence Livermore National
Laboratory
P.O. Box 808
Mail Stop L-204
Livermore, CA 94550

J. E. Boudreau
Los Alamos National Laboratory
P.O. Box 1663
Mail Stop F-671
Los Alamos, NM 87545

D. T. Oakley (3)
Technical Project Officer for NNWSI
Los Alamos National Laboratory
P.O. Box 1663
Mail Stop F-671
Los Alamos, NM 87545

W. W. Dudley, Jr. (3)
Technical Project Officer for NNWSI
U.S. Geological Survey
Post Office Box 25046
418 Federal Center
Denver, CO 80225

NTS Section Leader
Repository Project Branch
Division of Waste Management
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Document Control Center
Division of Waste Management
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

P. T. Prestholt
NRC Site Representative
1050 East Flamingo Road
Suite 319
Las Vegas, NV 89109

M. E. Spaeth
Technical Project Officer for NNWSI
Science Applications
International, Corp.
2769 South Highland Drive
Las Vegas, NV 89109

SAIC-T&HSS Library (2)
Science Applications
International, Corp.
2950 South Highland Drive
Las Vegas, NV 89109

W. S. Twenhofel, Consultant
Science Applications
International, Corp.
820 Estes Street
Lakewood, CO 80215

A. E. Gurrola
General Manager
Energy Support Division
Holmes & Narver, Inc.
Post Office Box 14340
Las Vegas, NV 89114

J. A. Cross, Manager
Las Vegas Branch
Fenix & Scisson, Inc.
Post Office Box 15408
Las Vegas, NV 89114

N. E. Carter
Battelle Columbus Laboratory
Office of Nuclear Waste Isolation
505 King Avenue
Columbus, OH 43201

V. M. Glanzman
U.S. Geological Survey
Post Office Box 25046
913 Federal Center
Denver, CO 80225

J. B. Wright
Technical Project Officer for NNWSI
Westinghouse Electric Corporation
Waste Technology Services Division
Nevada Operations
Post Office Box 708
Mail Stop 703
Mercury, NV 89023

ONWI Library (2)
Battelle Columbus Laboratory
Office of Nuclear Waste Isolation
505 King Avenue
Columbus, OH 43201

W. M. Hewitt, Program Manager
Roy F. Weston, Inc.
2301 Research Blvd., 3rd Floor
Rockville, MD 20850

H. D. Cunningham
General Manager
Reynolds Electrical &
Engineering Co., Inc.
Post Office Box 14400
Mail Stop 555
Las Vegas, NV 89114

T. Hay, Executive Assistant
Office of the Governor
State of Nevada
Capitol Complex
Carson City, NV 89710

R. R. Loux, Jr., Director (8)
Nuclear Waste Project Office
State of Nevada
Capitol Complex
Carson City, NV 89710

C. H. Johnson, Technical
Program Manager
Nuclear Waste Project Office
State of Nevada
Capitol Complex
Carson City, NV 89710

John Fordham
Desert Research Institute
Water Resources Center
Post Office Box 60220
Reno, NV 89506

Department of Comprehensive
Planning
Clark County
225 Bridger Avenue, 7th Floor
Las Vegas, NV 89155

Lincoln County Commission
Lincoln County
Post Office Box 90
Pioche, NV 89043

Community Planning and
Development
City of North Las Vegas
Post Office Box 4086
North Las Vegas, NV 89030

Richard A. Robinson, Manager
Engineering Technology Department
Office of Crystalline Repository
Battelle
Project Management Division
505 King Avenue
Columbus, OH 43201

James L. Ash, Manager
Engineering Design Department
Basalt Waste Isolation Project
Rockwell Hanford Operations
P.O. Box 800
Richland, WA 99352

Richard S. Kingsley, Manager
Repository Surface Facilities
BMPD-ONWI
Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

Dr. Martin Hifflin
Desert Research Institute
Water Resources Center
Suite 201
1500 East Tropicana Avenue
Las Vegas, NV 89109

Planning Department
Nye County
Post Office Box 153
Tonopah, NV 89049

Economic Development
Department
City of Las Vegas
400 East Stewart Avenue
Las Vegas, NV 89101

Nuri Bulut
Project Manager
U.S. Department of Energy
Chicago Operations Office - PMED
9800 South Cass Avenue
Argonne, IL 60439

Sam J. Basham, Manager
Repository Project Office
Office of Nuclear Waste Isolation
Battelle
Project Management Division
505 King Avenue
Columbus, OH 43201

Keith Robinette
Program Engineer
U.S. Department of Energy
NWTS Program Office
505 King Avenue
Columbus, OH 43201

Larry P. Skousen
Project Engineer
U.S. Department of Energy
P.O. Box 1440
Las Vegas, NV 89114

Martin P. Hanson
Repository Design Manager
WESTON
2301 Research Boulevard, 3rd Floor
Rockville, MD 20850

Bruce Nicoll
U.S. Department of Energy
BWIPO
P.O. Box 550
Richland, WA 99352

Virgil Lowery
Engineering and Licensing Division
Office of Geologic Repository
Deployment
U.S. Department of Energy
GTN (S-10), Room G-456
Washington, D.C. 20545

J. L. Younker (15)
Science Applications, Inc.
2769 South Highland Drive
Las Vegas, NV 89101

6300 R. W. Lynch
6310 T. O. Hunter
6310 NNWSICF
6311 L. W. Scully
6311 H. R. MacDougall (3)
6311 E. B. Barnett
6311 L. Perrine (2)
6312 F. W. Bingham
6313 J. R. Tillerson
6332 WMP Library
6430 N. R. Ortiz
3141 C. M. Ostrander (5)
3151 W. L. Garner (3)
8024 M. A. Pound
DOE/TIC (28)
(3154-3 C. H. Dalin)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |