

BRIEFING ON ENGINEERED SYSTEMS

For:

NUCLEAR WASTE TECHNICAL REVIEW BOARD

Presented By:

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Office of Civilian Radioactive Waste Management**

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DISCUSSION TOPICS

WASTE PACKAGE

REPOSITORY

- **Surface**
- **Underground**

WASTE PACKAGE PROGRAM

WASTE PACKAGE/ENGINEERED BARRIER SYSTEM

WASTE PACKAGE CONSTITUTES ONE PART OF "ENGINEERED BARRIER SYSTEM" (EBS)

- **Waste Package** - "including the waste form and any containers, shielding, packing and other sorbent materials immediately surrounding an individual waste container." (ref 10 CFR 60)
- **Underground Facility** - "the underground structure, including openings and backfill materials but excluding shafts, boreholes and their seals." (ref 10 CFR 60.2)

TWO PRINCIPAL COMPONENTS OF REFERENCE WASTE PACKAGE DESIGN

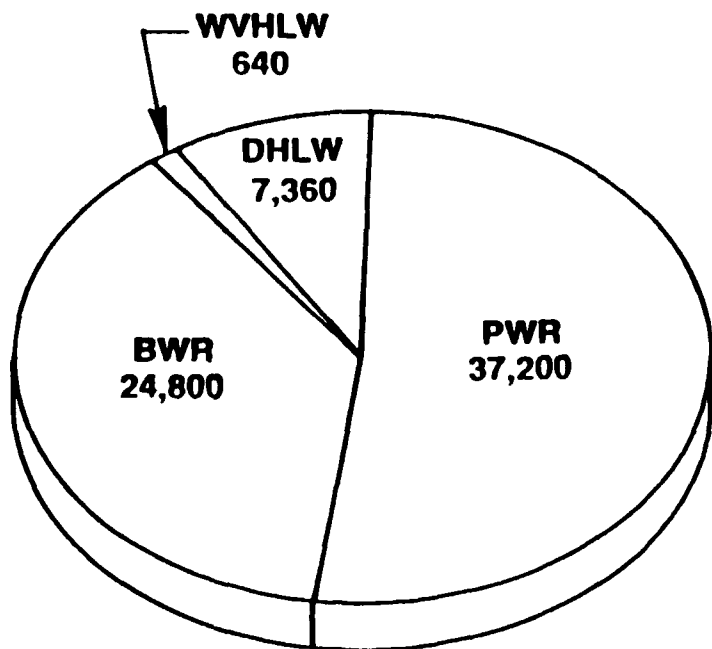
- **Waste Form**
- **Container**

TWO GENERIC TYPES OF WASTE

- **SPENT NUCLEAR FUEL FROM COMMERCIAL REACTORS**
- **HLW FROM COMMERCIAL & DEFENSE FUEL REPROCESSING**

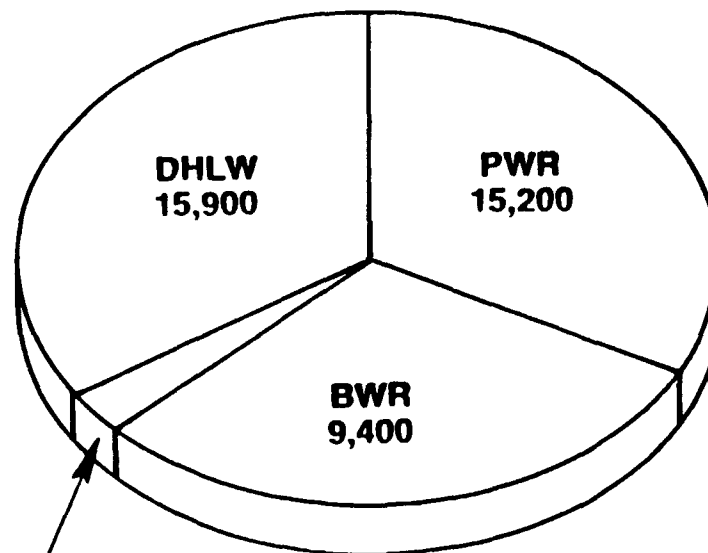
DESIGN BASIS SUMMARY

WASTE PARAMETERS



MTU EQUIVALENT

TOTAL = 70,000 MTU



NUMBER OF CONTAINERS

TOTAL = 40,800

REGULATORY REQUIREMENTS FOR WASTE PACKAGE DESIGN

10 CFR PART 60 (NRC)

- **"Disposal of High-Level Radioactive Wastes in Geologic Repositories"**

10 CFR PART 960 (DOE)

- **"General Guidelines for the Recommendation of Sites for Nuclear Waste Repositories"**

40 CFR PART 191 (EPA)

- **"Environmental Radiation Protection Standards for Management & Disposal of SNF, High-Level, & Transuranic Radioactive Wastes"**

10 CFR PART 60
DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTES IN
GEOLOGIC REPOSITORIES

NRC REGULATORY REQUIREMENTS

- **Part 60.113 - Performance of Particular Barriers After Permanent Closure**
 - **Substantially Complete Containment**
 - **Controlled Release**

- **Part 60.135 - Design Criteria for the Waste Package**

- **Other Requirements in Regulation**
 - **Consideration of Alternative Designs**
 - **Retrievability**
 - **Criticality**
 - **Performance Confirmation**

10 CFR PART 60

Features

ANTICIPATED PROCESS & EVENTS

- **"Anticipated" (and Unanticipated) Defined Qualitatively in Regulation**
- **DOE Has Established Quantitative Definitions as Follows:**
 - **Anticipated Process & Events: Probability of Occurrence > 0.1**
 - **Unanticipated Process & Events: < 0.1**
- **Examples of Unanticipated Process & Events**
 - **Greater Quantities of Water**
 - **More Corrosive Groundwater**

10 CFR PART 60 Features (Continued)

"SUBSTANTIALLY COMPLETE CONTAINMENT"

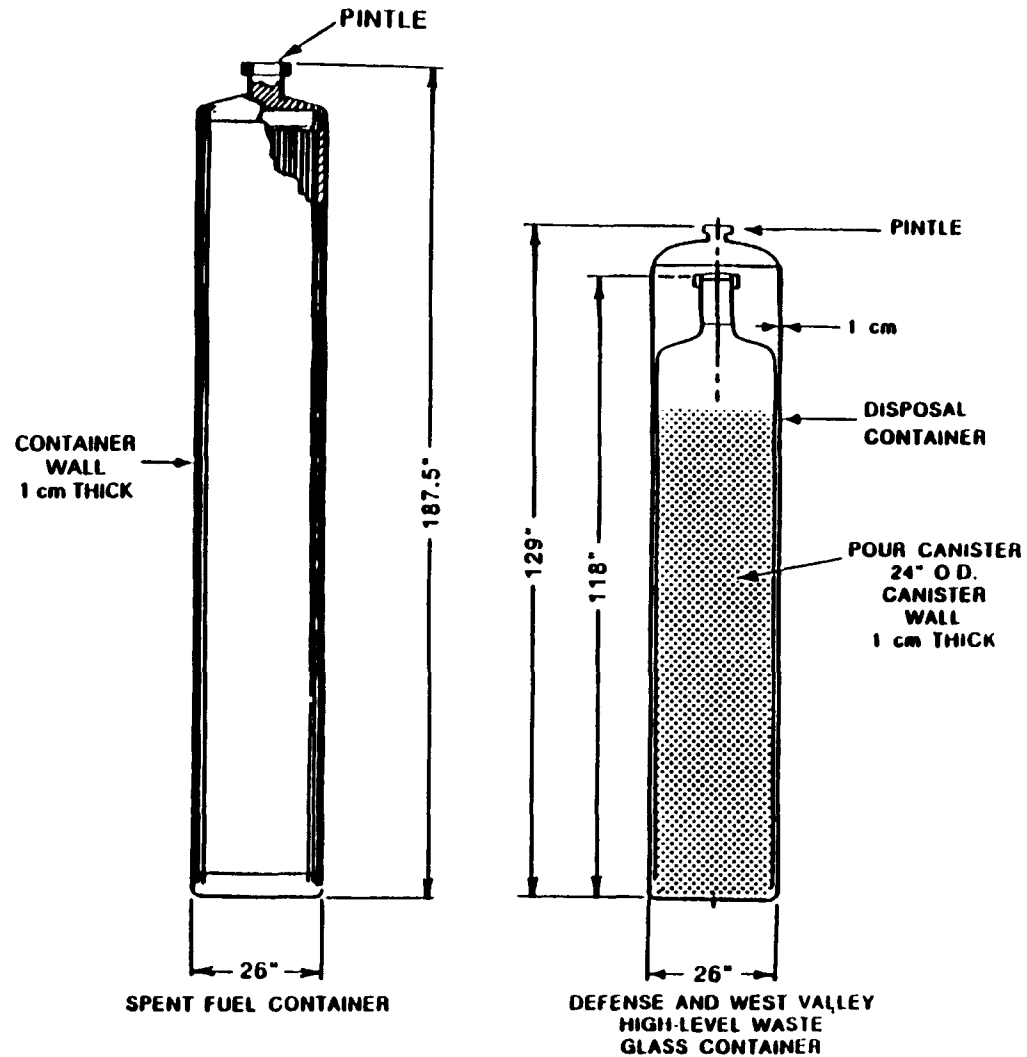
- **Complete Containment for 300 to 1,000 Years After Permanent Closure**
 - **Waste Package is Primary Barrier**
 - **Technology Limitations Considered**

10 CFR PART 60 Features (Continued)

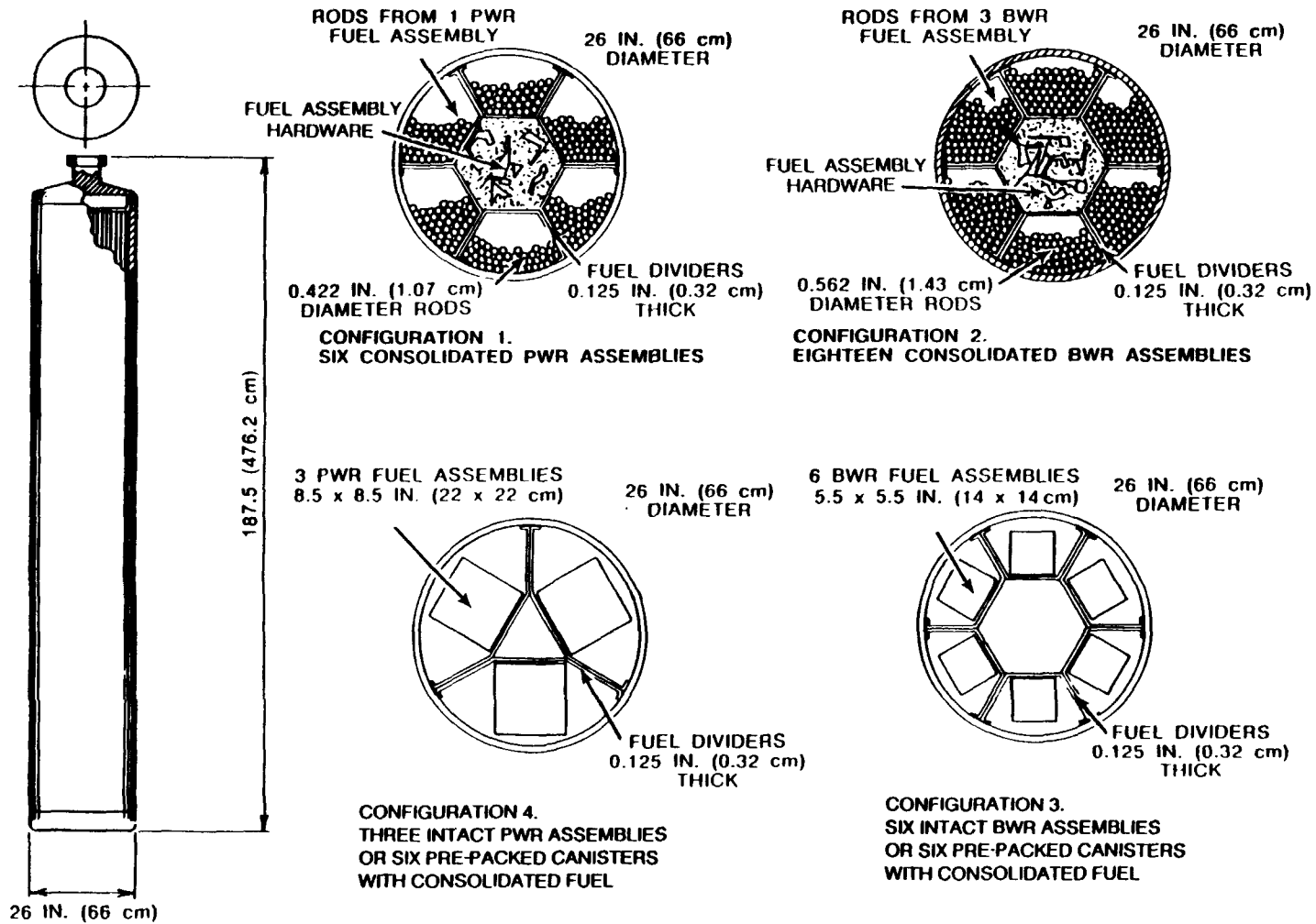
CONTROLLED RELEASE REQUIREMENTS

- **Gradual Release For 10,000 Years Following Containment Period**
 - **Release Rate < 1 Part in 100,000**
 - **Waste Form is Primary Barrier**

REFERENCE SPENT FUEL AND HIGH-LEVEL WASTE PACKAGES



REFERENCE DESIGNS OF SPENT FUEL WASTE PACKAGES



EXPECTED WASTE PACKAGE ENVIRONMENT

DENSELY-WELDED TUFF ROCK - UNSATURATED, FRACTURED, SLIGHTLY POROUS, WITH A LOW DOWNWARD WATER FLUX (0.5MM/YEAR)

WATER CHEMISTRY - NEUTRAL pH, MODERATELY OXIDIZING, LOW LEVELS OF CORROSIVE IONS SUCH AS CHLORIDE IONS

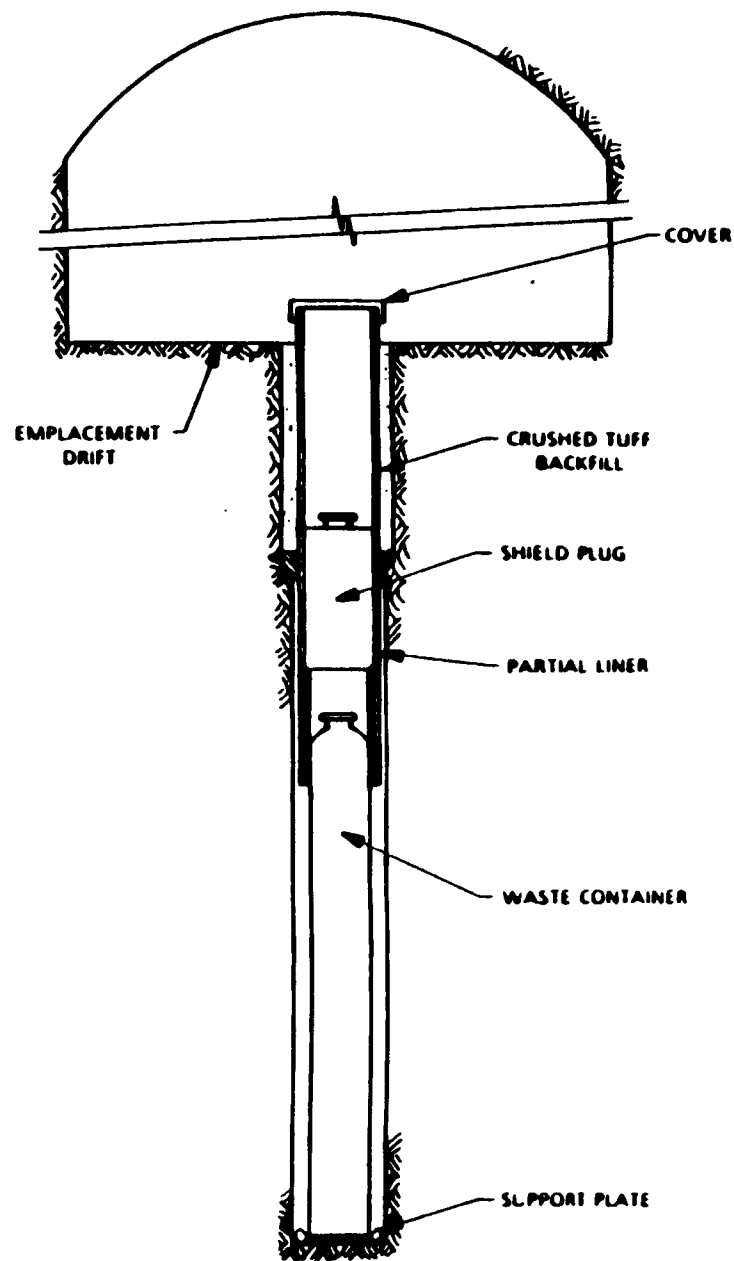
WATER QUANTITY - VERY LIMITED, ALTHOUGH SOME INTERMITTENT CONTACT WITH WATER POSSIBLE

RADIOLYSIS OF WATER VAPOR/AIR MIXTURE - POSSIBLE, BUT NOT EXPECTED TO BE SIGNIFICANT

REFERENCE DESIGN APPROACH

- **RELIANCE ON FAVORABLE NATURAL CHARACTERISTICS OF ENVIRONMENT**
- **RELIANCE ON PERFORMANCE OF THIN-WALLED (1-3CM) METAL WASTE PACKAGE CONTAINER**
- **CANDIDATE MATERIALS:**
 - 304L Stainless Steel**
 - 316L Stainless Steel**
 - 70/30 Copper Nickel**
 - Aluminum Bronze Alloy**
 - Copper**
 - 825 Incolloy**

CONCEPTUAL DESIGN OF A VERTICAL BOREHOLE



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CURRENT PROGRAM ACTIVITIES

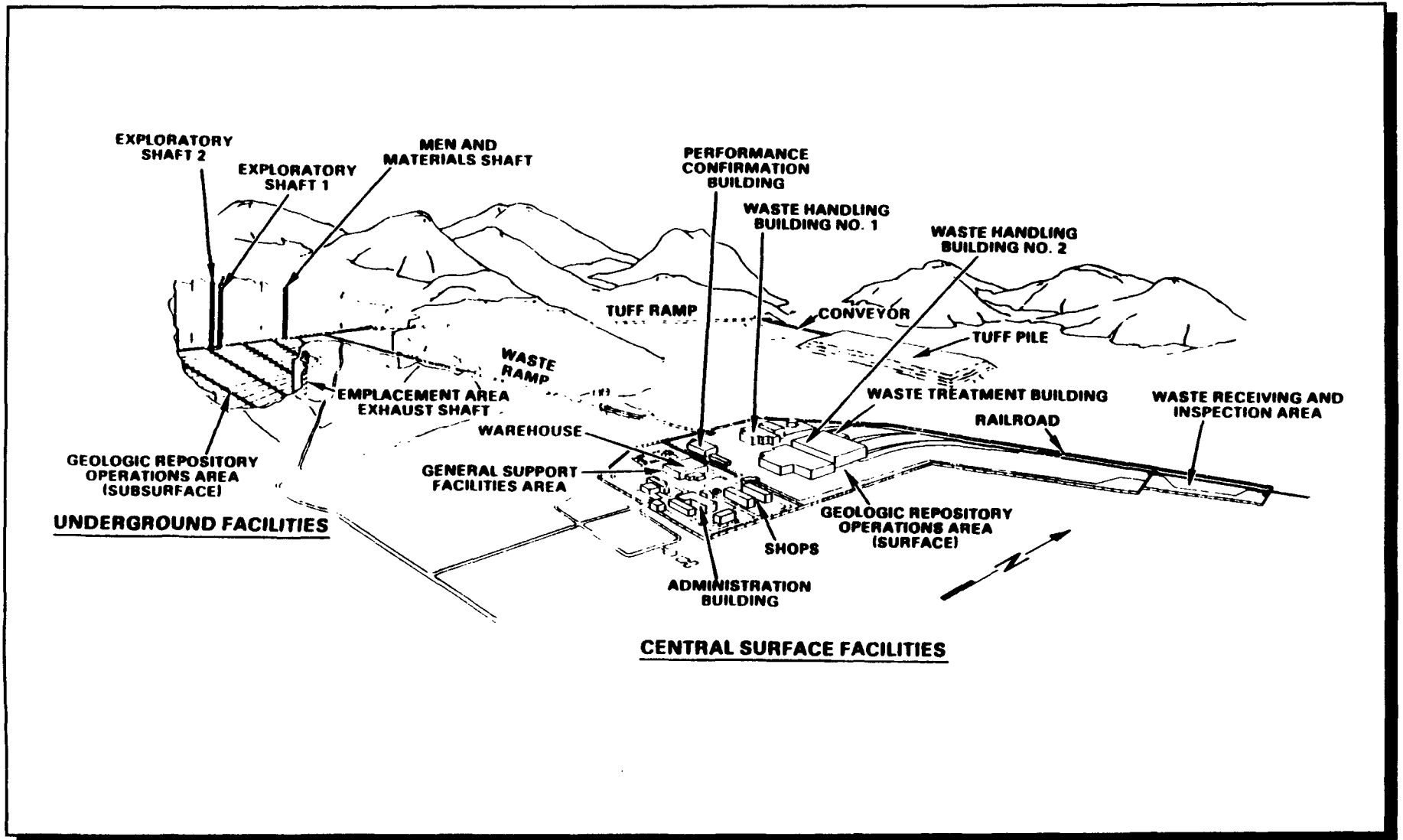
- **COMPLETING WASTE PACKAGE POST CLOSURE COMPLIANCE STRATEGY DOCUMENT**
- **DEFINING A REFERENCE WASTE PACKAGE ENVIRONMENT**
- **DEFINING REFERENCE WASTE FORM CHARACTERISTICS**
- **CHARACTERIZING REFERENCE BARRIER MATERIALS LEADING TO MATERIAL SELECTION**
- **CONDUCTING INTEGRATED TESTS AND THERMODYNAMIC PROPERTY MEASUREMENTS**
- **DEVELOPING PRELIMINARY ENGINEERING DRAWINGS AND COST ESTIMATES FOR WP CONTAINER CONCEPTS**
- **PREPARING WASTE PACKAGE ENVIRONMENTAL STUDY PLANS**

WASTE PACKAGE DESIGN ISSUES

- **CONTAINER MATERIAL DEGRADATION**
- **CHARACTERIZATION OF ENVIRONMENT**
- **WASTE FORM CHARACTERIZATION**
- **SPENT FUEL CLADDING PERFORMANCE**

REPOSITORY FACILITIES

CONCEPTUAL REPOSITORY DESIGN



SUMMARY OF DESIGN BASIS

WASTE TYPES: Spent Fuel (SF), High-Level Waste (HLW)

SPENT FUEL TYPES: 60% PWR, 40% BWR

SPENT FUEL BURNUP: Up to 33,000 MWD/MTU

SPENT FUEL AGE: Minimum 5 Years; Average Age > 10 Years

DESIGN CAPACITY:	62,000	MTU SF
	<u>8,000</u>	MTU HLW
	70,000	MTU

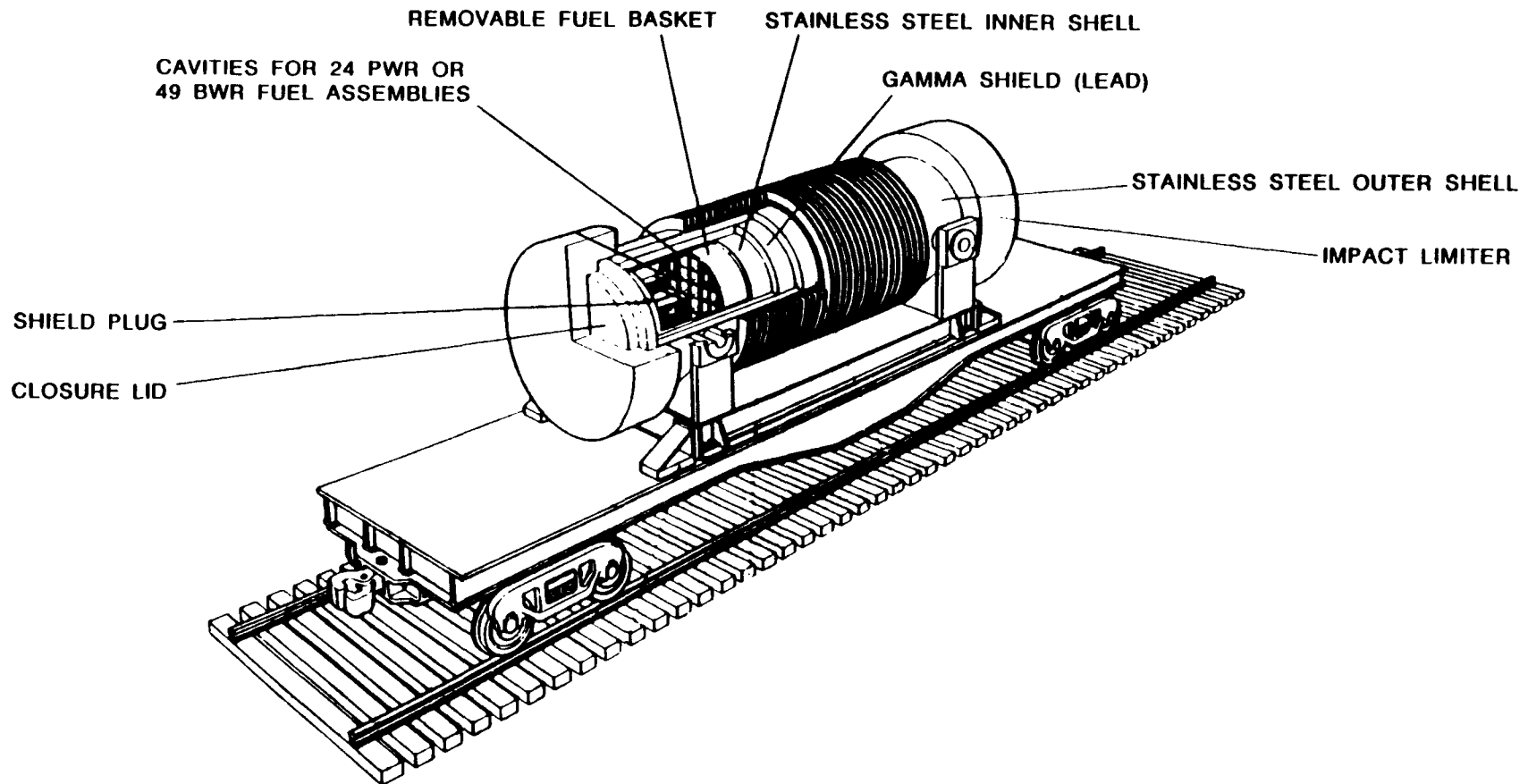
RECEIPT RATE:

Initial = 400 MTU/YR SF

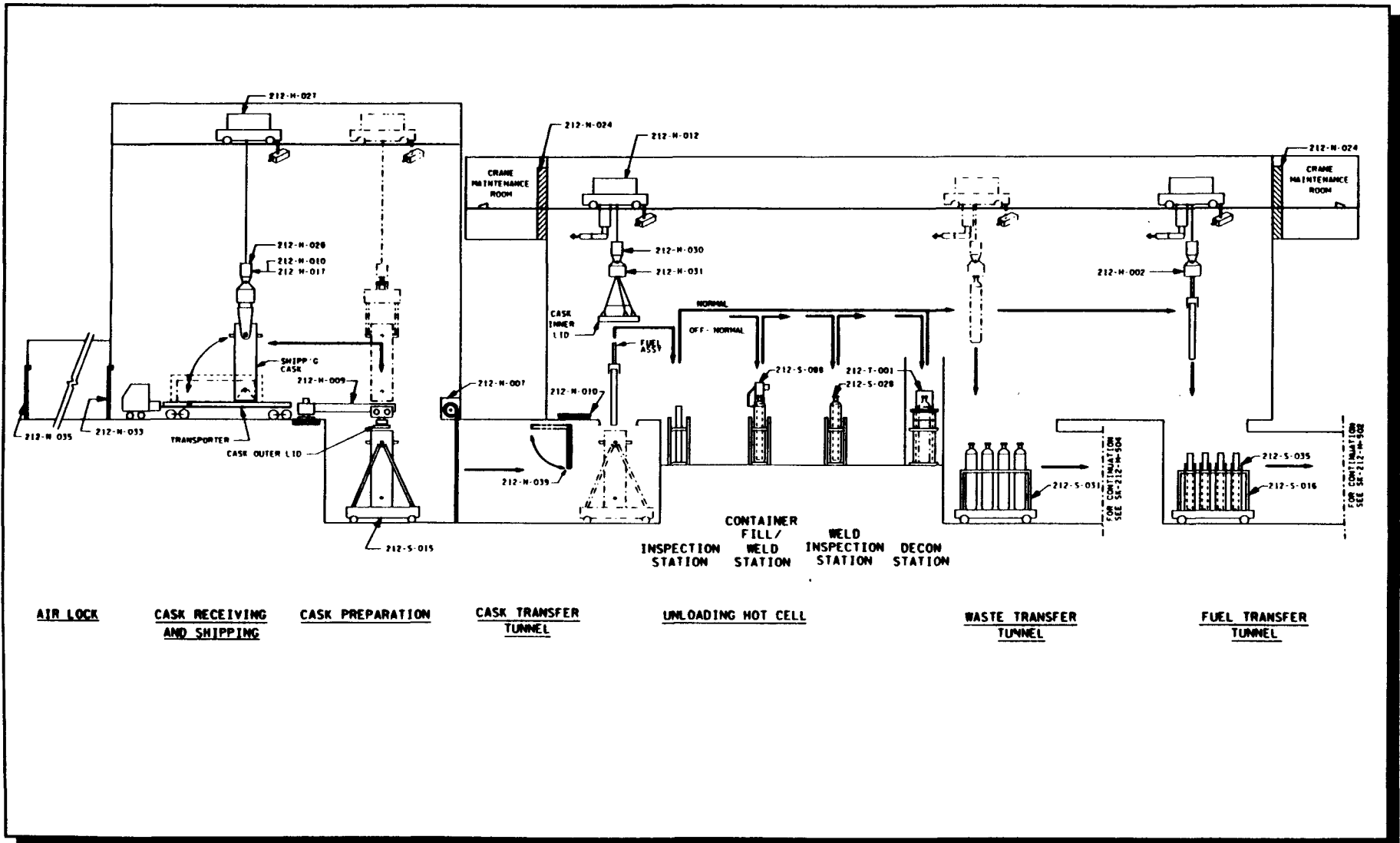
Full Operations = 3,000 MTU/YR SF + 400 MTU/YR HLW

SITE-GENERATED WASTE: Ship Off Site

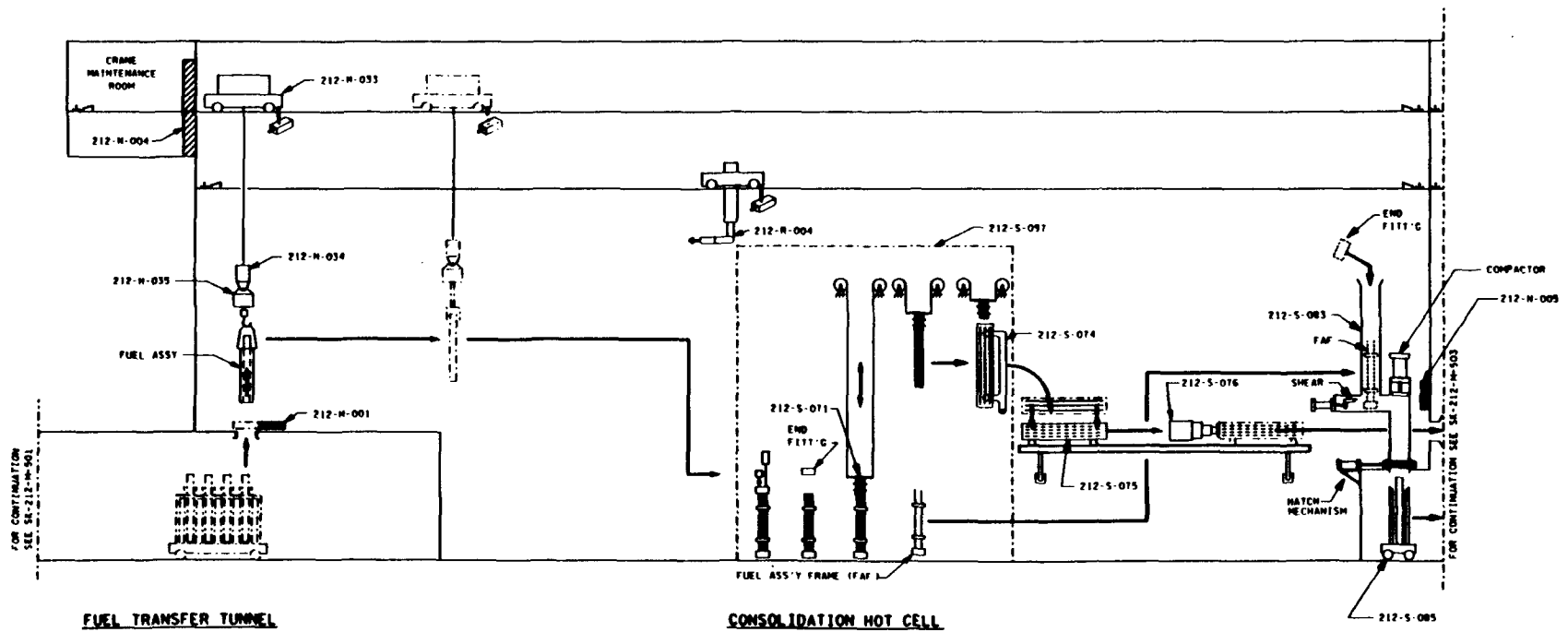
REFERENCE SHIPPING CASK DESIGN 100-TON RAIL/BARGE CASK



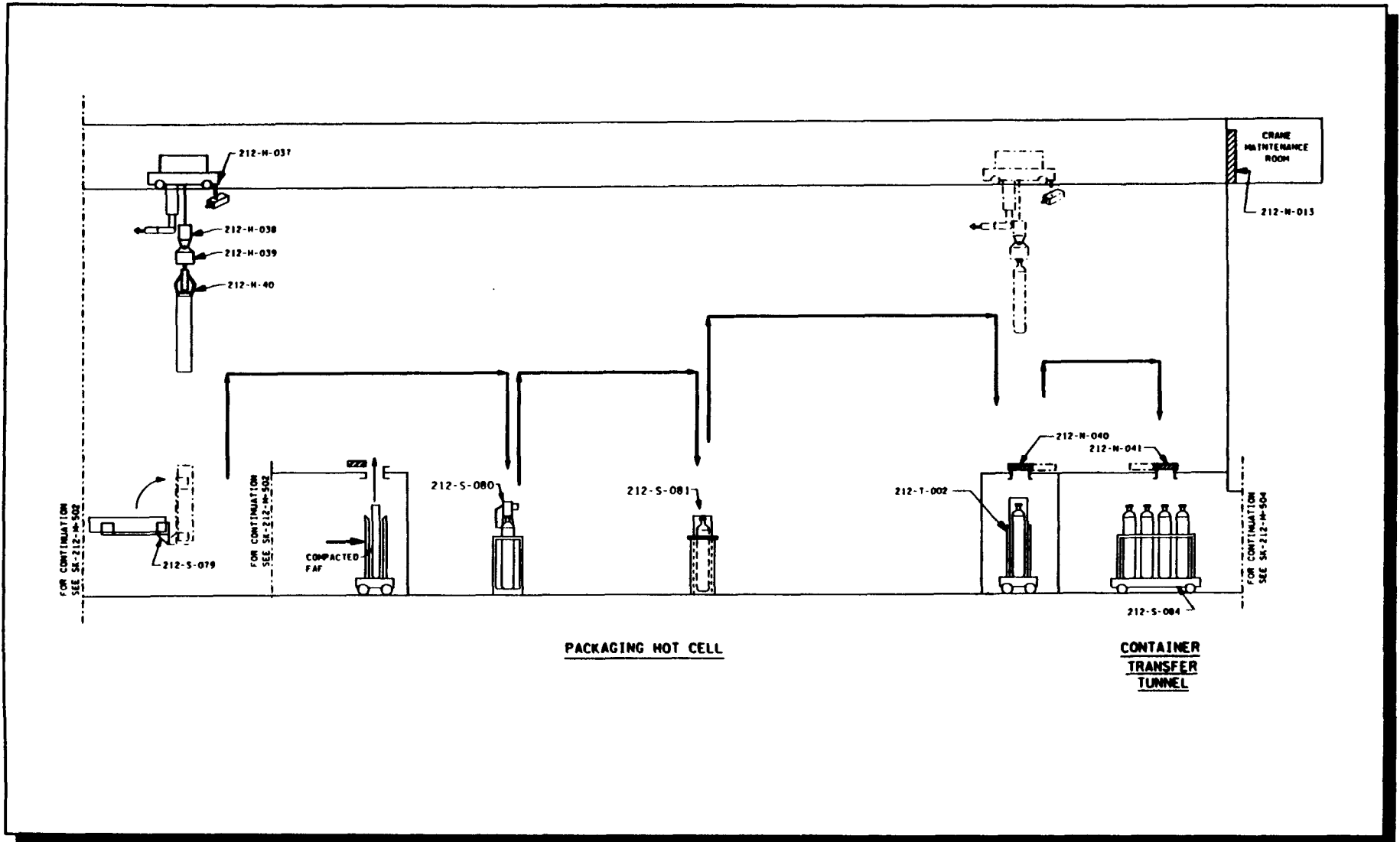
WASTE HANDLING OPERATIONS



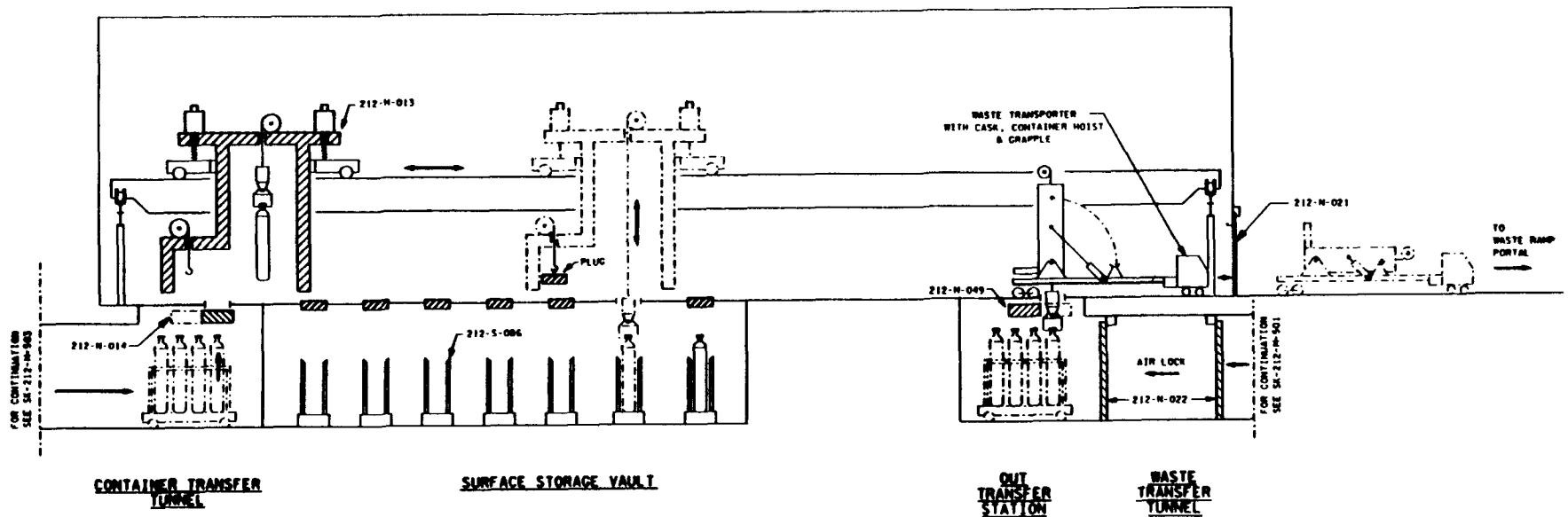
WASTE HANDLING OPERATIONS (Continued)



WASTE HANDLING OPERATIONS (Continued)



WASTE HANDLING OPERATIONS (Continued)



SURFACE FACILITIES CURRENT ACTIVITIES

- **PREPARING REPOSITORY DESIGN REQUIREMENTS**
- **CONDUCTING ADVANCED CONCEPTUAL DESIGN (ACD) STUDIES;**

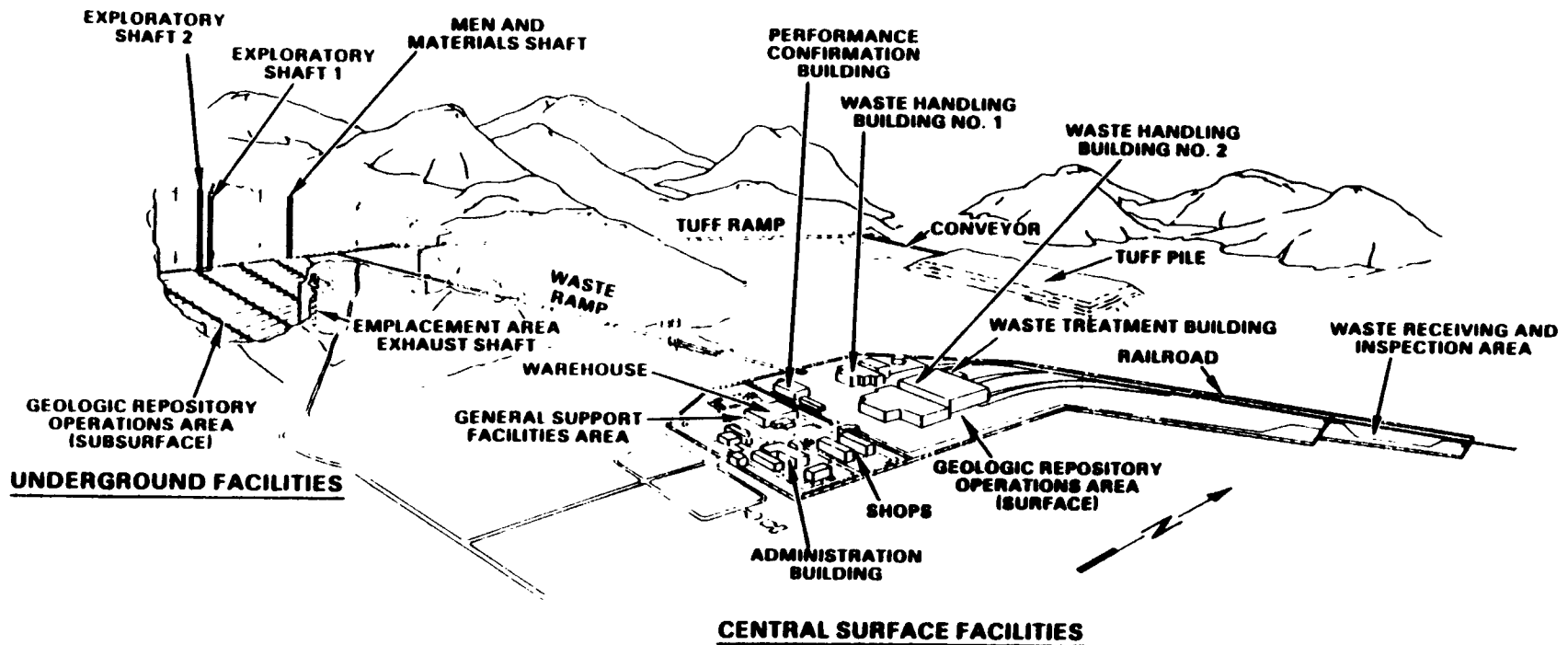
Examples:

- **Impact of Receipt Rates**
- **Seismic Design Criteria**
- **Fabrication/Closure Inputs to Container Material Selection**

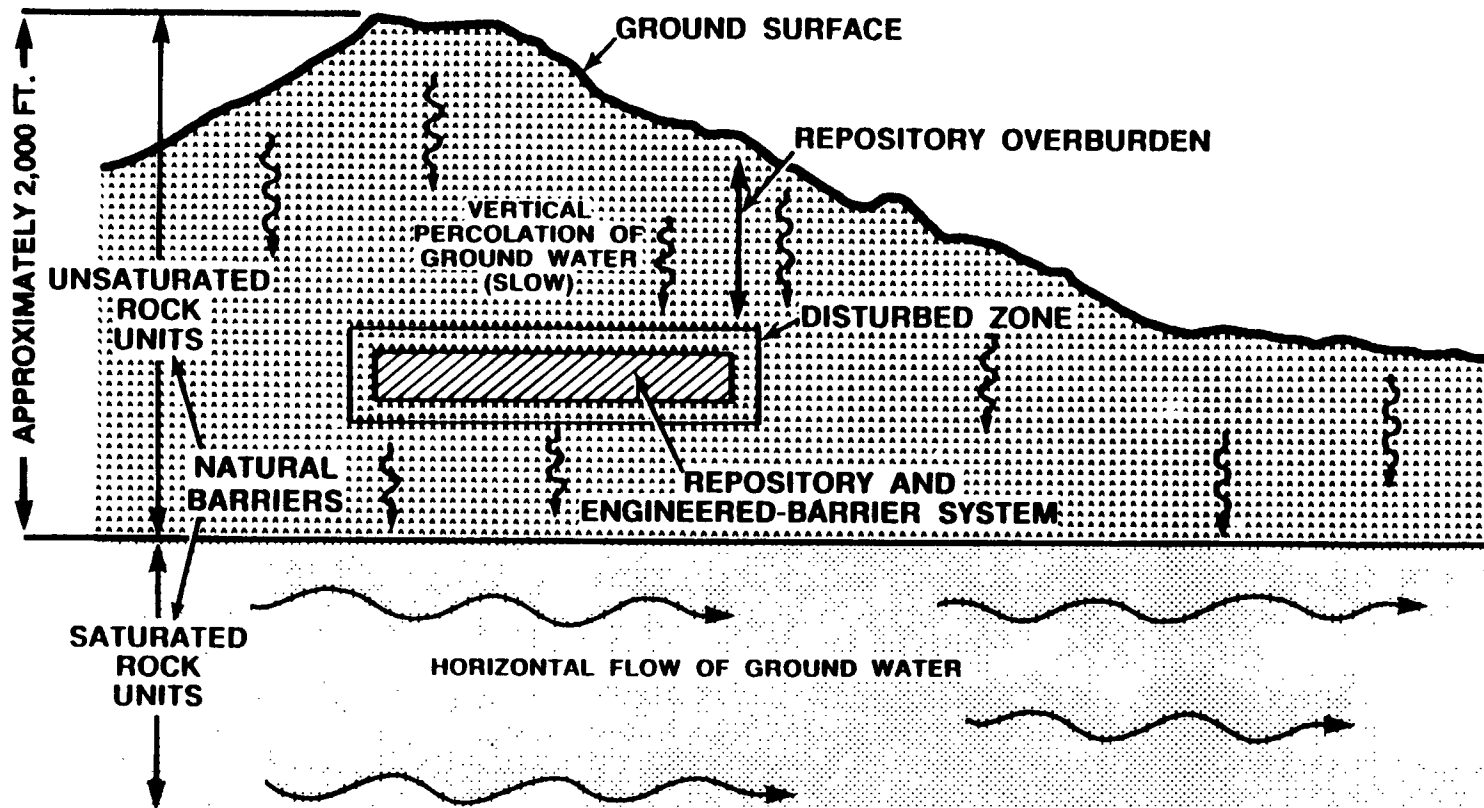
REPOSITORY

UNDERGROUND FACILITIES

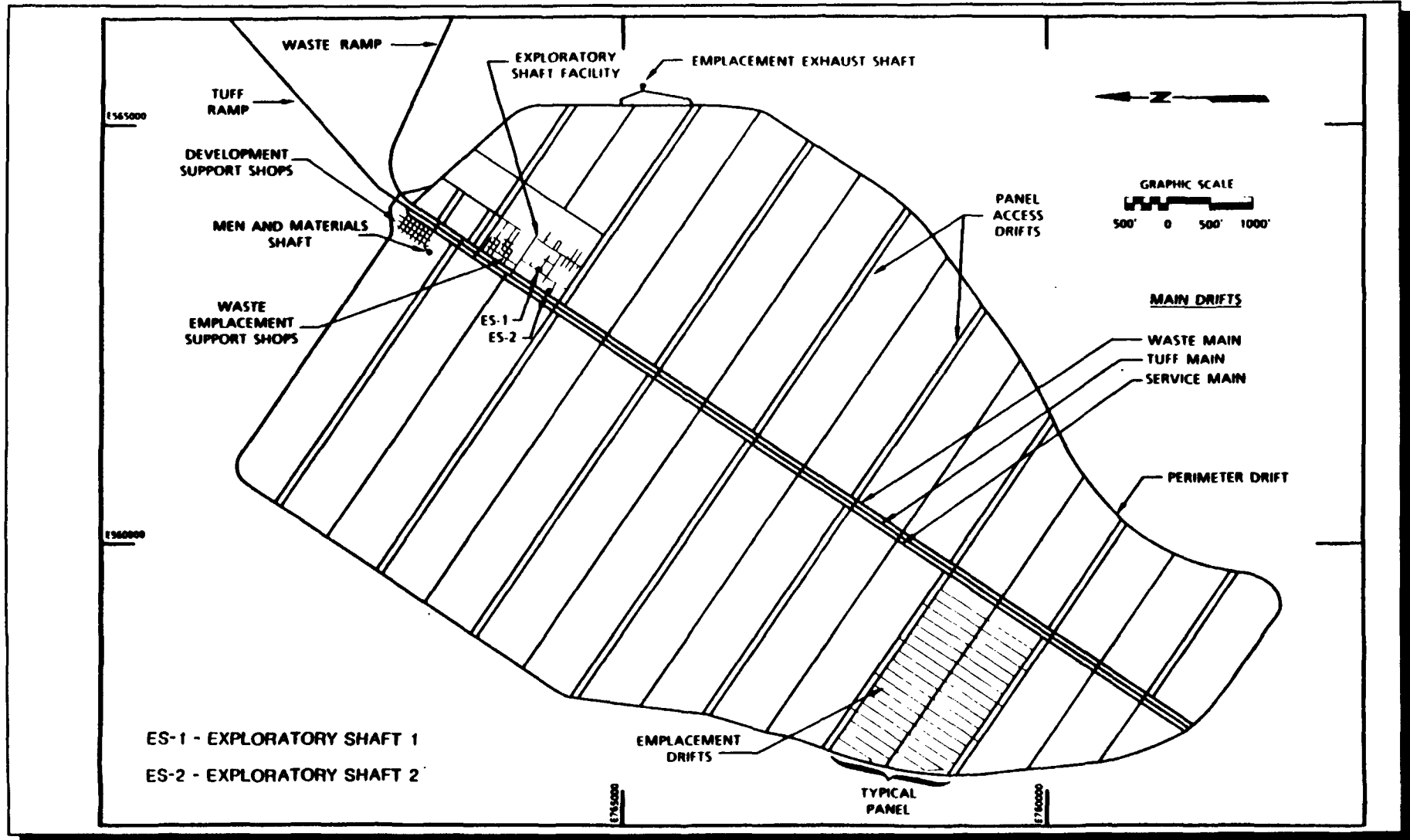
CONCEPTUAL REPOSITORY DESIGN



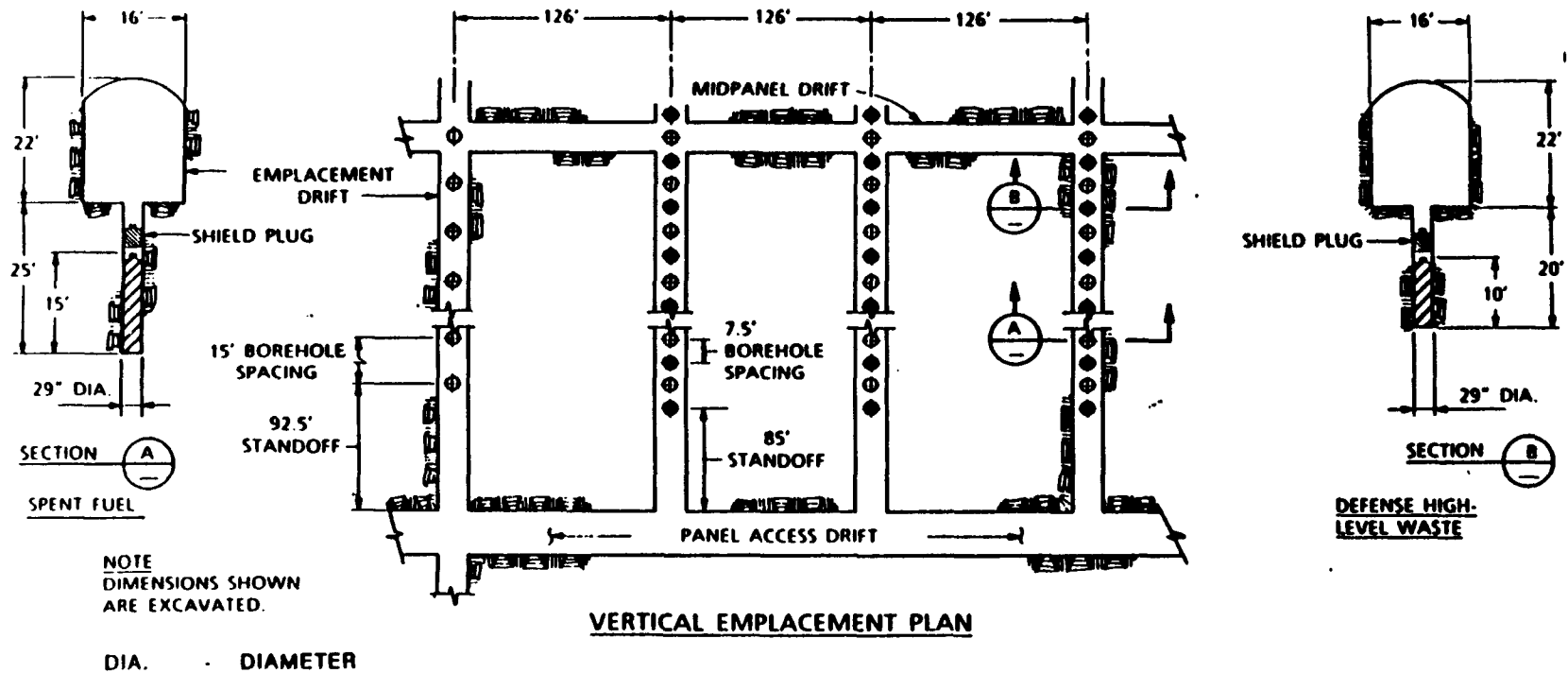
REPOSITORY OBJECTIVE IS TO ISOLATE RADIOACTIVE MATERIALS BY USING NATURAL AND ENGINEERED BARRIERS



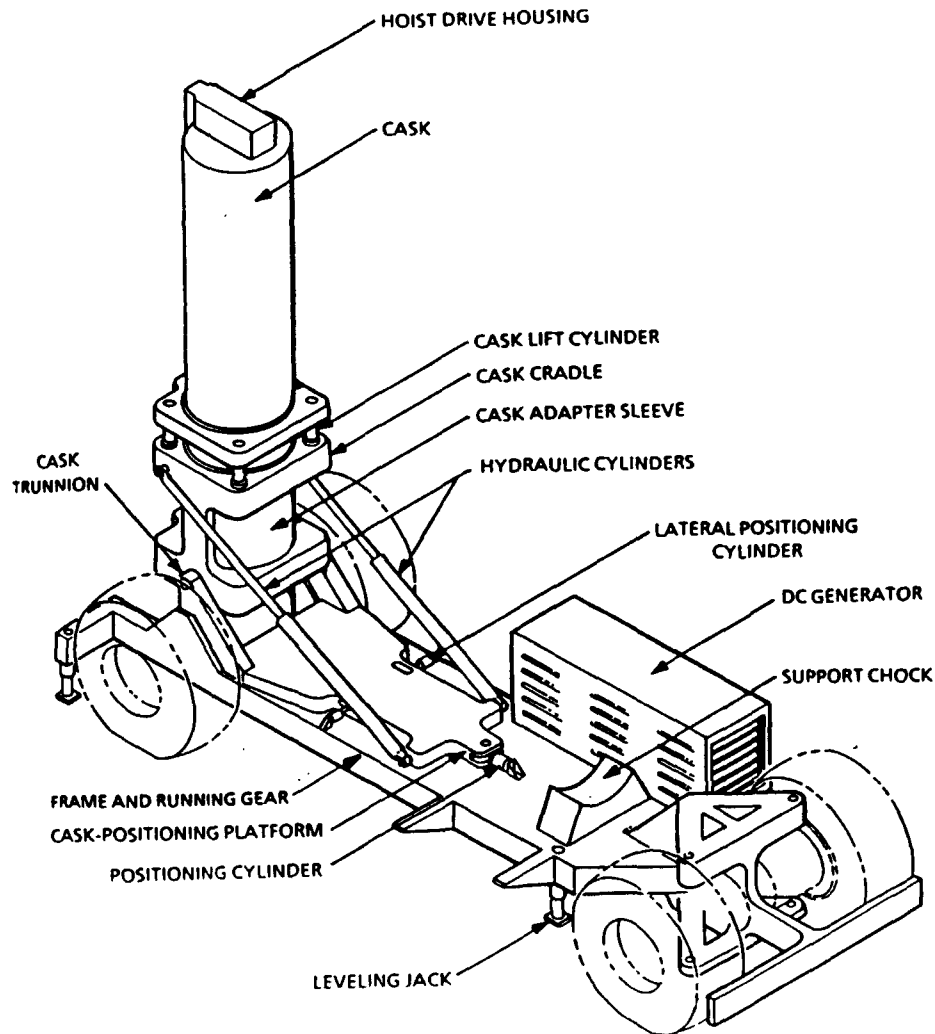
VERTICAL EMPLACEMENT CONFIGURATION



PANEL DETAILS FOR VERTICAL EMPLACEMENT



WASTE TRANSPORTER: EMPLACEMENT MODE



MAJOR DESIGN FEATURES

- **REPOSITORY HORIZON DEPTH: 1,010-1,060 FT**
- **ACCESS TO EMPLACEMENT HORIZON:**
 - **Waste Ramp (Waste Emplacement Intake): 23' DIA**
 - **Tuff Ramp (Development Exhaust): 25' DIA**
 - **Men & Materials Shaft (Development Intake): 20' DIA**
 - **Waste Emplacement Exhaust Shaft: 20' DIA**
 - **Two Exploratory Shafts (Waste Emplacement Intake): 12' DIA**

MAJOR DESIGN FEATURES (Continued)

UNDERGROUND AREAL EXTENT:

- **Area Available for Emplacement: 1,850 Acres**
- **Area Utilized for Emplacement: 1,420 Acres**

TOTAL LENGTH OF DRIFTING:

- **Approx 116 Miles/14.4 Million Tons Rock to be Excavated**

UNDERGROUND CONSTRUCTION:

- **Conventional Drill and Blast**
- **Tunnel Boring Machine**

UNDERGROUND FACILITIES CURRENT ACTIVITIES

COMPLETED AND PUBLISHED SCP CONCEPTUAL DESIGN REPORT

PRE-ACD STUDIES

- **Retrieval Strategy**
- **Areal Power Density Allowances**
- **ESF, Equipment, and Repository Interfaces**
- **Impact of Waste Characteristics/Receipt Rates
on Repository Design**
- **Seismic Design Criteria**

SEALING STRATEGIES

CURRENT ISSUES

- **VERTICAL OR HORIZONTAL EMPLACEMENT ORIENTATION**
- **USABLE AREA AND FLEXIBILITY IN DESIGN OF UNDERGROUND FACILITY**
- **PRECLOSURE RADIOLOGICAL SAFETY AND Q-LIST FOR ITEMS IMPORTANT TO SAFETY/WASTE ISOLATION**
- **SEISMIC DESIGN CONSIDERATIONS**
- **IMPLEMENT NECESSARY QA PROCEDURES**